UPPER EAST COAST

WATER SUPPLY PLAN

Support Document

February 1998

Upper East Coast Water Supply Plan

Support Document

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GLOSSARY AND LIST OF ABBREVIATIONS

Acre-foot. The volume that would cover one acre to a depth of one foot; 43,560 cubic feet; 1,233.5 cubic meters; 325,872 gallons.

Aquifer. A geologic formation or series of formations which yield water in sufficient quantities to be a valuable source of supply.

Aquifer Storage and Recovery (ASR). The injection of freshwater into a confined aquifer during times when supply exceeds demand (wet season), and recovering it during times when there is a supply deficit (dry season).

Aquifer System. A series of geologic formations which consist of two or more aquifers divided by lower permeability units.

AWWA. American Water Works Association.

Backpumping. The practice of pumping water that is leaving the area back into a surface water reservoir.

Basin (Ground Water). A hydrologic unit containing one large aquifer or several connecting and interconnecting aquifers.

Basin (Surface Water). A tract of land drained by a surface water body or its tributaries.

BEBR. Bureau of Economic and Business Research; a division of the University of Florida.

Best Management Practices (BMPs). Agricultural management activities designed to achieve an important goal, such as reducing farm runoff, or optimizing water use.

BOD. Biological Oxygen Demand.

BOR. Basis of Review.

Brackish. Water with a chloride level greater than 250 mg/L and less than 19,000 mg/L.

CARL. Conservation and Recreational Lands.

COD. Chemical Oxygen Demand.

Cone of Influence. The area around a producing well which will be affected by its operation.

Control Structure. A man-made structure designed to regulate the level and/or flow of water in a canal (e.g., weirs, dams).

Conservation Rate Structure. A water rate structure that is designed to conserve water. Examples of conservation rate structures include but are not limited to, increasing block rates, seasonal rates and quantity-based surcharges.

Critical Water Supply Problem Areas. Areas that have experienced, or are anticipated to experience water supply problems in the next 20 years.

Demand. The quantity of water needed to be withdrawn to fulfill a requirement.

Demand Management (Water Conservation). Reducing the demand for water through activities that alter water use practices, improve efficiency in water use, reduce losses of water, reduce waste of water, alter land management practices and/or alter land uses.

Desalination. A process which treats saline water to remove chlorides and dissolved solids.

Drawdown. When a well is pumped, water is removed from the aquifer surrounding the well, and the water table or piezometric surface is lowered. The drawdown at a given point is the distance the water level is dropped.

Effective Rainfall. The portion of rainfall that infiltrates the soil and is stored for plant use in the crop root zone, as calculated by the modified Blaney-Criddle model.

Exotic Nuisance Plant Species. A non-native species which tends to out-compete native species and become quickly established, especially in areas of disturbance or where the normal hydroperiod has been altered.

FAS. Floridan Aquifer System.

FASS. Florida Agricultural and Statistics Service; a division of the Florida Department of Agriculture and Consumer Services.

FDACS. Florida Dept. of Agriculture and Consumer Services.

FDEP. Florida Dept. of Environmental Protection.

Flatwoods (Pine). Natural communities that occur on level land and are characterized by a dominant overstory of slash pine. Depending upon soil drainage characteristics and position in the landscape, pine flatwoods habitats can exhibit xeric to moderately wet conditions.

GPD. Gallons per day.

GPM. Gallons per minute.

Ground Water. All water found beneath the surface of the earth in the voids, fractures, and pores or other openings of soil and rock material.

Hydroperiod. The frequency and duration of inundation or saturation of an ecosystem. In the context of characterizing wetlands, the term hydroperiod describes that length of time during the year that the substrate is either saturated or covered with water.

IFAS. The Institute of Food and Agricultural Sciences; the agricultural branch of the University of Florida, including research, education, and extension.

Infiltration. The movement of water through the soil surface into the soil under the forces of gravity and capillarity.

Inorganic. Pertaining to or composed of chemical compounds other than plant or animal origin.

Irrigation. The application of water to crops by artificial means. Purposes for irrigating may include, but are not limited to, supplying evapotranspiration needs, leaching of salts, and environmental control.

Irrigation Audit. A procedure in which an irrigation system's application rate and uniformity are measured.

Irrigation Efficiency. The average percent of total water pumped or delivered for use that is stored in the plant's root zone.

Irrigation Uniformity. A measure of the spatial variability of applied or infiltrated water over the field.

Lake Okeechobee. This lake measures 730 square miles and is the second largest freshwater lake wholly within the United States.

Levee. An embankment to prevent flooding, or a continuous dike or ridge for confining the irrigation areas of land to be flooded.

Marsh. A frequently or continually inundated wetland characterized by emergent herbaceous vegetation adapted to saturated soil conditions.

MCL. Maximum contaminant level.

MG. Million gallons.

MGD. Million gallons per day.

mg/L. Milligrams per liter.

MGY. Million gallons per year.

Micro Irrigation. The application of water directly to, or very near to the soil surface in drops, small streams, or sprays.

Mobile Irrigation Laboratory. A vehicle furnished with irrigation evaluation equipment which is used to carry out on-site evaluations of irrigation systems and to provide recommendations on improving irrigation efficiency.

NGVD. National Geodetic Vertical Datum; reference sea level from which elevations are measured.

Organics. Being composed of, or containing matter of, plant and animal origin.

Permeability. Defines the ability of a rock or sediment to transmit fluid.

Potable Water. Water that is suitable for drinking, cooking, and other domestic purposes. The maximum chloride concentration is 250 mg/L.

Potentiometric Surface. An imaginary surface representing the total head of ground water.

Process Water. Water used for nonpotable industrial usage, e.g., mixing cement.

Public Water Supply (PWS) Utilities. Utilities that provide potable water for public use.

Reclaimed Water. Water that has received at least secondary treatment and is reused after flowing out of a wastewater treatment facility.

Reuse. The deliberate application of water that has received at least secondary treatment, in compliance with the Florida Department of Environmental Protection and Water Management District rules, for a beneficial purpose.

Reverse Osmosis (RO). The process of pressurizing a saline solution to force it through a semi-permeable membrane and separate water from solutes.

Retrofitting. The replacement of existing water fixtures, appliances and devices with more efficient fixtures, appliances and devices for the purpose of water conservation.

SAS. Surficial Aquifer System.

Seepage Irrigation Systems. Irrigation systems which convey water through open ditches. Water is either applied to the soil surface (possibly in furrows) and held for a period of time to allow infiltration, or is applied to the soil subsurface by raising the water table to wet the root zone.

Semi-Closed Irrigation Systems. Irrigation systems which convey water through closed pipes, and distribute it to the crop through open furrows between crop rows.

Semi-Confining Layers. Layers with little or no vertical flow that can store ground water and also transmit it slowly from one aquifer to another. The rate of vertical flow is dependent on the head differential between the semi-confining beds and those above and below them.

Slough. A channel in which water moves sluggishly, or a place of deep muck, mud or mire. Sloughs are wetland habitats that serve as channels for water draining off surrounding uplands and/or wetlands.

Stage. The elevation of the top of a surface water body.

Standard Project Flood (SPF). A hypotentical flood resulting from the most severe combination of meteorological and hydrological conditions that are reasonably characteristic of a region. It is comparable to historical great floods which have been reported.

Storm Water. Rainfall that does not percolate into the ground or evaporate.

Superfund Sites. A contamination site of such magnitude that it has been designated by the federal government as eligible for federal funding to insure cleanup.

SWIM Plans. Surface Water Improvement and Management Plans, prepared according to Chapter 373, Florida Statutes.

TAZ. Traffic analysis zone, a geographic area used in transportation planning.

Transmissivity. This is the rate at which water is transmitted through a unit width of aquifer under a unit hydraulic gradient. It is a function of the permeability and thickness of the aquifer, and is used to judge its production potential.

Turbidity. The measure of suspended material in a liquid.

Uplands. Elevated areas which are characterized by nonsaturated soil conditions and support flatwood vegetation.

USACE. United States Army Corps of Engineers.

USEPA. United States Environmental Protection Agency.

USFWS. United States Fish and Wildlife Service.

USGS. United States Geological Survey.

Wastewater. The combination of liquid and waterborne discharges from residences, commercial buildings, industrial plants and institutions together with any ground water, surface runoff or leachate that may be present.

Water Supply Plans. These plans are regional water resource and demand analyses. They are District generated, and provide a detailed evaluation of available water supply and projected demands.

Wetlands. Areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support a prevalence of vegetation typically adapted for life in saturated soil conditions.

Xeriscape. The use of landscaping techniques to conserve water and reduce maintenance.

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Chapter 1

INTRODUCTION

PURPOSE AND SCOPE

The South Florida Water Management District (SFWMD or District) has undertaken development of long-term comprehensive regional water supply plans to provide better management of South Florida's water resources. The purpose of the water supply plans is to develop strategies to meet the future water demands of urban areas and agriculture, while meeting the needs of the environment. This process identifies areas where historically used sources of water will not be adequate to meet future demands, and evaluates several water source options to meet the deficit. The Upper East Coast (UEC) Planning Area is one of four regional planning areas, as indicated in Figure 1. These regions are generally defined by hydrologic divides.

This Upper East Coast Water Supply Plan Support Document (originally the UEC Background Document) provides a common set of data, assumptions, and potential water source options that were used by the District, advisory committee, other agencies, counties, municipalities, utilities, and various interested parties in the development of the UEC Water Supply Plan. This support document contains key data such as present and future water demands that was used for the analytical process during plan development. The computer modeling and analysis used to develop the water supply plan, as well as the plan development process, are summarized in this document.

Local governments, water users, and utilities may use the water supply plan to modify and update their local comprehensive plans, ordinances, and individual or utility plans.

BASIS OF WATER SUPPLY PLANNING

Legal Authority and Requirements

The District is charged by the Florida Legislature with managing water use in South Florida. One important task in this charge is planning for future water demand in specific geographic regions within the District. In partial fulfillment of this requirement, the District prepared a water supply plan for the UEC Planning Area. The following discussion describes the legal basis for the District's water supply planning program. Excerpts of specific Florida statutes and administrative codes cited in this section are provided in Appendix A.

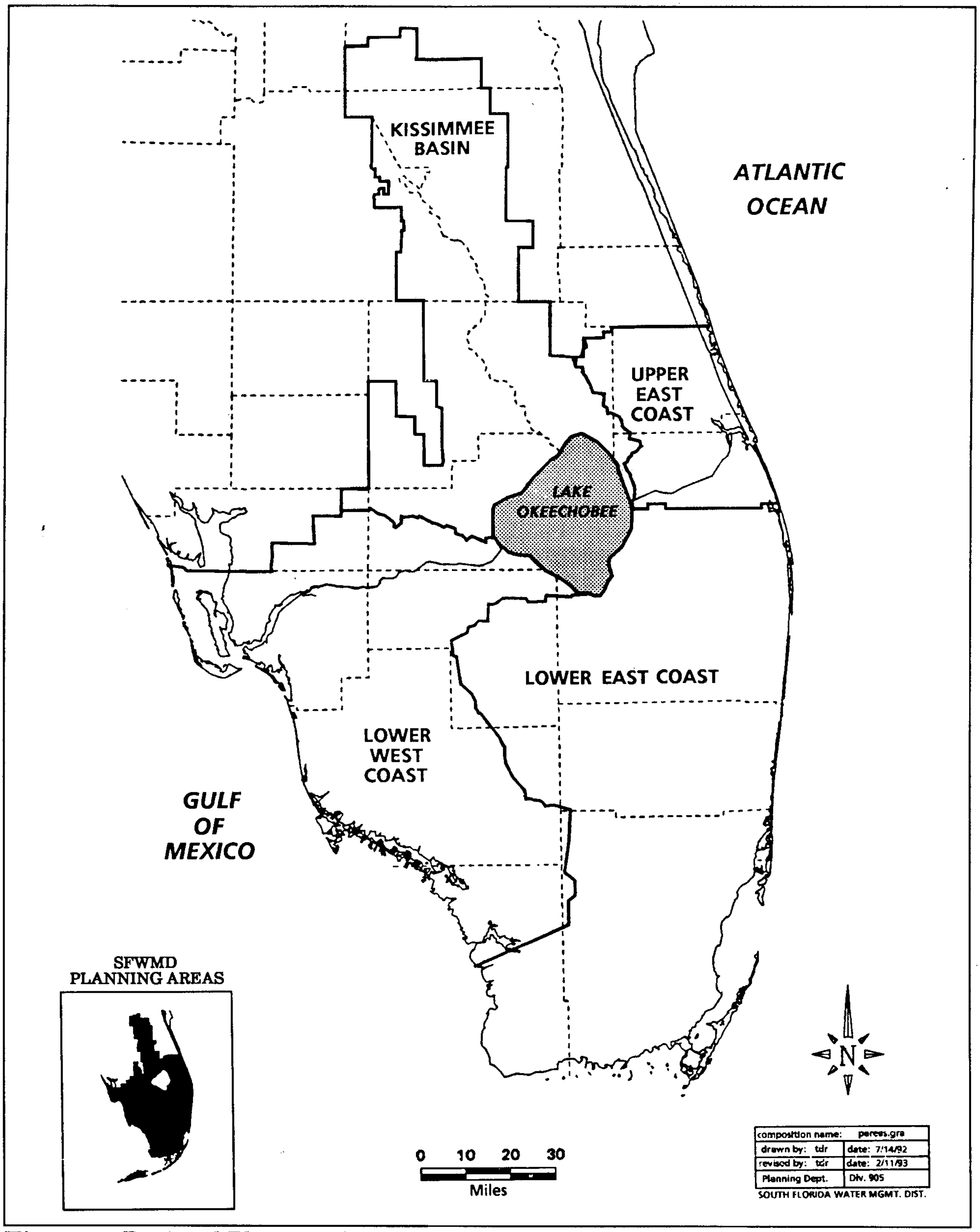


Figure 1. Regional Planning Areas.

Water supply planning activities were first required of the state's water management districts following adoption of the Florida Water Resources Act of 1972 (Chapter 373, Florida Statutes). The authors of "A Model Water Code" (Maloney *et al.*, 1972), upon which much of Chapter 373 is based, theorized that proper water resource allocation could best be accomplished within a statewide, coordinated planning framework. The State Water Use Plan and the State Water Policy were the primary documents to meet this objective.

During the 1997 legislative session, significant amendments were made to the Water Resources Act. The amendments clarified agency responsibilities related to regional water supply planning and included many of the provisions of the Governor's Executive Order 96-297. The Executive Order directs Florida's water management districts to establish minimum flows and levels and to complete regional water supply plans in areas where sources are not adequate to meet future demands.

Prior to these legislative amendments, the Water Resources Act required the Florida Department of Environmental Protection to prepare a State Water Use Plan. The State Water Use Plan defined objectives and operating policies which implemented selected goals and policies of the State Comprehensive Plan (Ch. 187, F.S.). Chapter 187 provides guidance for all state agencies as they develop their "agency functional plans," and to the water management districts, as they develop their water management plans. More specific guidelines for these plans are provided in the State Water Policy (now referred to as the Water Resource Implementation Rule), Ch. 62-40, F.A.C.

With the passage of the legislative amendments, the Legislature eliminated the State Water Use Plan and provided for the development of the Florida Water Plan. The Florida Water Plan is required to include the Water Resource Implementation Rule and District Water Management Plans.

The Water Resource Implementation Rule is intended to guide the Florida Department of Environmental Protection and the water management districts in implementing statutory directives prescribed in the Water Resources Act (Ch. 373, F.S.), the Florida Air and Water Pollution Control Act (Ch. 403, F.S.), and the State Comprehensive Plan (Ch. 187, F.S.), These statutes provide the basic authorities, directives, and policies for statewide water management, pollution control, and environmental protection. The current legal framework for water supply planning is shown in Figure 2.

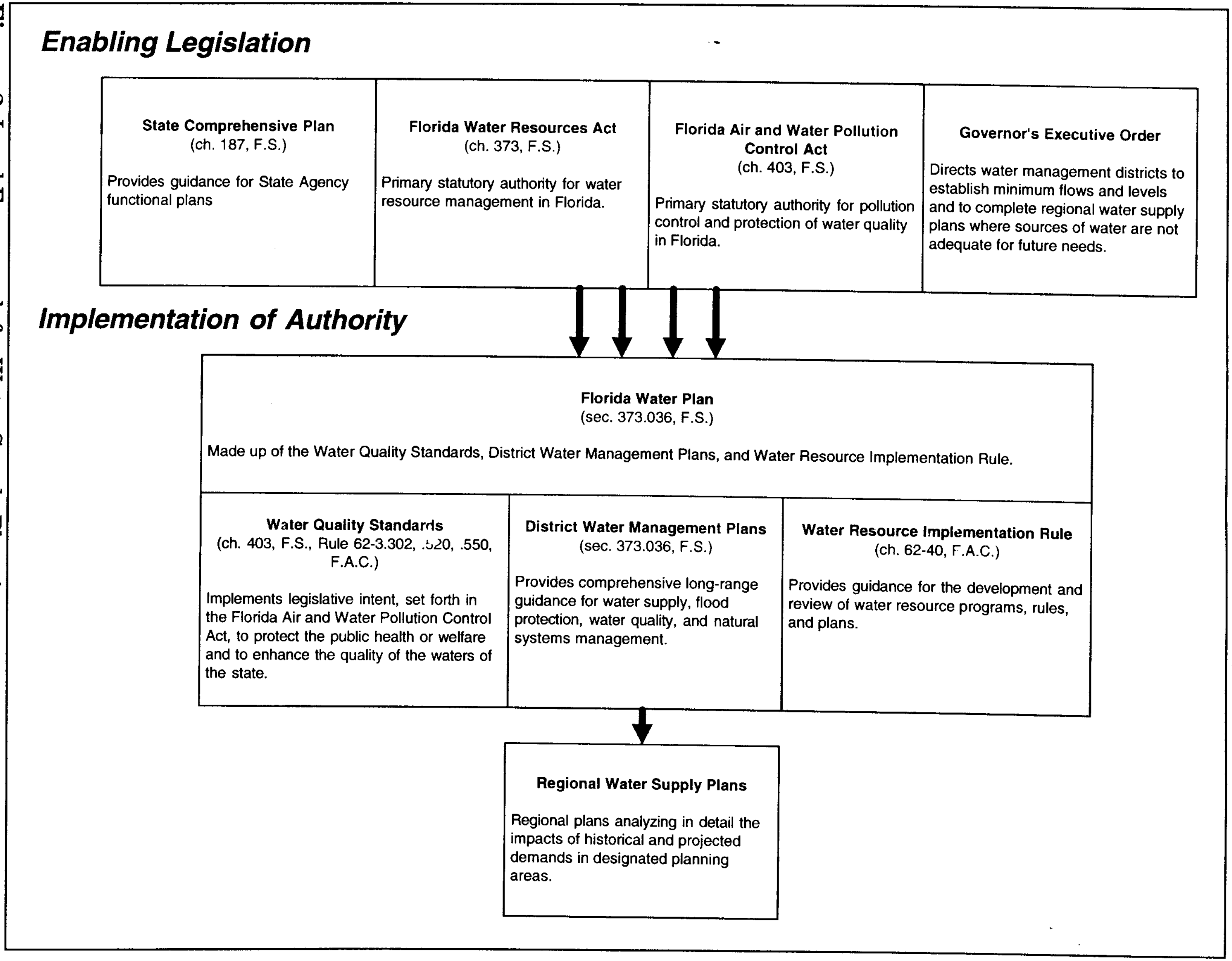


Figure 2. Legal Framework for Water Supply Planning.

District Water Management Plans are intended to provide comprehensive long-range guidance for the actions of the water management districts in implementing their responsibilities under state and federal laws. In addition to other information, the water management plans are required to include a district-wide water supply assessment. Where the assessment indicates that sources of water are not adequate to meet demands, a regional water supply plan is required to be developed. The SFWMD preempted this requirement by committing to a water supply planning initiative in the early 1990s that included developing water supply plans encompassing the entire District. The UEC Water Supply Plan development and analysis were substantially complete prior to the legislative amendments.

Water Supply Planning Initiative

The District has undertaken a water supply planning initiative to ensure prudent management of South Florida's water resources. This initiative includes the development of a Water Supply Policy Document, Water Supply Needs and Sources Document, Water Management Plan, and regional water supply plans.

Water Supply Policy Document

This direction-setting document is the SFWMD's interpretative summary of the many state statutes and rules governing the uses of surface and ground waters in Florida. The Water Supply Policy Document was accepted by the Governing Board in December 1991.

Water Supply Needs and Sources Document

Rule 62-40.520, F.A.C., requires water management districts to prepare water management plans, which include assessments of water needs and supply sources. The District, through discussions with the FDEP, bifurcated this process, and prepared a district-wide needs and sources analysis followed by regional water supply plans. The Water Supply Needs and Sources Document (July 1992) made a preliminary analysis of the District's water demand and available resources. Significant roles which this initial document served was the provision of information to local governments pursuant to Sections 373.0391 and 373.0395, F.S., and facilitating the completion of the District Water Management Plan.

The District Water Management Plan (April 1995) incorporated information from the Needs and Sources Document. Subsequent water management plans will include district-wide water supply assessments.

District Water Management Plan

The Water Management Plan represents the District's overall strategy for future planning and implementation activities and provides a comprehensive examination of the myriad issues of water supply, flood protection, water quality, and natural systems management in South Florida. This plan also established schedules for future District planning activities, including the Upper East Coast Water Supply Plan. The District published its Water Management Plan in April 1995, and will update the plan every five years.

Regional Water Supply Plans

Regional water supply plans provide more detailed region-specific information than the water supply assessments. Water supply plans are based upon data that are related to the specific water needs, sources and environmental features of regional planning areas, and are updated every five years. Area-specific goals and objectives were developed for the UEC Water Supply Plan during the water supply planning process.

Other Related Activities

The District has other activities with direct relationships to the water supply planning initiative (Table 1). These activities have elements that may affect or be affected by the results of water supply planning analyses.

Incorporation of State Directives into District Water Supply Goals

The District has committed to an overall water resources goal. This goal is derived from the State Comprehensive Plan, which states:

> Florida shall assure the availability of an adequate supply of water for all competing uses deemed reasonable and beneficial and shall maintain the functions of natural systems and the overall present level of surface and ground water quality. Florida shall improve and restore the quality of waters not presently meeting water quality standards.

This goal will be achieved by balancing six principal water use directives embodied in Florida law (Figure 3). The state's policies endorse conservation of available supplies, diversification of potential supply sources, protection and enhancement of water quality, and protection of environmental resources. At the same time, the state and the District are sensitive to the requirements of the region's population, and the need to provide clean water for drinking, other domestic uses, and agriculture.

Table 1. Upper East Coast Related Water Management Planning Efforts.

	Scope/Primary Goal	Relationship to UECWSP	Timeframes
UEC Water Supply Plan	Adequate and reliable water supply	N/A	1998
Indian River Lagoon SWIM Plan	Restoration of IRL and SLE	-Provides water quality and quantity targets for IRL and SLE	Update initiated in 1998
IRL Restoration Feasibility Study	Regional solutions to manage freshwater discharges to IRL and SLE and restoration of impacted watershed wetlands	-Evaluates options to meet SLE inflow range -Explore potential for supplemental water supply for agriculture -Provide detailed information needed for implementation	2001
Lake Okeechobee (L.O.) SWIM Plan	Protection and enhancement of Lake Okeechobee and its watershed (water quality)	-Backflow/inflow from C-44 Canal. -Potential C-131 backpumping if determined viable in IRL Feasibility Study.	Update completed 1997
Lake Okeechobee Regulation Schedule Environmental Impact Study	Evaluates environmental and economic impacts associated with proposed L.O. Regulation Schedules (quantity)	-Discharges from L.O. to SLE	1999
C&SF Project Restudy	Comprehensive review of environmental impacts of C&SF project	-Discharges from L.O. to SLE	1995-1999
IRL National Estuary Program Comprehensive Conservation and Mgmt. Plan	EPA program for IRL restoration	-Supports activities to enhance the IRL and SLE Creates framework for: -Identification of funding sources -Identification of lead/support partnering	1996
Lower East Coast Water Supply Plan	Adequate and reliable water supply for the Lower East Coast, for natural systems L.O. service area	-Water supply to C-44 basin -Minimum and maximum flows to SLE from L.O. -Potential C-131 if determined viable in IRL Feasibility Study	Interim Plan 1998

WATER USE DIRECTIVES

1. Prevent wasteful, uneconomical, impractical, or unreasonable uses of the water resources.
2. Promote economic development of the water resources consistent with other directives and uses.
3. Protect and enhance environmental resources while providing appropriate levels of service for drainage, flood control, water storage, and water supply.
4. Maximize levels of service for legal users, consistent with other directives.
5. Preserve and enhance the quality of the state's ground and surface waters.
6. Develop and maintain resource monitoring networks and applied research programs (such as forecasting models) required to predict the quantity and quality of water available for reasonable-beneficial uses.

Source: SFWMD, 1991, Water Supply Policy Document.

Figure 3. SFWMD's Water Use Directives.

PLANNING PROCESS

The Upper East Coast water supply planning process consisted of four overlapping phases: background work; analysis/issue identification; solution development; and implementation (Figure 4).

Background Work

Background work included gathering information for the region describing water resources, rainfall patterns, natural resources, historical and projected water demands, water conservation programs, and land use coverage that could be useful in developing the plan. This information was compiled into the UEC Water Supply Plan Background Document (October 1994), which is now the Support Document. The background work also included development and calibration of analytical tools used in the development of the UEC Water Supply Plan, including ground water models and surface water budgets.

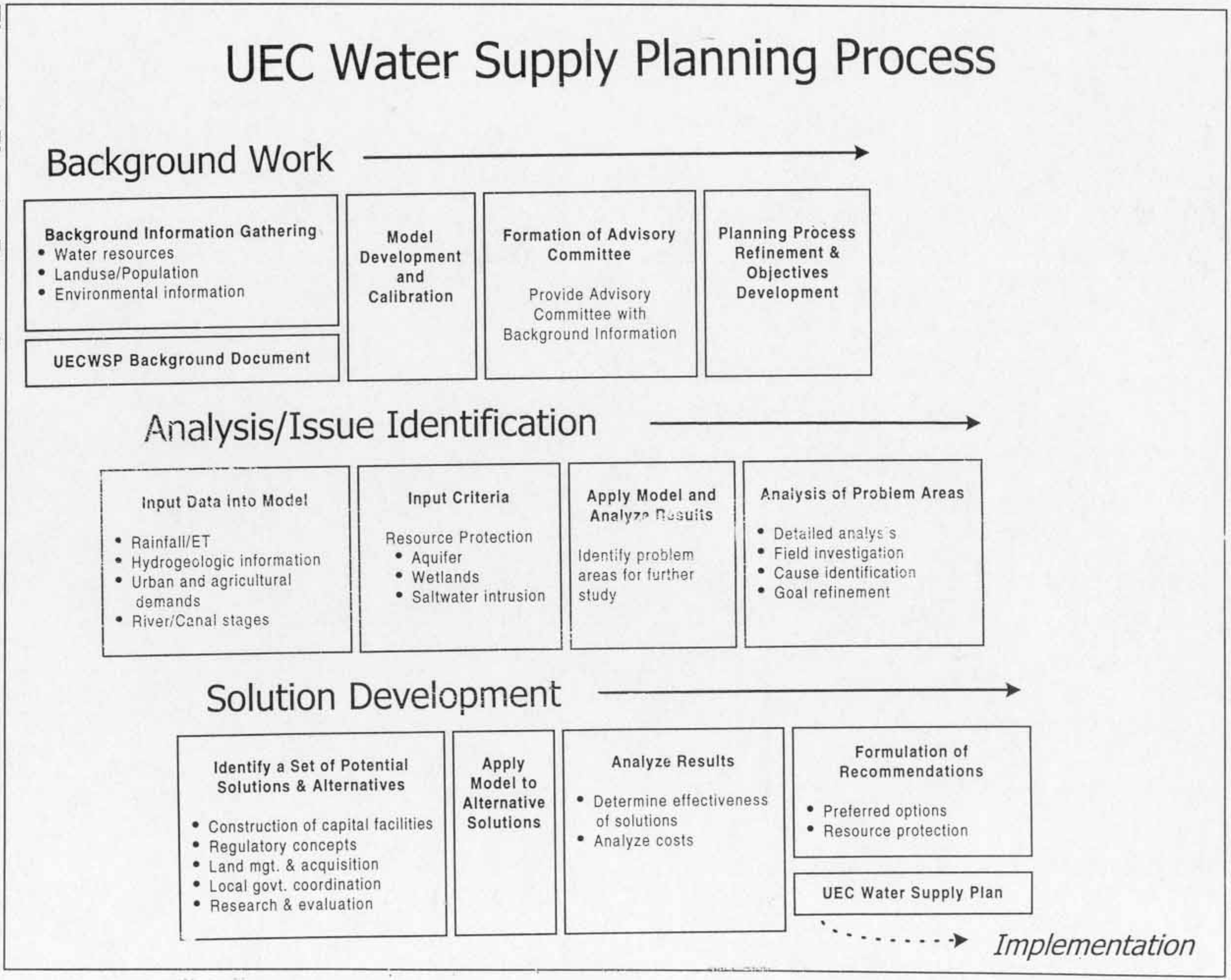


Figure 4. Planning Process Components.

An advisory committee was also established to provide public input throughout the planning process. Advisory committee meetings were held that facilitated the planning process, including the following: initial information sharing, issue identification, goal formulation, evaluation of modeling results, identification of possible solutions, strategy development, and draft plan document review. The advisory committee adopted the water resource goal of the State Comprehensive Plan as the overall goal of the UEC Water Supply Plan (page 6). To ensure that the water supply plan addresses the specific needs of the region, the committee also developed the following regional goals (no implied priority):

- Water Supply: Promote the use of water supply alternatives and conservation

- Floridan Aquifer: Establish water quality criteria limitations for the Floridan Aquifer System (FAS) within the UEC

- Wetland Protection: Protect wetland systems from significant harm due to water use drawdowns

- Saltwater Intrusion: Develop criteria and programs for Surficial Aquifer System protection from saltwater intrusion

- Level of Drought: Establish a level of certainty (annual rainfall event, expressed in terms of return frequency) for all permitted uses and for the environment

- Flood Protection: Consider flood protection during the water supply planning process

- Consistency with Local Governments: Promote compatibility between the UEC Water Supply Plan and local land use decisions and policies

- Estuary: Protect and enhance the St. Lucie Estuary and Indian River Lagoon

- Linkages with other Regional Planning Efforts: Promote compatibility and integration with other related regional water resource planning efforts, including Indian River Lagoon (IRL) SWIM Plan, IRL Restoration Feasibility Study, Lake Okeechobee SWIM Plan, Lake Okeechobee Regulation Schedule Study, Lower East Coast Water Supply Plan, Central and Southern Florida Comprehensive Review Study (a.k.a.: Restudy), the IRL National Estuary Program Comprehensive Conservation and Management Plan, Regional Attenuation Facility Task Force, Strategic Regional Policy Plan, St. Johns River Water Management District Needs and Sources

Analysis/Issue Identification

Analytical tools were used extensively to identify the potential issues of the region. The analysis phase included the use of ground water models, surface water budgets, and vulnerability mapping. The ground water models were used to identify potential impacts of water use on the environment and ground water resources. Surface water budgets were used to approximate surface water availability in each of the major surface water basins in order to quantify demands that could not be satisfied by surface water. Vulnerability mapping was used to identify areas that have the highest potential for saltwater intrusion in the Surficial Aquifer System.

Based on this analysis, issues relating to water supply were identified. Devising strategies to resolve these issues was the next step.

Solution Development

In areas where projected demands had the potential to exceed available supplies, there was a need to devise solutions. Potential solutions included increased use of water conservation and water source options which are described in chapters 7 and 8. Each water source option was evaluated, and local and regional responsibilities were identified for each.

Implementation

Concepts resulting from the solution development phase will be translated into strategies that will be implemented by the relevant departments within the District (Figure 5) and other responsible parties. Developing strategies and building partnerships for future implementation efforts will be emphasized.

PUBLIC AND AGENCY PARTICIPATION

Public and agency involvement was critical in the preparation of the UEC Water Supply Plan. The steps listed below were taken by the District to ensure adequate public input.

Advisory Committee

A 30-member water supply plan advisory committee was established in September 1995 to provide public input through out the planning effort. The committee consisted of representatives from interested and effected parties in the planning area (Table 2).

