Lower West Coast Water Supply Plan

Support Document

Volume 2

prepared by

South Florida Water Management District

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Water Supply Planning and
Development Department
West Palm Beach, Florida

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LIST OF ABBREVIATIONS AND ACRONYMS

AC-FT	acre-feet
ADAPS	Automated Data Processing System (USGS)
AFSIRS	Agricultural Field Scale Irrigation Requirements Simulation
AGWQMN	Ambient Ground Water Quality Monitoring Network
ASR	Aquifer Storage and Recovery
ATRP	Abandoned Tank Restoration Program
AWWA	American Water Works Association
BCBB	Big Cypress Basin Board
BCBWMP	Big Cypress Basin Water Management Plan
BMPs	Best Management Practices
BOD	Biochemical Oxygen Demand
BOR	Basis of Review
CARL	Conservation and Recreation Lands
C&SF Project	Central and Southern Florida Flood Control Project
CCMP	Comprehensive Conservation and Management Plan
CERP	Comprehensive Everglades Restoration Plan
CHNEP	Charlotte Harbor National Estuary Program
COD	Chemical Oxygen Demand
CR	County Road
CREW	Corkscrew Regional Ecosystem Watershed
CUP	Consumptive Use Permit
CWMP	Caloosahatchee Water Management Plan
DBP	Disinfection By-Product
D/DBPR	Disinfectant/Disinfection By-Product Rule
DEP	Florida Department of Environmental Protection
District	South Florida Water Management District
DRI	Developments of Regional Impact
DWMP	District Water Management Plan
DWSA	District Water Supply Assessment

DWSRF	Drinking Water State Revolving Funds
DSS	Domestic Self-Supplied
EAA	Everglades Agriculture Area
ECP	Everglades Construction Project
ECWCD	East County Water Control District
ED	Electrodialysis
EDD	Everglades Drainage District
EDI	Early Detection Incentive
EDR	Electrodialysis Reversal
EEL	Environmentally Endangered Lands
EOC	Emergency Operations Center
EPA	Everglades Protection Area
ERP	Environmental Resource Permitting
F.A.C.	Florida Administrative Code
FAU	Florida Atlantic University
FAS	Floridan Aquifer System
FCD	Central and Southern Florida Flood Control District
FDACS	Florida Department of Agriculture and Consumer Services
FDEP	Florida Department of Environmental Protection
FDOH	Florida Department of Health
FDOT	Florida Department of Transportation
FEMA	Federal Emergency Management Agency
FFA	Florida Forever Act
FFWCC	Florida Fish and Wildlife Conservation Commission (*now known as FWC*)
FGFWFC	Florida Game and Freshwater Fish Commission
FGS	Florida Geological Survey
FDHRS	Florida Department of Health and Rehabilitative Services (*now known as FDOH*)
F.S.	Florida Statutes
FWC	Florida Wildlife Commission
FY	Fiscal Year

GAC	Granular Activated Carbon
GIS	Geographic Information System
GWUDI	Ground Water under the Direct Influence of Surface Water
GPD	gallons per day
GPM	gallons per minute
IAS	Intermediate Aquifer System
IESWRT	Interim Enhanced Surface Water Treatment Rule
IFAS	Institute of Food and Agricultural Sciences
ISGM	Integrated Surface Water Ground Water Model
KOE	Kissimmee-Okeechobee-Everglades
LEC	Lower East Coast
LFA	Lower Floridan Aquifer
LWC	Lower West Coast
MCL	Maximum Contaminant Level
MED	Multiple Effect Distillation
MIL	Mobile Irrigation Laboratory
MFLs	Minimum Flows and Levels
mg/L	milligrams per liter
MGD	million gallons per day
MGY	million gallons per year
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MSF	Multistage Flash Distillation
MWC	Molecular Weight Cutoff
NEP	National Estuary Program
NFIP	National Flood Insurance Program
NGVD	National Geodetic Vertical Datum
NPDES	National Pollution Discharge Elimination System
NPL	National Priorities List
NPS	National Park Service
NRCS	Natural Resources Conservation Service

O&M	Operations and Maintenance
P2000	Preservation 2000
PACP	Pre-Approved Advanced Cleanup Program
PCPP	Petroleum Cleanup Participation Program
PIR	Project Implementation Report
PLRG	Pollution Loading Reduction Goals
PWS	Public Water Supply
RAA	Restricted Allocation Area
RECOVER	Restoration, Coordination, and Verification
Restudy	Central and Southern Florida Flood Control Project Comprehensive Review Study
RIB	Rapid Infiltration Basin
RO	Reverse Osmosis
RTA	Reduced Threshold Areas
RTE	Rare, Threatened, or Endangered Species
SALT	Saltwater Intrusion Database (SFWMD)
SAS	Surficial Aquifer System
SDWA	Safe Drinking Water Act
SFWMD	South Florida Water Management District
SGGE	South Golden Glades Estates
SJRWMD	St. Johns River Water Management District
SOR	Save Our Rivers
SOW	Statement of Work
STA	Stormwater Treatment Area
SWCD	Soil and Water Conservation District
SWFS	Southwest Florida Study
SWFWMD	Southwest Florida Water Management District
SWIM	Surface Water Improvement Management
TAZ	Traffic Analysis Zone
THM	Trihalomethane
TTHM	Total Trihalomethanes
TDS	Total Dissolved Solids

UEC	Upper East Coast
UFA	Upper Floridan Aquifer
UIC	Underground Injection Control
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USDW	Underground Source of Drinking Water
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WATBAL	Water Balance Model
WCA	Water Conservation Area
WHPA	Wellhead Protection Area
WICC	Water Independence for Cape Coral
WRCA	Water Resource Caution Area
WSTB	Water Science and Technology Board
WWTP	Wastewater Treatment Plant

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 Lower West Coast (LWC) Water Supply Planning Area is one of four designated planning regions, as indicated in **Figure 1**. Water supply plans for the planning regions have been sequenced based on the history of their water shortage problems. Due to its history of these problems, the LWC Planning Area was selected as the first water supply planning effort to be initiated. The first LWC Water Supply Plan was approved in 1994 and had a future planning horizon through year 2010.