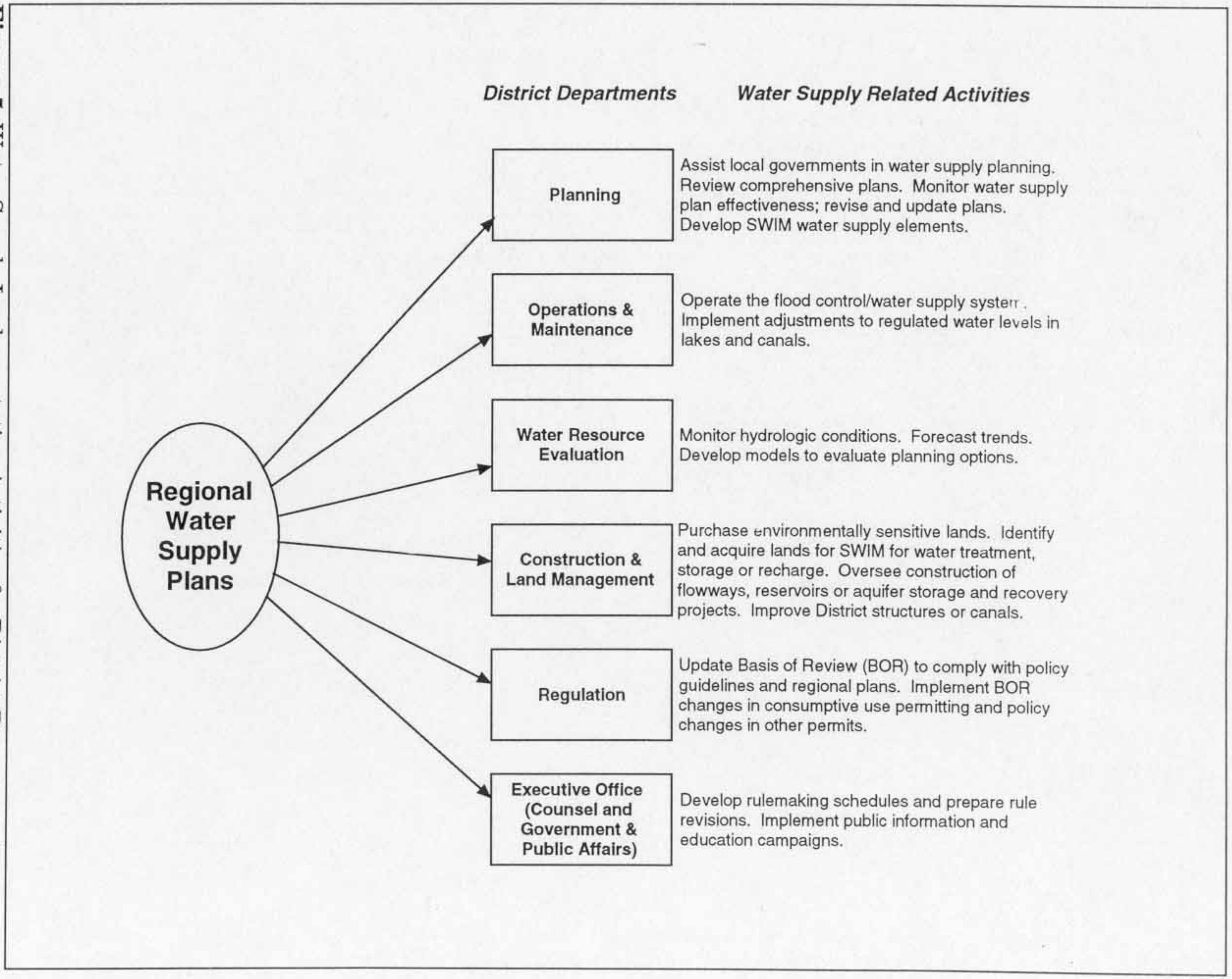


Figure 5. Water Supply Implementation Activities for District Departments.

Table 2. Composition of Advisory Committee.

Government/Agency	**Utilities**
Federal	Martin County Utilities
U.S. Army Corps of Engineers	Hobe Sound Water Company
U.S. Geological Survey	Hydratech Utilities
State	City of Stuart Public Works
Department of Community Affairs	Port St. Lucie Utilities
Department of Environmental Protection	Fort Pierce Utilities
SFWMD Governing Board	**Agriculture**
Regional	Institute of Food and Agricultural Science
Treasure Coast Regional Planning Council	St. Lucie Soil and Water Conservation District
Local	St. Lucie County Chamber of Commerce
Martin County Board of County Commissioners	- Agribusiness
Port St. Lucie Planning Department	Indian River Citrus League
St. Lucie County Community Development	Camayen Cattle Company
St. Lucie County - Public Works	**Economic**
Environmental	St. Lucie County Chamber of Commerce
St. Lucie River Initiative	Economic Council of Martin County
Martin County Conservation Alliance	**Golf Course**
Conservation Alliance of St. Lucie County	Turfgrass Association
Local Drainage Districts	**Development**
North St. Lucie River Water Control District	Treasure Coast Builders Association

The advisory committee met 25 times. During advisory committee meetings, water supply issues and potential water source options were explored. Information exchanged during these meetings proved useful in developing strategies for future water supply activities.

Local Government Linkage

Local government linkage meetings were established in January 1997 to better link the UEC Water Supply Plan with local government planning efforts. These meetings provided a forum for District and local government planners to exchange information on a variety of topics. Discussion topics included plan updates, new development projects, and the role of water supply planning in local land use planning, These meetings also furthered Goal 7 of the UEC Water Supply Plan which promotes compatibility between the UEC Water Supply Plan and local land use decisions and policies. Five linkages meetings were conducted in 1997. Periodic meetings will be held during implementation of the plan.

Data Confirmation

The technical information incorporated into this support document was the basis for discussions of water demand and availability in the UEC Planning Area; it was also the key data for analysis (i.e., predictive modeling and analysis of water management alternatives) of the water resources. Therefore, it is important that this information is accurate so that the most appropriate solutions are presented.

The District initiated data collection and preliminary planning efforts for the UEC Support Document (formerly the Background Document) in 1992. As part of this effort, many entities, such as local governments, state and federal agencies, environmental groups, agricultural interests, and utilities within the UEC Planning Area, were contacted to gather initial input and information, and informal meetings were held with several of these groups. Two examples where public input was utilized to generate and/or confirm information were the utility information and the population and urban demand projections.

Utility Information

To accurately reflect historic, current and projected water supply practices by the utilities in the UEC Planning Area, the District initiated an exhaustive survey of all regional public and private water and wastewater utilities in the study area. The utilities were sent a questionnaire addressing existing and future customers, service areas, treatment technologies, average daily flows, treatment plant locations, number of wells, interconnects with other utilities, and planned expansions for their respective utilities. Follow-up telephone calls were made to those utilities who did not respond, or whose response was incomplete.

This information was tabulated in a computerized spreadsheet and checked against other District sources, such as permits and comprehensive planning documents, for accuracy. Where inaccuracies were found, additional follow-up contacts were made.

Population and Urban Demand Projections

Population projections were taken directly from the adopted local government comprehensive plans so that the UEC Water Supply Plan will be consistent with, and support, local and state growth management policies. This population was broken down by utility service area and was further adjusted to account for self supply. The District's population and per capita water demand calculations were mailed to local governments and utilities for their review.

Chapter 2

PLANNING AREA DESCRIPTION

PLAN BOUNDARIES

The UEC Planning Area incorporates the northern reaches of the SFWMD on the east coast. The area includes most of Martin (92%) and St. Lucie (92%) counties, and a small portion of Okeechobee County (12%), as shown in Figure 6. The percentages do not include the county areas within Lake Okeechobee. The portions of these counties within the planning area will be referred to as the Martin Area, St. Lucie Area, and Okeechobee Area in this document. The boundary of the UEC Planning Area generally reflects the drainage basins of the C-23, C-24, C-25, and C-44 (St. Lucie Canal) canals. The northern boundary corresponds to the St. Lucie-Indian River county line which is also the SFWMD/St. Johns River Water Management District jurisdictional boundary. The southern boundary is the Martin-Palm Beach county line.

RELATED PLANNING AREAS

The District has established four water supply planning areas: (1) Upper East Coast, (2) Lower East Coast, (3) Lower West Coast, and the (4) Kissimmee Basin. The planning areas are generally defined by the drainage divides of major surface water systems in South Florida. The major water bodies considered in establishing these boundaries include the Kissimmee River, Lake Okeechobee, the Everglades and the Big Cypress Swamp. The series of canals, levees, pump stations, and storage areas that comprise the Central and South Florida Flood Control Project were also considered because these structures have altered the hydrology of the natural water bodies (see Surface Water Resources discussion in Chapter 3).

Lake Okeechobee is considered part of each of the planning areas, which are connected to the lake through a regional surface water system. The Kissimmee River (Kissimmee Basin Planning Area) is the predominant surface water inflow into the lake, while the remaining three planning areas receive outflows from the lake. The major outflows are: (a) the Caloosahatchee River to the Lower West Coast; (b) the St. Lucie Canal to the Upper East Coast; and (c) the West Palm Beach, Hillsborough, North New River, and Miami canals to the Lower East Coast.

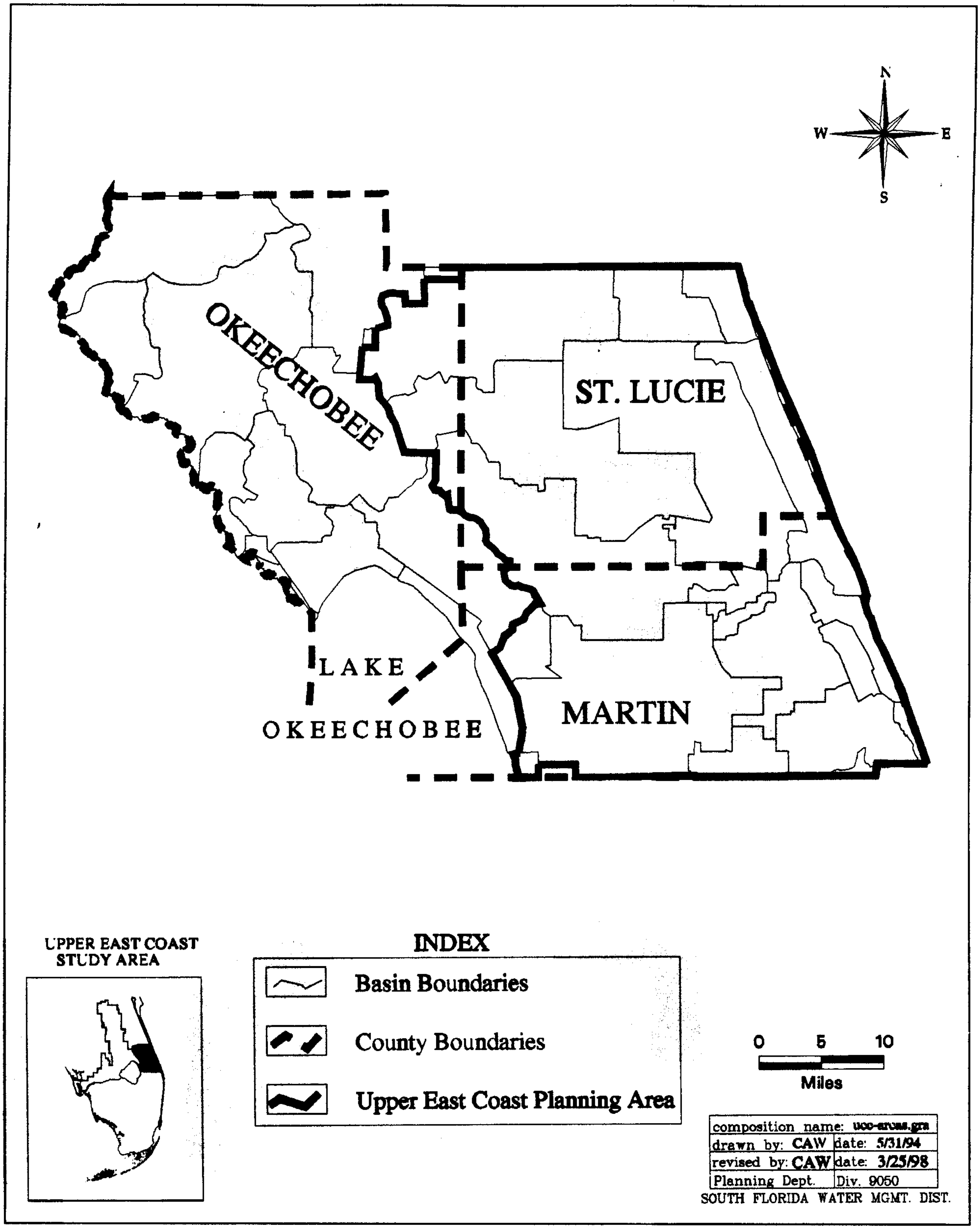


Figure 6. Upper East Coast Planning Area.

The Caloosahatchee River (C-43) and the St. Lucie Canal (C-44) are used primarily for water releases from the lake when lake levels exceed water stages of the U.S. Army Corps of Engineer's regulation schedule. In addition to regulatory discharges for flood protection, these canals receive water deliveries from the lake to maintain water levels for navigation and water supply. The C-44 Basin within the UEC Planning Area is partially dependent on the lake for supplemental water supply and aquifer recharge. Evaluation of Lake Okeechobee and its associated demands is incorporated into the Lower East Coast Water Supply Plan.

PHYSICAL FEATURES

Geography and Climate

The UEC Planning Area covers over 1,100 square miles and has an average elevation of 20 feet. Average seasonal temperatures range from 64 degrees during the winter to about 81 degrees during the summer (University of Florida, 1993). Annual average rainfall in the planning area is about 51 inches. About 72 percent of the annual rainfall occurs during the May through October wet season. Rainfall is further discussed in Chapter 3.

Physiography

The Upper East Coast Planning Area is characterized by three principal physiographic zones which generally trend from east to west. These zones are identified by White (1970) as: (1) the Atlantic Coastal Ridge, (2) the Eastern Valley, and (3) the Osceola Plain. The Atlantic Coastal Ridge, made of relict beach ridges and sand bars, parallels the coast and has a width ranging from several hundred feet to a couple of miles. The ridge varies in elevation from sea level to a high of 86 feet above sea level in the sand hills of Jonathan Dickinson State Park.

West of the Atlantic Coastal Ridge is the Eastern Valley, which is a flat relict beach ridge plain. Most of the planning area lies within the Eastern Valley. The valley is generally lower than the ridge, with land elevations ranging from 15 to 30 feet above mean sea level, and an average width of 30 miles. These areas are characteristically pocketed with shallow lakes and marshes and have limited natural drainage. Prior to development and construction of canals, the valley drained by a slow drift of water through multiple sloughs to the St. Lucie River, the Loxahatchee River and the Everglades. This area contains the Savannas State Park, Pal-Mar, Loxahatchee Slough, and the Allapattah, St. Lucie and Osceola Flats.

The Osceola Plain lies west of the Eastern Valley in St. Lucie County and intrudes into the Eastern Valley in Martin County, where it terminates at Indiantown. The elevation of the plain in Martin County is approximately 40 feet.

POPULATION

The driving force behind urban water demand is population, and most of the population in the planning area resides along the coast in Martin and St. Lucie counties. The most significant population increase is expected to occur in the St. Lucie Area. By contrast, the Okeechobee Area is expected to have a minor increase of 610 residents (Table 3).

Table 3. Population, 1990-2010.

Region	1990	2010	Increase	% Growth
Martin Area	100,900	154,200	53,300	53
St. Lucie Area	150,171	290,100	139,929	93
Okeechobee Area	1,015	1,625	610	60
UEC Planning Area	252,086	445,925	193,839	77

Source: 1990 data from U.S. Bureau of the Census; 2010 data from local govt. comprehensive plans.

MUNICIPALITIES

There are seven municipalities in the planning area, all of which are in Martin and St. Lucie counties. These are Fort Pierce, Port St. Lucie, St. Lucie Village, Stuart, Sewalls Point, Jupiter Island, and Ocean Breeze Park.

AGRICULTURE

The driving force behind agricultural water demand is acreage of irrigated agricultural crops. Citrus is the major irrigated agricultural crop in the planning area, comprising 86 percent of the total irrigated crop acreage. While Okeechobee County is anticipated to have the highest percent increase in irrigated citrus acreage, St. Lucie County is expected to have the highest actual increase in irrigated citrus acreage by 2010 (Table 4). Estimates and projections of irrigated acreage for all crops are presented in Chapter 6.

Table 4. Irrigated Citrus Acreage, 1990-2010.

Region	1990	2010	Increase	% Growth
Martin County	46,283	50,079	3,796	8
St. Lucie County	85,390	121,832	36,442	43
Okeechobee Area	2,460	4,474	2,014	82
UEC Planning Area	134,133	176,385	42,252	32

Source: 1990 estimates from Florida Agricultural Statistics Service; 2010 projections from SFWMD staff calculations (provided in Appendix G).

LAND USE

Existing Land Use

The UEC Planning Area is predominantly agricultural, especially in St. Lucie County and the Okeechobee Area. Urban land use is primarily located in the coastal portions of the Martin and St. Lucie areas. The highest percentages of wetlands are in Martin County and the Okeechobee Area (Table 5). Maps of land uses within the UEC Planning Area are provided in Appendix B.

Table 5. Acreages and Percentages of Land Use by County.

Land Use	Martin County		St. Lucie County		Okeechobee Area		UEC Planning Area	
	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
Agriculture	137,361	40	191,081	50	35,601	60	364,043	46
Urban and Transportation	50,416	15	72,500	19	717	1	123,633	16
Wetlands	54,116	16	33,374	9	11,669	20	99,159	13
Upland Forest	64,201	19	38,880	10	7,874	13	110,955	14
Rangeland	5,503	2	8,129	2	1,558	3	15,190	2
Barren	2,075	1	316	0	87	0	2,478	0
Water	26,706	8	40,612	10	1,955	3	69,273	9
Total	340,378	100	384,892	100	59,461	100	784,731	100

Source: SFWMD Florida Land Use/Land Cover GIS database, 1995.
Note: Percentages rounded to the nearest tenth.

Updated Land Use Classification System

The Florida Department of Transportation (FDOT) Florida Land Use/Land Cover Classification System (FLUCCS) was used to delineate and classify land use/land cover for this plan. This FDOT FLUCCS classification system is now the statewide standard for all water management districts and state agencies. Prior to 1995, the District's 1988 land use/land cover classification system was used, including information contained in the Draft UEC Water Supply Plan Background Document, dated October 1994.

The migration to the FDOT FLUCCS classification system has resulted in dramatic changes in the acreage estimates for a number of land use/land cover types in the UEC Planning Area. Those land uses most affected include wetlands, forests, and water. Wetland acreage decreased while upland forests increased. This change was caused by reclassifying certain types of forested wetlands, such as pine flatwoods, to forested uplands. The large increase in water acreage was caused by the addition of the Indian River Lagoon, and the delineation of numerous reservoirs and onsite retention ponds in agricultural areas under the FDOT FLUCCS classification system.

Other acreage changes are due to the actual changes in land use/land cover that occurred from 1988 to 1995.

Land Use Trends

Based on local government comprehensive plans, urbanization is anticipated to increase in the Martin and St. Lucie areas while the Okeechobee Area is expected to remain agricultural. Agriculture has been the predominant land use in all three counties and is projected to remain so in the future. However, in Martin and St. Lucie counties, the percentage of agricultural land use is projected to decrease as a result of urban encroachment. The most significant change in land use is the doubling of urban acreage, which reflects population growth in these two counties.

Chapter 3

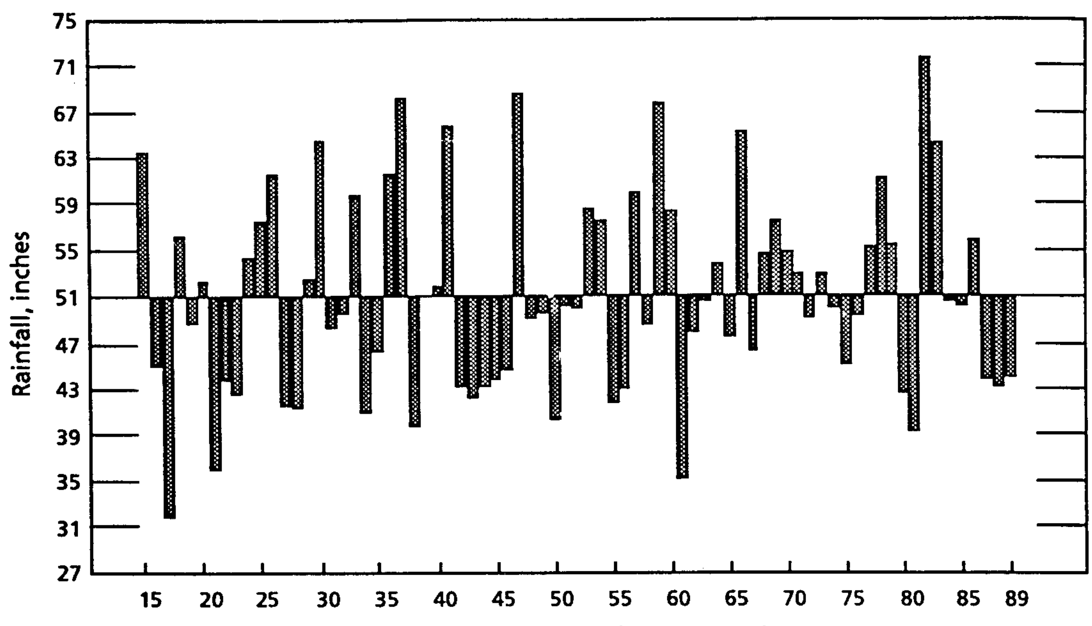
WATER RESOURCES AND SYSTEM OVERVIEW

REGIONAL HYDROLOGIC CYCLE

The main components of the hydrologic cycle in the UEC Planning Area are precipitation, evapotranspiration, surface water inflow and outflow, and ground water flow.

Precipitation and Evapotranspiration

The 52-year average rainfall in the planning area is about 51 inches per year, but varies considerably from year to year (Figure 7). There is a wet season from May through October, and a dry season from November through April. The maximum monthly average rainfall is 7.52 inches in September (St. Lucie County) and the minimum monthly average rainfall is 1.93 inches in December (Martin County). Monthly rainfall displays a higher measure of relative variability during the dry period. Rainfall also varies areally (from location to location), with rainfall amounts generally decreasing from east to west. Historical rainfall data and the results of a frequency analysis are presented in Appendix C.



Source: Sculley, 1996

Figure 7. Variation from Annual Average Rainfall in the UEC Planning Area.

Evapotranspiration (ET) is the sum of evaporation and transpiration. Like rainfall, ET is generally expressed in inches per year. Approximately 45 inches of water per year is returned to the atmosphere by evapotranspiration in South Florida. The excess of average precipitation over average ET is equal to the combined amounts of average surface water runoff and average ground water recharge.

Surface Water Inflow and Outflow

Essentially all surface water inflows and outflows in the planning area are derived from rainfall. The exception to this is the St. Lucie Canal (C-44), which also receives water from Lake Okeechobee. In addition, most of the flows and stages in the region's canals are regulated for water use and flood protection. The amount of stored water is of critical importance to both the natural ecosystems and the developed areas in the UEC Planning Area. Management of surface water storage capacity involves balancing two conflicting conditions. When there is little water in storage, drought conditions may occur during periods of deficient rainfall. Conversely, when storage is at capacity, flooding may occur due to excessive rainfall, especially during the wet season. Management of surface water systems is one of the main factors affecting movement of water through the regional hydrologic cycle.

Exchange with Ground Water

Another distinctive feature of South Florida's hydrologic system is the aquifer system and its use for water supply. Two vast aquifer systems, the Surficial Aquifer System (SAS) and the Floridan Aquifer System (FAS), underlie the planning area. Ground water inflows from outside the planning area form an insignificant portion of recharge to the SAS. Rainfall is the main source of recharge to the SAS, and because of this, long-term utilization of this source must be governed by local and regional recharge rates. The FAS, on the other hand, receives most of its recharge from outside of the UEC Planning Area. This fact must also be incorporated into long-term planning decisions.

SURFACE WATER RESOURCES

Prior to development, most of the UEC Planning Area was characterized by nearly level, poorly drained lands subject to frequent flooding. The natural surface drainage systems included large expanses of sloughs and marshes such as St. Johns Marsh, Allapattah Slough (also referred to as Allapattah Flats), Cane Slough, and the Savannas (Figure 8). Drainage systems with higher conveyance included the North and South Forks of the St. Lucie River, Ten Mile Creek, Five Mile Creek, the Loxahatchee River and Bessey Creek. Most of these surface water systems, especially

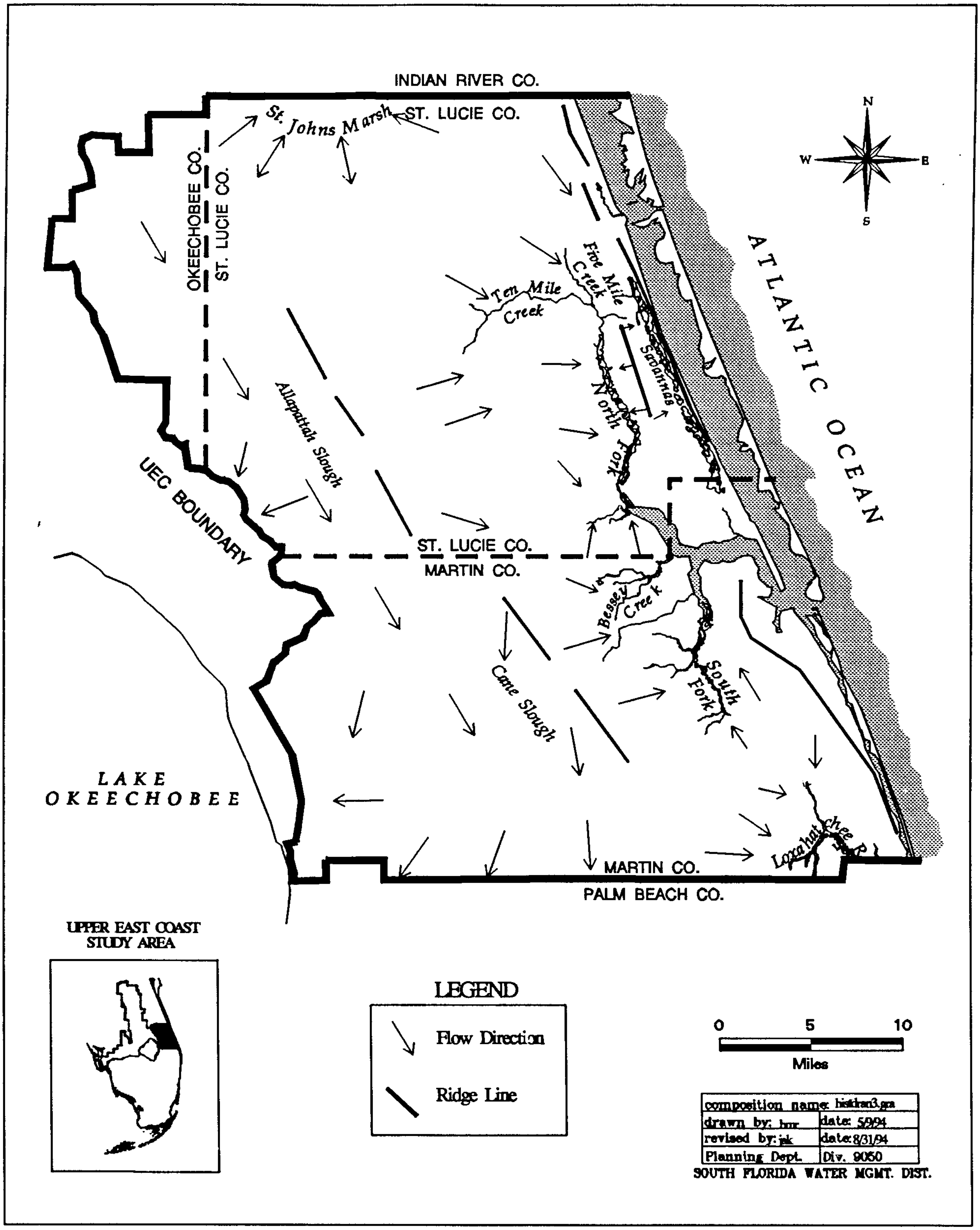


Figure 8. Historic Surface Water Drainage System in UEC Planning Area.

those with poor drainage, have been altered to make the land suitable for development and provide flood control

Since the early 1900s, numerous water control facilities have been constructed to make this region suitable for agricultural, industrial, and residential use. The St. Lucie Canal (C-44) was constructed between 1916 and 1924 to provide an improved outlet for Lake Okeechobee floodwaters. From 1918 to 1919, the Fort Pierce Farms Drainage District (FPFDD) and the North St. Lucie River Drainage District (NSLRDD) were formed to provide flood control and drainage for citrus production in east-central and northeastern St. Lucie County. The C-25 Canal (also known as Belcher Canal) provided a drainage outlet for the FPFDD, as well as limited flood protection for western areas of the basin. The C-24 Canal (also known as the Diversion Canal) provided drainage and limited flood protection west of the NSLRDD protection levee. The C-23 Canal provided water control in Allapattah Flats during the dry season. However, large areas continued to be under water for months at a time during the wet season.

Torrential rains and extensive flooding in South Florida in 1947 prompted the U.S. Congress to authorize the design and construction of the Central and Southern Florida Flood Control Project (C&SF Project). The C&SF Project included construction of levees, canals, spillways, pump stations and dams. Within the area that is now the UEC Planning Area, the project incorporated the existing canals and provided increased outlet capacity for Lake Okeechobee by making improvements to the St. Lucie Canal. The present surface water system of the UEC Planning Area, including C&SF Project structures, is shown on Plate 1.

Surface water management basins in the UEC Planning Area were first delineated in the 1950s by the U.S. Army Corps of Engineers (USACE) in their General Design Memorandum for the C&SF Project (1957). Nine basins in the planning area are served by C&SF Project works. Detailed descriptions of these basins can be found in the atlases of surface water management basins for Martin County (Cooper and Santee, 1988) and St. Lucie County (Cooper and Ortel, 1988).

There are 12 basins without Project works in the planning area. The level of flood protection in these non-Project basins varies widely, depending on the conveyance of the natural drainage system and extent of land development. Water control districts have been established in some basins to provide drainage, flood control and water supply (see Drainage Districts on page 38).

Surface Water Planning Areas

The following sections provide a description of the surface water resources for basins within the UEC Planning Area. Because adjacent basins tend to have similar needs and resources, the basins have been grouped into five geographical planning areas for the purposes of this report. These areas are the: (1) St. Lucie Agricultural Area; (2) Eastern St. Lucie Area; (3) St. Lucie River Area; (4) Southeastern Martin Area; and (5) Tidal Area (Plate 1).

St. Lucie Agricultural Area

The St. Lucie Agricultural Area is located in western St. Lucie County, eastern Okeechobee County and northern Martin County. It includes all of the C-23, C-24, C-25 basins, and parts of the North Fork St. Lucie River Basin (Figure 9).

The C-23, C-24 and C-25 canals and control structures were improved under the C&SF Project. Their current functions are: (1) to remove excess water from their respective basins; (2) to supply water during periods of low rainfall; and (3) to maintain ground water table elevations at the coastal structures to prevent saltwater intrusion.

The canals and control structures were designed to pass 30 percent of the Standard Project Flood, and to meet irrigation delivery requirements for the basin. In this planning area, a Standard Project Flood is statistically equivalent to a 10-year, 72-hour storm event. Excess water may be discharged from C-25 to tidewater by way of S-99 and S-50, or to C-24 by way of G-81. Excess water in C-24 may be discharged to tidewater by way of S-49, to C-25 by way of G-81, or to C-23 by way of G-78. Excess water in C-23 may be discharged to tidewater by way of S-97 and S-48, or to C-24 by way of G-78. A 1993 study concluded that the capacity of the C-23 was insufficient to convey design flows within the banks. Please refer to the “Canal Conveyance Capacity of C-23” report (SFWMD, 1993) for further details.

Flow in each of the C&SF Project canals is regulated by their respective control structures. For flood control and drainage, water elevations in the canal are set far enough below ground surface to provide slope in the secondary drainage systems. Water supply, on the other hand, requires the water surface in the primary canal be maintained sufficiently high to prevent overdrainage. When flow in the canals is adequate, control structures are operated to maintain a headwater stage within a seasonally dependent range (Table 6).

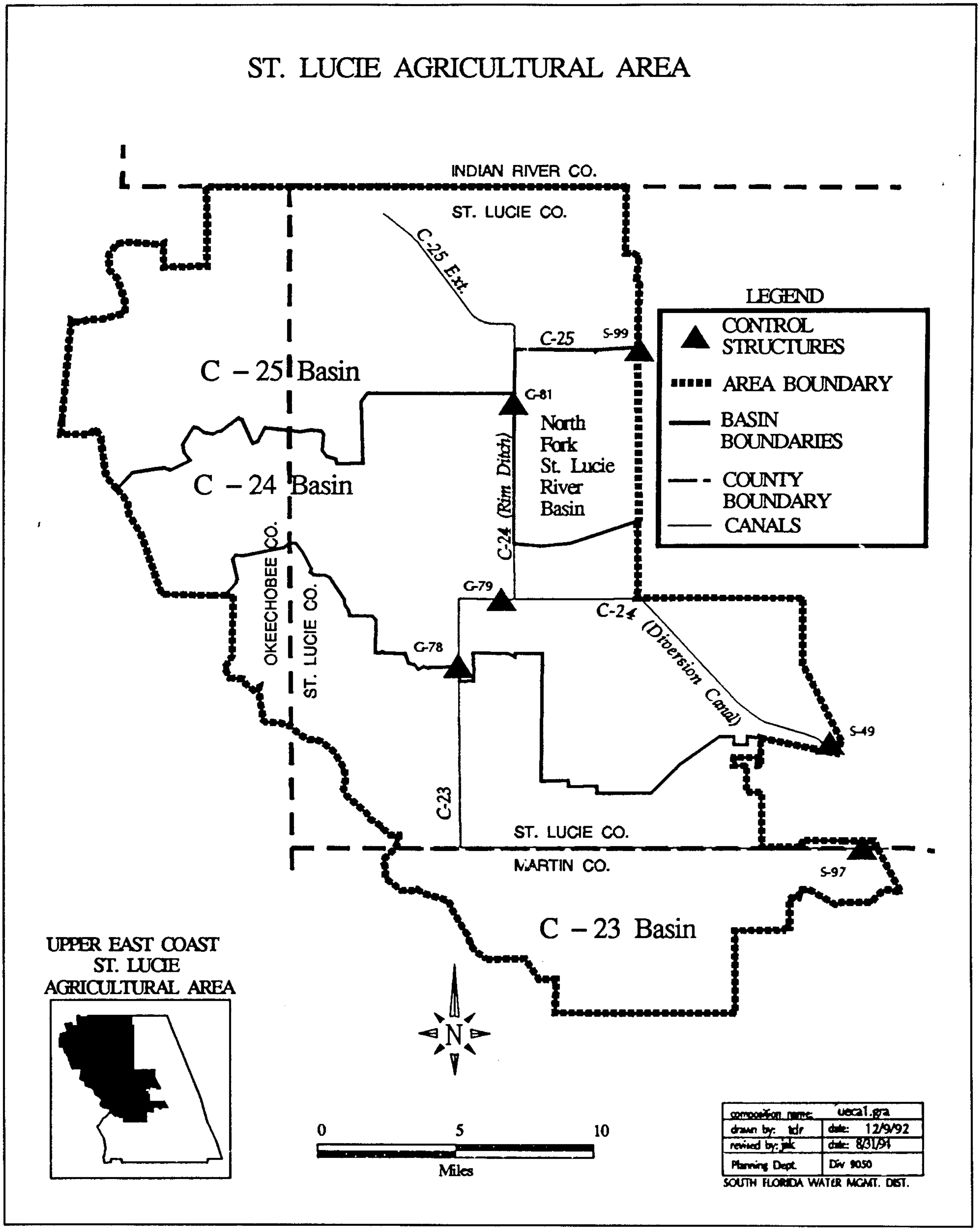


Figure 9. Drainage Basins of the St. Lucie Agricultural Area.

Table 6. Optimal Headwater Stage for Project Canals.

Canal	Structure	Headwater Stage (ft. NGVD)	
		Wet Season*	Dry Season
C-25	S-99	19.2-20.2	21.5-22.5
C-25	S-50	>12.0	>12.0
C-24	S-49	18.5-20.2	19.5-21.2
C-23	S-97	20.5-22.2	22.2-23.2
C-23	S-48	>8.0	>8.0

*Wet season is from May 15 to October 15.
Source: Cooper and Ortel, 1988.

Although the primary function of the C&SF Project was for flood control and drainage, the drainage network formed by the Project canals and the secondary canals and ditches have become an important source of irrigation water and frost protection for agriculture. In general, water stored in the canals is replenished by rainfall, ground water inflow, and runoff.

Prior to the large-scale expansion of citrus in the 1960s, storage in the drainage network in St. Lucie County was adequate to meet irrigation demands. However, the drainage and development of the large marsh areas in western St. Lucie County have depleted much of the surface water storage. The lowering of water tables have also reduced the amount of water in ground water storage. The reduction of surface and ground water storage coupled with increased acreages of citrus have resulted in inadequate supplies of surface water to meet demands during droughts. Therefore, an equitable distribution of the available surface water in the C-23, C-24 and C-25 basins is maintained by limiting the invert elevation of irrigation culverts and the intake elevation of pumps to a minimum of 14.0 feet NGVD. Artesian well water from the FAS is used as an irrigation supplement when surface water supplies become limited. Due to the high mineral content of the Floridan Aquifer, this water is generally blended with surface water before it is used as irrigation water.

Although early proposals addressed potential water supply problems in the area, local opposition and lack of funds made these efforts futile. The original General Design Memorandum envisioned a large conservation area north of C-25 in the St. Johns Marsh. The C-23, C-24 and C-25 canals and associated control structures were designed to deliver irrigation water from the water conservation area to 320 square miles of land in St. Lucie County. However, this portion of the C&SF Project was redesigned without the water conservation area due to local opposition to taking 200,000 acres of the floodplain out of production. Another proposal would have provided a link from Lake Okeechobee to C-23. This proposed C-131 Canal and its associated control structures and pumps would have supplied irrigation water to St. Lucie County, and permitted backflow of surplus rainfall runoff from the C-23, C-24 and C-25 basins into Lake Okeechobee. The C-131 proposal was later modified to include a flowway adjacent to C-131, which was designed to improve the water quality of the backflow prior to discharging into the lake. Although the flowway would have resolved the water quality concerns, it significantly increased the cost of the project, making the overall project economically unviable.

Eastern St. Lucie Area

The Eastern St. Lucie Area includes most of the North Fork St. Lucie River Basin and all of Basin 1 (Figure 10).

There are two C&SF Project canals (C-23A and C-24) in the North Fork St. Lucie River Basin. C-23A is a short section of canal in the lower reach of the North Fork of the St. Lucie River. This canal passes discharges for both the North Fork of the St. Lucie River and the C-24 Canal to the St. Lucie River Estuary. A short reach of the C-24 Canal extends from the S-49 control structure to the North Fork of the St. Lucie River, just north of C-23A. C-23A was designed to pass 30 percent of the Standard Project Flood from the North Fork St. Lucie River Basin and from the C-24 Basin.

Two drainage districts in the Eastern St. Lucie County Area have been established to coordinate surface water management within their districts. The districts are the Fort Pierce Farms Water Control District (FPFWCD) and the North St. Lucie River Water Control District (NSLRWCD). These drainage districts are shown in Figure 15. The City of Port St. Lucie has also established the Port St. Lucie Storm Water Utility (PSLSWU).

The FPFWCD was created originally as the Fort Pierce Farms Drainage District in 1919, under the provisions of Chapter 298, F.S. and incorporates 15,000 acres of land in the basin. All canals in the FPFWCD system drain to Canal 1, which discharges to the lower reach of C-25.

The NSLRWCD was created originally as the North St. Lucie River Drainage District in 1918, under the provisions of Chapter 298, F.S. and incorporates 65,000 acres in the North Fork St. Lucie River Basin. The water control system consists of man-made canals, improved natural streams and control structures.

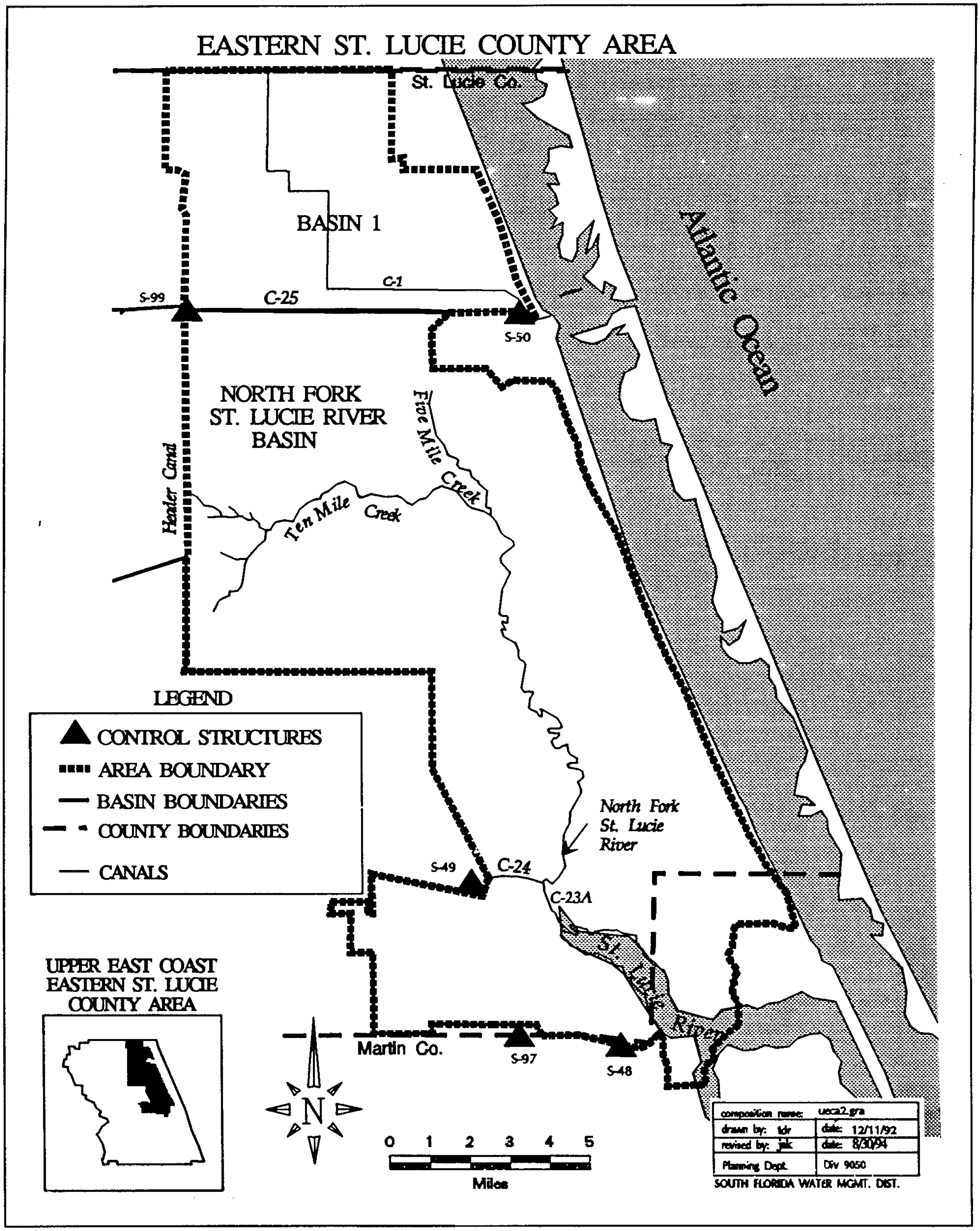


Figure 10. Drainage Basins of the Eastern St. Lucie Area.

The Header Canal is parallel to the west boundary NSLRWCD, and is located three miles east of the north-south reach of the C-24 Canal. It collects runoff from secondary canals extending westwardly, and it is connected to Ten Mile Creek to the east, C-25 to the north, and C-24 to the south. Ten Mile Creek and Five Mile Creek are natural streams which have been improved to transport water from the secondary drainage system to the North Fork of the St. Lucie River.

Water control structures in both FPFWCD and NSLRWCD are regulated on a day-to-day basis to maintain optimum canal water levels for agricultural production. During the dry season and as canal stages permit, water can be diverted from C-25 to FPFWCD for irrigation. Stage levels in the Header Canal are maintained by backpumping water from Ten Mile Creek.

St. Lucie River Area

The St. Lucie River Area covers most of Martin County (Figure 11). It can be subdivided in two categories: (1) the Canal Area which includes all of the C-44, S-153, and Tidal St. Lucie basins served by C&SF Project canals; and (2) basins 4, 5, 6, and 8. Basin 8 drains out of the UEC Planning Area and has little interaction with the St. Lucie River Area.

The Canal Area contains the only basin (C-44 Basin) in the UEC Planning Area which is hydrologically connected to Lake Okeechobee. Therefore, this section includes a discussion of the lake's regulation schedule.

Canal Area. The C&SF Project canal and control structures in the C-44 Basin have five functions: (1) to provide drainage and flood protection for the C-44 Basin; (2) to accept runoff from the S-153 Basin and discharge this runoff to tidewater; (3) to discharge water from Lake Okeechobee to tidewater when the lake is over schedule; (4) to supply water to the C-44 Basin during periods of low natural flow; and (5) to provide a navigable waterway from Lake Okeechobee to the Intracoastal Waterway. Excess water is discharged to tidewater by way of S-80 and C-44A. Under certain conditions, excess water may backflow to Lake Okeechobee by way of S-308. Regulatory releases from Lake Okeechobee are made to C-44 by way of S-308. Water supply to the basin is made from Lake Okeechobee by way of S-308 and from local rainfall. Both S-80 and S-308 have navigation locks to pass boat traffic.

Lockages are performed on an "on-demand" basis at S-80, except when water shortages have been declared or maintenance and repairs to the structure are taking place. Although there is no water shortage plan for S-80, the USACE will curtail lockages at the request of the District. Maintenance and repairs that result in stoppage of lockages are done on an as-needed basis, usually occuring every three to

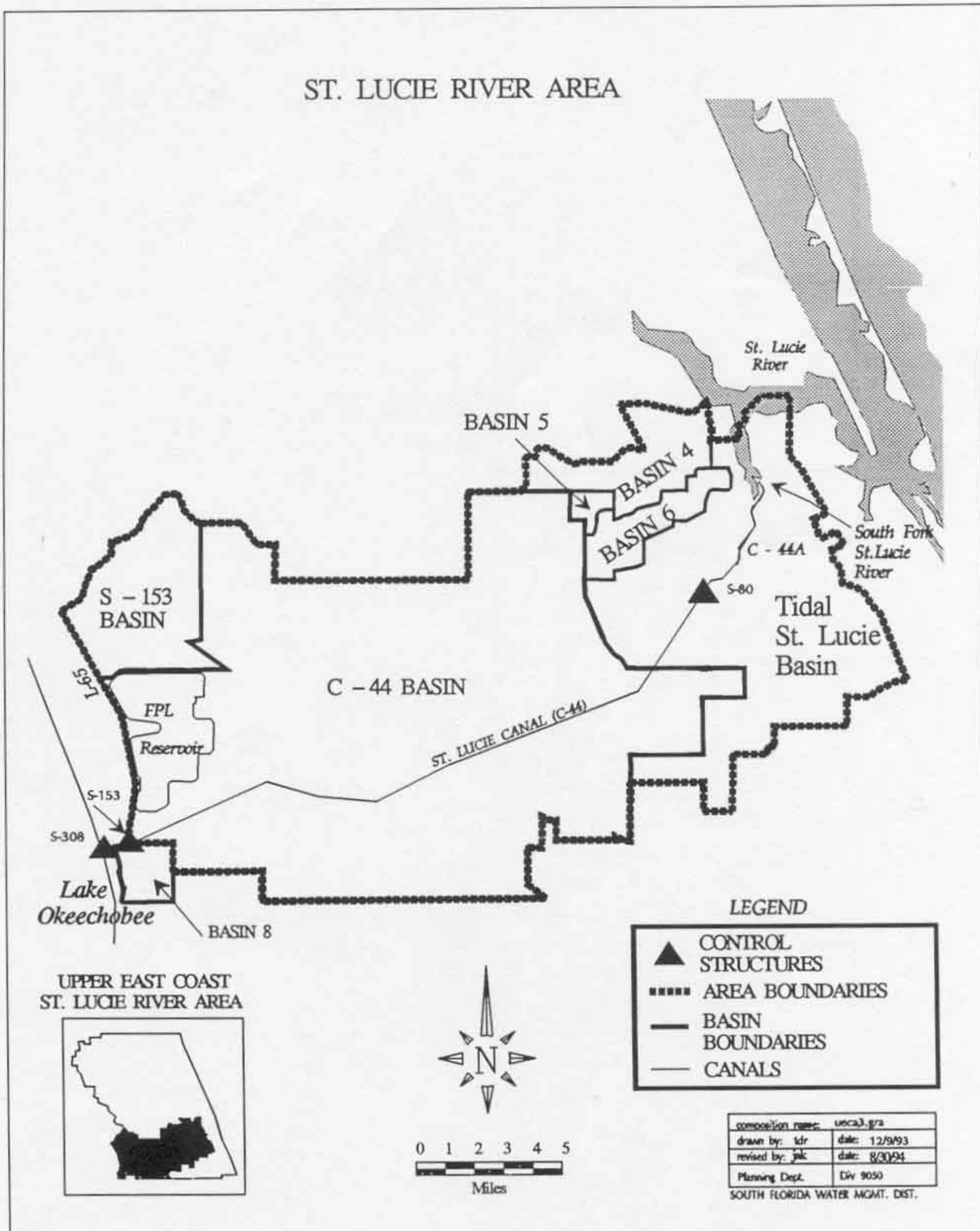


Figure 11. Drainage Basins of the St. Lucie River Area.

five years (phone conversation January 29, 1993 with Bill Mason, Lockmaster at S-80, USACE, Stuart, FL.). Each lockage at S-80 releases over 1.3 million gallons of water. The average number of lockages at S-80 vary monthly. Between 1987 and 1991, there were an average of 15 lockages per day, with maximum and minimum monthly averages ranging between 19 and 11 lockages per day (facsimile received February 1, 1993 from James Vearil, Hydraulic Engineer, USACE, Jacksonville, FL.).

The S-153 structure provides flood protection and drainage for the S-153 Basin. Excess water in the basin is discharged to C-44 by way of the L-65 borrow canal and S-153. The cooling reservoir for the Florida Power and Light power plant was originally part of the S-153 Basin. This 6,600 acre reservoir is now hydraulically connected to C-44, and is considered part of the C-44 Basin. The S-153 control structure is operated to maintain an optimum stage of 18.8 feet NGVD.

The S-80 structure in the Tidal St. Lucie Basin has three functions: (1) to accept flow from C-44 and to discharge those flows to tidewater in the St. Lucie River; (2) to provide a navigable waterway from the St. Lucie Canal to the Intracoastal Waterway; and (3) to provide drainage for portions of the Tidal St. Lucie Basin.

C-44 and S-80 were designed to pass the Standard Project Flood from the C-44 Basin and the S-153 Basin and to pass regulatory discharges from Lake Okeechobee to tidewater. The S-308 and S-80 control structures are operated to maintain an optimum canal stage of 14.5 feet NGVD within the Tidal St. Lucie Basin.

Basins 4, 5 and 6. Basins 4 and 6 are drained by Bessey and Danforth creeks, respectively. Bessey Creek discharges to the mouth of C-23, which in turn empties into the St. Lucie River. Danforth Creek discharges to the South Fork of the St. Lucie River Estuary. Basin 5 is generally landlocked, with a poor hydraulic connection to Bessey Creek. Inadequate conveyance in the drainage systems in these basins have frequently resulted in areas of inundation in flood-prone areas. See Needle (1992) for a detailed study of the Bessey and Danforth Creek drainage system.

Lake Okeechobee. Lake Okeechobee is managed as a multipurpose freshwater resource in the C&SF Project. The primary tool for managing lake water levels is the regulation schedule. This schedule defines the ranges of water levels in which specific discharges are made to control excessive accumulation of water within the lake's levee system. The schedule varies seasonally to best meet the objectives of the C&SF Project. A number of lake regulation schedules have been adopted since the construction of the C&SF Project (see Trimble and Marban, 1988). In 1978, the USACE adopted the "15.5 - 17.5" schedule, in which regulatory releases were made if lake stage exceeded 15.5-17.5 feet NGVD. A pulse release program was added in 1991, to reduce the likelihood of making large freshwater releases to the St. Lucie and

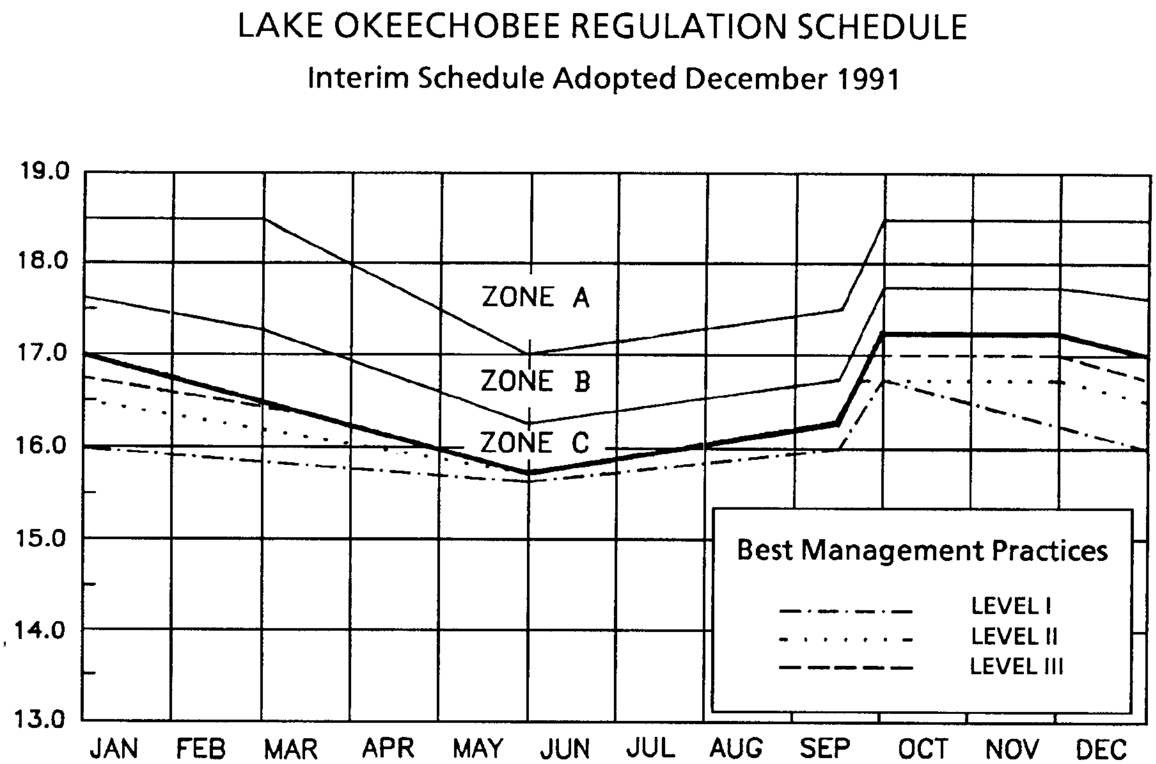
Caloosahatchee river estuaries. This schedule is commonly referred to as "Run 25" and is currently being used to regulate water levels in the lake (Figure 12).

Run 25 contains three management zones: Zone C, Zone B and Zone A, as identified by individual lines of zones shown in Figure 12. Below Zone C is three "Best Management Zones," identified as Level I, II, and III, which correspond to specific discharge criteria developed for the Caloosahatchee River and St. Lucie River estuaries, as shown in Table 7. When the lake stage falls below the Zone C line, no regulatory discharges are required. When lake stages reach Zone B or Zone A, releases of water are made by the USACE in accordance with the parameters shown in Figure 12. In Zone A, the USACE has the authority to make maximum discharges to all outlets in an effort to reduce lake levels to protect the structural integrity of the levee system from a major storm.

The large-scale discharges required in Zone A and Zone B are damaging to the downstream estuarine systems. The Best Management Zones below Zone C were developed to provide a buffer or safety factor for making early or pulsed releases of lake water to downstream estuaries. These release patterns are called pulse releases because they mimic the pulse release associated with a rainfall event that would normally occur in an upstream watershed of the estuary. This release concept allows the estuary to absorb the freshwater release without drastic or long-term salinity fluctuations.

Although Lake Okeechobee is a potentially large source of water, there are competing users of this water elsewhere within the Lake Okeechobee Service Area, as well as the Lower East Coast and Lower West Coast planning areas. During periods of water shortage in the lake, water supply allocations are determined through procedures described in the Lake Okeechobee Supply-Side Management Plan. This plan states that the amount of water available for use during any period is a function of the anticipated rainfall, lake evaporation, and water demands for the balance of the dry season in relation to the amount of water currently in storage.

Water availability from the lake is calculated on a weekly basis, along with a provision that allows users to borrow from their future supply to supplement existing shortfalls. The borrowing provision places the decision of risk with the user and can significantly affect the distribution of benefits among users because the amount of water borrowed is mathematically subtracted from future allocations. The Lake Okeechobee Supply-Side Management Plan is implemented if the projected lake stage falls below 11.0 feet NGVD at the end of the dry season, or below 13.5 feet NGVD at the end of the wet season (Figure 13).



Releases Through Outlets

Zone	Agricultural Canals	Caloosahatchee River	St. Lucie Canal
A	Pump maximum practical to WCAs	Up to maximum capacity at S-77	Up to maximum capacity at S-80
B	Maximum practical to WCAs	6500 cfs	3500 cfs
C	Maximum practical to WCAs	4500 cfs	2500 cfs
Levels I, II, & III	Maximum practical to WCAs	See Table II-2 for a schedule of the pulse releases for the Caloosahatchee River	See Table II-2 for a schedule of the pulse releases for the St. Lucie Estuary

Figure 12. Lake Okeechobee Interim Regulation Schedule.

Table 7. Pulse Release Schedules for the St. Lucie and Caloosahatchee River Estuaries and their Effect on Lake Okeechobee Water Levels.

Day	Daily Discharge Rate (cubic feet per second)					
	St. Lucie Level I	St. Lucie Level II	St. Lucie Level III	Caloosa. Level I	Caloosa. Level II	Caloosa. Level III
1	1,200	1,500	1,800	1,000	1,500	2,000
2	1,600	2,000	2,400	2,800	4,200	5,500
3	1,400	1,800	2,100	3,300	5,000	6,500
4	1,000	1,200	1,500	2,400	3,800	5,000
5	700	900	1,000	2,000	3,000	4,000
6	600	700	900	1,500	2,200	3,000
7	400	500	600	1,200	1,500	2,000
8	400	500	600	800	800	1,000
9	0	400	400	500	500	500
10	0	0	400	500	500	500
Acre Feet per Pulse and Correlating Lake Level Fluctuations						
AF per pulse	14,476	18,839	23,201	31,728	45,609	59,490
Impact on lake (feet)	0.03	0.04	0.05	0.07	0.10	0.13

Source: SFWMD, 1997, Lake Okeechobee SWIM Plan.

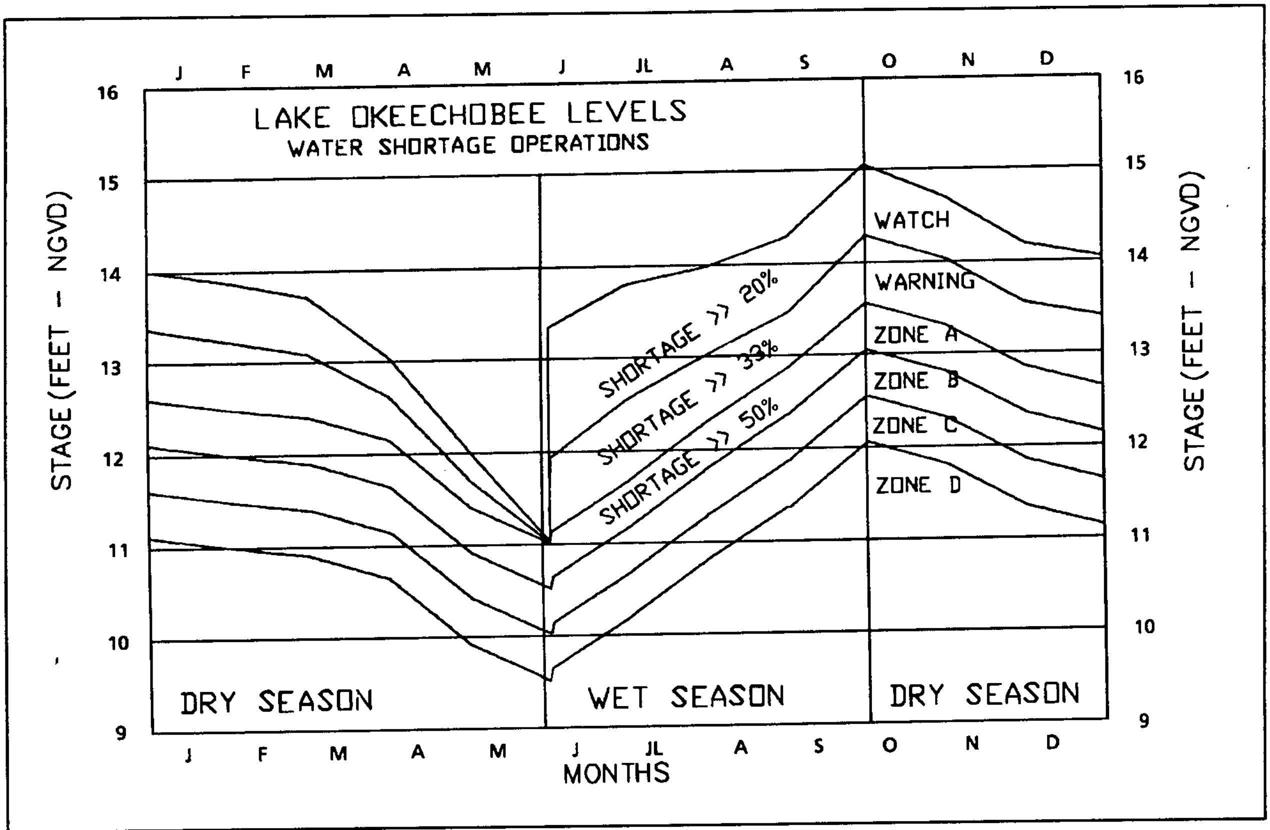


Figure 13. Lake Okeechobee Supply-Side Management Plan.

Southeastern Martin Area

The Southeastern Martin Area includes three basins: (1) Pal-Mar Basin; (2) Jonathan Dickinson Basin; and (3) Basin 2 (Figure 14).

The Pal-Mar Basin contains wet prairie ponds and pine flatwoods, portions of which are being acquired through land various acquisition programs (see Chapter 3, Environmental Resources and Needs). This basin does not drain to adjacent basins except through sheetflow during heavy rainfall. When this occurs, the Pal-Mar Basin overflows to the North Fork of the Loxahatchee River via Cypress Creek.

The Jonathan Dickinson Basin is a state park bounded by the Coastal Ridge to the east, which is vegetated with sand pine scrub, pine flatwoods, and a mixture of wetland types. The basin drains to the Loxahatchee River located in the southern half of the basin. The sandy coastal ridge soils produce little surface water runoff as a result of high infiltration rates.

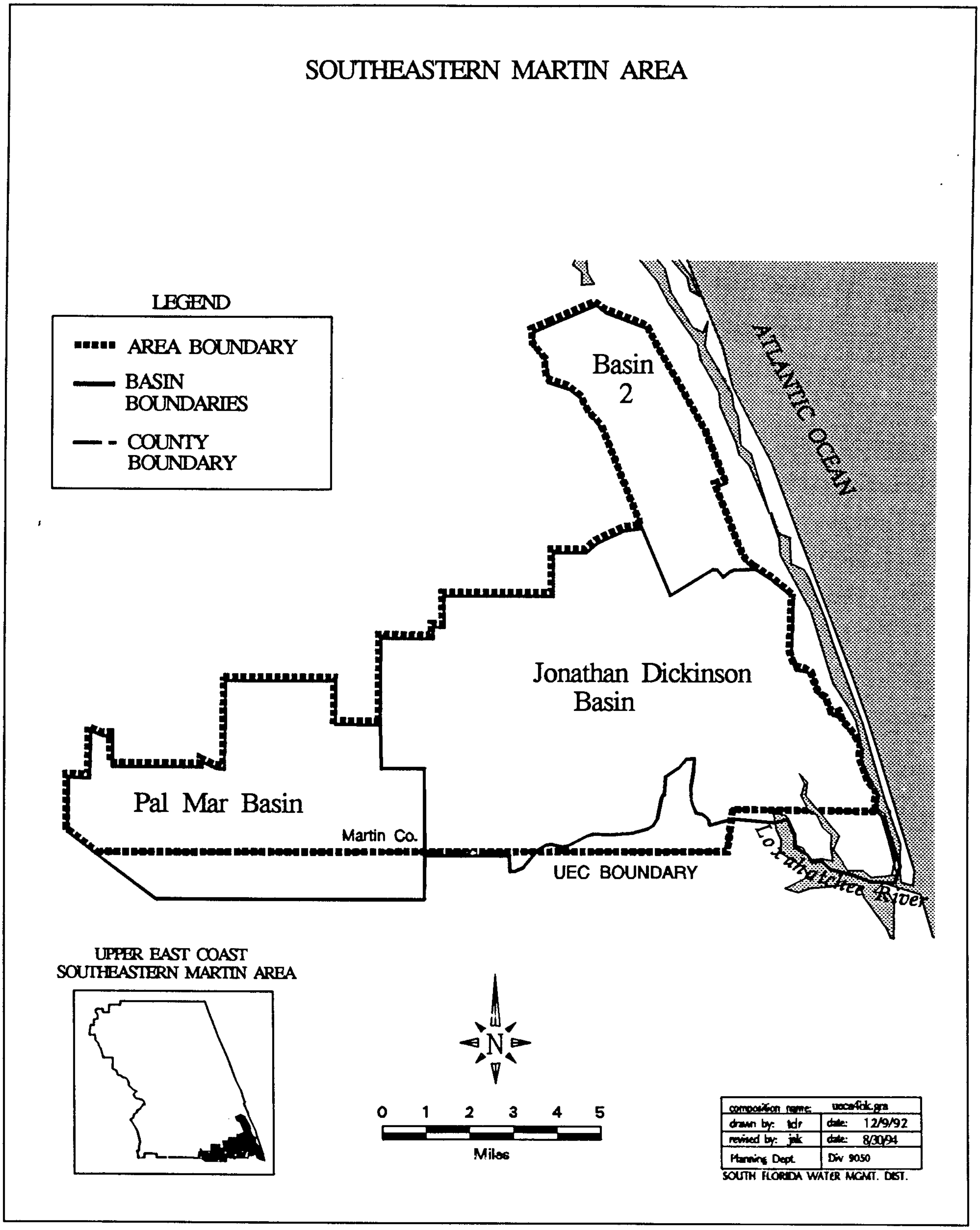


Figure 14. Drainage Basins of the Southeastern Martin Area.

Basin 2 is bounded by the coastal ridge to the east and pine flatwoods to the west. The basin has poorly defined internal drainage, and about one-third of the basin drains north to the Manatee Pocket, which is part of the St. Lucie River/Indian River Lagoon estuarine system.

Tidal Area

There are three basins within the Tidal Area: (1) North Coastal; (2) Middle Coastal; and (3) South Coastal. These basins are located in coastal St. Lucie and Martin counties. In general, these basins contain barrier islands, the Intracoastal Waterway, and mainland beaches. Most of the surface water in these basins is tidal.