During the 1997 legislative session, significant amendments were made to the Florida Water Resources Act of 1972 (Chapter 373, Florida Statutes) regarding regional water supply planning. These changes required the District to prepare a Districtwide Water Supply Assessment (DWSA) by July 1, 1998, and to then prepare water supply plans for regions that are anticipated to have the potential of demand outstripping available supply by the year 2020. The District had already committed to preparing water supply plans for each of its planning regions, which cumulatively cover the entire District. The DWSA affirmed that commitment. The 1997 amendments also incorporated minimum requirements of water supply plans. In many respects, these amendments also dovetailed with an existing Executive Order 96-297.

This LWC Water Supply Plan Support Document revises information, assumptions, and potential water source options to address new statutory requirements in the 1994 LWC Water Supply Plan, through year 2020. Support Document information was used throughout the LWC Water Supply Plan development process by advisory committee members, regulatory agencies, counties, municipalities, utilities, and various interested parties.

BASIS OF WATER SUPPLY PLANNING

Legal Authority and Requirements

In 1972, the Florida Legislature created the water management districts to manage the state's water resources for various purposes, including water supply. As mentioned

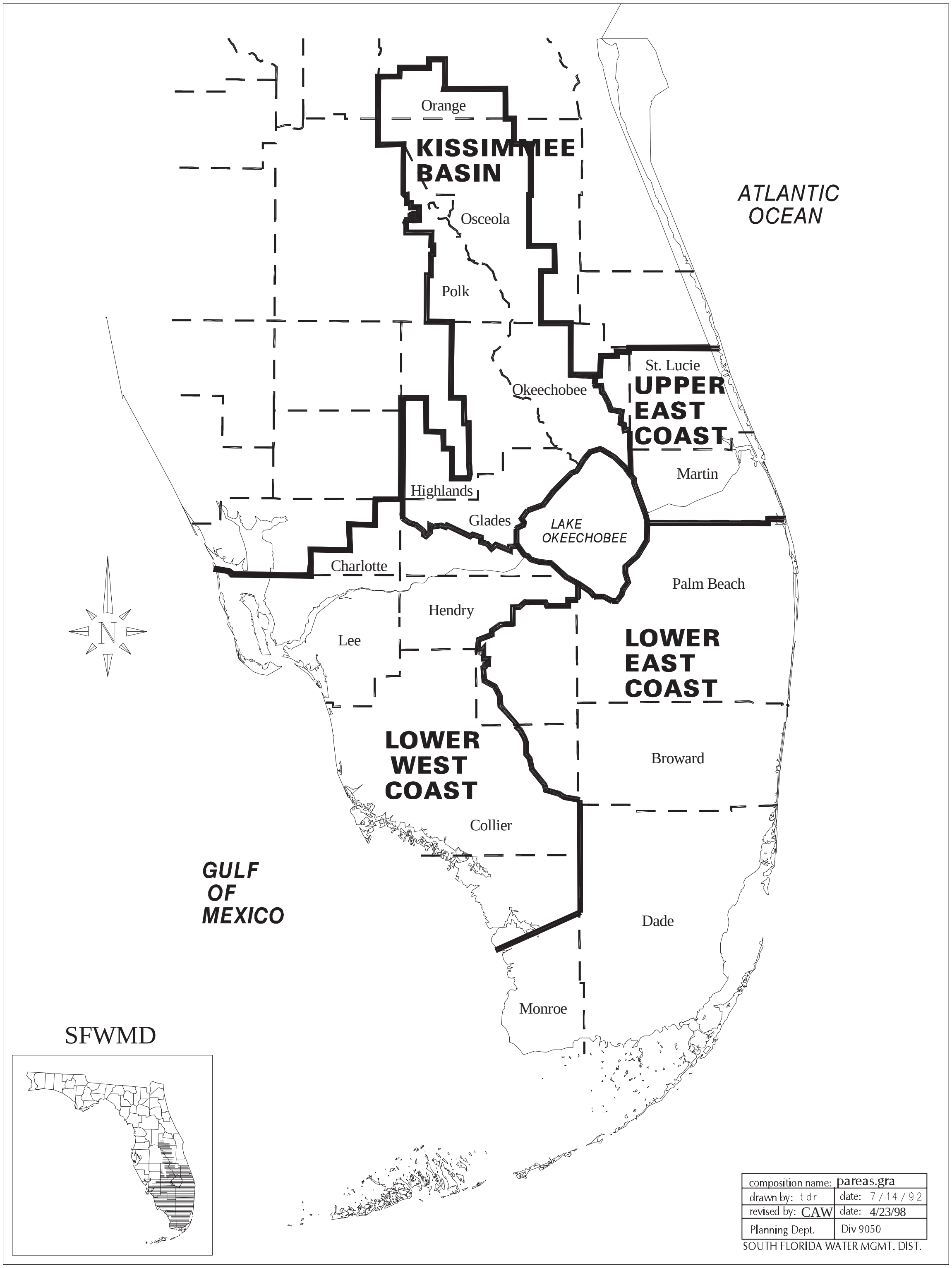


Figure 1. Regional Planning Areas.

above, the 1997 Legislature adopted more specific legislation concerning the role of the water management districts in water supply planning and development. The legislative intent is to provide for human and environmental demands, thereby avoiding competition. The legal basis of the District's water supply planning program in the LWC Planning Area is described in this section. Excerpts of specific Florida statutes and administrative codes cited in this section are provided in Appendix A.

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.

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 FDEP and the water management districts in implementing statutory directives. These directives are prescribed in the Water Resources Act (Chapter 373, F.S.), the Florida Air and Water Pollution Control Act (Chapter 403, F.S.), and, the State Comprehensive Plan (Chapter 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**.

District Water Management Plans are intended to provide comprehensive long-range guidance for the actions of the water management districts in implementing their water supply, water quality, flood protection, and natural system responsibilities under state and federal laws. In addition to other information, the water management plans are required to include a Districtwide water supply assessment. Where the assessment indicates that sources of water are not adequate to meet demands, the development of a regional water supply plan is required. The District 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.

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 began with the development of a Water Supply Policy Document (1991), and continued with the Water Management Plan (1995), Districtwide Water Supply Assessment (1998), and regional water supply plans (on going).

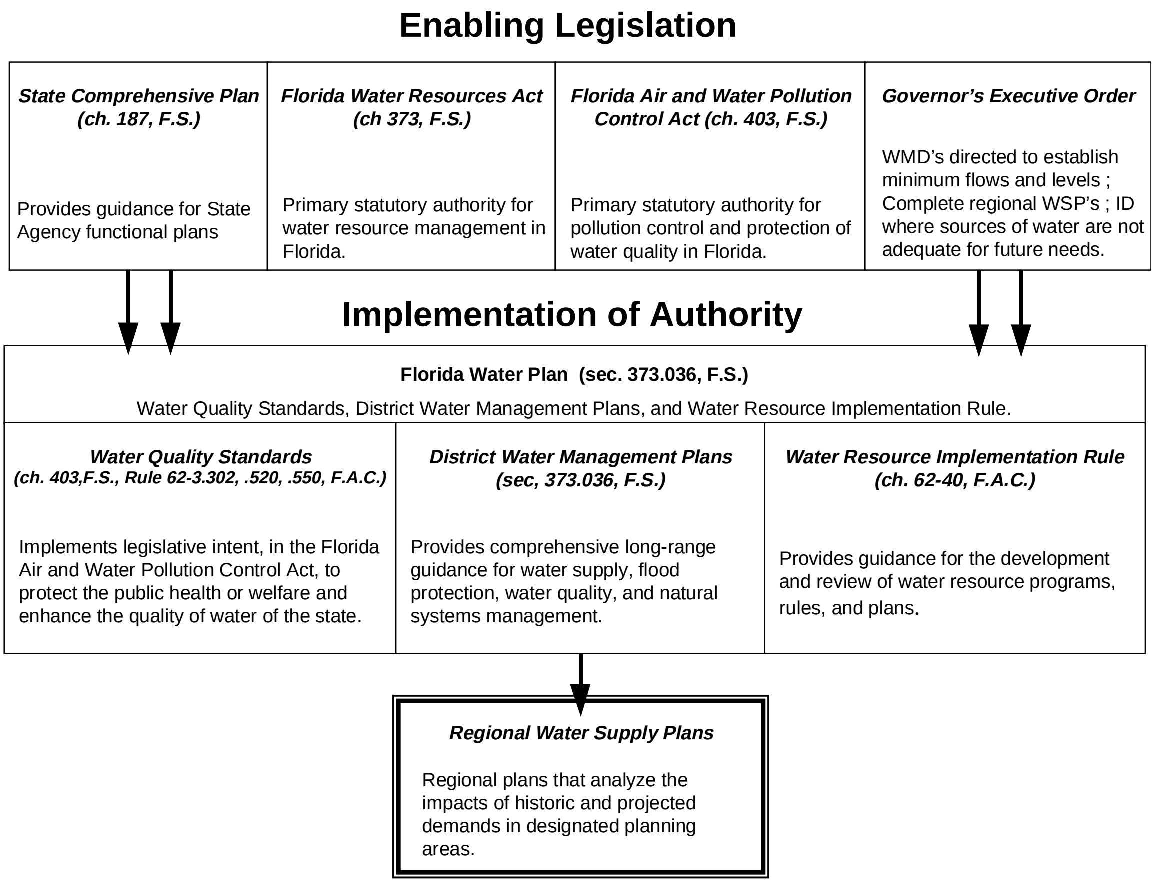


Figure 2. Legal Framework for Water Supply Planning.

Water Supply Policy Document

The District's interpretative summary of the many state statutes and rules governing the uses of surface and ground water in Florida are provided in the Water Supply Policy Document, approved in 1991. The six Water Use Directives, outlined in this document, guide the development of water supply plans:

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) which are required to predict the quantity and quality of water available for reasonable-beneficial uses.

The LWC Water Supply Plan vision, goal and objectives conform to the principles established in these Directives.

District Water Management Plan

The District approved the initial District Water Management Plan (DWMP) in April 1995, which incorporated information from the Needs and Sources Document. One outcome of new legislative revisions of Section 373.036, F.S., in 1997 was that the District would be required to develop a district water management plan that is representative of an overall strategy for future planning and implementation activities. As mentioned above, the DWMP will provide a comprehensive examination of the complex issues of water supply, flood protection, water quality, and natural systems management in South Florida. Based on the 20-year planning period, the DWMP incorporates established schedules for future District planning activities.