Drainage Districts

Chapter 298, Florida Statutes governs local water control districts. These 298 districts (Figure 15) are empowered to develop and implement a plan for draining and reclaiming the lands, and control all water movement within their jurisdiction. The 298 districts have the power to construct and maintain canals, divert flow of water, construct and connect works to canals or natural watercourses, and construct pumping stations. They may also enter into contracts, adopt rules, collect fees, and hold, control, acquire or condemn land and easements for the purpose of construction and maintenance.

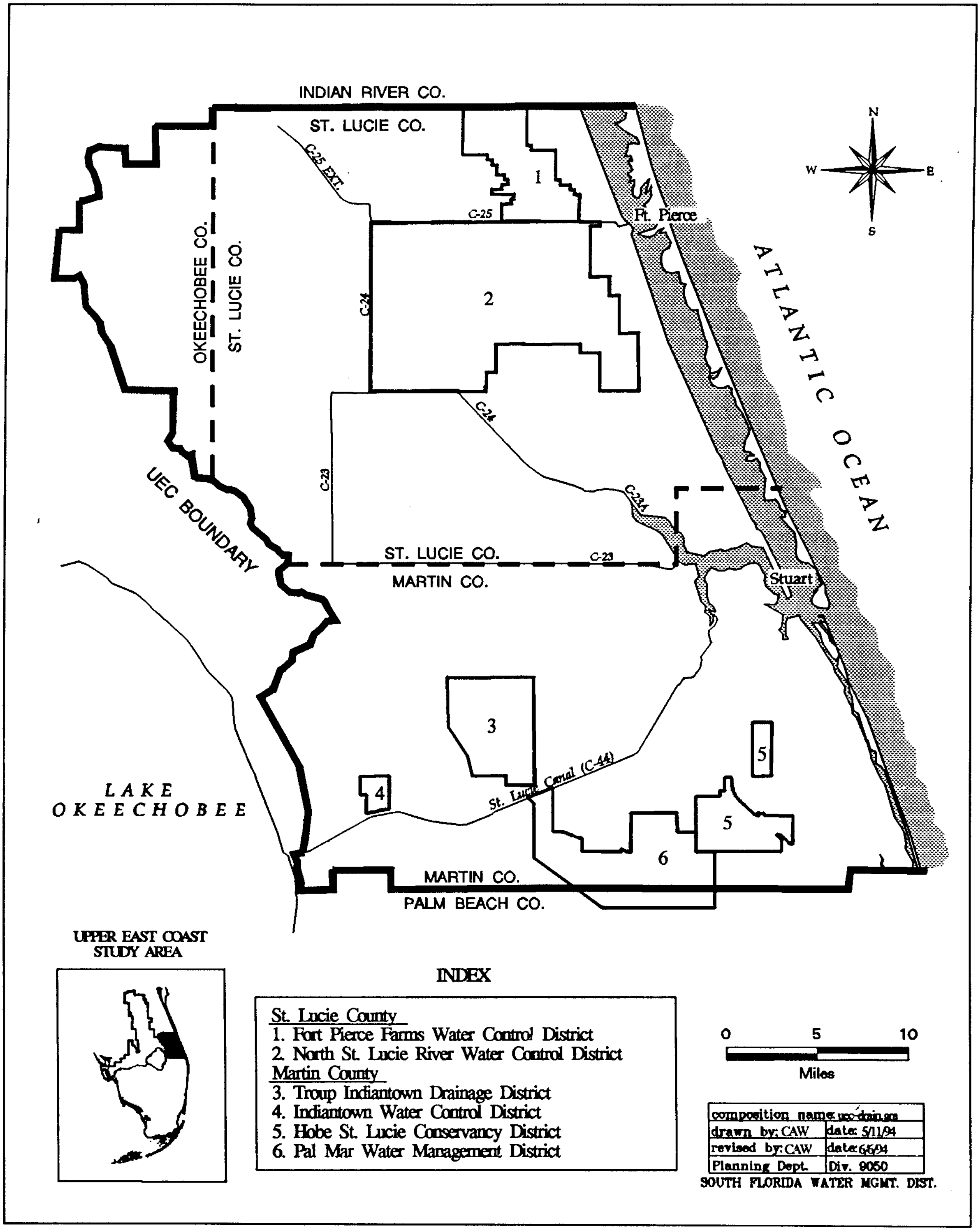


Figure 15. Chapter 298 Drainage Districts.

GROUND WATER RESOURCES

The hydrogeology of South Florida is diverse. It includes aquifers which are confined (in which ground water is under greater than atmospheric pressure and isolated from vertical recharge), semi-confined (having some vertical recharge), and unconfined (ground water is at atmospheric pressure and water levels correspond to the water table). Within an individual aquifer, hydraulic properties and water quality may vary both vertically and horizontally. Because of this diversity, ground water supply potential varies greatly from one place to another. It is the purpose of this section to identify the aquifers in the region, and describe their current usage and water producing capability.

The two major aquifer systems, the Floridan Aquifer System (FAS) and the Surficial Aquifer System (SAS), are summarized in Tables 8 through 10 for Martin, St. Lucie, and Okeechobee counties. Appendix D includes a collection of ground water resources graphics. Table D-1 outlines the temporal and physical relationships between these different aquifer systems. In addition, a stratigraphic cross section (Figure D-1), and maps showing the elevation and thickness of each of the hydrogeologic units (figures D-2 to D-5) are provided in Appendix D. Ground water flow models used to evaluate hydrogeologic systems and identify problem areas are discussed in Chapter 10.

Table 8. Ground Water Systems in Martin County.

Hydrogeologic System	Hydrogeologic Unit	Thickness (feet)	Water Resource Potential
Surficial Aquifer System	Surficial Aquifer	100-250	Principal source of fresh water for public and agricultural water supply. Yields moderate amounts of water. Water quality is generally fair, with areas of high iron, hardness, and/or total dissolved solids.
Intermediate Confining Unit	Hawthorn Confining Beds	400-650	Does not produce significant quantities of water within Martin County.
Floridan Aquifer System	Floridan Aquifer	2,900-3,400	Confined aquifer. Yields moderate to large amounts of water. Requires desalination for potable uses, but is suitable for irrigation purposes in the northern part of the county when mixed with surface water. Water quality deteriorates toward the south, and with increasing depth.

Table 9. Ground Water Systems in St. Lucie County.

Hydrogeologic System	Hydrogeologic Unit	Thickness (feet)	Water Resource Potential
Surficial Aquifer System	Surficial Aquifer	90-150	Principal source of fresh water for public water supply. Yields small amounts of water. Water quality is fair to good, with localized areas of high iron, chlorides, and/or dissolved solids.
Intermediate Confning Unit	Hawthorn Confining Beds	400-700	Does not produce significant quantities of water within St. Lucie County.
Floridan Aquifer System	Floridan Aquifer	2,700-3,100	Confined aquifer. Requires desalination treatment for potable use, but is suitable for most irrigation purposes when mixed with fresh surface water. Water quality deteriorates with increasing depth.

Table 10. Ground Water Systems in Eastern Okeechobee County.

Hydrogeologic System	Hydrogeologic Unit	Thickness (feet)	Water Resource Potential
Surficial Aquifer System	Surficial Aquifer	10-180	Principal source of fresh water for residential self-supply in unincorporated areas. Yields small amounts of water. Water quality is generally good, except near Lake Okeechobee where chloride concentrations exceed potable standards.
Intermediate Confining Unit	Hawthorn Confining Beds	200-600	Does not produce significant quantities of water within Okeechobee County.
Floridan Aquifer System	Floridan Aquifer	2,700-3,000	Confined aquifer. Yields moderate to large amounts of water. Primary source of supply for agricultural uses. Water quality is very good in the north, but deteriorates to the south and east and with increasing depth.

Surficial Aquifer System

The SAS is the principal source of water for urban uses, including potable water, within the UEC Planning Area. It includes all saturated rock and sediment from the water table to the top of the underlying intermediate confining unit. Geologically, this includes the Pamlico and Anastasia formations and part of the Tamiami formation. Over most of the planning area, the aquifer is composed primarily of sand interbedded with thin beds or lenses of limestone, sandstone, or shell.

The lithology, and consequently the productivity of the aquifer, varies both laterally and vertically. Producing zones are not always found at the same depth within the aquifer, and may be missing entirely. In general, the permeable limestone, sandstone and shell strata are more prevalent in the eastern than western part of the counties (Lichtler, 1960). Productivity and water quality in the aquifer also tend to improve from north to south and west to east.

Upper Confining Unit for the Floridan Aquifer System

Within the UEC Planning Area, the upper confining unit for the FAS is comprised of the relatively impermeable sequence of phosphatic clays, silts and limestones of the Hawthorn group. The top of the confining beds lies around -80 feet NGVD in the northwest corner of St. Lucie County. It dips gently to the southeast, reaching a maximum depth of over -200 feet NGVD in southeastern Martin County. Thickness also varies, ranging from less than 300 feet in northern St. Lucie County, to more than 600 feet at the extreme southern end of the planning area.

Floridan Aquifer System

The FAS, which underlies all of Florida and portions of southern Georgia and Alabama, ranges in thickness from 2,700 to 3,400 feet within the planning area (Scott *et al*., 1991). The top of the FAS lies around -300 feet NGVD in the northwest corner of the planning area, then dips to the southeast to more than -900 feet NGVD in southeast Martin County. Parker *et al*. (1955) designated the FAS to include "parts of the middle Eocene (Avon Park and Lake City Limestone), upper Eocene (Ocala Limestone), Oligocene (Suwannee Limestone), and Miocene (Tampa Limestone, and permeable parts of the Hawthorn formation that are in hydrologic contact with the rest of the aquifer)."

Within the FAS are multiple permeable intervals, or producing zones, sandwiched between low permeability confining materials. The permeable intervals are associated with solution cavities and formational unconformities, the latter of which can be correlated over large areas (Brown and Reece, 1979). Tibbals (1991) divided the FAS into two aquifers based on the vertical occurrence of two highly permeable zones. These are the upper Floridan and lower Floridan aquifers. They are separated by a low permeability interval named the middle semi-confining unit. The term lower Floridan, as it appears here, refers to the upper portion of the lower Floridan aquifer. This zone shall henceforth be referred to as the upper part of the lower Floridan aquifer. This terminology and the geologic description of the FAS which follows were adopted from Lukasiewicz (1992).

The FAS is an important source of agricultural irrigation water, particularly in the northern portion of the planning area. The FAS, however, requires desalination treatment in order to supply potable uses. The quality of water in the FAS deteriorates to the south, increasing in hardness and salinity. Salinity also increases with depth, making the deeper producing zones less suitable for development than those near the top of the system.

Upper Floridan Aquifer

The upper Floridan aquifer (UFA) is the principal source of supply to users of the FAS in the planning area. It is approximately 500 feet thick, and characterized by two distinct and continuous producing zones. These two zones occur along the unconformities which serve as the lithologic contacts between the Suwannee formation and the Ocala Group, and the Ocala Group and the Avon Park formation. There are also numerous high permeability zones created by solutioning and dolomitization (the replacement of calcium carbonate with magnesium carbonate). These zones are not stratigraphically controlled, and occur irregularly throughout the planning area.

The UFA is an important source of irrigation water for agriculture in St. Lucie County and to a lesser extent in Martin County. Floridan wells, which flow without pumping, produce large volumes of relatively poor quality water. UFA water averages about 900 mg/L total dissolved solids in St. Lucie County, and deteriorates toward the southeast to 3,000 mg/L in southeastern Martin County. Because of its poor quality, ranchers and grove operators tend to discharge Floridan water into irrigation ditches, where it mixes with better quality surface water and ground water from the SAS. This dilutes the brackish Floridan water to a level acceptable for agricultural irrigation, and allows growers to supplement their surface water supplies when availability is limited.

Where chlorides are sufficiently low, upper Floridan water can be blended with SAS water for use by public water supplies (i.e., Fort Pierce Utilities Authority). In most cases, however, desalination treatment will be necessary to provide potable quality water. Martin County Utilities and the Town of Jupiter, as well as numerous development communities along the coast, are currently using, or have immediate plans to use desalinated UFA water to supply their service areas. The productivity of the UFA is considerably greater than that of the SAS throughout most of the planning area, although a structural feature which is approximately aligned with the Intracoastal Waterway results in reduced productivity along the coastal margin north of Vero Beach. Overall, chlorides are within a reasonable range for current desalination technologies. It is expected that, as the area continues to grow, use of the UFA for augmenting urban supply will increase.

Middle Semi-Confining Unit

The middle semi-confining unit, corresponding stratigraphically to the Avon Park Formation, is composed of chalky calcilucite interbedded with limestones and dolomites. Because few wells in the planning area fully penetrate this unit, data on its variability is limited. Data from a few test wells in the planning area place its thickness at 200 to 400 feet.

Upper Part of the Lower Floridan Aquifer

The deeper producing zones of the FAS are associated with the Lake City Limestone, a hard, porous, crystalline dolomitic limestone, with stringers of chalky fossiliferous limestone.

There are two distinct flow zones within the upper part of the lower Floridan aquifer (ULFA), one at the contact between the Lake City Limestone and the Avon Park Formation, and a deeper one where the Lake City Limestone contacts the Oldsmar formation. In this document, these flow zones are referred to as Lower Floridan Aquifer Production Zones 1 and 2. Borehole geophysical logs and drill stem tests performed at two test wells in the planning area indicate the permeability of the two zones is cavernous in nature. The zones are separated by approximately 250 feet of low permeability material.

The two producing zones may also be distinguished by a significant difference in water quality. Water samples collected from a test well in central St. Lucie County showed TDS levels between 1,100 to 1,200 ppm in the upper producing zone, and 2,000 or more in the lower zone.

Although very transmissive zones have been documented within the ULFA, they are generally not used as supply sources within the UEC Planning Area due to the high salinity and mineral content of their water and high drilling costs. Most interest in this portion of the FAS lies in its potential for use in aquifer storage and recovery (ASR) projects (see Chapter 8). This portion of the lower Floridan has been determined to have high potential for ASR due to its capacity for receiving and storing large quantities of injected water (Lukasiewicz, 1992).

Directly below the ULFA lies an extremely thick confining interval of dense limestones and dolomites which effectively preclude flow between the ULFA and the Lower Floridan Aquifer. An area of extremely high transmissivity, known as the "boulder zone," occurs at the base of the lower Floridan aquifer. In South Florida the boulder zone has been used for disposal of treated wastewater effluent and reject water/concentrate from reverse osmosis water treatment facilities.

SURFACE WATER/GROUND WATER RELATIONSHIPS

In the preceding sections, surface water and ground water resources have been addressed as separate entities. In many ways, however, they are highly interdependent. The construction and operation of surface water management systems affect the quantity and distribution of recharge to the SAS. Although a major source of water supply, in terms of their interaction with ground water, surface water management systems within the planning area function primarily as aquifer drains. Adams (1992) estimated that 19 percent of ground water flow in Martin County is discharged into surface water bodies, while only one percent of aquifer recharge is derived from surface water sources. Surface water management systems also impact aquifer recharge by diverting rainfall from an area before it has time to percolate down to the water table. Once diverted, this water may contribute to aquifer recharge elsewhere in the system, supply a downstream consumptive use, or it may be lost to evapotranspiration (ET) or discharged to tide.

Although the FAS is not hydraulically connected to surface water within the planning area, FAS water is usually diluted with surface water to achieve an acceptable quality for agricultural irrigation. Consequently, surface water availability for dilution purposes can be a limiting factor on the use of FAS water.

Chapter 4

NATURAL RESOURCES

The UEC Planning Area contains a variety of natural resources, ranging from coastal barrier islands, mangrove forests, beaches and estuaries to inland forested, shrub, herbaceous wetlands, and uplands. This chapter provides an overview of these resources, discusses the water supply needs of natural resources, and describes some of the resource protection activities that are underway within the planning area.

COASTAL RESOURCES

Description of Coastal Resources

Coastal resources within the UEC Planning Area include barrier islands, coastal wetlands, and estuarine systems. Hutchinson Island is a low barrier island located along the eastern shoreline of Martin and St. Lucie counties. The eastern edge of the island supports a coastal dune community, which includes salt- and drought-tolerant species. West of the dune community, cabbage palm, saw palmetto, oaks and sea grape are present. The western edge of the island supports mangrove wetlands.

A coastal ridge is present along the eastern edge of the mainland within the planning area. This ridge forms a one-to-three mile wide area dominated by sand pine, saw palmetto, scrub oaks, and other xeric plant species. The Savannas, a remnant coastal wetland system, is located west of the coastal ridge and is discussed in greater detail in the Inland Resources section of this chapter.

Estuarine systems in the planning area include the Indian River Lagoon (IRL), St. Lucie Estuary (SLE), and a small portion of the Loxahatchee River Estuary (this estuary is being addressed in the Lower East Coast Water Supply Plan). These estuaries provide important habitat for threatened and endangered species and support commercial and recreational fisheries.

The IRL extends about 155 miles through six coastal counties from Ponce De Leon Inlet in Volusia County southward to the Jupiter Inlet in Palm Beach County. Within the SFWMD boundaries, the IRL encompasses approximately 48 square miles and includes the IRL proper from Fort Pierce to Stuart, the St. Lucie Estuary, Hobe Sound, and Jupiter Sound. The IRL watershed within the planning area incorporates approximately 1,120 square miles (20 surface water management basins). Land uses within this watershed include high density urban, extensive citrus operations, and large stretches of improved pasture.

The SLE is located in the southern region of the IRL in Martin and St. Lucie counties. The SLE watershed encompasses about 781 square miles and is divided into five major basins and several small basins (see Surface Water Resources section). The western basins are predominantly agricultural with about 70 percent of land in citrus and improved pasture. The two eastern basins (North St. Lucie and Tidal) are more urban with about 45 percent of the land devoted to agricultural activities.

The SLE is divided into three sections: the North Fork, the South Fork, and the Middle Estuary (Plate 1). The North Fork is about 4 miles long with a surface area of 4.5 square miles. Depths range from 10 feet in the central portion to 20 feet at its juncture with the South Fork. The North Fork is designated as an aquatic preserve. The South Fork has about half the surface area of the North Fork, and is relatively shallow except for an eight-foot navigation channel. This channel is part of the Okeechobee Waterway which links Stuart with Fort Myers through Lake Okeechobee and the Caloosahatchee River. The Middle Estuary begins at the confluence of the North and South Forks and continues to Hell Gate Point near the IRL proper.

Water Needs of the Coastal Resources

Maintenance of appropriate freshwater inflows is essential for a healthy estuarine system. Preliminary findings indicate that the total mean monthly inflows to the SLE need to be between 350 cfs and 1,600 cfs. Currently, flows range from 150 cfs to more than 4,000 cfs. Excessive changes in freshwater inflows to the estuary result in imbalances beyond the tolerances of estuarine organisms. The retention of water within upland basins for water supply purposes can reduce inflows into the estuary and promote excessive salinities. Conversely, the inflow of large quantities of water into the estuary as a result of flood control activities can significantly reduce salinities and introduce storm water contaminants. In addition to the immediate impacts associated with dramatic changes in freshwater inflows, long-term cumulative changes in water quality constituents or water clarity may also adversely affect the estuarine community.

INLAND RESOURCES

Description of Inland Resources

Water Bodies

Water bodies within the UEC Planning Area include natural lakes, man-made surface water impoundments, rivers, and creeks. Natural lakes within the planning area include Lake Eden in the Savannas State Preserve, Mile Lake which is west of the North Fork of the St. Lucie River in southern Port St. Lucie, and Banner Lake which is south of State Road 708 in Hobe Sound. These lakes provide habitat for aquatic plants and animals and other wildlife that rely on open water during some portion of their life. They are not considered important sources of water supply for agricultural and urban uses in the planning area.

Man-made water bodies are also prevalent in the planning area. The largest of these is the Florida Power and Light (FPL) reservoir (Figure 8) which covers approximately 6,600 acres in western Martin County. Many small borrow pits and surface water management lakes have been dug throughout the planning area for fill and to improve drainage in low-lying areas. These ponds are common in the newer residential and golf course communities.

Major rivers in the planning area include the Loxahatchee and St. Lucie Rivers (Plate 1). The Loxahatchee River and the North Fork of the St. Lucie River have been designated aquatic preserves by the State of Florida. This designation is intended to preserve the biological, aesthetic, or scientific values of these resources for the enjoyment of future generations. Regulation of these resources should be reasonable and not interfere with traditional public uses, such as fishing, boating and swimming.

The Northwest Fork of the Loxahatchee River is the only river in Florida to be designated a Wild and Scenic River by the federal government. Although the Northwest Fork of the Loxahatchee River and its headwaters are within Martin County, the entire Loxahatchee River system is being addressed in the Lower East Coast Water Supply Plan.

Numerous creeks feed the St. Lucie River in both Martin and St. Lucie counties (Plate 1). These include Bessey, Danforth, and Mapps creeks, which are tributaries of the South Fork of the St. Lucie River downstream of the St. Lucie Canal; Five and Ten Mile Creeks which are tributaries of the North Fork of the St. Lucie River; and Willoughby and Manatee creeks, which enter the St. Lucie River near its junction with the Indian River Lagoon.

Wetlands

Wetlands are lands transitional between uplands and aquatic systems (water bodies) and are typically defined by vegetation, soils, and hydrology. Chapter 62-340, F.A.C., provides the statewide methodology for delineating wetlands in Florida and includes the following definition of wetlands: “those areas that are inundated or saturated by surface water or ground water at a frequency and a duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soils.” Wetlands within the planning area include swamps, marshes, bayheads, cypress domes and strands, sloughs, wet prairies, riverine wetland hardwoods, and mangrove swamps.

Functions and Values of Wetlands. Wetlands perform a number of hydrologic and biological functions which make them valuable to man. Hydrologic functions performed by wetlands include receiving and storing surface water runoff. This is important in controlling flooding, erosion, and sedimentation. Surface water that enters a wetland is stored until the wetland overflow capacity is reached and water is slowly released downstream. As the water is slowed by wetland vegetation, sediments in the water (and chemicals bound to the sediments) drop out of the water column, improving water quality.

Wetlands also function hydrologically as ground water recharge-discharge areas. Wetlands may recharge the ground water when the water level of a wetland is higher than the water table. Conversely, ground water discharge to wetlands may occur when the water level of the wetland is lower than the water table of the surrounding land.

Biological wetland functions include providing habitat for fish and wildlife, including organisms classified as endangered, threatened, or species of special concern. Some species depend on wetlands for their entire existence, while other semi-aquatic and terrestrial organisms use wetlands during some part of their life cycle. Their dependence on wetlands may be for over-wintering, residence, feeding and reproduction, nursery areas, den sites, or corridors for movement. Wetlands are also an important link in the aquatic food web. They are important sites for microorganisms, invertebrates and forage fish which are consumed by predators such as amphibians, reptiles, wading birds and mammals.

Types of Wetlands. Inland wetlands within the planning area can be grouped into three major categories: forested, scrub shrub, and herbaceous wetlands. These classes were generalized from the National Wetlands Inventory (NWI), a branch of the U.S. Fish and Wildlife Service. The NWI is a nationwide wetland mapping system which was completed for the state of Florida in 1984. The NWI data was updated for the planning area by the District using 1990 and 1991 satellite images and aerial photographs. This update was not a detailed re-evaluation of the UEC Planning Area wetlands, but a generalized overview of the changes that have occurred in the region since the original NWI map was created. Plate 3 shows the updated wetland systems map of the planning area.

The three wetland categories are briefly described below:

Forested Wetlands. Freshwater forested wetland communities within the planning area include cypress, cabbage palm, mixed hardwood and bayheads.

Scrub Shrub Wetlands. The scrub shrub communities of the planning area can be found in a number of different habitat and hydroperiod ranges. Shrubs such as wax myrtle and St. Johns Wort, which are indicative of temporarily flooded soil, often border the wetter herbaceous marshes and prairie ponds. In the wetter areas, willow and small bay are the dominant shrub species.

Herbaceous Wetlands. Most of the herbaceous (emergent) wetlands in the planning area can be referred to as marsh. There are also sloughs, wet prairies and prairie ponds.

Distribution of Wetlands. Wetlands are present throughout the planning area as shown on Plate 3. Although numerous man-made impacts have altered the landscape, significant wetland systems remain in the planning area.

Martin County. The area now known as the Allapattah Flats (Figure 5) was historically a series of sloughs that flowed from St. Lucie County southwest into Martin County through Barley Barber Swamp and into Lake Okeechobee. This drainage pattern has been modified by highways, railroads, and drainage projects (Florida Power and Light, 1988). Currently, a series of isolated creeks, ponds, hammocks, sloughs and wet prairies exist within the footprint of the original Allapattah Slough (Martin County Growth Management Department, 1990).

Another large wetland system, Cane Slough (Figure 5), is located immediately west of Interstate 95. This slough flows from the northwest to southeast and is a recharge area for the headwaters of the St. Lucie River. A channelized connection exists between Cane Slough and the St. Lucie Canal. As a result of channelization and dikes, Cane Slough now consists of isolated cypress areas, ponds, and wet prairies.

The DuPuis Reserve and Pal-Mar Tract (Plate 2) also contain significant wetland systems. The 21,875 acre DuPuis Reserve is located in southwestern Martin County and northwestern Palm Beach County. This site contains numerous ponds, wet prairies, cypress domes, and remnant Everglades marsh. Save Our Rivers (SOR) funds were used to purchase the property. Management efforts are being directed toward improving wildlife habitat by restoring the hydrology of marshes and wet prairies and implementing prescribed burning and melaleuca control programs.

The 37,314 acre Pal-Mar Tract is located in Martin and Palm Beach counties. This tract is in the process of being acquired through the SOR program, Conservation And Recreation Lands (CARL) program, and Martin and Palm Beach County acquisition programs. As of September 1997, 4,422 acres had been purchased through the SOR program. Pal-Mar wetlands are primarily wet prairie ponds interspersed within a pine flatwood community. Despite some ditching, these wetlands are generally in good condition. The proposed Pal-Mar SOR acquisition boundary includes a wildlife corridor which would connect Jonathan Dickinson State Park, Pal-Mar, Corbett Wildlife Management Area (in Palm Beach County), and the DuPuis Reserve.

Jonathan Dickinson State Park consists of 10,000 acres in southeast Martin County. It contains a variety of native uplands and wetlands, including pine flatwoods, sand pine scrub, palmetto prairies, cypress sloughs and domes, marsh, and wet prairies.

St. Lucie County. Emergent shrub and forested wetlands once covered much of St. Lucie County. However, many of these wetlands have been extensively drained to support agricultural and urban development. The few large remaining inland wetland systems include the Savannas; wetlands associated with Five Mile, Ten Mile, Cow, Cypress, and Van Swearingen creeks; remnant portions of St. Johns Marsh; and the floodplain of the North Fork of the St. Lucie River (Figure 3).

The Savannas is a freshwater wetland system located west of the Atlantic Coastal Ridge. It is one of the most endangered natural systems in the planning area. Historically, the Savannas formed a continuous system which stretched the length of the county. It was later interrupted by the drainage and development of Fort Pierce. Much of the system south of Fort Pierce has been purchased by the State of Florida under the CARL program (Plate 2). A 930 acre tract of the historic savannas community (North Savannas) is located north of Fort Pierce and has been acquired through the county SOR programs.

Okeechobee County Area. Large portions of Okeechobee County are comprised of wetland communities. The portion of the county located within the planning area includes large tracts of forested and emergent wetlands. These wetlands dominate the landscape creating a northwest to southeast system which continues into St. Lucie County.

Uplands

Upland plant communities in the UEC Planning Area include pine flatwoods, scrubby flatwoods, sand pine scrub, xeric oak, and hardwood hammocks. Uplands serve as recharge areas, absorbing rainfall into soils where it is used by plants or stored underground within the aquifer. Ground water storage in upland areas reduces runoff during extreme rainfall events, while plant cover reduces erosion and absorbs nutrients and other pollutants that might be generated during a storm. Upland communities, particularly, pine flatwoods and sand pine scrub, are seriously threatened by development in the planning area.

Pine flatwoods are the dominant upland habitat within the planning area. These plant associations are characterized by low, flat topography and poorly drained, acidic, sandy soils. Under natural conditions, fire maintains flatwoods as a stable plant association. However, when the natural frequency of fire is altered by drainage improvements and construction of roads and other fire barriers, flatwoods can succeed to other community types. The nature of this succession depends on soil characteristics, hydrology, available seed sources or other local conditions (Myers and Ewel, 1990).

Xeric sand pine scrub communities, although not as diverse as pine flatwood communities, contain more endangered and threatened plants and animals than any other South Florida habitat. Most of the sand pine scrub in the planning area is associated with the one to three mile wide ancient dune that lies along the eastern edge of the coastal ridge in Martin and St. Lucie Counties.

Water Needs of Inland Resources

Wetland Water Needs

Maintaining appropriate wetland hydrology (water levels and hydroperiod) is the single most critical factor in maintaining a viable wetland ecosystem (Duever, 1988; Mitch and Gosselink, 1986; Erwin, 1991). Rainfall, along with associated ground water and surface water inflows, is the primary source of water for the majority of wetlands in the planning area. The natural variation in annual rainfall makes it difficult to determine what the “typical” water level or hydroperiod should be for a specific wetland system. Because wetlands exist along a continuous gradient, changes in the hydrologic regime may result in a change in the position of plant and animal communities along the gradient. The effects of hydrologic change are both complex and subtle. They are influenced by, and reflect regional processes and impacts as well as local ones (Gosselink *et al.*, 1994). Hydrology, as well as other factors which influence wetland systems, such as fire, geology and soils, and climate, is further discussed in Appendix G.

James Gosselink states in a 1994 study on wetland protection from aquifer drawdown that a critical issue to be considered in the water supply planning process is how wellfield induced ground water drawdowns affect wetlands. An adverse environmental impact can be defined as: (1) a change in surface or shallow ground water hydrology that leads to a measurable change in the location of the boundary of a wetland; or (2) a measurable change in one or more structural components of a wetland as compared to control or reference wetlands, or to the impacted wetland before the change occurred (Gosselink *et al.*, 1994). Lowered ground water tables in areas adjacent to wetland communities have been shown to decrease wetland surface water depths and shorten the hydroperiod (length of inundation).

Aquifer drawdown and its subsequent effect on wetlands are best measured using three parameters; severity (the depth of the drawdown), duration (the length of time), and frequency (how often that drawdown occurs). The most obvious impact of reducing hydroperiods is a decrease in the size of the wetland. This is especially true of shallow, low gradient wetlands, which may be entirely eliminated by lowered water levels. Decreased wetland size reduces the available wildlife habitat and the area of vegetation capable of nutrient assimilation. Lowered water levels and reduced hydroperiod also: (a) induce a shift in community structure towards species characteristic of drier conditions; (b) reduce rates of primary and secondary aquatic production; (c) increase the destructiveness of fire; (d) cause the subsidence of organic soils; and (e) allow for exotic plant invasion (Gosselink *et al*., 1994).

Upland Water Needs

The water supply needs of upland plant communities are not well known. It is assumed that the upper 6 to 10 feet of the Surficial aquifer is utilized by upland vegetation. Seasonal variations and local withdrawals from ground water play an important role in determining the type of upland vegetation that will develop.

Wildlife Water Needs

Appropriate hydrology is not just an issue for the plant communities, but also for the associated wildlife, including endangered and threatened species, and species of special concern (a list of endangered, threatened, and species of special concern found in the UEC Planning Area is provided in Appendix F). In South Florida, species composition, distribution and abundance are influenced by the annual pattern of rainfall, water level fluctuations, and fire. Alterations in water depth and/or hydroperiod that result in changes to vegetative composition and diversity may lead to the degradation of fish and wildlife habitat. In some portions of the planning area, reduced ground water levels have contributed to the invasion of wetlands by exotic species such as melaleuca. These pest plants quickly spread to disturbed areas where they crowd out native plants. This invasion reduces the number and diversity of wildlife that depend on native vegetation for food and shelter.

PROTECTION OF NATURAL RESOURCES

The District protects and enhances natural resources through its wetland policies and rules, wellfield location criteria, wetland buffers, wellfield monitoring, wetland mitigation banking, surface water planning, and land acquisition programs.

Wetland Policies

The District prevents significant adverse impacts to wetlands from ground water withdrawals by incorporating numerous state laws (Appendix A) into its consumptive use permitting process, which limit drawdowns beneath wetlands. The obligation to leave enough water in natural areas to maintain their functions and protect fish and wildlife is central to water supply planning.

The State Comprehensive Plan (Chapter 187, F.S.) states as a goal that Florida "shall maintain the functions of natural systems and the overall present level of surface and ground water quality." The same document lists as a policy: "Reserve from use that water necessary to support essential non-withdrawal demands, including navigation, recreation, and the protection of fish and wildlife." The Water Resources Act of 1972 (Chapter 373, F.S.) states: "The minimum water level shall be the level of ground water in an aquifer and the level of surface water at which further withdrawals would be significantly harmful to the water resources of the area." The District's Water Supply Policy Document affirms that "the District recognizes the state policies which establish priority protection of the water supply required to maintain and enhance healthy natural systems."

The extent to which wetland preservation conflicts with water supply development depends greatly on the approach of that development. For example, options that increase water storage relieve the conflict between wetlands and human development, as does appropriate location and design of wellfields or the use of surface water. The challenge is to accept wetland protection as a constraint and then come up with the most reliable and cost-effective water supply strategy. The water needs of wetlands must be met; the plan's approach at this time is to meet the intent of specific flows and levels for isolated inland wetlands, and to protect them against changes in existing water regimes.

Wellfield Location

Locating wellfields away from wetlands is an approach that can reduce local environmental effects but is not always easy to implement. Often the choice is reduced to either locating the wellfield in undeveloped areas with environmentally sensitive wetlands or in developed uplands where the potential for wellfield contamination is a serious concern.

Wetland Buffers

Another approach involves using man-made lakes or reservoirs as a buffer between wellfields and natural wetland systems. The water in these lakes act as a buffer by managing the local water table at a sufficient level to avoid impacts to nearby wetlands. The surface water that is available in these reservoirs can also be used to supplement groundwater withdrawals.

Wellfield Impact Monitoring

The District's Resource Assessment division began a research program in 1995 to support development of wetland drawdown criteria. The research project is broken down into three phases.

Phase I consisted of: (1) a literature review to determine if sufficient information is present to support existing drawdown criteria or to recommend new criteria; (2) groundwater modeling; and (3) a scientific wetland expert workshop. This phase was completed November 1995.

The objectives of Phase II were to: (1) determine the extent and severity of impacts, if any, caused by ground water withdrawals under present and past drawdown criteria; and (2) identify wetland sites throughout the District for well installation and hydrobiological monitoring. The scheduled completion date for Phase II is December 1996.

Phase III has two main objectives: (1) implement long-term hydrobiological monitoring at wetlands located along a gradient of drawdown in selected study sites; and (2) test hypotheses regarding: (a) the effects of groundwater drawdowns on wet season biological productivity; (b) the dependence of surface soil moisture on the dry season water table position; (c) differences in ecosystem structure and function between wetlands subject to different amounts of drawdown; (d) the effects of local versus regional calibration of groundwater models used in the permit application process; and (e) symptoms of impact observed during drought.

Site characterization and well drilling contracts are presently underway. Monthly photographic monitoring began April 1996, while hydrologic monitoring began in the fall of 1996. There are two monitoring sites within the planning area; one at Jonathan Dickinson State Park, and the other at Sea Branch State Preserve.

Monitoring wetlands adjacent to wellfields ensures that withdrawal impacts are detected. Steps can then be taken to limit further impacts. Long-term monitoring of wetlands adjacent to wells provides documentation of impacts to wetlands that occur over time.

The hydrologic and biologic consequences of ground water withdrawal from wellfields in the Northern Tampa Bay region have been documented by the Southwest Florida Water Management District (SWFWMD). After long-term monitoring of wells and wetland systems, SWFWMD concluded that adverse impacts are especially evident in areas where ground water modeling of withdrawals indicates a drawdown of one foot or more.

The type of impacts noted for marsh and cypress wetlands were:

- Extensive invasion of weedy upland species
- Destructive fires
- Abnormally high treefall
- Excessive soil subsidence/fissuring
- Disappearance of wetland wildlife

The SWFWMD ground water modeling has also shown that it may take one to two decades for the full effect of wellfield pumpage to be realized. Therefore, actual water levels in newer wellfields, or in wellfields currently not pumping at their maximum permitted levels, could become lower in the future. For these and other reasons, SWFWMD suggests that continued environmental monitoring will be necessary to ensure that Florida's wetlands are adequately protected (Rochow, 1994).

Wetland Mitigation Banking

Wetland mitigation banking is a relatively new natural resource management concept which provides for the advanced compensation of unavoidable wetland losses due to development. The Florida Environmental Reorganization Act of 1993 directed the water management districts and FDEP to participate in and encourage the establishment of public and private regional mitigation areas and mitigation banks. The act further directed the WMDs and FDEP to adopt rules by 1994, which led to the state's mitigation banking rule (Chapter 62-342, F.A.C.), becoming effective January 1994. In 1996, House Bill 2241 further developed this program by providing for the acceptance of monetary donation as mitigation in District and FDEP endorsed offsite regional mitigation areas. The bill clarified service area requirement credit criteria and release schedules, assurances and provisions that apply equally to public and private banks. As a result, the District and FDEP will adopt rules to implement these provisions. Wetland mitigation banking does not apply to water use related impacts.

Surface Water Improvement and Management

Two Surface Water Improvement and Management (SWIM) Plans have been adopted which incorporate portions of the UEC Planning Area: the Indian River Lagoon (IRL) SWIM Plan and the Lake Okeechobee SWIM Plan. The overall goal of both plans is to protect and restore surface water bodies.

Indian River Lagoon SWIM Plan

The Indian River Lagoon (IRL) was designated in 1987 as a state priority water body for protection and restoration under the Surface Water Improvement and Management (SWIM) Act. Under provisions of the Act, the two water management districts (SJRWMD and SFWMD) which encompass the IRL were required to develop and implement a SWIM plan to preserve protect and restore the water body. The IRL SWIM plan was completed in 1989 and updated in 1994. The goals of the plan are to:

1) Attain and maintain water and sediment of sufficient quality to support a healthy macrophyte-based lagoon system which supports species of fisheries and wildlife including endangered and threatened species.

2) Achieve heightened public awareness and coordinated interagency management of the IRL ecosystem.

The 1994 plan update identifies the St. Lucie Estuary (SLE) as the major problem area within the SFWMD portion of the lagoon. The plan identifies excessive freshwater runoff as a problem within the SLE and proposes reduction in these inflows through the development of specific pollutant load reduction goals (PLRGs). These are biologically based numeric targets for specific pollutants, with concurrent reduction strategies to achieve the target levels. Through the SWIM planning process, timelines for establishing PLRGs were established as required in Section 62-40.432, F.A.C.

As part of the effort to develop PLRGs, the SFWMD is quantifying appropriate freshwater inflows (both maximum and minimum) necessary to restore a productive ecological balance within the SLE. As previously stated, preliminary findings indicate that the total mean monthly inflows need to be between 350 cfs and 1,600 cfs. Currently, flows range from 150 cfs to more than 4,000 cfs. The relative target inflows for each specific SLE basin must now be determined so that appropriate management strategies can be developed for each basin.

Better management of SLE freshwater inflows will require modification of water management practices within the upland basins. Some of the potential options being considered in the SWIM program and Indian River Lagoon Restoration Feasibility Study include both regional and local retention facilities, better on-site management through the utilization of Best Management Practices (BMPs), operational changes within the C&SF canal system, and modified regulatory criteria for discharges to the IRL.

Lake Okeechobee SWIM Plan

The Lake Okeechobee SWIM Plan was enacted in 1989 and had its second update in August 1997. The environmental element recognized that adverse impacts to the St. Lucie Estuary occur when regulatory releases are made through the St. Lucie Canal (C-44) for lake flood protection purposes. Large, unnatural freshwater releases from the lake through the C-44 to the St. Lucie Estuary alter the estuarine salinity gradient and transport significant quantities of sediment to the estuary. Biota within the St. Lucie Estuary, Indian River Lagoon and near-shore reefs can be negatively affected by these high volume discharges.

The U.S. Army Corps of Engineers (USACE) in cooperation with the SFWMD, is currently evaluating environmental and economic impacts associated with proposed regulation schedules for Lake Okeechobee. The regulation schedule dictates the water levels within the lake, and regulatory discharge strategies to maintain these levels. This study will be completed in 1999.

Indian River Lagoon Restoration Feasibility Study

The SFWMD, in cooperation with the USACE, is conducting the Indian River Lagoon Restoration Feasibility Study (Feasibility Study) to address freshwater discharges to the SLE and IRL. The Feasibility Study, which is scheduled to be completed in July 2000, includes three phases. The first phase, problem identification/plan formulation, was completed in July 1997. The second phase, alternative plans evaluation, is schedule for completion in April 1999. The Feasibility Study concludes with the completion of the third phase, engineering design and report preparation, in July 2000.

The following alternative plans will be evaluated in the Feasibility Study to address environmental restoration of areas adversely impacted by the C&SF Project system, flood damage protection, and urban and agricultural water supply:

- Regional Attenuation Facilities (RAFs). RAFS are expected to serve a number of objectives, including improved water supply for environmental base flow to the estuary, improved water supply for urban and agricultural uses, increased short hydroperiod wetlands, reduced sediment loading the estuary, and improved flood control in the region. Alternative RAF sites will be studied to determine those sites that reduce costs, ensure existing wetlands are not impacted, or provide for additional water uses.

- Upper East Coast Flowway (C-131). The flowway concept involves construction of a 10,500 acre water quality treatment facility located at the western juncture of Martin and St. Lucie counties, and a feature that would allow excess treated water to be backpumped into Lake Okeechobee through the proposed C-131 canal.

- On-site Detention/Retention. This concept is similar to the RAF alternative except that the detention/retention facilities are constructed on developed land as opposed to having large regional facilities. On a site by site basis, similar benefits to those provided by regional detention facilities may be realized.

- St. Lucie Flowway. The flowway would capture some excess runoff in the C-44 basin that is now diverted to tide and divert the flow to the Loxahatchee Wildlife Refuge (Water Conservation Area 1).

- Removal of St. Lucie Organic Sediments. This alternative involves further investigation of a potential muck removal demonstration project that was completed by the SFWMD in January 1994. The report concluded that large-scale sediment removal may improve water quality by reducing re-suspension of fine sediments during periods of physical disturbance, and would reduce oxygen demands in the water column. The report recommended that further studies be undertaken prior to proceeding with the demonstration project.

- Water Supply Alternatives. Alternatives developed for the Feasibility Study will identify urban and agricultural water supply demands and will include water supply features related to the C&SF Project to help meet identified region needs, including the needs of the environment and the potential conflicts that may arise that this may create with other water users.

- Future "Without Project" Condition (No Action Plan). This alternative assumes that the Feasibility Study will at least include the Lake Okeechobee Regulation Schedule, and several SWIM projects including the St. Lucie Five Mile Creek retrofit, St. Lucie Virginia Avenue Structure Replacement, Indian River Community College Structure and Treatment Area, East Hanson Grant Treatment Area, and other St. Lucie and Martin county storm water retrofits identified by the SWIM Plan.

The evaluation process outlined in the Feasibility Study will include qualitative analysis and public workshops to screen the most viable alternatives for detailed study. This process will ensure that the alternatives are consistent with local interests and perspectives with respect to wetlands and wildlife conservation, economic development, comprehensive land planning, maintenance of water supplies, and agriculture.

National Estuary Program

The Indian River Lagoon (IRL) has been designated an estuary of national significance and is a component of the U.S. Environmental Protection Agency sponsored National Estuary Program (NEP). The IRLNEP program was initiated in 1991 and was given five years to develop a Comprehensive Conservation Management Plan for the IRL. The plan was finalized May 1996. The Comprehensive Conservation and Management Plan incorporates the IRL SWIM goals listed above, with the addition of a goal of identifying and developing long-term funding sources to implement the plan.

Land Acquisition Programs

Natural resources in the UEC Planning Area which have been, or are proposed to be, acquired for conservation/preservation purposes are shown on Plate 2. Some of the ongoing acquisition programs in the planning area are discussed below.

Save Our Rivers (SOR)

Florida's Save Our Rivers Program was started in 1981. The purpose of the SOR program is to obtain fee simple or other interests in lands necessary for water management, water supply, and the conservation and protection of water resources. SOR acquisitions and proposed acquisitions within the UEC Planning Area are shown on Plate 2.

Conservation and Recreation Lands (CARL)

The CARL program was established by the Florida Legislature in 1979. The primary purpose of this land acquisition program is conservation and protection of environmentally unique, irreplaceable ecological resources. CARL acquisitions within the UEC Planning Area are shown on Plate 2.

County Land Preservation Programs

In 1989, Martin County passed a $20 million bond referendum to purchase conservation (environmentally sensitive) and recreation (active parks) lands. In 1996, the Martin County Board of County Commissioners passed a resolution establishing the Martin County Preservation/CARL Acquisition Task Force. This committee recommended to the commissioners ways to leverage money in order to ensure that the three CARL/SOR properties in Martin County are acquired prior to the sunset of P2000. Those properties are the Atlantic Ridge (14,200 acres), Pal-MAR (23,700 acres in Martin County) and Allapattah (32,800 acres). The Commissioners are considering another $27 million bond referendum in the fall of 1998.

St. Lucie County voters passed a $20 million bond in November of 1994. Since then, this money has been used to match the District's SOR funds, thereby allowing the completion of land purchases in the Indrio North Savannas project and the North Fork St. Lucie corridor. It will also be used to help fund future public lands purchases including mangrove parcels in the Indian River Lagoon Blueway," the Cypress Creek/Trail Ridge Property, and Round Hammock.

County land acquisitions are shown on Plate 2. In addition to acquisition of environmentally sensitive areas, Martin County has a strict wetland protection policy. The 1990 Martin County Comprehensive Growth Management Plan protects all wetlands, regardless of size or biological condition.Their destruction (and subsequent mitigation) is not permitted.

Chapter 5

RESOURCE REGULATION

The District implements two permitting programs for wetland protection and water resource allocation: the environmental resource permitting (ERP) program and the consumptive use permitting (CUP) program. Both require an evaluation of wetland impacts which may occur due to an applicant's request.

ENVIRONMENTAL RESOURCE PERMITTING

The ERP program deals with the construction of surface water management systems and dredge and fill activities. Surface water management systems are required for all forms of development ranging from agriculture to commercial and residential. This means that developed sites containing more impervious surfaces or altered topography, must provide a way for storm water to be directed to water management areas for water quality treatment and flood attenuation.

During the ERP process, wetlands are evaluated both on and adjacent to the project site. If wetland impacts are proposed in an ERP application, an analysis is conducted to determine if the impacts can be eliminated or reduced. Impacts to wetlands can occur through direct physical alteration, such as filling or dredging, or through alteration of the normal hydrologic regimes, such as lowering of the water table. All types of impacts are reviewed during the ERP process.

If the proposed wetland impacts are determined to be permittable, an applicant will need to provide compensation for the loss of the wetland functions. Generally this is accomplished through mitigation, consisting of the restoration or enhancement of existing wetlands, the creation of new wetland habitat, or a combination of these methods. The mitigation areas must be monitored and maintained over the long term and protected with a conservation easement.

If the applicant proposes to preserve the wetlands on the project site, an analysis is conducted to determine what effects the development will have on the wetlands. An applicant must provide an upland buffer, must ensure that adequate quantities of water will be available to wetlands and that the wetlands will not be over inundated for prolonged periods of time. A conservation easement is required to ensure the long-term protection of the wetlands.

CONSUMPTIVE USE PERMITTING

The District has the authority and responsibility to establish policies for the use and regulation of water that maximize reasonable-beneficial uses that are in the public interest, as long as these policies safeguard the environment, other legal users, and water quality. These policies are implemented through intergovernmental coordination, establishment of programs, and the permitting process.

Water resources are used for many purposes including agricultural, landscape, and golf course irrigation; potable water; commercial; and industrial uses. All water withdrawals within the District require a District water use permit except: (1) water used in a single family dwelling or duplex, and provided that the water is obtained from one well for each single family dwelling or duplex, and is used either for domestic purposes or outdoor uses; (2) water used for fire fighting; and (3) the use of reclaimed water. The first exemption is provided in state legislation; the latter two are District exemptions.

The District issues water use permits in two forms, individual water use permits and general water use permits. An individual water use permit is issued for projects whose water use exceeds 100,000 gallons per day (GPD) while general permits are issued when the use does not exceed 100,000 GPD, except in reduced threshold areas. A general water use permit is issued for a duration of up to 20 years while individual permits are generally issued for a shorter period. Individual permits are issued with an expiration date that corresponds with the basin expiration date, at which time water use permits for the entire basin will have to be renewed. The current basin expiration date in the planning area is December 15, 2001.

The District has issued 818 individual consumptive use permits in the planning area (Table 11). Most of these permits are for agricultural uses. Total allocations and permits are listed by county in Appendix D.

Basis of Review Criteria

The permitting process involves reviewing water use permits for consistency with criteria in the District's Basis of Review (BOR). Chapter 2 of the BOR, Water Need and Demand Methodologies, include criteria for demonstration of need, calculation of water demands, and water conservation requirements for the different use classes. The criteria in Chapter 3, Water Resource Evaluations, address the evaluation of the potential impacts to the resource, existing legal users, the environment, saline water intrusion, and water quality degradation (SFWMD, 1994).

Table 11. Individual Permit Allocations.

Water Use Category	Number of Permits	Allocation (MGD)	% of Total Allocations
Agriculture	505	562.1	86
Public Water Supply	143	45.7	7
Golf	32	12.9	2
Landscape	91	8.0	1
Dewatering	15	19.2	3
Other*	32	7.0	1
Total	818	654.9	100

*Includes the following water use categories: Industrial, Nursery, Recreational, Aquaculture, Livestock, and Other.
Source: SFWMD, 1992, Consumptive Use Permitting Program data.

Areas with Increased Permitting Restrictions

An increased level of consumptive use permitting restrictions is applied to areas where there is potentially a lack of water available to meet demands. These areas include reduced threshold areas, restricted allocation areas, areas of special concern, and critical water supply problem areas.

Reduced Threshold Areas

The volume of usage which delineates a general permit from an individual permit is referred to as the permit threshold. In most of the District, the permit threshold is 100,000 GPD. However, in resource depleted areas, where there has been an established history of substandard water quality, saline water movement into ground water and surface water bodies or the lack of water availability to meet projected needs of a region, the District has reduced this threshold to 10,000 GPD average or 20,000 GPD maximum. These areas are referred to as reduced threshold areas (RTAs). RTAs have been established in the UEC Planning Area at Stuart Peninsula, Lighthouse Point Peninsula, and the Savannas and Jensen Beach Peninsula. About 5.5 percent of the planning area is covered by RTAs. A map displaying these areas is located in Appendix D.

Restricted Allocation Areas

In addition to RTAs, the District has also designated areas as restricted allocation areas. These are designated areas within the District for which allocation restrictions are applied to the use of specific water sources. A map displaying these areas is provided in Appendix D. The water resources in these areas are managed in response to specific sources of surface water and ground water for which there is a lack of water availability to meet the needs of the region. The UEC Planning Area contains three restricted allocation areas, as identified in the BOR:

1. Projects located in the Eastern Okeechobee - Northwestern St. Lucie Basin (Figure B-3 in BOR) withdrawing water from the Floridan Aquifer are limited to 1.5 inches for the maximum month, with the balance of water needs being withdrawn from other sources.

2 Pumps designed to increase the withdrawal rate above that which occurs naturally are prohibited on all Floridan wells located in Martin and St. Lucie counties unless the pump was in place and operational on the well prior to March 2, 1974 or the applicant justifies that the pumping will not have an adverse impact on any existing legal use.

3. No additional water will be allocated from, or direct connections to, the C-23, C-24, or C-25 over and above existing allocations, until District investigations show that additional water is available for allocation.

Areas of Special Concern

Areas of special concern are areas where there are limitations on water availability or there are other potentially adverse impacts associated with a proposed withdrawal. These areas are determined by the District on a case-by-case basis. There are no designated areas of special concern in the UEC Planning Area.

Water Resource Caution Areas

Water resource caution areas are areas that have existing water resource problems or areas in which water resource problems are projected to develop during the next 20 years. These areas were formerly referred to as critical water supply problem areas and were required to be designated by rule by each water management district pursuant to Chapter 62-40, F.A.C., the Water Resource Implementation Rule. This chapter further states that applicants in these areas must make use of a reclaimed water source unless the applicant demonstrates that its use is not economically, environmentally or technologically feasible. The entire UEC Planning Area is designated as a water resource caution area. The Water Resource Implementation Rule requires these designations be updated within one year of completion of the District Water Management Plan and its future updates.

WATER SHORTAGE MANAGEMENT

Water shortages, and the associated restrictions, are declared by the District's Governing Board when there is not enough water available for present or anticipated needs, or when a reduction in demand is needed to protect water resources. Ground water and surface water levels are continuously monitored, and if they fall to levels considered critical for the time of year and anticipated demands, then the water shortage process is initiated. There are different levels of drought, and these require corresponding levels of restrictions. Water shortage declarations range from a "warning," which has voluntary moderate restrictions, through four phases of water shortage, to an "emergency," which can restrict withdrawals up to the point of disallowing any further withdrawals from a source.

The water shortage phases reflect the percent reduction in withdrawals necessary to reduce demand to the anticipated available water supply.

The phases are:

- Phase I: Moderate - up to 15 percent reduction
- Phase II: Severe - up to 30 percent reduction
- Phase III: Extreme - up to 45 percent reduction
- Phase IV: Critical - up to 60 percent reduction

Each declared source class is assigned a water shortage phase, and source classes can be combined if appropriate. A water shortage warning has the same restrictions associated with a Phase I, but participation is voluntary. Any of the phases of water shortage can be modified by the Governing Board if necessary. The District's Water Shortage Plan is located in Chapter 40E-21, F.A.C. The current water shortage procedure was originally adopted by the District in 1982. Prior to that, restrictions were made during periods of drought but did not necessarily correspond to the current requirements of the phases of water shortage.

In March 1981 a water shortage in the UEC Planning Area was declared for both ground and surface water, and restrictions were in place through September of that year. Another drought in the region resulted in a water shortage warning for the entire region in March and April of 1985. The most recent water use restrictions in the planning area began with water shortage warnings in 1989 for ground and surface water, which escalated into Phase I, Phase II, and emergency restrictions for some surface water users. These restrictions were reduced as conditions improved and were rescinded in March 1992. A summary of the water shortages declared in the planning area is presented in Table 12.

Table 12. History of Water Shortages.

Issue Order #	Restrictions	Area Affected	Date Declared	Date Rescinded
81-13	10% reduction for ground and surface water users	Martin County	5-6-81	9-11-81
81-14	25% reduction for agriculture, golf courses, nurseries	Martin County	5-14-81	9-11-81
81-28	10% reduction all uses	All of St. Lucie, area in Okeechobee not directly served by Lake Okeechobee	7-21-81	7-27-81
81-29	10% reduction for shallow aquifer and surface water systems	All of St. Lucie, area in Okeechobee not directly served by Lake Okeechobee	7-27-81	9-11-81
85-1	Warning: Ground and surface water	St. Lucie, Okeechobee, and Martin counties	3-14-85	4-24-85
89-07	Warning: Voluntary phase I – ground water	Southeastern Martin County	2-9-89	6-17-91
89-12	Phase I: Ground and surface Water	Southeastern Martin County	7-13-89	12-20-90
89-14	Warning: Voluntary phase I – ground and surface water	St. Lucie River Basin	9-14-89	3-12-92
90-04	Phase I: Surface water	St. Lucie River Basin	10-12-89	3-12-92
90-06	Phase II: Surface water	St. Lucie River Basin	12-14-89	3-12-92
90-18	Emergency: Surface water from C-24	Portions of St. Lucie County Agricultural Area	4-27-90	3-12-92
90-19	Warning: Surface water from C-25	Portions of St. Lucie County Agricultural Area	4-27-90	3-12-92
90-22	Emergency: Surface water from C-24 to 14.0 ft. NGVD	Portions of St. Lucie County Agricultural Area	5-10-90	3-12-92
91-02	Modified phase I: (specific restrictions) – Ground and surface water	Southeastern Martin County	12-20-90	6-14-91
91-05	Modified phase I: (specific restrictions) – Ground and surface water	Southeastern Martin County	6-14-91	3-12-92

Note: Dashed line indicates beginning of phased water shortages.

WELLHEAD PROTECTION ORDINANCES

The purpose of a wellhead protection program is to protect the ground water in the vicinity of a public water supply wellfield from potential sources of contamination. A wellhead protection program entails a management process that acknowledges the relationship between activities that take place in wellfield areas and the quality of the ground water supply for those wells. A Wellhead Protection Area (WHPA) is delineated as the surface area, projected from the subsurface, surrounding a well or wellfield through which water (and potential contaminants) will pass and eventually reach the well(s).

Wellhead protection area boundaries (zones) are determined based on a variety of criteria (e.g., travel time, drawdown, distance, etc.) and methods (e.g., analytical/numerical flow models, fixed radii, etc.). Factors such as the such as the aquifer physical characteristics, aquifer boundaries, the extent of pumping, the degree of confinement, the vulnerability of the aquifer to surface contamination, and the degree of development and land use activity surrounding the well(s) are used in the process. Because methods/criteria employed and physical conditions vary, WHPAs can range anywhere from a distance of a few hundred feet to several miles from pumping wells. Management activities commonly employed within these protection areas include regulation of land use through special ordinances and permits, prohibition of specified activities, and acquisition of land.

Martin and St. Lucie counties have adopted permanent wellhead protection ordinances. These ordinances, as well as federal and state aquifer protection laws, are discussed in Appendix H.

Chapter 6

DEMAND ESTIMATES AND PROJECTIONS

Demand assessments for 1990 and projections for 2010 were made for five categories of water use. The category of *public water supply* refers to all potable water supplied by regional water treatment facilities with pumpage greater than 500,000 gallons per day (GPD) to all types of customers, not just residential. The other four categories of water use are self supplied. *Commercial and industrial* refers to operations using over 100,000 GPD. *Recreation self supplied* includes landscape and golf course irrigation demand. The landscape subcategory includes water used for parks, cemeteries and other irrigation applications greater than 100,000 GPD. The golf course subcategory includes those operations not supplied by a public water supply or regional reuse facility. *Residential self supplied* is used to designate only those households whose primary source of water are private wells. *Agriculture* includes water used to irrigate all crops, and for cattle watering. For 1990, the total assessed water demand for the UEC Planning Area was 154,279 million gallons for the year (Figure 16).

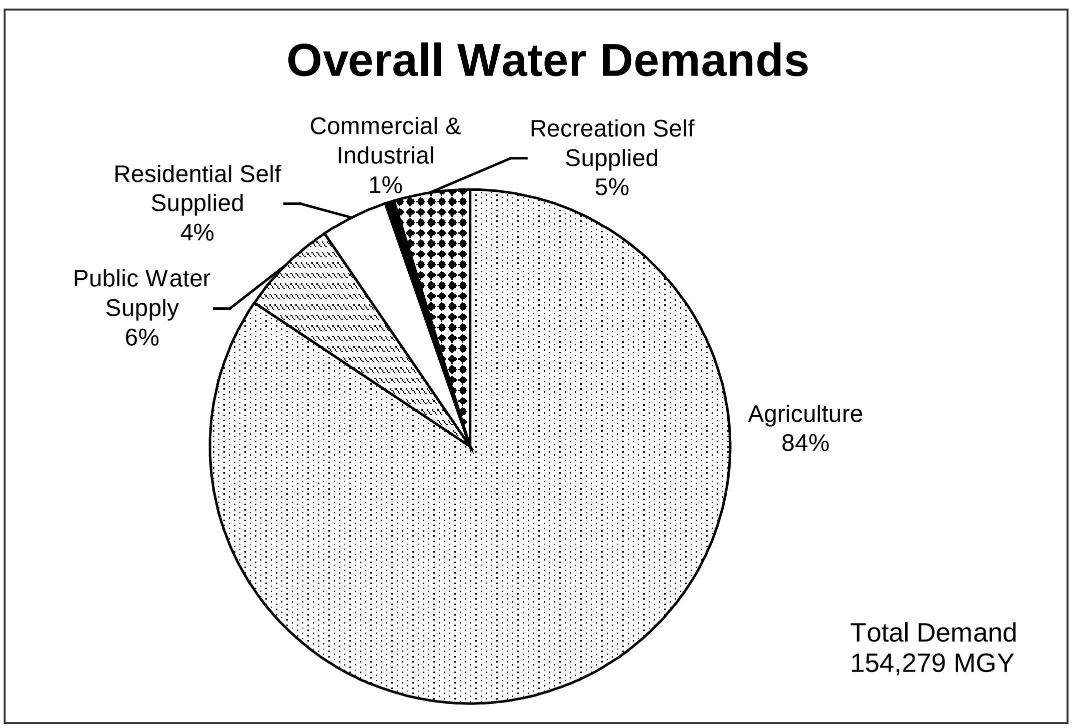


Figure 16. Overall Water Demands for 1990 in the UEC Planning Area.

From 1990 to 2010, the total water demand is projected to increase by 34 percent from 154,279 to 206,255 million gallons per year (MGY), as shown in Table 13 and Figure 17. Public water supply has the largest projected increase of 143 percent. However, agricultural water demand is projected to remain the single largest category of use. In 1990, agriculture accounted for 84 percent of the total demand. Agricultural demands are projected to increase by 23 percent by 2010, accounting for 78 percent of the total demand in that year.

Table 13. Overall Water Demands for 1990 and 2010 (MGY).

Category	Estimated Demands 1990	Projected Demands 2010	% Change 1990-2010
Agriculture	130,191	160,528	23
Public Water Supply	9,607	23,371	143
Residential Self Supplied	6,398	6,876	7
Commercial & Industrial	850	1,570	85
Recreation Self Supplied	7,233	13,910	92
Total	154,279	206,255	34

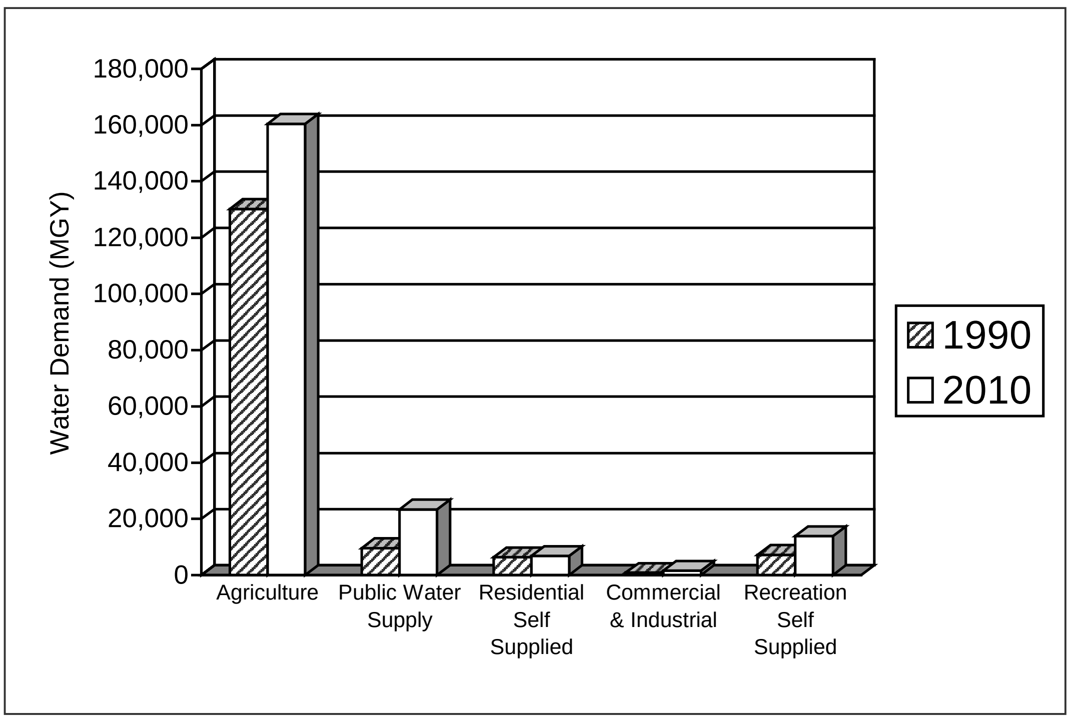


Figure 17. Comparison of 1990 and 2010 Water Demands (MGY).

URBAN WATER DEMAND

Urban water demand includes: (1) public water supply (PWS) provided by utilities; (2) residential self supplied (RSS); (3) commercial and industrial self supplied; and (4) recreation self supplied. Public water supply was the largest component (40%) of urban water demand in 1990, followed by recreation self supplied (30%), residential self supply (27%), and commercial and industrial self supply (4%). Urban water demand in 1990 was estimated to be about 24 billion gallons per year and is projected to increase to almost 46 billion gallons per year in 2010.

The driving force behind urban demand is population. Population numbers for 1990 were taken from the U.S. Census. Population projections for the year 2010 were obtained from the county and local government comprehensive plans, derived for the portions of the counties within the planning area (Table 14), and used to develop urban demand projections. The total population of the planning area for 1990 was 252,086, and is projected to increase 77 percent to 445,925 in 2010.

Table 14. Population in the UEC Planning Area, 1990-2010.

Region	1990			2010		
	Total	PWS	RSS	Total	PWS	RSS
St. Lucie Area	150,171	86,808	63,364	290,100	221,320	68,780
Martin Area	100,900	54,935	45,965	154,200	101,520	52,680
Okeechobee Area	1,015	0	1,015	1,625	0	1,625
Total Planning Area	252,086	141,743	110,344	445,925	322,840	123,085

Source: Local Government Comprehensive Plans, and U.S. Bureau of the Census, 1990.

Urban demand is projected for the St. Lucie and Martin areas. The Okeechobee Area is not included in the urban water demand analysis because the portion of the county within the UEC Planning Area has very small demands for urban uses.

Public Water Supply and Residential Self Supplied

The estimated water demand for PWS and residential self supplied users was 44 million gallons per day (MGD) in 1990. These water demands are projected to increase 89 percent from 1990 to 2010 to a total water demand of 83 MGD (Table 15). About 44 percent of the 1990 population were self supplied and this is projected to be 28 percent in 2010. More specific information on utility service area populations and water demands, as well as the methodology used to develop these values is provided in Appendix G.

Table 15. Public Water Supply and Residential Self-Supplied Demand (MGD).

County Area	1990		2010	
	Public Water Supplied	Residential Self Supplied	Public Water Supplied	Residential Self Supplied
St. Lucie Area	13.58	8.85	39.67	9.32
Okeechobee Area	0.00	0.12	0.00	0.20
Martin Area	12.74	8.56	24.36	9.32
Total	26.32	17.53	64.03	18.84

Commercial and Industrial Self Supplied

Commercial and industrial demands supplied by public utilities are included in the PWS demands. The Martin Area has the highest self-supplied demands (Table 16). The projection methodology for commercial and industrial self-supplied demand is discussed in Appendix G.