The next DWMP update (anticipated by mid-2000) will include: scientific methodologies used in the establishment of minimum flows and levels Section 373.042, F.S.); planning region boundaries; and revised technical data and information (Sections 373.0391 and 373.0395). Data and recommendations will be included from both this LWC Water Supply Plan and the Districtwide Water Supply Assessment (July 1998). The District compiles an annual DWMP progress report on project status, performance measures, and funding requirements.

Districtwide Water Supply Assessment

Section 373.036, F.S., requires water management districts to prepare assessments of water needs and supply sources. The District, through discussions with the FDEP, bifurcated this process, and prepared a Districtwide 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. The significant role of this initial document was to provide information to local governments pursuant to Section 373.0391 and Section 373.0395, F.S., and to facilitate the completion of the District Water Management Plan. As a current data source, the Districtwide Water Supply Assessment (July 1998) (DWSA) presents a composite of water demands for 1995, projections for 2020, and descriptions of surface water and ground water resources within each planning area. The water demands and projections within this LWC Water Supply Plan Support Document were made in conjunction with the DWSA. Additional agricultural water demand and projections were used where new data was available.

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 are developed for each region during the water supply planning process.

Other Related Activities

The District is involved in other plans, studies and activities with direct relationship to the water supply planning initiative and specifically the LWC Water Supply Plan (**Table 1**). These related activities have elements that may affect or be affected by the results of water supply planning analyses.

Table 1. Lower West Coast Related Water Management Planning Efforts.

Plan	Scope/Primary Goal	Relationship to LWCWSP	Timeframes
Caloosahatchee Water Management Plan	Water supply / availability from Caloosahatchee River	Subregional component of the LWCWSP	Completed April 2000
Lake Okeechobee SWIM Plan	Protection and enhancement of Lake Okeechobee and its watershed (water quality)	Backflow/inflow from C-43 Canal	Update completed 1997
Lake Okeechobee Regulation Schedule Environmental Impact Study	Evaluates environmental and economic impacts associated with proposed Lake Okeechobee. Regulation Schedules (quantity)	Discharges from Lake Okeechobee to Caloosahatchee Estuary	1999
Central and Southern Florida Project Comprehensive Review Study (Restudy)	Comprehensive review of environmental impacts of C&SF project	Discharges from Lake Okeechobee to Caloosahatchee River	Completed 1999
Charlotte Harbor National Estuary Program Comprehensive Conservation and Management Plan	USEPA program for restoration	- Supports activities to enhance the Caloosahatchee Estuary - Creates framework to identify funding sources and support partnering	1999
Lower East Coast Regional Water Supply Plan	Adequate and reliable water supply for the Lower East Coast, for natural systems, and Lake Okeechobee service area	Quantify current and future demands and supplies, including surface water in the Caloosahatchee watershed	Draft Plan Completed 1997 Interim Plan 1998 Final Plan 2000
Caloosahatchee River and Estuary Minimum Flow and Level	Prevent significant harm to the water resources and ecology of the Caloosahatchee Estuary	Recovery or prevention strategy has potential to alter future water management activities, including water use	2000
LWC Aquifer System Minimum Flow and Level	Prevent significant harm to the LWC aquifers	Has potential to alter future water management activities, including water use	2000

Incorporation of State Directives into District Water Supply Goals

The District is committed to an overall goal in water supply plans, that is derived from the State Comprehensive Plan:

> 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.

District water supply plans must conform to the six Water Use Directives from the Water Supply Policy Document (1991), referenced earlier in this chapter, if this goal is to be achieved. 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 water resource needs of the region's population, and the need to provide clean water for drinking, other domestic uses, and agriculture. This goal is reflected in the planning process of the LWC Water Supply Plan.

PLANNING PROCESS

The LWC water supply planning process consisted of three overlapping phases: background work; analysis/issue identification; and solution development **(Figure 3)**. Implementation will follow completion of the plan. Advisory committee meetings were held that facilitated the planning process. The advisory committee participated in various activities involving: initial information sharing; issue identification; vision, goal, and objective formulation; identification of possible solutions; strategy development; and, review of draft plan document.

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 this Support Document and Appendices. The assumptions, projections, and results of the 1994 LWC Water Supply Plan were also reviewed.

An advisory committee was established to provide public input throughout the planning process. The primary function of the advisory committee was to provide assistance to the District in the identification and clarification of basin issues, development of acceptable impact criteria, solution identification, and preparation of the plan recommendations presented in this report. The role of the advisory committee is considered to be a key element in the development of this plan and through their assistance, it is hoped that the recommendations contained in this plan will be more

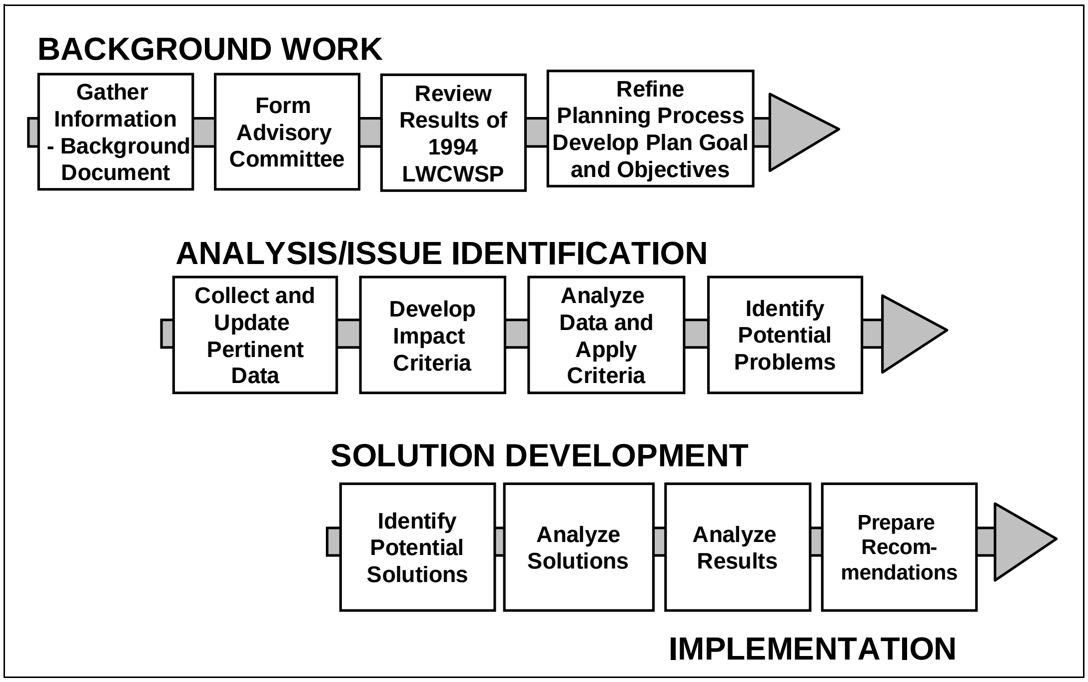


Figure 3. The Lower West Coast Planning Process.

readily accepted by the public during implementation. The advisory committee is discussed in the Public and Agency Participation section, later in this chapter. The advisory committee developed a vision, goal, and objectives for this plan.

Plan Vision

The advisory committee adopted the water resource goal of the State Comprehensive Plan (Chapter 187, F.S.) as the overall vision for the LWC Water Supply Plan:

> 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 vision advances the six principal Water Use Directives from the Water Supply Policy Document (1991), referenced earlier in this chapter.

Plan Goal

To ensure that the LWC Water Supply Plan addresses the specific needs of the region, the advisory committee developed the following goal:

> Identify sufficient sources of water and funding to meet the needs of all reasonable-beneficial uses within the LWC Planning Area through the year 2020 during a drought event that has the probability of occurring no more frequently

than once every ten years, while sustaining the water resources and related natural systems.

Plan Objectives

To ensure that the LWC Water Supply Plan addresses the specific needs of the region, the advisory committee developed the following objectives (no implied priority):

- **Water Sources**: Identify and ensure sustainable and efficient use of water resources sufficient to meet future demands
- **Natural Systems Protection**: Protect natural resources from harm due to water use
- **Level of Certainty**: Establish a 1-in-10 level of certainty for all existing and proposed legal water uses and the environment
- **Compatibility with Local Governments**: Promote compatibility and linkage between the LWC Water Supply Plan and local land use decisions and policies
- **Linkage with Other Regional Plan Efforts**: Promote compatibility and integration with other related regional water resource planning efforts
- **Conservation of Water Supplies**: Promote water conservation and efficient use of water resources
- **Water Supply Needs**: Meet existing and future water supply demands for all reasonable-beneficial uses for the appropriate level of certainty
- **Funding**: Identify adequate sources of funding to support water resource development and water supply development to meet the water supply needs of the LWC Planning Area through the year 2020
- **Water Resource Protection**: Protect water resources from harm due to water use

These objectives captured the key issues and concerns in the LWC Planning Area and provided direction for the planning process.

Analysis/Issue Identification

To identify potential problems or issues that this plan needs to address, District staff consulted several methods and sources including:

- The 1994 LWC Water Supply Plan
- Relevant consumptive use permitting information
- Expertise of the advisory committee

- Information from the Caloosahatchee Water Management Plan

Based on the above 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 Chapter 7. Each water source option was discussed and evaluated by the advisory committee, including the identification of related local and regional responsibilities.

Implementation

Concepts resulting from the solution development phase will be translated into implementation and funding strategies for use by the appropriate departments within the District **(Figure 4)** and other responsible parties. Developing strategies, identifying funding sources and building partnerships for future implementation efforts will be emphasized.