Table 16. Commercial and Industrial Self-Supplied Demand (MGD).

County Area	1985	1990	1995	2000	2005	2010
St. Lucie Area	0.11	0.81	1.00	1.19	1.37	1.56
Martin Area	1.28	1.52	1.81	2.10	2.40	2.74
Total	1.39	2.33	2.81	3.29	3.77	4.30

Recreation Self Supplied

Recreation demands supplied by PWS utilities are included in the PWS demands. Recreation self-supplied demands include withdrawals for landscape and golf course irrigation.

Landscape

Demand projections for this section include irrigated acreage permitted for landscaping and recreation in the St. Lucie and Martin areas, excluding golf courses. The St. Lucie Area has the highest demands (Table 17). Projection methodology is discussed in Appendix G.

Table 17. Landscape Self-Supplied Demand (MGD).

County Area	1985	1990	1995	2000	2005	2010
St. Lucie Area	2.76	3.98	4.89	5.80	6.71	7.62
Martin Area	0.27	1.87	2.23	2.60	2.96	3.38
Total	3.03	5.85	7.12	8.40	9.67	11.00

Golf Course

Golf course self-supplied demand was 13.96 MGD in 1990, and is projected to increase to 27.11 in 2010 (Table 18). Descriptions of the golf courses in the St. Lucie and Martin areas, projection methodology, and the calculation of irrigation requirements are provided in Appendix G.

Table 18. Golf Course Self-Supplied Demand (MGD).

County Area	1985	1990	1995	2000	2005	2010
St. Lucie Area	3.17	3.58	4.88	5.90	6.92	7.94
Martin Area	8.39	10.38	12.11	14.39	16.74	19.17
Total	11.56	13.96	16.99	20.29	23.66	27.11

AGRICULTURAL WATER DEMAND

Summary of Agricultural Demand

There are eight categories of agricultural water demand analyzed in this section: (1) citrus; (2) sugarcane; (3) vegetables; (4) sod; (5) cut flowers; (6) ornamental nursery; (7) improved pasture; and (8) cattle watering. Agricultural water demand was estimated for 1990 to be approximately 130 billion gallons. Citrus was by far the largest 1990 agricultural water demand (82%) and is followed by sugarcane (11%). Vegetables, sod, cut flowers and ornamental nurseries combined account for about three percent of the total agricultural demand. The combined water demand for cattle watering and irrigation of improved pasture also account for about three percent.

Agricultural water demand is forecast to increase by 23 percent to 161 billion gallons per year in the year 2010. Approximately 95 percent of the agricultural water demand in the year 2010 is anticipated to be for citrus (85%) and sugarcane (10%). Vegetables, sod and ornamental nurseries are each projected to represent about one percent of the total 2010 agricultural water demand.

The UEC Planning Area continues to experience growth in irrigated agricultural acreage, especially citrus. The irrigated crops in this region are citrus, sugarcane, vegetables, sod, cut flowers and ornamental nursery. Growth in citrus acreage is usually on land that was formerly pasture. Except for 10,000 acres, pasture is seldom irrigated in the planning area. When irrigation does take place it is invariably in a period of extreme drought, and is done to prevent the grass from dying. There are, however, some requirements for cattle watering associated with the total pasture acreage. Descriptions of the agricultural acreage in each county, projection methodology, and the calculation of irrigation requirements, including data sources, are detailed in Appendix G.

Agricultural irrigation requirements are seasonal, especially for crops such as vegetables which are grown only at specific times of the year. Therefore, agricultural requirements are presented by month for each crop in each county, and the summations for the planning area are presented as million gallons per year.

Table 19 shows the annual average agricultural irrigation demand by crop. Figure 18 presents a graphical comparison of agricultural demand by crop type for 1990 and 2010.

Citrus

Citrus is by far the dominant agricultural crop in the planning area, and occupies over four-fifths of the irrigated agricultural acreage in the region. Between 1968 and 1980 acreage remained at about the same level. Since 1980, acreage has grown moderately but continuously, and is associated with the interregional movement of citrus acreage southward from central Florida following several severe winter freezes in the mid-1980s.

Citrus acreage in the planning area is projected to grow from 143,621 acres in 1990 to 185,873 acres in 2010. This growth in acreage represents an increase in average irrigation requirements from 107,195 MGY in 1990 to 137,004 MGY in 2010. The 2010 projected citrus acreage equaled the 1995 total permitted irrigated citrus acreage.

Table 19. Water Demand and Irrigated Acreage by Crop (MGY).

Category	Estimated Demands 1990	Total Irrigated Acreage 1990	Projected Demands 2010	Total Irrigated Acreage 2010	% Change in Demands 1990-2010	% Change in Acreage 1990-2010
Citrus	107,195	134,133	137,004	176,385	28	32
Sugarcane	14,744	13,433	15,335	13,952	4	4
Vegetables	1,731	2,401	1,731	2,401	0	0
Sod	1,599	960	1,599	960	0	0
Cut Flowers	38	40	38	40	0	0
Ornamental Nursery	1,015	597	988	929	-3	56
Improved Pasture	2,671	10,000	2,671	10,000	0	0
Cattle Watering	2,671	---	1,179	---	-3	---
Total Planning Area	130,191	161,564	160,528	204,667	23	27

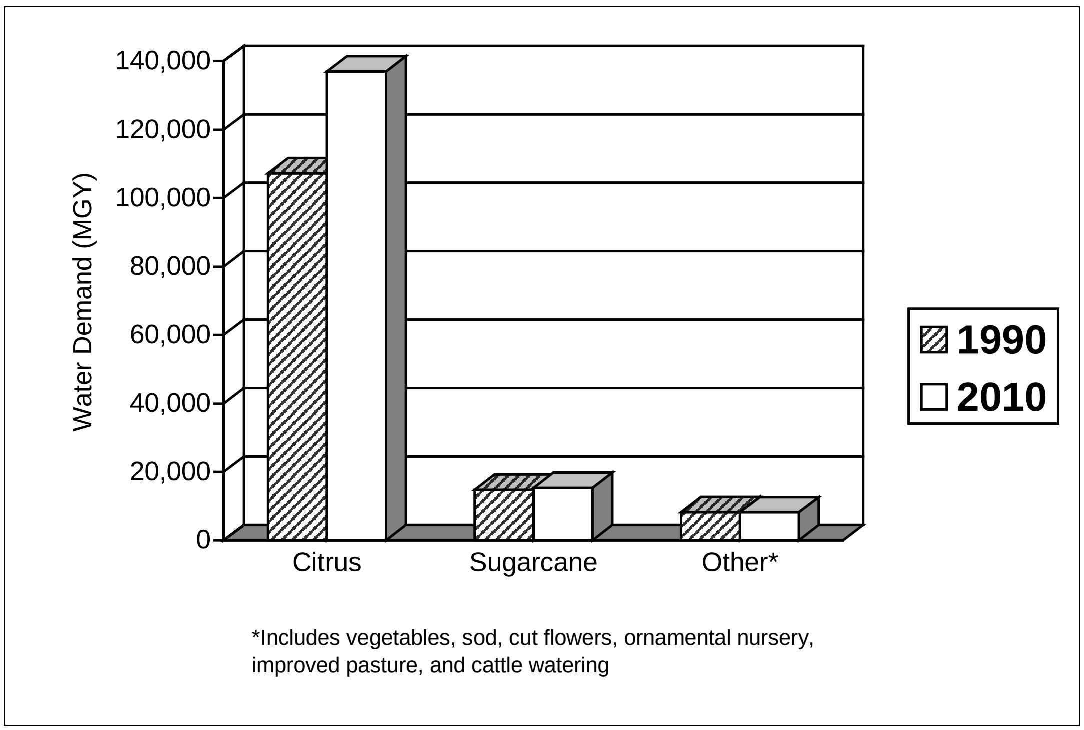


Figure 18. Comparison of 1990 and 2010 Agricultural Demands (MGY).

Sugarcane

Martin County is the only part of the planning area where sugarcane is produced. In 1990, there were 13,433 acres of production. Sugarcane acreage is projected at 13,952 acres for future time horizons, which is the average production for the seven years of production from 1986 through 1992. As a result of the cultivation practices used for sugarcane (ratoon and fallow), 20 percent of the land used for sugarcane production is idle in any given year. This idle land does not require irrigation and is not included in the demand projections presented here. The 1990 production of 13,433 acres has associated average irrigation requirements of 14,744 MGY in 1990 and this is projected to grow to 13,952 acres with an irrigation requirement of 15,335 MGY in 2010.

Vegetables

Vegetable crops grown in the planning area include cabbage, zucchini, potatoes, tomatoes, cucumbers, snap beans, peppers, Chinese vegetables, squash, sweet corn, eggplant, and strawberries. Different types of vegetables are often grown interchangeably. In 1990, there were 2,401 acres of land used for vegetable production. This is projected to remain at the same level through 2010, and represents an average irrigation requirement of 1,731 MGY.

Sod

In 1990, there were a total of 960 acres of irrigated sod production in the planning area. There is additional sod harvested from pasture land, but this is rarely irrigated. Sod production is projected to remain fairly constant through 2010, with an associated average irrigation requirement of 1,599 MGY.

Cut Flowers

Martin is the only county in the planning area with cut flower acreage, and this is forecasted to remain at about 40 acres through 2010. The associated average irrigation requirement is 38 MGY.

Ornamental Nursery

In 1990, there were 597 acres of ornamental nursery in the planning area, and this is projected to increase to 929 acres by the year 2010. The District's increased irrigation efficiency requirements for nurseries outweigh the projected growth in acreage. Average demands by nurseries in the planning area are projected to decrease from 1,015 MGY in 1990 to 988 MGY in 2010.

Improved Pasture

Improved pasture in the planning area is rarely irrigated, with the exception of about 10,000 acres (out of 167,000 total pasture acres) in St. Lucie County. This 10,000 acres has average irrigation requirements of 2,671 MGY and is forecasted to remain at that level throughout the projection period.

Cattle Watering

Demand for cattle watering and barn washing is associated with cattle production (which is in turn associated with pasture acreage). This was assessed at 1,215 MGY in 1990, and is projected to decline slightly to 1,179 MGY in 2010. This decline is related to the displacement of pasture land by citrus.

Chapter 7

WATER CONSERVATION

Water conservation, also called demand management, refers to water use practices and technologies that provide the services desired by the users while using less water. The water conservation measures discussed in this section achieve long-term permanent reductions in water use. This separates them from the short-term water conservation measures and cutbacks that are required of users during water shortage situations or when short-term problems with the capacity of supply systems occur. Because of their short-term emergency nature, water shortage reductions rely almost exclusively on behavioral changes by the users (e.g., skipping or rescheduling lawn watering and taking shorter showers). Water conservation, on the other hand, generally requires changes in water use systems and technology, and little behavioral change. The water use reductions resulting from conservation will provide a basis for adjusting historical rates and patterns of water use in the modeling of the UEC Water Supply Plan.

MANDATORY WATER CONSERVATION MEASURES

In District water use permitting rule amendments adopted in October 1992, specific water conservation requirements were imposed on public water supply utilities (and associated local governments), on commercial/industrial users, on landscape and golf course users, and on agricultural users. All of these requirements apply to users required to obtain individual water use permits. Water use (consumptive use) permitting is further discussed in Chapter 5.

Public Water Supply Utilities

All individual permit applicants for a public water supply permit must submit a water conservation plan as a condition of issuance. The conservation plan must include the following measures: (a) adoption of an irrigation hours ordinance; (b) adoption of a Xeriscape landscape ordinance; (c) adoption of an ultra-low volume fixtures ordinance; (d) adoption of a rain sensor device ordinance; (e) adoption of a water conservation-based rate structure; (f) implementation of a leak detection and repair program; (g) implementation of a water conservation public education program; and (h) an analysis of reclaimed water feasibility.

The implementation status of these mandatory water conservation measures within public water supply utility service areas in the Martin and St. Lucie areas are indicated in Table 20. Analysis of reclaimed water feasibility is omitted from the table. Implementation of the measures in the Okeechobee Area is not discussed due to the lack of public water supply utilities within that area.

Table 20. Public Water Supply Utility Conservation Implementation Status.

Utility	Irrigation Hours Ordinance	Xeriscape Ordinance	ULV Fixtures Ordinance	Rain Sensor Ordinance	Water Conserv Rate Structure	Leak Detect & Repair Program		Public Educ Program
						% Lost	Status	
Martin County								
Hobe Sound Water Co.	Yes	No	Yes	Yes	Yes	13.3	No	Yes
Hydratech	Yes	Yes	Yes	Yes	Yes	4.4	No	Yes
Indiantown	Yes	Yes	Yes	Yes	Yes	3.5	No	Yes
Martin County – Martin Downs	Yes	Yes	Yes	Yes	Yes	18.4	Yes	Yes
Martin County - North	Yes	Yes	Yes	Yes	Yes	13.3	Yes	Yes
Martin County – Port Salerno	Yes	Yes	Yes	Yes	Yes	10.2	Yes	Yes
Martin County - Tropical Farms	Yes	Yes	Yes	Yes	Yes	N/A	Yes	Yes
Stuart	Yes	Yes	Yes	No	Yes	13.5	Yes	Yes
St. Lucie County								
Ft. Pierce	No	No	No	No	Yes	10.0	Yes	Yes
Holiday Pines	No	Yes	No	Yes	No	3.9	No	No
Port St. Lucie	No	Yes	Yes	Yes	No	9.0	No	Yes
Reserve	No	Yes	No	Yes	No	9.0	No	No
St. Lucie West	No	Yes	Yes	Yes	No	5.0	Yes	Yes

Source: July 1997 phone interviews with local planners and utility staff.

Four of the mandatory water conservation measures require adoption of an ordinance by local government. Generally, because of the autonomy of local governments in the UEC Planning Area, each ordinance has to be adopted by each unit of local government for the measure to be fully implemented. Positive responses in the table reflect the adoption of the appropriate ordinance by the applicable local government.

Adoption of an Irrigation Hours Ordinance. The ordinance, at a minimum, limits all lawn and ornamental irrigation to the hours of 4:00 P.M. to 10:00 A.M. Exemptions such as hand watering with a self-canceling nozzle, low volume irrigation systems, irrigation systems whose sole source is reclaimed water or seawater, or to operations for the purpose of system repair or maintenance may be included in the ordinance. It is assumed that most urban landscape irrigation already takes place during acceptable hours.

Irrigation during daytime hours is generally less efficient. The sunlight and increased winds during the restricted daytime hours cause some of the water to evaporate before hitting the ground or to blow onto impervious surfaces such as sidewalks, roads and driveways. The wind also causes the water that reaches the plants to be more unevenly applied. In addition to changing the time of irrigation, users will need to reduce the length and frequency of irrigation. Public education programs can contribute to the irrigation hours ordinance by informing irrigators how they can reduce applications while still meeting the water requirements of their plants. Even if applications are not reduced, more water will reach the plants and soil when the prescribed hours are followed.

Adoption of a Xeriscape Landscape Ordinance. Xeriscape is defined by the Florida Legislature to mean "a landscaping method that maximizes the conservation of water by the use of site-appropriate plants and an efficient watering system" (Section 373.185, F.S.). The principles of Xeriscape include planning and design, soil analysis, efficient irrigation, practical turf areas, appropriate plant selection, and mulching.

The legislation requires that the water management districts establish incentive programs and provide minimum criteria for qualifying Xeriscape codes. These codes prohibit the use of invasive exotic plant species, set maximum percentages of turf and impervious surfaces, include standards for the preservation of existing native vegetation, and require a rain sensor for automatic sprinkler systems. District rules, as mandated by the legislature, require that all local governments consider a Xeriscape ordinance and that the ordinance be adopted if the local government finds that Xeriscape would be of significant benefit as a water conservation measure relative to the cost of implementation. The Xeriscape landscape ordinance will affect new construction and landscapes undergoing renovation which require a building permit.

Adoption of an Ultra-Low Volume Fixture Ordinance. This measure requires adoption of an ordinance which requires the installation of ultra-low volume (ULV) plumbing fixtures in all new construction. The District's water use permit regulations specify that the fixtures have a maximum flow volume when the water pressure is 80 pounds per square inch (psi) as follows: toilets, 1.6 gal/flush; shower heads, 2.5 gal/min.; and faucets, 2.0 gal/min. The previous standard for plumbing devices was: toilets, 3.5 gal/flush; shower heads, 3.0 gal/min.; and faucets, 2.5 gal/min.

ULV fixtures save water by using less water to provide the services desired. Available data indicate that the performance of the systems is such that the savings per unit (per flush or per minute) will not be offset by having the users increase the number of units (number of double flushes or length of shower). Thus these permanent ongoing water savings can be obtained without any behavioral changes by the users.

Adoption of a Rain Sensor Device Ordinance. This measure requires adoption of an ordinance which requires any person purchasing or installing an automatic sprinkler system to install, operate, and maintain a rain sensor device or an automatic switch. This equipment will override the irrigation cycle of the sprinkler system when adequate rainfall has occurred.

Adoption of a Conservation Rate Structure. A conservation rate structure is a charging system used by utilities that provides a financial incentive for users to reduce demands. Water conservation rates are generally either (a) increasing block rates, where the marginal cost of water to the user increases in two or more steps as water use increases; or (b) seasonal pricing, where water consumed in the season of peak demand, such as from October through May, is charged a higher rate than water consumed in the off-peak season. Maddaus (1987) also lists uniform commodity rates as a conservation rate structure.

Users faced with higher rates will often achieve water conservation by implementing a number of the conservation measures discussed in this chapter. The most frequently used conservation rate structure used by utilities is increasing block rates. This rate structure generally is expected to have the largest impact on heavy irrigation users. The responsiveness of the customers to the conservation rate structure depends on the existing price structure, the water conservation incentives of the new price structure, and the customer base and their water uses.

Adoption of a Utility Leak Detection and Repair Program. The District encourages public water supply systems to have no more than 10 percent unaccounted-for water losses. The implementation of leak detection programs by utilities with unaccounted-for water losses greater than 10 percent is required. The leak detection program must include water auditing procedures, and in-field leak detection and repair efforts.

Implementation of a Water Conservation Public Education Program. Public information, as a water conservation measure, involves a series of reinforcing actions to inform citizens of opportunities to reduce water use, give reasons why they should choose to practice water conservation, and publicize the conservation options being promoted by the District, local governments and utilities. Virtually all users can be affected by public information efforts, although they are typically targeted at the uses with the broadest participation, including domestic indoor and outdoor uses.

Analysis of Reclaimed Water Feasibility. For potable public water supply utilities who control a wastewater treatment plant, an analysis of the economic, environmental, and technical feasibility of making reclaimed water available is required. Wastewater reuse is discussed in Chapter 8, Water Source Options.

Commercial/Industrial Users

District regulations require that all individual commercial/industrial permit applicants submit a conservation plan. This plan must include:

a. An audit of water use,
b. Implementation of cost-effective conservation measures,
c. An employee water conservation awareness program,
d. Procedures and time frames for implementation, and
e. The feasibility of using reclaimed water.

Landscape and Golf Course Users

Landscape and golf course permittees are required to use Xeriscape landscaping principles for new projects and modifications when they find this to be of significant benefit as a conservation measure relative to its cost. They are also required to install rain sensor devices or switches, irrigate between the hours of 4:00 P.M. and 10:00 A.M., and analyze the feasibility of using reclaimed water. There are, however, six specific exceptions to the irrigation hours limitations in the rule which provide for protection of the landscape during stress periods and help assure the proper maintenance of irrigation systems.

Agricultural Users

Citrus and container nursery permittees are required to use micro irrigation or other systems of equivalent efficiency. This applies to new installations or upon modifications to irrigation systems. The permittees are also required to analyze the feasibility of using reclaimed water.

SUPPLEMENTARY WATER CONSERVATION MEASURES

Urban Users

Indoor Audit and Retrofit. Indoor audits provide information and services directly to households and other urban water users to achieve greater efficiency in the use of indoor water-using appliances. This option generally includes inspections to locate leaks and determine if plumbing devices are operating properly, repair of minor problems, and providing information on conservation measures and devices. In some cases, a retrofit program will include installation of water-conserving shower heads and toilet dams.

Residential retrofit measures encourage the installation of ULV plumbing fixtures or modifications which improve the performance of existing fixtures. One possible incentive is a partial financial subsidy to increase the installation of ULV water fixtures. Another incentive, recently undertaken in Tampa, is the delivery of retrofit kits to homes. The targeting and participation in efforts such as this will generally affect only a portion of the population. Utilities and local governments can devise programs that carefully target the most cost-effective applications of these measures. In retrofit programs, one option is to target residences with only high water consuming fixtures (generally those built pre-1980). Another option is to include residences with low water use fixtures (post-1980) for retrofit with ULV water use fixtures.

Another characteristic which will increase the savings and the cost effectiveness of retrofit of the earlier dwelling units (homes) is that many of these units have fewer bathrooms and fixtures per unit and per person. The larger the number of people using a retrofit device, the more cost effective and water saving the retrofit. An appropriate strategy would be to target homes with large numbers of persons per fixture for complete retrofit, and other homes for retrofit of only the most heavily used fixtures. This suggests that a particularly suitable target for retrofit programs are public restrooms and other facilities which have high use rates.

Landscape Audit and Retrofit. Landscape audits are measures that improve the efficiency of irrigation systems, and include services to determine if the irrigation system is operating properly. This may include adjustments to irrigation timers (to assure that a water-conserving schedule is being followed), head replacement (to assure that the system is providing adequate coverage and not wasting water by irrigating impervious surfaces), recalibration of the irrigation system, and installation of rainfall sensing/irrigation controlling devices.

Audits are generally implemented by utilities and other water management agencies. Because of the large outdoor component of water use in South Florida, irrigation audits can be effective. This is particularly important due to the peaking of outdoor demand during periods of low rainfall and maximum stress on water resources.

Landscape retrofit measures provide information and incentives for users to implement physical changes to their landscapes and irrigation systems. Devices suitable for landscape retrofit include those that prevent unnecessary irrigation by detecting recent rainfall or sensing soil moisture. Other retrofit options include replacing existing landscaping with site-appropriate plants and practicing landscape management which includes rezoning irrigation systems and mulching.

Cost and water savings for several indoor and outdoor urban retrofit water conservation measures are provided in Tables 21 and 22. In addition, the cost and water savings for irrigation system conversion for agricultural are discussed. This information in this section should not be interpreted as a benefit-cost analysis of these conservation measures, since no discounting is applied to the streams of cost and benefits.

Table 21. Representative Water Use and Cost Analysis for Retrofit Indoor Water Conservation Measures.

	Toilet	Showerhead
Cost/unit ($)	$200	$20
Flushes/day/person	5	--
Gallons saved/flush	1.9	--
Minutes/day/person	--	10
Gallons saved/minute	--	2
Persons/unit	2.5	2.5
Life (years)	40	10
Savings/year/unit (gallons)	8,670	9,125
Savings/unit over life (gallons)	346,800	91,250
Cost/1000 gallons saved	$0.58	$0.22
Savings/cost	1.73	4.56

Table 22. Representative Water Use and Cost Analysis for Retrofit Outdoor Water Conservation Measures.

	Rain Switch	Mobile Irrigation Lab
Cost/unit or visit ($)	$68	$50*
Acres/unit	0.11	0.11
Water savings (inches/year)	70	70
Water savings (gallons/year)	209,070	209,070
Life (years)	10 years	7 years
Water savings/life (gallons)	2,090,700	1,463,493
Cost/1,000 gallons saved ($)	$0.033	$0.034
Savings per 1,000 gallons/cost	30.75	29.27

*Represents additional cost of site visit (currently compensated by NRCS and the District).

For the urban water conservation methods, the analysis indicated the savings are greater than the costs. The savings per unit of cost associated with the outdoor conservation measures are generally greater than those for indoor conservation measures, primarily because of the larger volumes of water involved per unit affected by the outdoor conservation measures. Water savings associated with implementation of retrofit programs can be significant. For example, if 10,000 showerheads were retrofitted in an area, this could result in a water savings of 182 MGY (0.50 MGD). Likewise, if 10,000 irrigation systems were retrofitted with rain switches, this could result in a water savings of over 2 BGY (5.73 MGD).

Public Water Supply Utilities

Filter Backwash Recycling. This measure encourages water utilities using filter systems that are cleaned by backwashing (cleaning the filter by reversing the flow of water) to recycle the backwash water to the head of the treatment plant for retreatment. Otherwise, the backwash water is usually disposed of into a pit from which the water seeps back into the ground. An August 1994 survey of utilities in the UEC Planning Area indicated that only two (Fort Pierce and Stuart) out of the six lime softening facilities recycle their filter backwash.

Distribution System Pressure Control. Potable water distribution system pressure control measures reduce water usage while providing acceptable water pressures to all customers. System pressure should keep water-using devices working properly while providing for public health and fire safety needs. Pressure reduction valves and interconnecting and looping utility mains, are methods used to equalize and, therefore, reduce overall operating pressure. Unlike the pressure reduction efforts during water shortages, which call for reductions in pressures to levels necessary to meet minimums for fire flow, these changes target reductions at locations where pressures are high within the system.

Control of pressures can save water in a number of ways. High pressures increase losses of water through leaks, and increase use when the amount of water used is based on time rather than the volume of water discharged. Irrigation systems on timers are the major uses wherein the use is for set periods of time. High pressures cause increases in water application and can cause atomization of the spray, which reduces irrigation efficiency. Low pressures, however, reduce the areas covered by poorly designed sprinkler systems, and this results in stress to the uncovered areas. This may encourage users to increase irrigation time in an attempt to improve the results of the irrigation efforts.

Wastewater Utility Infiltration Detection and Repair. Wastewater utility infiltration detection and repair includes estimation and detection efforts to quantify and locate the infiltration of ground water or surface water into wastewater collection systems, and repair efforts to reduce the infiltration. Infiltration is important in the UEC Planning Area because many wastewater collection lines are located below the water table for much of the year. Reducing infiltration of ground water prevents waste by allowing the ground water to be used for other purposes. In coastal areas, infiltration of saline ground water minimizes the potential reuse of the wastewater by increasing the chloride level. Infiltration also uses available treatment and disposal capacity.

Agricultural Users

Irrigation Audit and Improved Scheduling. Growers are encouraged to adopt irrigation management practices, which conserve water. To assist growers with agricultural irrigation, audits are carried out by the federally funded Mobile Irrigation Laboratory which operates in the UEC Planning Area. Agriculture is a major water user in the planning area. Changing on-farm irrigation scheduling and water management practices will play an increasingly important role in agricultural water conservation.

Irrigation management practices and technology interact, so that for example, a change in the type of irrigation system will generally require a change in irrigation scheduling to achieve the goal of water conservation while maintaining crop yield and economic return. An additional factor in agricultural water conservation is the energy savings possible through water conservation.

Micro Irrigation Systems. Micro irrigation systems achieve water savings by directly applying a high percentage of water to the root zone of the crop in controlled amounts, so losses through deep percolation, drainage, etc. are reduced. In addition, application of water to areas not underlain by the root zone is limited. Installation of micro irrigation systems, or systems of equivalent efficiency, are required for new citrus and container nursery crops. Additional water savings can be achieved by promoting the installation of water-conserving irrigation systems on crops where it is not required (such as vegetables), and retrofitting irrigation systems for existing citrus and nursery crops.

Conversion of existing flood-irrigated citrus to micro-irrigation is another potential source of water savings (Table 23). It is estimated by IFAS that the initial cost to install a micro-irrigation system on citrus is $1,000 per acre and the system would have estimated annual maintenance costs of $25 per year (IFAS, 1993).

Table 23. Irrigation Costs and Water Use Savings Associated with Conversion from Seepage Irrigation to Low Volume.

Initial cost ($/acre)	$1,000
Operating cost ($/acre)	$25
Water savings (inches/year)	8.519
Water savings (gallons per year)	230,805
Life (years)	20
Cost over life ($)	$1,500
Water savings over life	4,616,100
Cost/1,000 gallons saved ($)	$0.33

The table summarizes the cost and potential water savings from one acre of conversion. The water savings from converting 25,000 acres of citrus from flood irrigation with a 50 percent efficiency to micro-irrigation with an 85 percent efficiency could result in a water savings of approximately 6 BGY (15.8 MGD). The analysis illustrates that given the large volumes of water used for irrigation by agriculture, water conservation savings (which can be achieved at a reasonable cost) will often be extremely cost effective compared to the costs of developing additional water supplies.

Chapter 8

WATER SOURCE OPTIONS

Water source options has been defined in the Planning Document as options that make additional water available from existing or new sources, such as wastewater reuse or the Floridan aquifer, or options that reduce water use, such as conservation. This chapter discusses options that increase water availability. Water conservation is discussed in Chapter 7.

WELLFIELD EXPANSION

Expansion of an existing public water supply wellfield is usually selected by a utility when additional raw water is required. The costs related to wellfield expansion for the major aquifer systems in the planning area are provided in Table 24. The costs are based on a 16-inch diameter well and a maximum Surficial well depth of 200 feet and maximum Floridan well depth of 900 feet.

Table 24. Well Costs for Aquifer Systems.

Aquifer System	Drilling Cost (per well)	Equipment Cost (per well)	Engineering Cost (per well)	O&M Cost (per 1000 gal)	Energy Cost (per 1000 gal)
Surficial	$36,000	$49,000	$13,000	$.003	$.020
Floridan	$92,000	$52,000	$14,000	$.003	$.032

Source: PBS&J, 1991, Water Supply Cost Estimates.

Ground water wells are limited in the amount of water they can yield by the rate of water movement in the aquifers, the rate of recharge, the storage capacity of the aquifer, environmental impacts, and proximity to sources of contamination and saltwater intrusion. These factors together determine the number, size, and distribution of wells that can be developed at a specific site. Long-range planning by the water suppliers to identify future wellfield sites, and to protect those future sites from contamination by controlling land use activities within the influence of the wellfield, is important in ensuring satisfactory future water supply.

UTILITY INTERCONNECTIONS

Interconnection of treated and/or raw water distribution systems between two or more utilities can provide a measure of backup water service in the event of disruption of a water source or treatment facility. Additionally, when considering future potable water needs, bulk purchase of treated water from neighboring utilities should be evaluated in lieu of expanding an existing withdrawal and/or treatment plant. A detailed study of distribution systems proposed for interconnection should address system pressures, physical layout of the supply mains, impacts on fire flows and compatibility of the waters.

WASTEWATER REUSE

Reuse is the deliberate application of reclaimed water for a beneficial purpose, in compliance with the FDEP and water management district rules. Reclaimed water is wastewater that has received at least secondary treatment and is reused after flowing out of a wastewater treatment plant (Chapter 62-610, F.A.C.). Potential uses of reclaimed water include landscape and agricultural irrigation, ground water recharge, industrial uses, environmental enhancement and fire protection. Additional discussion of reuse, including reclaimed water regulations and more detailed information on potential uses, is provided in Appendix I.

Encouragement and promotion of wastewater reuse and water conservation are formal state objectives. The State Water Policy requires the FDEP and water management districts to advocate and direct the reuse of reclaimed water as an integral part of water management programs, rules, and plans. Several regulations also require an evaluation of reuse versus other disposal methods prior to issuance of Department permits.

Reuse Costs

The costs associated with implementation of a reuse program vary depending on the size of the reclamation facility, the facility equipment needed, the extent of the reclaimed water transmission system, and the regulatory requirements. Some of the major costs to implement a public access reuse system are:

- Advanced secondary treatment
- Reclaimed water transmission system
- Storage facilities
- Alternate disposal
- Application area modifications

Cost savings include negating the need for or reducing the use of alternative disposal systems, negating the need for an alternate water supply by the end user, and reduction in fertilization costs for the end user. These costs and savings are further discussed in Appendix I.

Existing Treatment Facilities

There are 12 existing regional wastewater treatment facilities in the UEC Planning Area. These facilities treated 13.05 MGD of wastewater in 1993. Of this, 3.07 MGD was reused by eight facilities. In addition to reuse, 3.59 MGD was disposed of by deep well injection and 6.39 MGD was disposed of by surface water discharge. (As of February 1998, there were no regional utilities that used surface water discharge for disposal in the planning area.) The water that was disposed of by deep well injection or discharged to surface water could be made available for reuse with the addition of regulatory mandated equipment including filtration and the associated chemical feed system, disinfection facilities and reclaimed water monitoring equipment. The volume of wastewater treated by regional wastewater treatment facilities is projected to increase to about 43 MGD by 2010. Summarized wastewater facility information is provided in Appendix E.

SURFACE WATER STORAGE

This option involves the capture and storage of excess surface water during rainy periods and subsequent release during drier periods for environmental and human uses. Regionally, surface water storage could be used to attenuate freshwater flows to the St. Lucie Estuary (SLE) and the Indian River Lagoon (IRL) during rainy periods and meet minimum flows during drier periods. In addition, these facilities could increase surface water availability for current and projected agricultural uses, and decrease the demand on the Floridan aquifer. This option also includes the interdistrict transfer of surface water, potentially with the SJRWMD.

Locally, strategically located surface water storage (primarily storage in combination with improved storm water management systems) could recharge SAS wellfields, reduce the potential for saltwater intrusion and reduce drawdowns under wetlands. Onsite storage in agricultural areas may reduce the need for water from the regional canal system and withdrawals from the Floridan aquifer.

Costs associated with surface water storage vary depending on site specific conditions of each reservoir. A site located near an existing waterway will increase the flexibility of design and management and reduce costs associated with water transmission infrastructure. Another factor related to cost would be the existing elevation of the site. Lower site elevations would allow for maximum storage for the facility while reducing costs associated with water transmission and construction excavation. Depth of the reservoir will have a large impact on the costs associated with construction. Deeper reservoirs result in higher levee elevations which can significantly increase construction costs.