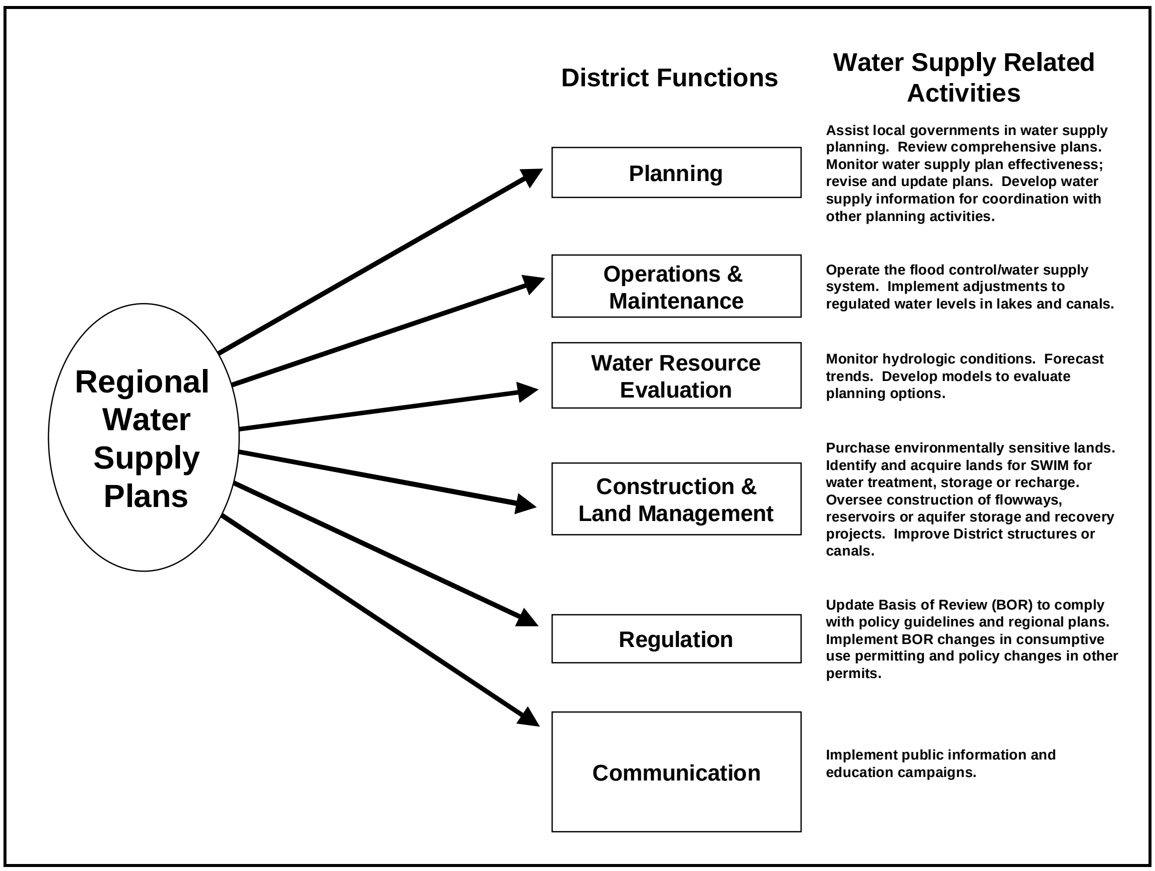


Figure 4. District Water Supply Plan Implementation Activities.

PUBLIC AND AGENCY PARTICIPATION

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

Advisory Committee

A 47-member water supply plan advisory committee was established in December 1998 and provided public input throughout the planning effort. The advisory committee consisted of representatives from interested and affected parties in the LWC Planning Area. The advisory committee began meeting December 2, 1998 and met regularly throughout the planning process. During advisory committee meetings, water supply issues and potential water source options were explored and the information exchanged was useful in developing strategies for future water supply activities. After plan approval, committee members will continue to be informed of the implementation activities through newsletters and periodic status meetings.

Data Confirmation

The technical information incorporated into this Support Document was the basis for discussions of water demand and availability in the LWC Planning Area. Therefore, it is important that this information is accurate so that the most appropriate solutions are presented.

As part of the data collection effort, many entities, such as local governments, state and federal agencies, environmental groups, agricultural interests, and utilities within the LWC 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 LWC 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 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. Demand calculations were finally compiled in the Districtwide Water Supply Assessment (DWSA), approved by the District in 1998. The DWSA projections are referred to in Chapter 6, Demand Estimates and Projections. During the LWC Water Supply Plan development process, these projections were reviewed by area utilities.

Chapter 2
PLANNING AREA DESCRIPTION

PLAN BOUNDARIES

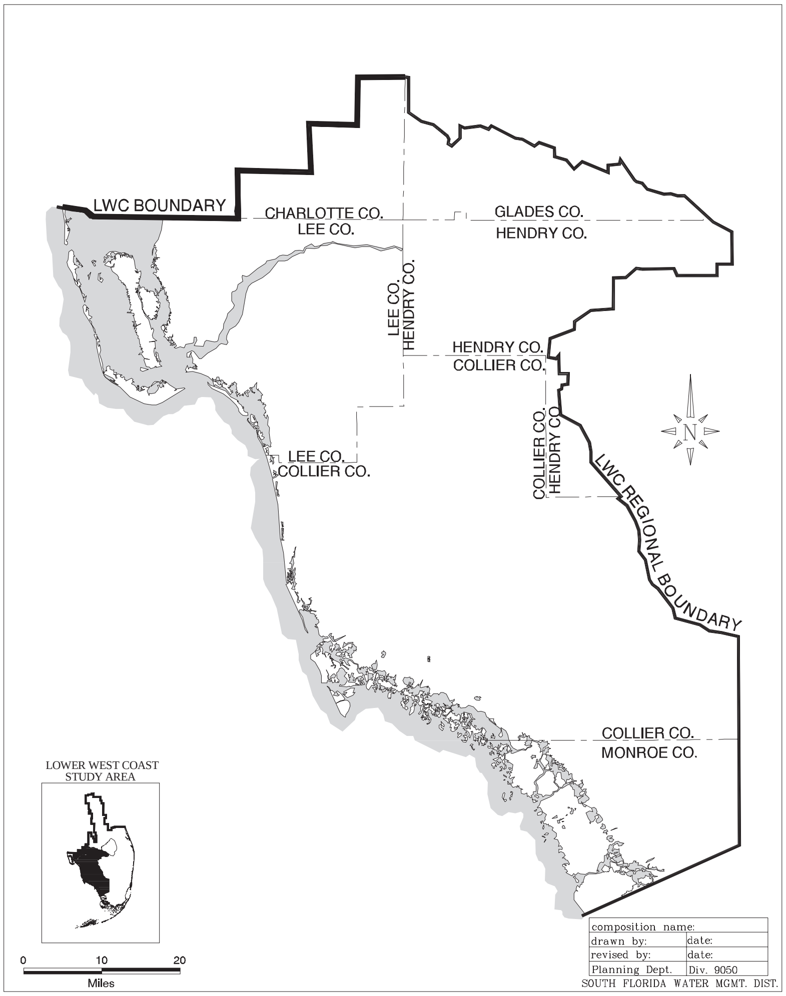


Figure 5. Lower West Coast Planning Area.