Costs associated with two types of reservoirs are depicted in Table 25. The first is a minor facility with pumping inflow structures and levees designed to handle a maximum water dept of 4 feet. It also has internal levees and infrastructure to control internal flows and discharges. The second type shown below is a major facility with similar infrastructure as the minor facility. However, the water design depths for this facility range from 10 to 12 feet. Costs increase significantly for construction of higher levees but can be offset somewhat by the reduced land requirements.

Table 25. Surface Water Storage Costs.

Reservoir Type	Construction Cost $/Acre	Engineering/ Design Cost $/Acre	Construction Admin. $/Acre	Land $/Acre	Operations & Maint. $/Acre
Minor Reservoir	2,842	402	318	4,500	118
Major Reservoir	7,980	904	451	4,500	105

Costs for the minor reservoir are based on actual construction bid estimates received and awarded for similar projects currently being built in the Everglades Agricultural Area (EAA). Costs of these four Stormwater Treatment Areas (STAs) were averaged to develop the $/Acre costs. Land costs have been changed to generally reflect land values in the Upper East Coast Planning Area. Costs for the major reservoir were developed based on the average cost estimates from the proposed Ten Mile Creek project and from the Regional Attenuation Facility Task Force Final Report, April 1997 estimates for major Water Preserve Areas.

AQUIFER STORAGE AND RECOVERY

Aquifer storage and recovery (ASR) is defined as the underground "storage" of injected water in an acceptable aquifer during times when water is available, and the subsequent "recovery" of this water when it is needed. Simply stated, the aquifer acts as an underground reservoir for the injected water, reducing the water loss to evaporation. Sources of injection water could include treated and untreated ground- and surface-water, and reclaimed water.

Because of limited water resources, increasing demands, and more stringent water quality standards, ASR technology is receiving growing attention. The regulatory criteria for ASR permitting is discussed in Appendix I.

ASR Costs

Estimated project costs for ASR consisting of a 900-foot, 16-inch well, with two monitoring wells using treated water in Florida are shown in Table 26. One system uses pressurized water from a utility; whereas the second ASR system uses unpressurized treated water, thus requiring pumping equipment as part of the system cost. Using the assumptions that the capital costs are amortized at 8 percent over 20 years, that the water recovery efficiency is 75 percent, and 100 days of recovery at the daily recovery capacity, the costs in Table 26 translate into costs of $.23 to $.27 per thousand gallons. However, utilities implementing ASR systems may incur additional costs for surface facilities, such as piping, storage, and rechlorination. Other available data indicate that "typical unit costs for water utility ASR systems now in operation tend to range from $200,000 to $600,000 per MGD of recovery capacity" (CH2M Hill, 1993). At the same annual recovery rate used above (100 days at the daily recovery capacity), the costs per thousand gallons recovered would be $.30 to $.70 per thousand gallons. These systems have well capacities from 0.3 to 3 MGD and store treated water. Savings in treatment system costs are likely to be substantial when the ASR system offsets the need for capacity to meet peaks in demands.

Table 26. Aquifer Storage and Recovery System Costs.

System	Well Drilling Cost	Equipment Cost	Engineering Cost*	O&M Cost (per 1000 gal)	Energy Cost (per 1000 gal)
Treated Water at System Pressure	$200,000	$30,000	$360,000	$.004	$.06
Treated Water Requiring Pumping	$200,000	$100,000	$400,000	$.006	$.06

*Engineering costs include the permitting process, hydrogeologic investigation, monitoring during well construction, and design.
Source: PBS&J, 1991, Water Supply Cost Estimates.

Existing ASR Facilities

ASR facilities are already in operation in New Jersey, Nevada, California, and Florida. Five operational facilities are in Florida: Manatee County (1983), Peace River (1984), Cocoa (1987), Port Malabar (1989), and Boynton Beach (1993). These facilities all use treated water and are further discussed in Appendix I. There are ASR development studies currently underway in Washington, Utah, Arizona, Georgia, South Carolina, Texas, and Virginia.

FLORIDAN AQUIFER SYSTEM (FAS)

In the UEC Planning Area, the primary use of the FAS is for supplemental water for agriculture. The FAS yields nonpotable water throughout most of the planning area. The quality of water in the FAS deteriorates, increasing in hardness and salinity from north to south. Salinity also increases with depth, making the deeper producing zones less suitable for development than those near the top of the system. The system is areally persistent and displays hydrogeologic characteristics favorable to ASR development.

Developments in desalination technology have made treatment of water from the upper portion of the FAS feasible in the planning area where chloride concentrations are not prohibitively high. The cost of tapping the FAS in a given location would depend on a number of variables, including well construction, operation and maintenance, and water treatment. Cost estimates for drilling wells in the major aquifer systems of the planning area are discussed in the Wellfield Expansion section. Treatment costs of desalination technologies (e.g., reverse osmosis and electrodialysis reversal) are discussed in the Water Treatment Technologies section.

Water quality varies throughout the upper portion of the FAS. Generally speaking, the two parameters of greatest concern for use by reverse osmosis and other water treatment technologies are total dissolved solids (TDS) and chloride. Common values for TDS in the upper portion of the FAS are 1,900 mg/L to 8,500 mg/L, chloride range from 1,000 mg/L to 2,000 mg/L. These values vary with depth and production zone.

One of the major constraints on future development of the upper portion of the FAS is degradation of water quality rather than limited quantity. Upconing of saline water is an important consideration in planning additional development in the upper portion of the FAS.

OCEAN WATER

Ocean water averages about 3.5 percent dissolved salts, most of which is sodium chloride, with lesser amounts of magnesium and calcium. Ocean water treatment systems are used successfully worldwide in areas with very limited freshwater supplies. In these areas, reverse osmosis and distillation are two treatment methods which have been used for conversion of ocean water to fresh water. While ocean water is plentiful and obtainable along the Atlantic Ocean, costs associated with the construction and operation of ocean water reverse osmosis and distillation systems are very high. The cost of ocean water desalination is estimated to be four to eight times the cost of reverse osmosis of the Floridan aquifer. As with all surface waters, the ocean is also vulnerable to discharges or spills of pollutants which could impact a water treatment system.

Chapter 9

WATER QUALITY AND TREATMENT

An important interrelationship exists between water quality and human activities, including the withdrawal of water for supply. Increased withdrawals may cause a rise in the concentrations of impurities in the remaining water. Other human activities such as waste deposal or pollution spillage have the potential of degrading ground and surface water systems.

There are standards of quality that must be met for different types of uses. These standards are based on health or water use technology requirements; water frequently needs treatment in order to meet these standards. Technology can also be employed to augment and make the most of available water resources.

WATER QUALITY STANDARDS

Drinking Water Standards

There are two types of drinking water standards, primary and secondary. Both of these standards are the maximum contaminant levels for public drinking water systems. Primary drinking water standards include contaminants which can pose health hazards when present in excess of the maximum contaminant level (MCL). Secondary drinking water standards, commonly referred to as aesthetic standards, are those parameters which may impart an objectionable appearance, odor or taste to water, but are not necessarily health hazards. Current Florida Department of Environmental Protection (FDEP) primary and secondary drinking water standards are presented in Appendix H.

The U.S. Environmental Protection Agency (U.S. EPA) is anticipated to establish MCLs for trihalomethanes (THMs) that may be as low as 0.005 mg/L for individual THM compounds, but not higher than 0.05 mg/L for total trihalomethanes (TTHMs). The anticipated strengthening of the current trihalomethane MCL may have an impact on public water supplies in the UEC Planning Area. Most systems in the planning area have been able to meet the current THM standard of 0.10 mg/L by modifying or optimizing operation of their treatment and/or disinfection processes. THM concentrations in some cases are close to the current MCL of 0.10 mg/L. Some utilities in the planning area will have difficulty in meeting more stringent THM standards without some plant modification.

Nonpotable Water Standards

Water for potable and nonpotable water uses have different treatability constraints. Each type of water use has certain water quality requirements which, if violated, render the water source useless. Nonpotable water sources include surface water, ground water, and reclaimed water. Unlike potable water, with very specific quality standards to protect human health, water quality limits for nonpotable uses are quite variable and are dictated by the intended use of the water. For example, high iron content is usually not a factor in water used for flood irrigation of food crops, but requires removal for irrigation of ornamentals, which if iron stained, are not marketable. Excessive iron must also be removed for use in micro irrigation systems which become clogged by iron precipitate.

Nonpotable water uses include agricultural, landscape, golf course, and recreational irrigation. This water may also be acceptable for some industrial and commercial uses. For a source to be considered for irrigation for a specific use, there must be sufficient quantities of that water at a quality that is compatible with the crop it is to irrigate. Agricultural irrigation uses require that the salinity of the water not be so high as to damage crops either by direct application or through salt buildup in the soil profile. In addition, constituents that can damage the irrigation system infrastructure or equipment must be absent or economically removable. Water used for landscape, golf course, or recreational irrigation uses often has additional aesthetic requirements regarding color and odor. Irrigation water quality requirements are summarized in Appendix H.

In addition to water quality considerations associated with the intended use of nonpotable water, reclaimed water is subject to wastewater treatment standards which ensure the safety of its use (see Appendix I). As with any irrigation water, reclaimed water may contain some constituents at concentrations that are not desirable. Problems that might be associated with reclaimed water are no different from those of other water supplies and are only of concern if they hinder the use of the water or require special management techniques to allow its use. A meaningful assessment of irrigation water quality, regardless of the source, should consider local factors such as the specific chemical properties, the irrigated crops, climate, and irrigation practices.

GROUND WATER CONTAMINATION AND IMPACTS TO WATER SUPPLY

The SAS is easily contaminated by activities occurring at land's surface in the UEC Planning Area. Once a contaminant enters the aquifer, it may be cumbersome to remove. In many cases, leaks, spills or discharges of contaminants migrate over long periods of time, resulting in contamination of large areas of the aquifer. The preferred method of addressing the issue of water supply contamination, therefore, is to prevent contamination of the aquifer, and protect public water supply wells and wellfields from activities that present a possible contamination threat.

Ground Water Contamination Sources

There are many potential ground water contamination sources in the UEC Planning Area. These include solid waste sites, hazardous waste sites, Superfund Program sites, and septic tanks. All contamination sites do not necessarily contain contamination.

Solid Waste Sites. Landfills, old dumps and domestic sludge-spreading sites within the boundaries of the UEC Planning Area are listed in Table H-3, with an accompanying location map included as Figure H-7. The sludge spreading sites are included for reference, although not classified as landfills or dumps. These are usually tracts of land, often open range or citrus, where domestic wastewater treatment plant (WWTP) sludge is spread and incorporated into the soil.

Many of the older landfills and dumps were used for years with little or no control over what materials were disposed of in them. Although most have not been active for some time, they may still be a potential threat to the ground water resource.

Ground water beneath most unlined landfills and dumps is typically nutrient-rich, with elevated levels of nitrogen and ammonia compounds. Two common indicators used in tracking of leachate plumes are chloride and total dissolved solids (TDS). Iron levels are typically very high in leachate. Sodium is also likely to be elevated, as well as sulfate, total organic carbon (TOC), biological oxygen demand (BOD) and chemical oxygen demand (COD).

Less common constituents which may also be present include metals such as lead or chromium, and volatile or synthetic organic compounds associated with industrial solvents, such as trichloroethylene, tetrachloroethylene, and benzene.

The presence and concentration of these constituents in the ground water are dependent upon several factors that dictate the extent and character of the resulting ground water impacts, these factors include:

a. landfill size and age,
b. types and quantities of wastes produced in the area,
c. local hydrogeology, and
d. landfill design/landfilling techniques.

An effective ground water monitoring program is crucial for accurate determination of ground water degradation. Improperly located monitoring wells can result in the oversight of a contaminant plume, or certain parameters may not be observed in the ground water for many years, depending upon soil adsorption capacities and ground water gradient.

Hazardous Waste Sites. The Florida Department of Environmental Protection (FDEP) Waste Management Division sponsors several programs which provide support for contamination cleanup. There are over 400 documented contamination sites in the UEC Planning Area. These include locations in the Early Detection Incentive (EDI) Program, the Petroleum Liability and Restoration Program (PLIRP), the Abandoned Tank Restoration Program (ATRP), and other nonfunded programs. Locations and cleanup status can be obtained through the FDEP Waste Management Division.

Superfund Program Sites. The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), commonly known as Superfund, authorizes the U.S. EPA to identify and remediate uncontrolled or abandoned hazardous waste sites. The U.S. EPA has identified 11 Superfund sites in the planning area (Figure H-8). The National Priorities List (NPL), a subset of the most serious Superfund sites, targets sites considered to have a high health and environmental risk. There is only one NPL site in the UEC Planning Area: Florida Steel located in Indiantown.

Septic Tanks. Septic systems provide an easy method for on-site disposal of waste. Local public health units estimate there are 55,000 septic tanks in the planning area. However, septic tanks may threaten ground water resources used as drinking water sources. Ground water contamination by septic systems has been responsible for disease outbreaks and chemical contamination of drinking water (U.S. EPA, 1990).

In 1990, the Florida Legislature passed the Chapter 90-262, Laws of Florida. This bill prohibits new discharges, or increased loadings from existing sewage treatment facilities, into the Indian River Lagoon system, which includes almost all of St. Lucie and Martin counties. Elimination of existing discharges is required by July 1, 1995. The “No Discharge” bill also directs both the South Florida and St. Johns River water management districts to identify areas where the existing on-site sewage disposal systems (OSDS) are considered a threat to the water quality of the Indian River Lagoon. These studies have been completed to assist counties and municipalities in developing programs to provide centralized sewage collection and treatment facilities. Many of these septic tanks in the planning area have been identified as a threat to the water quality of the Indian River Lagoon.

Impacts to Water Supply

The costs and difficulty of removing a contaminant by a drinking water treatment plant can be considerable, depending on the material to be removed. The lime softening/filtration water treatment process, widely used throughout the area, is effective in removing microorganisms, most inorganics, hardness, manganese, and iron. It is only moderately effective at removing color, and poorly effective at removing nitrate, nitrite, THMs and THM precursors, VOCs, SOCs, pesticides, chlorides, sulfates and silver.

Many of the major contamination sources identified in the planning area can generate contaminants that are not easily treated by the lime softening process. Nitrate is generated by septic systems or by fertilizer application, benzene from leaking gasoline tanks, and VOCs and SOCs from various hazardous waste contamination sites. Treatment processes are available to remove these contaminants.

WATER TREATMENT TECHNOLOGIES

Several water treatment technologies are currently employed by the regional water treatment facilities in the UEC Planning Area. Higher levels of treatment may be required to meet increasingly stringent drinking water quality standards. In addition, higher levels of treatment may be needed where lower quality raw water sources are pursued to meet future demand. This section provides an overview of several water treatment technologies and their associated costs.

Lime Softening

Lime softening is used at 6 of the 12 existing regional water treatment facilities in the planning area. Lime softening treatment systems are designed primarily to soften hard water, reduce color and to provide the necessary treatment and disinfection to ensure the protection of public health.

Lime Softening Process

Lime softening refers to the addition of lime to raw water to reduce water hardness. When lime is added to raw water, a chemical reaction occurs that reduces water hardness by precipitating calcium carbonate and magnesium hydroxide. Disinfectant may be added at several places in the treatment process, but adequate disinfectant residual and contact time must be provided prior to distribution to the consumer. The lime softening process is effective at reducing hardness, but is relatively ineffective at controlling contaminants such as chloride, nitrate, trihalomethane (THM) precursors and others (Hamann *et al*., 1990).

Community public water supplies are required to provide adequate disinfection of the finished/treated water and to provide a disinfectant residual in the water distribution system. The use of free chlorine as a disinfectant often results in the formation of levels of trihalomethanes (THMs) that exceed the maximum contaminant level (MCL) of 0.10 mg/L. THMs are formed when free chlorine combines with naturally occurring organic matter in the raw water source.

Lime softening is ineffective in removing the chloride ion and only fairly effective at reducing total dissolved solids (TDS). Chloride levels of raw water sources expected to serve lime softening facilities should be below the chloride maximum contaminant level of 250 mg/L to avoid possible exceedences of the standard in the treated water. The current finished water TDS MCL is 500 mg/L. Concentrations above 500 mg/L in the treated water are acceptable so long as no other MCLs are exceeded.

Nitrate is not effectively removed by the lime softening process. Lime softening facilities with raw water sources with nitrate concentrations exceeding the MCL of 10 mg/L will probably require additional treatment to meet the standard.

Proposed Safe Drinking Water Act regulations for THMs and disinfection byproducts (DBPs) will require that many existing lime softening facilities modify their treatment processes to comply with the standards for these groups of compounds. Add-on treatment technologies that are effective at removing these compounds or preventing their formation include ozone disinfection, granular activated carbon (GAC), and air stripping.

Lime Softening Treatment Costs

Capital construction costs for lime softening treatment facilities tend to be similar to those of other treatment processes (Table 27). Lime softening's cost advantages are in operating and maintenance expenses, where costs are typically 10 to 20 percent less than for comparable membrane technologies (see Table 31). However, an increase in total hardness of the raw water source will require increased amounts of lime to maintain the same water quality. In addition, any free carbon dioxide present in the raw water must first be satisfied by the lime before any significant softening can occur, which will impact the costs associated with this treatment process.

Table 27. Lime Softening Treatment Costs.

Facility Size (MGD)	Capital Cost (per gal/day capacity)	Engineering Cost (per gal/day capacity)	Land Requirements (Acres)	O&M Cost (per 1000 gal)	Energy Cost (per 1000 gal)
3	$1.30	$.20	1.5	$.48	$.018
5	$1.25	$.19	2.5	$.45	$.018
10	$1.22	$.18	4.0	$.40	$.017
15	$1.00	$.15	6.0	$.33	$.016
20	$.90	$.13	8.0	$.30	$.016

Source: PBS&J, 1991, Water Supply Cost Estimates.

Reverse Osmosis

Reverse Osmosis (RO) technology has been used in Florida for a number of years. About 100 membrane treatment systems are operational in the state with a combined capacity of about 50 MGD. Major Florida public water supply RO facilities include Cape Coral, Venice, Sanibel, Englewood and Jupiter.

Reverse Osmosis Process

RO is a pressure-driven process that relies on forcing water molecules (feed water) through a semipermeable membrane to produce fresh water (product water). Dissolved salts and other molecules unable to pass through the membrane remain behind (concentrate or reject water). RO is capable of treating feed waters of up to 45,000 mg/L total dissolved solids (TDS). Most RO applications involve brackish feed waters ranging from about 1,000 to 10,000 mg/L TDS. Transmembrane operating pressures vary considerably depending on TDS concentration (Table 28). In addition to treating a wide range of salinities, RO is effective at rejecting naturally occurring and synthetic organic compounds, metals, and microbiological contaminants. The molecular weight cutoff (MWC) determines the level of rejection of a membrane.

Advantages of RO treatment systems include their ability to reject organic compounds associated with formation of THMs and other disinfection by-products (DBPs), small space requirements, modular type construction and easy expansion. Disadvantages of RO systems include high capital cost, requirements for pretreatment and post-treatment systems, high corrosivity of the product water, and disposal of the reject. RO is also less efficient than lime softening, so more raw water is needed to produce finished water.

Table 28. Reverse Osmosis Operating Pressure Ranges.

System	Transmembrane Pressure Operating Range (psi)	Feed Water TDS Range (mg/L)	Recovery Rates (%)
Seawater	800-1500	10,000-50,000	15-55
Standard pressure	400-650	3,500-10,000	50-85
Low pressure	200-300	500-3,500	50-85
Nanofiltration	45-150	Up to 500	75-90

Source: AWWA, 1990, Water Quality and Treatment.

Disposal of RO reject is regulated by the FDEP. Various disposal options include surface water discharge, deep well injection, land application and reuse. Whether a disposal alternative is permittable depends on the characteristics of the reject water and disposal site (letter dated December 12, 1990 from B.D. DeGrove, Point Source Evaluation Section, FDER, Tallahassee, FL).

Reverse Osmosis Costs

RO treatment and associated concentrate disposal costs for a typical South Florida system, (2,000 mg/L TDS, 400 PSI) are provided in tables 29 and 30. Variables unique to RO capital costs include system operating pressures and concentrate disposal, while variables unique to RO operations and maintenance costs include electrical power, chemical costs, membrane cleaning and replacement, and concentrate disposal.

Table 29. Reverse Osmosis Treatment Costs.

Facility Size (MGD)	Capital Costs (per gal/day capacity	Engineering Cost (per gal/day capacity)	Land Requirements (Acres)	O&M Cost (per 1000 gal)	Energy Cost (per 1000 gal)
3	$1.40	$.21	.40	$.46	$.23
5	$1.27	$.19	.40	$.43	$.23
10	$1.17	$.18	.50	$.41	$.23
15	$1.14	$.17	.63	$.40	$.23
20	$1.16	$.16	.78	$.30	$.23

Source: PBS&J, 1991, Water Supply Cost Estimates.

Table 30. Concentrate Disposal Costs.

Deep Well Disposal Facility (MGD)	Capital Cost (per gal/day capacity)	Engineering Cost (per gal/day capacity)	Land Requirements (Acres)	O&M Cost (per 1000 gal)
3	$.58	$.087	0.5	$.032
5	$.44	$.066	0.5	$.024
10	$.40	$.060	1.0	$.022
15	$.37	$.056	2.0	$.020
20	$.30	$.045	3.0	$.016

Source: PBS&J, 1991, Water Supply Cost Estimates.

Methods of determining capital and O&M costs vary from utility to utility, and as a result, cost comparisons of treatment processes can be difficult (Dykes and Conlin, 1989). Site-specific costs can vary significantly as a result of source water quality, reject disposal requirements, land costs, use of existing water treatment plant infrastructure, etc. Detailed cost analyses are necessary when considering construction of RO water treatment facilities. As a general rule, however, RO costs are 10 to 50 percent higher than lime softening.

Membrane Softening

Membrane softening or nanofiltration (NF) is an emerging technology that is currently in use in Florida. Membrane softening differs from standard RO systems in that the membrane has a higher MWC, lower operating pressures and feed water requirements of 500 mg/L or less of TDS. One significant advantage of the membrane softening technology is its effectiveness at removing organics that function as THM and other DBP precursors. Given the direction of increasing federal and state regulation of drinking water quality, membrane softening seems to be a viable treatment option towards meeting future standards. A number of membrane softening facilities have been installed in Florida.

The costs associated with membrane softening are similar to those of reverse osmosis, with operations and maintenance expenses tending to be lower. Membrane softening treatment costs are shown in Table 31.

Table 31. Membrane Softening Costs.

Facility Size (MGD)	Capital Costs (per gal/day capacity	Engineering Cost (per gal/day capacity)	Land Requirements (Acres)	O&M Cost (per 1000 gal)	Energy Cost (per 1000 gal)
3	$1.33	$.20	0.40	$.44	$.159
5	$1.21	$.18	0.40	$.42	$.159
10	$1.12	$.17	0.50	$.40	$.159
15	$1.10	$.17	0.63	$.38	$.159
20	$1.06	$.16	0.78	$.37	$.159

Source: PBS&J, 1991, Water Supply Cost Estimates.

Electrodialysis and Electrodialysis Reversal

Electrodialysis (ED) is an electrochemical process that involves the movement of ions through anion- and cation-selective membranes from a less concentrated solution to a more concentrated solution by the application of direct electrical current. Electrodialysis reversal (EDR) is a similar process but provides for the reversing of the electrical current which causes a reversing in the direction of ion movement. ED and EDR are useful in desalting brackish water with TDS feedwater concentrations of up to 10,000 mg/L. ED/EDR, however, is generally not considered to be an efficient and cost-effective organic removal process and therefore is usually not considered for THM precursor removal applications (AWWA, 1988). Available cost data for ED/EDR is limited, but for the same area appear to be 5 to 10 percent higher than RO treatment (Boyle Engineering, 1989).

Distillation

The distillation treatment process is based on evaporation. Saltwater is boiled and the dissolved salts, which are non-volatile, remain behind. The water vapor is cooled and condenses into fresh water. Two distinct treatment processes are in use: multistage flash (MSF) distillation and multiple effect distillation (MED). Capital construction costs and operation and maintenance expenses are three to five times as expensive as brackish water RO systems and/or EDR (Buros, 1989).

WATER TREATMENT FACILITIES

Potable Water Treatment Facilities

Potable water in the UEC Planning Area is supplied by three main sources: (a) regional water treatment facilities, municipal or privately owned; (b) small developer/homeowner association or utility owned water treatment facilities; (c) self-supplied individual wells that serve individual residences. Many of the smaller facilities are constructed as interim facilities until regional potable water becomes available. At that time, the smaller water treatment facility is abandoned upon connection to the regional water system.

There are 12 existing regional water treatment facilities within the planning area. In addition, there is a proposed facility and service area in Martin County (Figure 19). All of these facilities use raw ground water, and most are considering ground water sources to meet future demands. Wellfield locations for these facilities are shown in Figure 20.

Detailed maps showing the location of each treatment facility and associated wellfields are provided in Appendix E. Other detailed information provided in the appendix includes the source aquifer and pump capacity for each of the wells; existing, proposed, and future sources of raw water; and water treatment methods for each facility.

The existing treatment technologies employed by the facilities are lime softening, reverse osmosis, membrane softening and chlorination. Of the 12 existing facilities, 5 use lime softening exclusively, 2 use a membrane technology exclusively, 4 use aeration, and 1 uses a combination of lime softening and membrane technology. More stringent future drinking water standards (see Chapter 6), combined with deteriorating water quality and decreasing available freshwater supplies, may necessitate that greater emphasis be placed on nonconventional methods of treatment (e.g., membrane technologies) and alternative raw water sources (e.g., brackish/saline water).

Public water systems in the UEC Planning Area are regulated by the Florida Department of Environmental Protection (FDEP) for all facilities, with the following exceptions: (1) those water systems that have less than 15 service connections; or (2) facilities which regularly serve less than 25 individuals daily at least 60 days out of the year; or (3) facilities which serve at least 25 individuals daily less than 60 days out of the year. All other systems in are regulated by the local health departments (Chapter 62-550, F.A.C.).

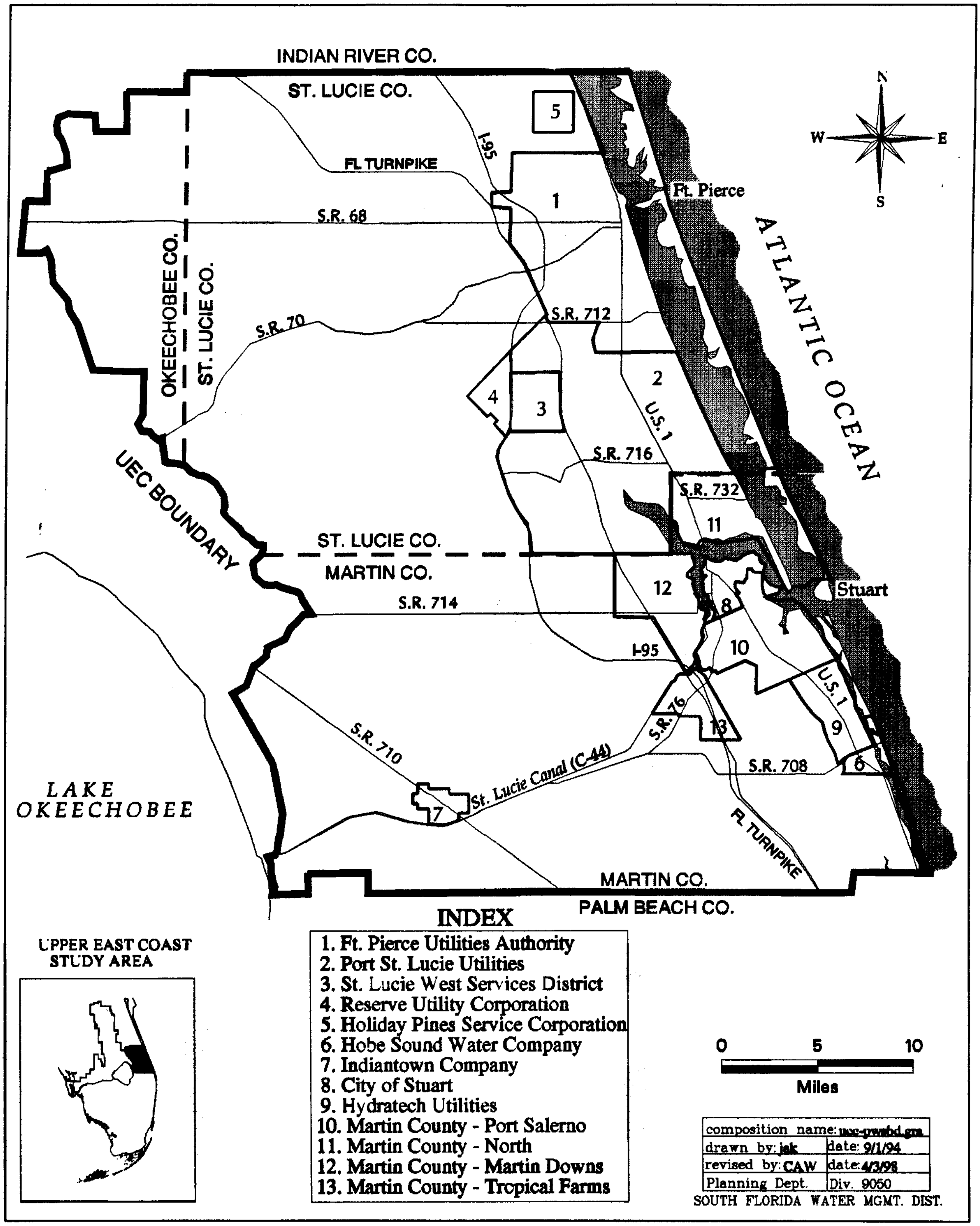


Figure 19. Regional Potable Water Treatment Facility Service Areas.

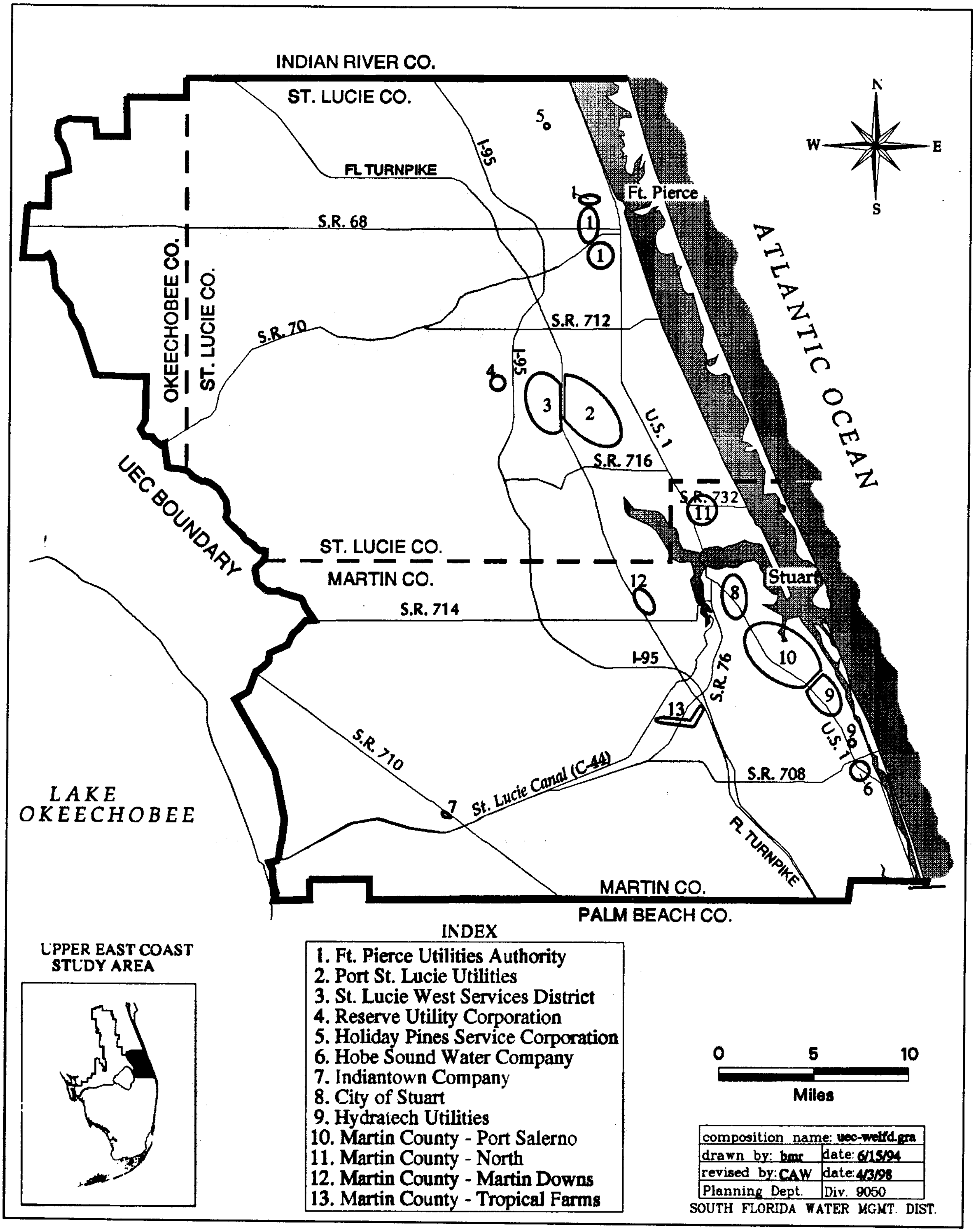


Figure 20. Location of Wellfields for Regional Potable Water Treatment Facilities.