The LWC Planning Area includes all of Lee County, most of Collier and Hendry counties, and portions of Charlotte, Glades, and Monroe counties (**Figure 5**). Partial counties are shared with other regional planning areas. The portions of these counties within the LWC Planning Area are referred to as the Collier County Area, Hendry County Area, Charlotte County Area, Glades County Area, and Monroe County Area. The boundaries of the LWC Planning Area generally reflect the drainage patterns of the Caloosahatchee River basin and the Big Cypress Swamp. The northern boundary corresponds to the drainage divide of the Caloosahatchee River, which is generally the SFWMD/ SWFWMD jurisdictional boundary in Charlotte County, while the eastern boundary delineates the divide between the Big Cypress Swamp and Everglades system. The area east of this divide is in the Lower East Coast Planning Area.

Related Planning Areas

The District has established four water supply planning areas: (1) Lower West Coast, (2) Kissimmee Basin, (3) Upper East Coast, and the (4) Lower East Coast. 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 (C-43); (b) the St. Lucie Canal (C-44) to the Upper East Coast; and (c) the West Palm Beach, Hillsborough, North New River, and Miami canals to the Lower East Coast.

The Caloosahatchee River and the St. Lucie Canal are used primarily for water releases 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 Caloosahatchee Basin within the LWC 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 Regional Water Supply Plan.

PHYSICAL FEATURES

Geography and Climate

The LWC Planning Area covers approximately 4,300 square miles. Average seasonal temperatures range from 64.3 degrees in January to 82.6 degrees in August (SWFRPC, 1990). Nearly two-thirds of annual rainfall occurs during the May to October wet season. Rainfall is further discussed in Chapter 3.

Physiography

South Florida is characterized by low topographic relief and a high water table. With this type of flat terrain, a few vertical feet may have a profound effect on surface water drainage, vegetation, and settlement patterns. The dominant surface water feature of South Florida is the Kissimmee-Okeechobee-Everglades (KOE) drainage system, which is critical to the ecology of South Florida. The Kissimmee River, which is currently undergoing restoration, once meandered through a marsh floodplain into Lake Okeechobee. The natural outflow of the lake in the past was through the Everglades to the south. This sheetflow to the “River of Grass” has been replaced with a series of water control structures which regulate the stage and flow of the KOE drainage system.

A large part of the LWC Planning Area lies within the boundary of the Big Cypress physiographic province. This region, which is flat and has large areas with solutionriddled limestone at the surface, drains to the coastal marshes and mangrove swamps of the Ten Thousand Islands. The only major waterway in the LWC Planning Area other than the Caloosahatchee River is the system of canals in western Collier County which are monitored, controlled, and managed by the Big Cypress Basin (a subunit of the SFWMD). The physiography of South Florida is discussed in further detail in “Environments of South Florida: Present and Past II” (Gleason, 1984).

Population

The Lower West Coast Planning Area is expected to experience substantial growth between now and the year 2020 (**Table 2**). The region's population is expected to increase by 68 percent from 1995 levels, (compared to Districtwide projected increase of 43 percent) with urban expansion occurring mostly in the coastal areas. Rapid growth in population, in addition to irrigated agricultural acreage within the LWC Planning Area has caused demands for water to increase significantly.

Table 2. Population, 1995-2020.

County Area	1995	2020	Increase	% Growth
Lee	375,238	594,300	219,062	58
Collier	182,933	349,200	166,267	91
Charlotte	645	1,746	1,101	171
Hendry	27,714	39,999	12,285	44
Glades	4,409	7,560	3,151	71
LWC Planning Area Total	590,939	992,805	401,866	68

Source: Bureau of Economic Business Research (BEBR) Medium Projections.

The estimate of total population in the LWC Planning Area for 1995 was 590,939. The total population is projected to increase by 68 percent to 992,805 in 2020. Most of the population is settled in Lee and Collier counties. More detailed population figures and their associated demands are discussed in Chapter 6. The data sources and methodologies that were used to develop population estimates and projections are provided in Appendix F.

MUNICIPALITIES

There are twelve municipalities in the LWC Planning Area. These are the city of Bonita Springs City, the city of Cape Coral, the city of Clewiston, the city of Everglades City, the city of Fort Myers, the town of Fort Myers Beach, the city of LaBelle, the town of Longboat Key, the city of Marco Island, the city of Moore Haven, the city of Naples, and the city of Sanibel.

AGRICULTURE

The LWC Planning Area continues to experience growth in irrigated agricultural acreage, especially citrus. The irrigated crops in this region are citrus, sugarcane, vegetables, sod, and greenhouse/nursery. Overall growth in citrus acreage in the LWC Planning Area is projected to increase by 30 percent to 166,739 acres by 2020. While the Glades County Area is anticipated to have the highest percent increase in irrigated citrus acreage, the Collier County Area is expected to have the highest actual increase in irrigated citrus acreage by 2020 **(Table 3)**. Estimates and projections of irrigated acreage for all crops are presented in **Chapter 6**.

Table 3. Irrigated Citrus Acreage, 1995-2020.

County Area	1995	2020	Increase	% Growth
Lee	12,197	16,150	3,953	32
Collier	36,559	55,966	19,407	53
Hendry	71,560	82,054	10,494	15
Glades	4,855	8,261	3,406	70
Charlotte	3,088	4,308	1,220	40
LWC Planning Area Total	128,259	166,739	38,480	30

LAND USE

Existing Land Use

Percentage of land uses in each of the county areas within the LWC Planning Area is presented in **Table 4**. Land use within the LWC Planning Area is predominantly wetland, especially in the Charlotte, Collier, Lee, and Monroe county areas. The Collier County Area has the largest percentage and acres of wetlands, while Lee County contains the most urban land use. Urban land use is primarily located in the coastal portions of Lee and Collier county areas. The highest percentages of agriculture is in the Hendry and Glades county areas **(Table 4 and Plates 1 - 4)**.