Wastewater Treatment Facilities

Wastewater treatment in the UEC Planning Area is provided by: (a) regional wastewater treatment facilities, municipal or privately owned; (b) small developer/homeowner association or utility owned wastewater treatment facilities; and (c) septic tanks. There are approximately 170 wastewater treatment facilities permitted by the FDEP with approved capacities between 0.005 and 9 MGD in the planning area. Of these, 12 facilities have an existing or 2010 proposed capacity of 0.50 MGD or greater. Many of the smaller facilities are constructed on an interim basis until regional wastewater becomes available, at which time the smaller wastewater treatment facility is abandoned upon connection to the regional wastewater system. The regional wastewater service areas are shown in Figure 21.

All the facilities use the activated sludge treatment process. The methods of reclaimed water/effluent disposal include surface water discharge, reuse, and deep well injection. One facility uses a surface water discharge to the Indian River and four facilities use deep well injection systems. The methods of reclaimed water disposal via reuse include golf course, residential lawn, and other green space irrigation, and ground water recharge by percolation ponds.

Specific information on each of these regional facilities is provided in Appendix E. The information includes summaries of the existing, proposed, and future wastewater treatment and disposal methods. Capacity and reuse feasibility for each facility, as well as future plans are also discussed.

Wastewater treatment in the planning area is regulated by the FDEP for all facilities. The following wastewater treatment facilities are exempt from FDEP regulation: (1) those with a design capacity of 2,000 GPD or less which serve the complete wastewater and disposal needs of a single establishment; or (2) septic tank drainfield systems and other on-site sewage systems with subsurface disposal and a design capacity of 5,000 GPD (3,000 GPD for restaurants) or less, which serve the complete wastewater disposal needs of a single establishment. All other systems are regulated by the local health department for each county (Chapter 62-600, F.A.C.).

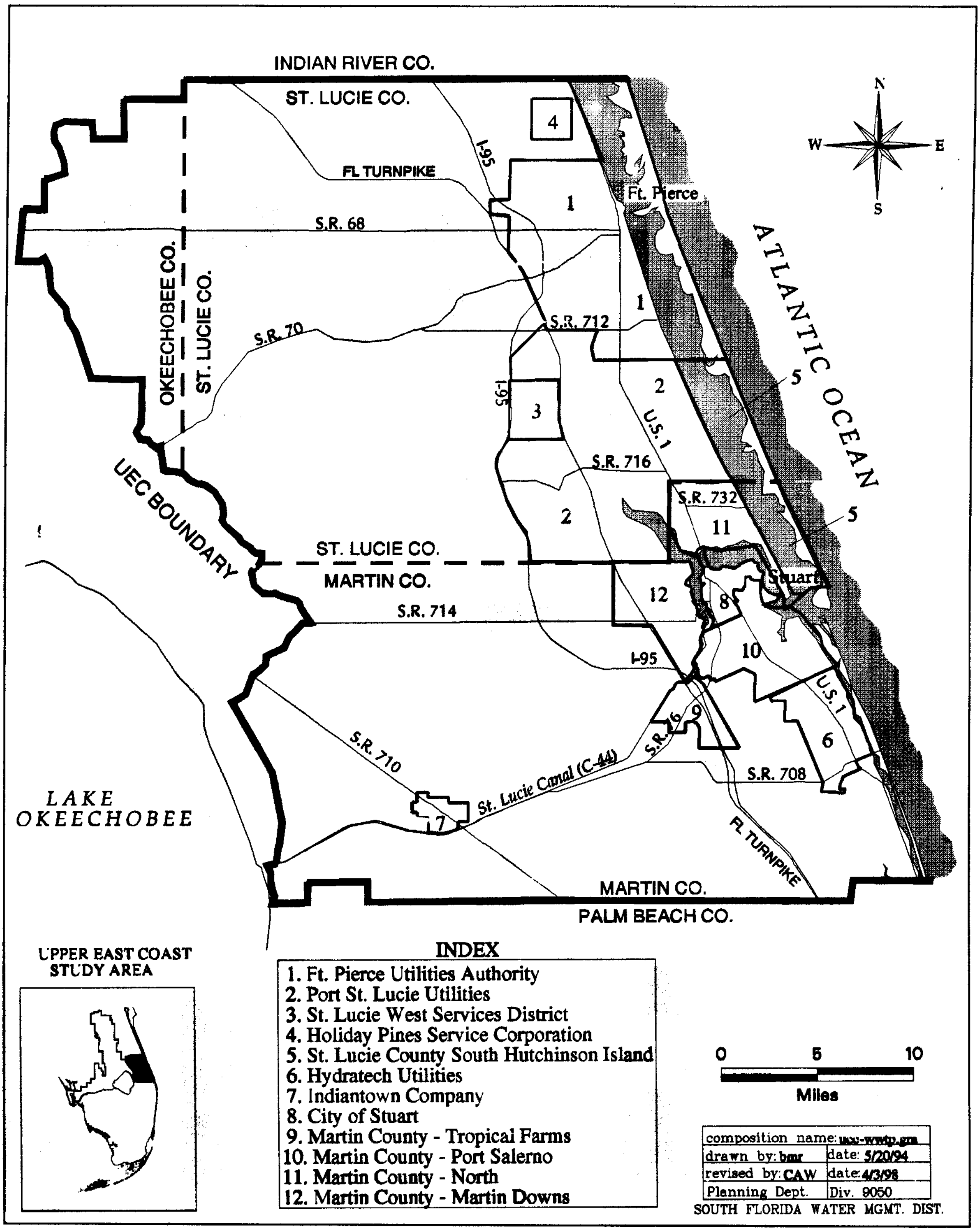


Figure 21. Regional Wastewater Treatment Facility Service Areas.

Chapter 10

ANALYTICAL TOOLS AND MODEL ASSUMPTIONS

ANALYTICAL TOOLS

Computer models were used extensively to assist in development of this plan. The models represent the performance of a real system through a series of equations which describe the physical processes that occur in that system; they represent a simplified version of the real world that may be used to predict the behavior of the modeled system under various conditions. Models were used to simulate the potential impact of 1990 estimated water demands and projected water demands on the environment and ground water sources in the UEC Planning Area, during a 1-in-10 year drought condition and average rainfall conditions. Information from local comprehensive plans, utilities, University of Florida Institute of Food and Agricultural Sciences (IFAS), and the District's permitting data base was used to support this analysis. Where specific information was not available, conservative professional judgement was used.

Analytical tools used in this analysis included surface water budgets, numerical ground water models, and vulnerability mapping. Surface water budgets were used to approximate surface water availability in each of the major surface water basins in order to quantify the demands that could not be satisfied by surface water. The ground water models were used to identify potential impacts of water use on the environment and ground water resources. Vulnerability mapping was used to identify areas where there is the potential for future saltwater intrusion in the SAS. A process diagram of the analytical tools used in the UEC Water Supply Plan is located in Figure 22. Additional information on the analysis associated with this plan can be found in Appendix J.

Surface Water Budgets

Surface water budgets were used to assess surface water availability for water supply in each of the major surface water basins in the UEC region (C-23, C-24, C-25, North Fork St. Lucie River, Tidal St. Lucie), except the C-44 Basin. The surface water budgets indicate whether there is a surplus or deficit (a deficit of surface water would indicate there is insufficient surface water to meet demands) of surface water in each of the major canal basins for the rainfall event chosen. For a given surface water basin, the budget considers the inflows and outflows that affect surface water storage. If inflows exceed outflows, then surface water is sufficient to meet the surface water demand. If outflows exceed inflows, then there is not sufficient surface water to meet

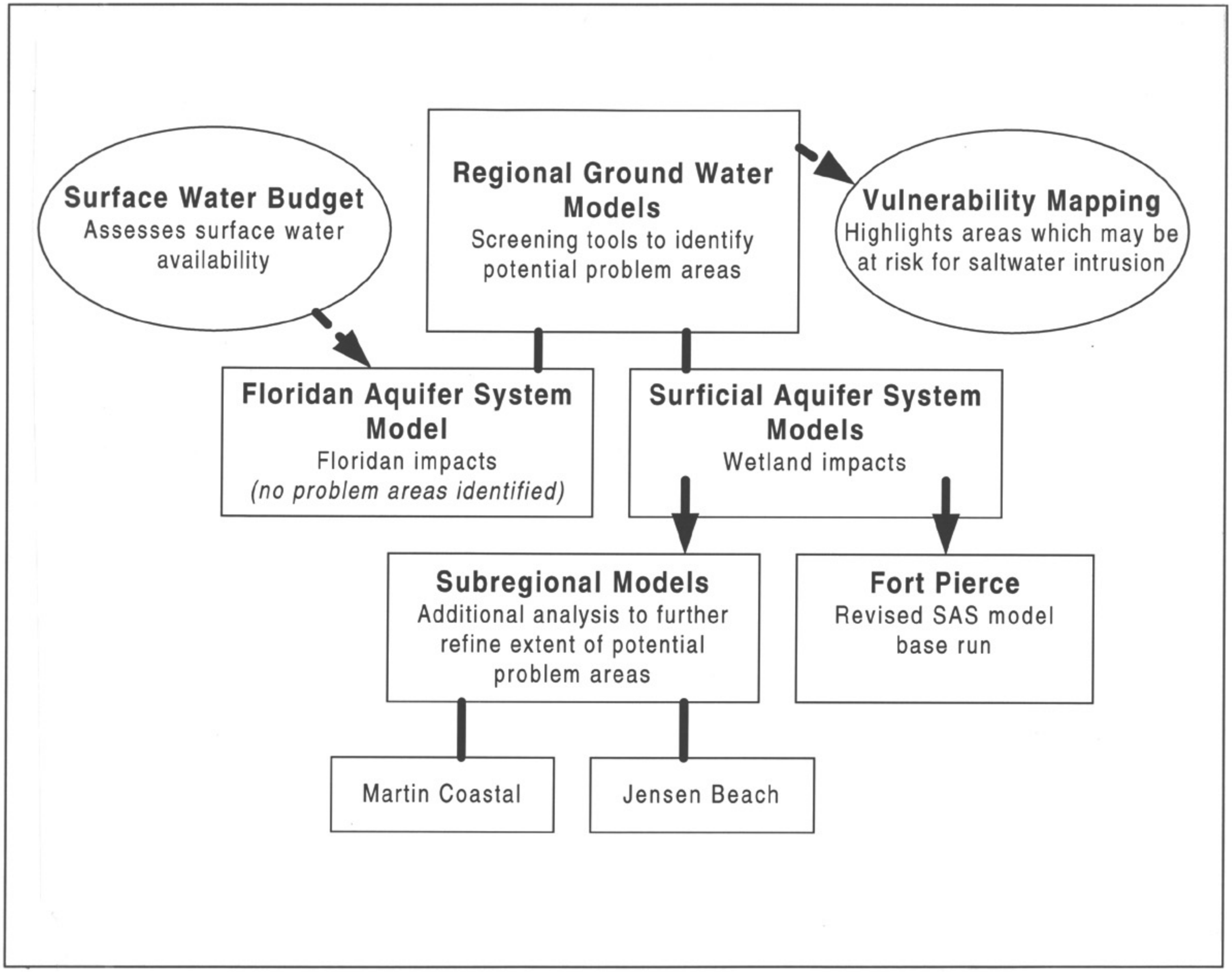


Figure 22. UEC Water Supply Plan Process Diagram and Analytical Tools.

the surface water demand. Unmet surface water needs were distributed to available ground water sources, primarily the Floridan aquifer.

The surface water budgets did not include minimum flows to the St. Lucie Estuary and Indian River Lagoon in that minimum flows have not been determined for these estuarine systems and the tools are not available to analyze the surface water implications. A discussion of minimum flows and levels is provided in Chapter 5. In addition, there are numerous combinations of potential solutions to meet the minimum flow, which are being evaluated in the Indian River Lagoon Restoration Feasibility Study. The results of these efforts will be incorporated into the five-year update of this Plan.

Ground Water Models

Ground water models used in the development of the UEC Water Supply Plan included regional and subregional models. Regional ground water models were used as screening tools to identify areas where water use, based on historical water sources and existing and proposed withdrawal facilities, is potentially impacting the environment or aquifer, during a 1-in-10 year drought condition. In locations where there were concentrated areas of potential impacts, more detailed analyses were conducted.

Based on the regional modeling results, three surficial aquifer system (SAS) areas in the UEC Planning Area were identified for additional analysis: (1) the Jensen Beach Area; (2) the Martin Coastal Area; and (3) the Fort Pierce Area. For the Jensen Beach and Martin Coastal areas, finer resolution subregional “zoom” ground water models were used to conduct the additional analysis. The Fort Pierce Area was examined in more detail using the regional SAS model with refined inputs. Figure 23 indicates the areas encompassed by the regional ground water models and the areas that required additional analysis.

Both the regional and subregional ground water models use the U.S. Geological Survey (USGS) modular three-dimensional finite difference ground water flow model, commonly known as MODFLOW (McDonald and Harbaugh, 1988). The finite difference method depends upon the discretization of the region of flow into a finite number of cells within which hydrogeologic properties are assumed to be uniform. MODFLOW was selected because it allows detailed examination of ground water flow, is available in the public domain, is compatible with most computer systems, and it contains many features, which make it easy to use and modify.

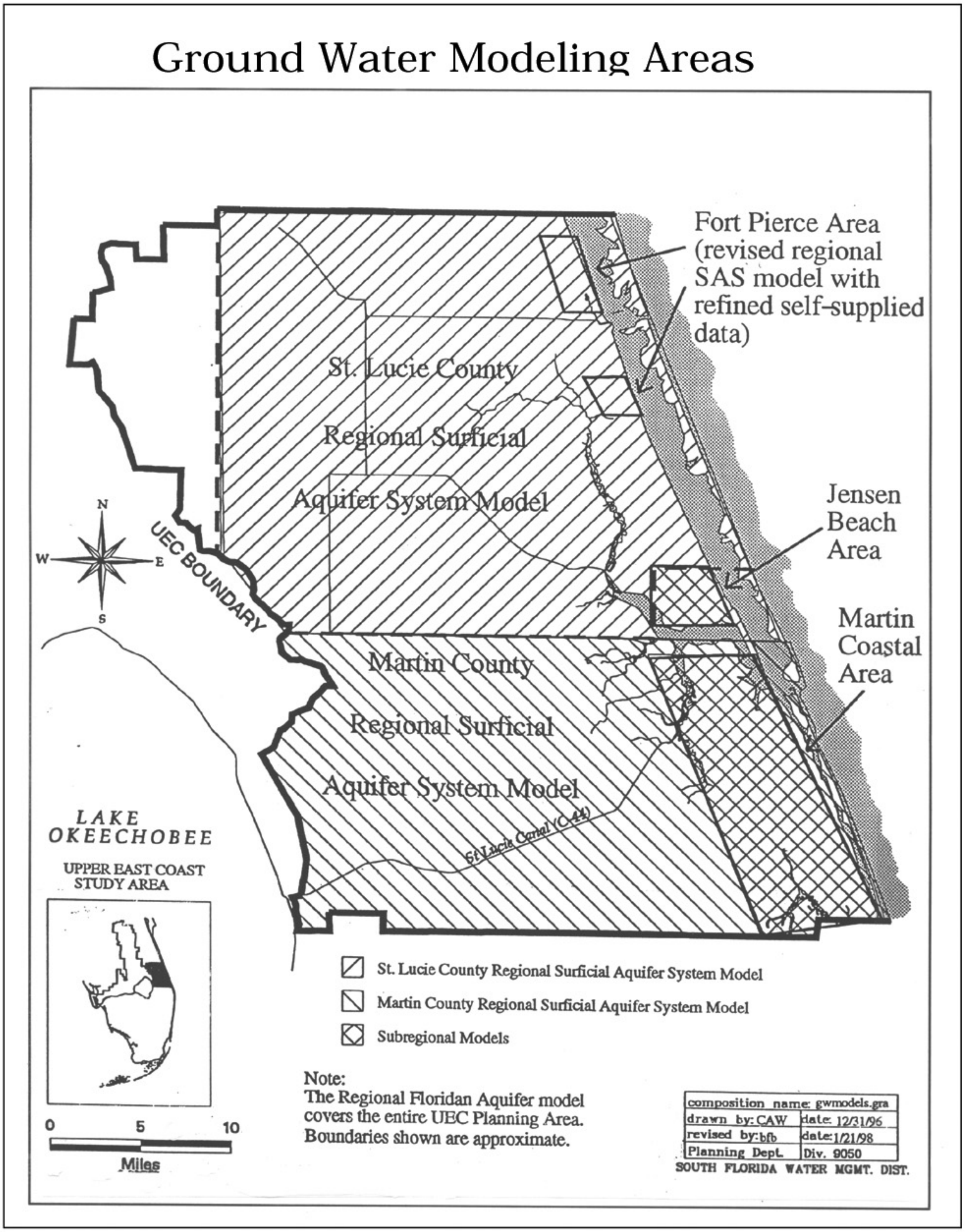


Figure 23. Regional Ground Water Modeling and Subregional Areas.

Each of the ground water models that was used in this plan has been calibrated, tested and reviewed; descriptions and results are presented in SFWMD Technical Publications except for the Martin Coastal Subregional ground water model. The reader who wishes to obtain detailed information regarding model development is referred to Adams (1992) for a description of the Martin County model, Butler and Padgett (1994) for the St. Lucie County model, Lukasiewicz (1992) for the Upper East Coast FAS model and Hopkins (1991) for the Jensen Beach Peninsula Model.

In addition to the identified peer-review of the regional ground water model and Jensen Beach subregional ground water model during their development, the Martin Coastal model and the post-calibration modeling activities for all the ground water models were peer-reviewed for their reasonableness and appropriateness. The reviewers concluded the Martin Coastal model was acceptable, the post-calibration modeling activities were reasonable, and that the overall ground water modeling effort was appropriate for development of this water supply plan.

The area encompassed by the model is divided into cells by a model grid (defined by a system of rows and columns). The ground water models generate two principal types of output, computed head (water levels) which result from the conditions simulated, and water budgets for each active cell. The water budget shows the inflows and outflows for each of the cells.

There are numerous hydrologic properties that the model can represent:

- The aquifer properties of hydraulic conductivity or transmissivity, storage capacity, and vertical conductance
- Initial water level conditions
- Recharge
- Evapotranspiration (ET)
- Ground water/surface water interactions. Rivers and canals can both drain and recharge the aquifer, depending on the relationship of river and aquifer heads; drains do not recharge
- Wells, as either discharge or recharge

Regional Ground Water Models

Three regional ground water models were used to simulate the potential impacts of water use in the UEC region: (1) the Martin County Surficial Aquifer System Model; (2) the St. Lucie County Surficial Aquifer System Model; and, (3) the Floridan Aquifer System Model which encompasses the entire UEC Planning Area. The Surficial Aquifer System models are comprised of cells that are 2,000 feet by 2,000 feet, while the Floridan Aquifer System model is comprised of cells that are one mile by one mile.

These regional models were developed by District staff and documented in peer-reviewed technical publications prior to their use in the UEC Water Supply Plan effort. The regional models were updated to reflect 1990 and future water use demands.

Subregional Ground Water Models

Aside from the regional models, two finer resolution subregional SAS models were used for the Jensen Beach Area and Martin Coastal Area to determine if the potential impacts were an artifact of the scale of the regional models or water use. The ability of the ground water models to reflect the actual ground location of a withdrawal is a function of the cell size or scale used in the model. All withdrawals (wells) that fall within the boundaries of a cell are viewed as coming from the center of that cell, regardless of their specific location. Because of this, as cell sizes are decreased, withdrawals are placed closer to their actual position. The same holds true for the position of wetlands. Consequently, by using the finer scale models, the models more closely represent actual conditions.

The Jensen Beach Area subregional SAS model (Jensen Beach model) was an existing model developed by District staff and documented in a peer-reviewed technical publication that was updated for this planning effort. The Jensen Beach model encompasses the Jensen Beach peninsula in Martin County and is comprised of cells that are 240 by 240 feet. Approximately 69 Jensen Beach model cells fit into one regional model cell.

The Martin Coastal Area subregional SAS model (Martin Coastal model) was developed during the planning process and encompasses the area from the St. Lucie River south to the Loxahatchee River and from the Atlantic Ocean west to the turnpike and is comprised of cells that are 500 by 500 feet. Approximately 16 Martin Coastal model cells fit into one regional model cell. Documentation on the Martin Coastal Subregional Model is provided in Appendix J.

Vulnerability Mapping

Vulnerability mapping is a technique used to identify potential problem areas, especially in water resource investigations, by weighting key factors that can cause the problem. It was used in the UEC Water Supply Plan to evaluate the potential for saltwater intrusion. The factors and weights used in this evaluation were: water levels or heads (50%), proximity or distance to saltwater (25%), and potential (25%). The potential factor is calculated from flow through a cell, magnitude of the flow, and "historic" or "previous" chloride recordings greater than 100 mg/L. Several of these factors were outputs from the regional SAS models. Vulnerability mapping for this application highlights areas that have the highest potential for saltwater intrusion relative to the rest of the region. It does not determine areas that have or will have saltwater intrusion.

Vulnerability mapping is intended to provide a comprehensive view of the potential for saltwater intrusion within the region. By identifying those areas most vulnerable to saltwater intrusion, the plan provides users and regulators the foundation from which to take a strong proactive approach to the management of saltwater intrusion.

MODEL ASSUMPTIONS

The model is first calibrated by matching computed responses to observed conditions in the natural system. During this process, certain data and assumptions are applied to the range of conditions that the model can represent. Once calibrated, certain conditions can be varied to represent alternate circumstances, while others remain fixed. Conditions of water levels, recharge, evapotranspiration, wells, and surface water can be altered to determine response to stress. Those that remain fixed are the area discretization and the aquifer properties. Following is a description of the conditions and assumptions used in each of the models for predictive planning purposes. Additional discussion and information of the post-calibration modeling activities is provided in Appendix J.

Water Supply Needs

The water supply needs or water demands for human uses (public water supply and residential self supplied) and irrigation uses (agriculture, turf grass, etc.) needs to be reflected in the analysis. The methodology and projections for these uses are explained in Appendix G in addition to the information provided below.

It was assumed water use characteristics and management conditions would remain the same as 1990. It was assumed that future water users would obtain water from the same sources as existing users. It was further assumed that existing water users would utilize the same sources for both their current and future demands unless information was made available indicating a change. The existing and projected use of reclaimed water (where information was available) was incorporated into the simulations, as well as reductions in public water supply water use resulting from implementation of mandatory conservation measures.

Public Water Supply and Residential Self Supplied Demands

Public water supply and domestic self-supplied demands were based on historic per capita water use and monthly distribution patterns. Actual pumpage information was used in the 1990 model simulations, while projected demands were based on population projections from local government comprehensive plans. Public water supply demand was taken from existing and/or proposed facilities. Some of these facilities may not have been intended to supply that level of demand. Simulated pumpages, facilities, and sources for each utility are provided in Appendix J.

For the regional model runs, self-supplied demand, which is not usually incorporated in the cumulative analysis associated with consumptive use permitting, was uniformly distributed over utility service areas and planning areas. More refined data inputs were developed for the subregional analysis. Specifically, rather than distributing domestic self-supplied demand evenly over an entire planning or utility service area, more precise locations for domestic self-supplied and small water treatment “package” plant withdrawals were determined by looking at aerial photographs and meeting with utility representatives. Maps indicating the location of residential self-supplied areas are located in Appendix J.

Recharge from septic tanks was not incorporated into the analysis, but local public health units estimate these systems are treating up to 8 mgd in the UEC Planning Area. Recharge from septic tanks could potentially offset potential impacts from residential self-supplied users, since many wells coexist with septic tanks.

Irrigation Demands

All irrigation demands were calculated using the modified Blaney-Criddle method for each rainfall condition. A detailed discussion of this method can be found in the District’s Management of Water Use Permitting Information Manual, Volume III (1994). Blaney-Criddle is currently used in estimating supplemental crop requirements in the District’s consumptive use permitting (CUP) program.

The Blaney-Criddle model calculates monthly ET based on average air temperature, hours of daylight, and growth coefficients of a crop. Effective rainfall is then determined, based on ET rate, rainfall amount, and soil water retention capability. Finally, the supplemental irrigation requirement is calculated, as the difference between ET and effective rainfall. The 1990 demand level represents the estimated agricultural water demand for the use type and acreage that was permitted by the District through the end of 1990. The associated demand was then calculated based on the simulated rainfall event. The future demand level is based on projected agricultural acreage. The location of withdrawals was based primarily on the District's CUP database.

Rainfall Recharge

Two rainfall conditions were simulated to identify the difference between likely chronic problems, occurring under average rainfall conditions, versus problems expected only during droughts. A 12-month dry rainfall event that occurs, statistically, no more frequently than once every ten years was simulated for each county. This rainfall event is referred to as a 1-in-10 year drought condition or a 1-in-10 level of certainty. Rainfall is discussed in greater detail in Appendix C.

All recharge to the models was assumed to be derived either from rainfall or from lateral recharge from outside the model boundaries. Not all rainfall becomes recharge; some is used by vegetation and some evaporates from the ground surface before it infiltrates. In the Surficial Aquifer models, generally between 60 and 85 percent of monthly rainfall ultimately become recharge to the models. There is no rainfall-derived recharge to the FAS model.

Evapotranspiration

Evapotranspiration (ET) is assumed to be a function of potential ET. This maximum rate occurs when water levels are at or above an ET surface assumed to be equivalent to or slightly below land surface. The rate diminishes as water levels approach the extinction depth, which is a function of land use, predominant vegetation type, or both.

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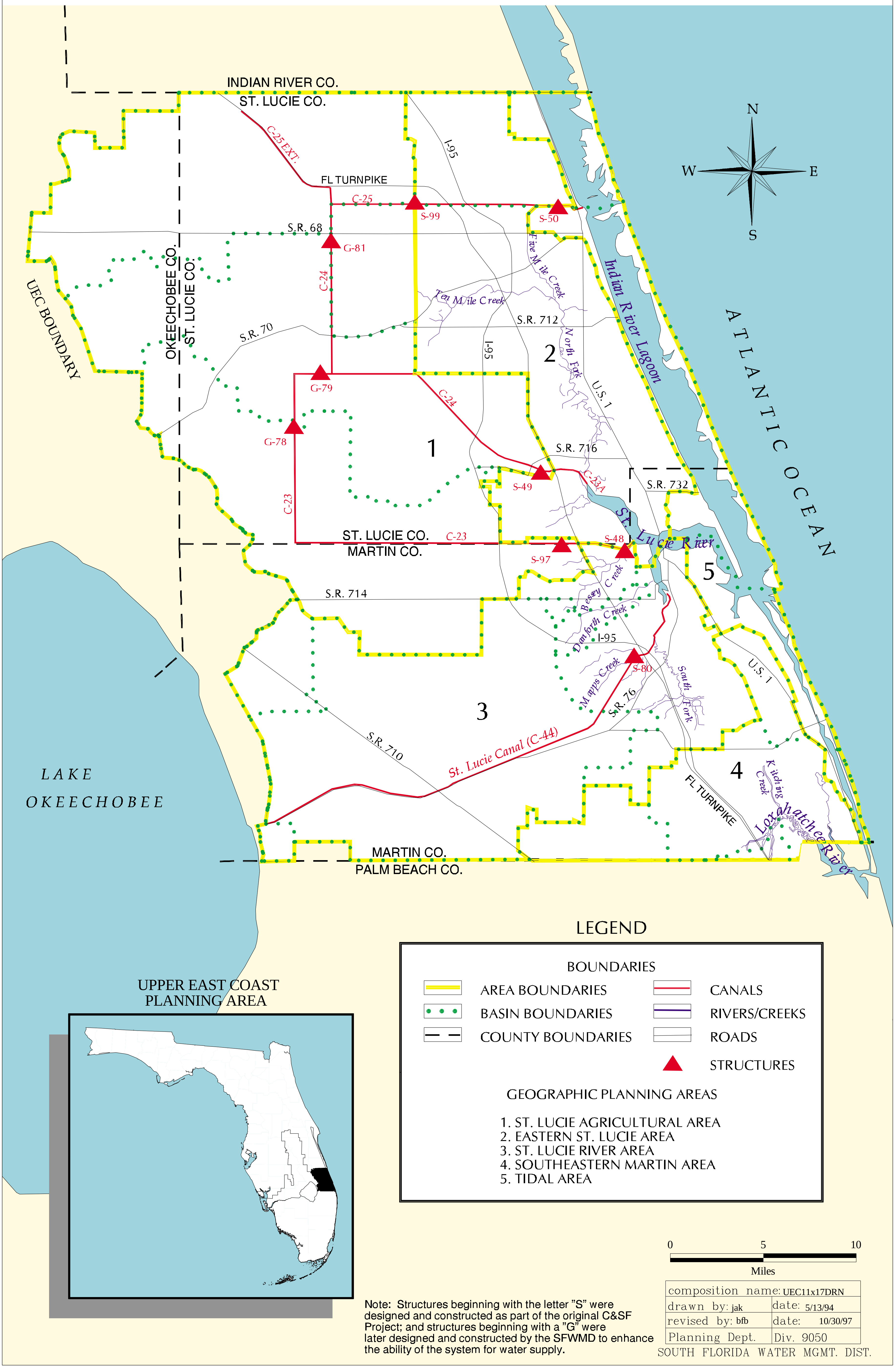
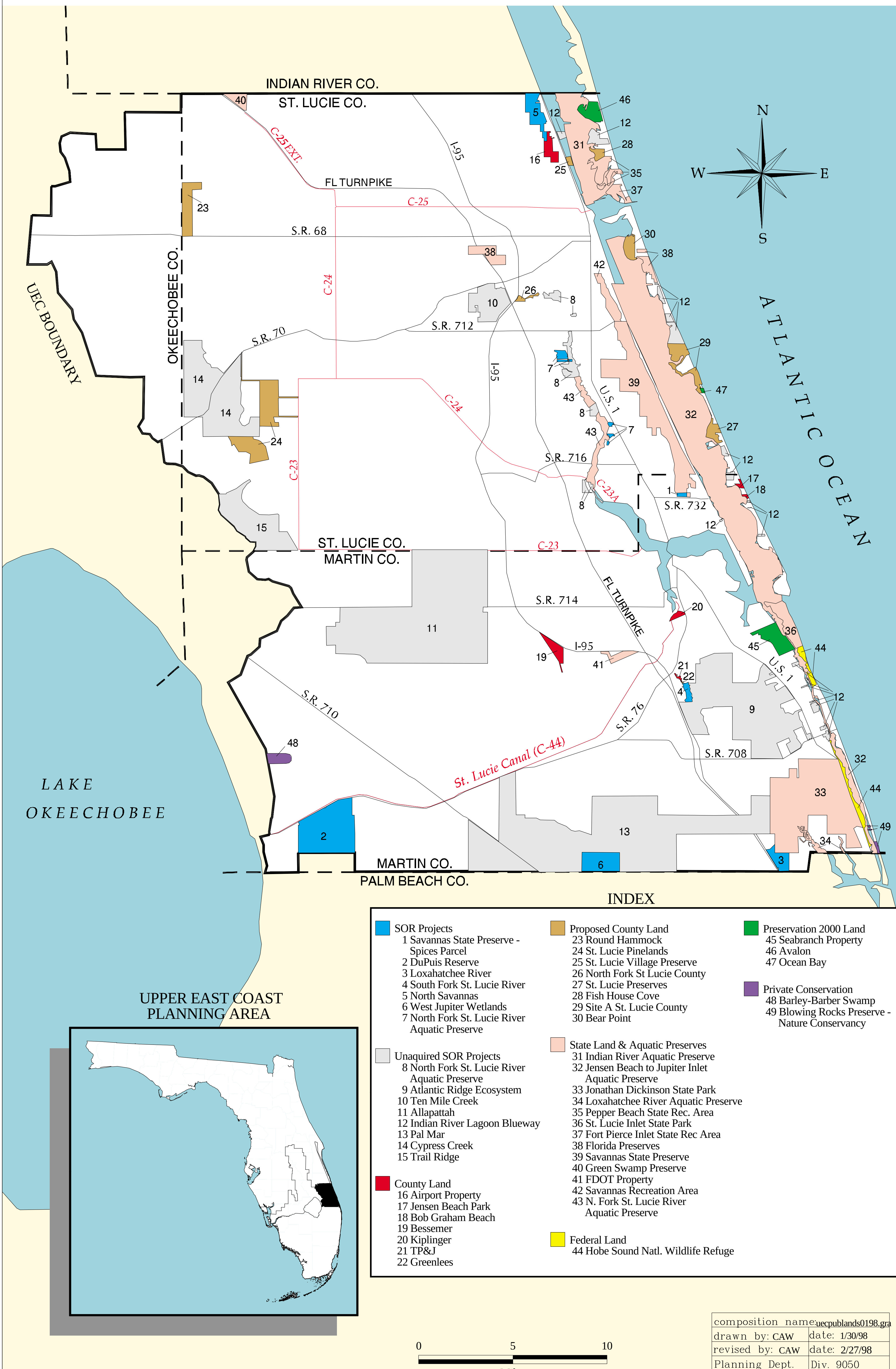
MAJOR DRAINAGE BASINS, RIVERS AND CANALS IN THE UPPER EAST COAST PLANNING AREA



Note: Structures beginning with the letter "S" were designed and constructed as part of the original C&SF Project; and structures beginning with a "G" were later designed and constructed by the SFWMD to enhance the ability of the system for water supply.

CONSERVATION AND PUBLIC LANDS IN THE UPPER EAST COAST PLANNING AREA



WETLAND SYSTEMS IN THE UPPER EAST COAST PLANNING AREA