Updated Land Use Classification System

The Florida Department of Transportation (FDOT) Florida Land Use and 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 LWC Water Supply Plan Background Document (1994).

Table 4. Acreage and Percentage of Land Use by County Planning Area.

	Charlotte Area		Collier Area		Hendry Area		Lee Area		Glades Area		Monroe Area[a]		LWC Planning Area	
Land Use	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**
Urban	2,428	2	79,663	7	21,140	5	196,424	37	7,464	3	30	0	324,338	11
Agriculture	45,598	30	135,980	12	242,391	62	77,467	15	96,236	48	104	0	654,983	22
Range	13,787	9	14,552	1	15,834	4	18,281	3	12,156	6	0	0	61,952	3
Upland Forest	50,763	33	118,655	10	32,168	8	88,974	17	49,597	25	3891	1	285,360	13
Water	371	0	16,064	1	4,194	1	25,413	5	998	1	4,554	2	21,082	1
Wetland	39,171	26	810,739	69	72,334	19	115,194	22	32,478	16	272,483	97	1,344,253	49
Barren	769	0	4,929	0	2,460	1	10,205	1	2012	1	78	0	13,619	1
Total	152,890	100	1,180,584	100	390,524	100	531,960	100	200,943	100	281,140	100	2,705,587	100

a. The Monroe County Area consists of portions of Everglades National Park and Big Cypress Basin which have neither agricultural nor urban demands.

Source: SFWMD Florida Land Use/Land Cover GIS database, 1995.

Land Use Trends

Based on local government comprehensive plans, urbanization is anticipated to increase in the Lee and Collier county areas. Agriculture has been the predominant land use in Hendry and Glades county areas and is projected to remain so in the future. In Lee and Collier counties, the percentage of agricultural land use is projected to decrease as a result of urban encroachment.

Chapter 3
WATER RESOURCES AND SYSTEM OVERVIEW

REGIONAL HYDROLOGIC CYCLE

The main components of the hydrologic cycle in the LWC Planning Area are precipitation (and the resulting infiltration); evapotranspiration (and the resulting withdrawal); surface water inflow and outflow; and ground water flow.

Precipitation and Evapotranspiration

The average annual precipitation in the LWC Planning Area is approximately 52 inches (**Figure 6**). Nearly two-thirds of the rainfall occurs during the six-month wet season from May through October. Much of this rainfall is returned to the atmosphere by plant transpiration or evaporation from soils and water surfaces. Hydrologic and meteorologic methods are available to measure and/or estimate the combined rate at which water is returned to the atmosphere by transpiration and evaporation. The combined processes are known as evapotranspiration (ET).

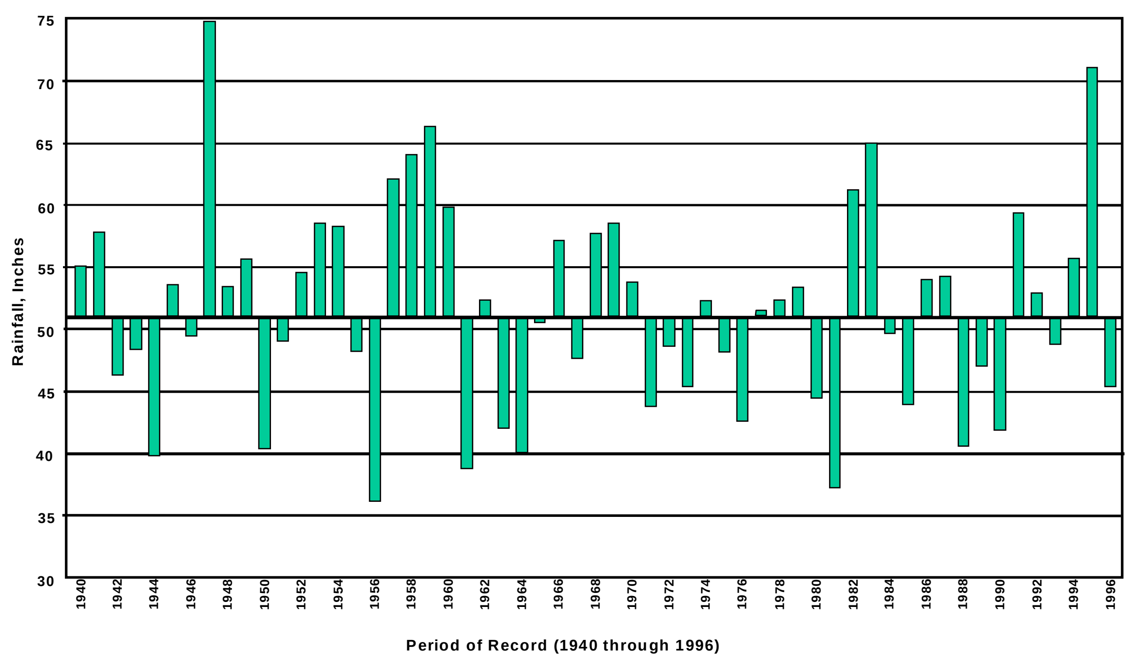


Figure 6. Variation from Annual Average Rainfall in the Lower West Coast Planning Area.

Evapotranspiration (ET), like rainfall, 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. Historical rainfall data and the results of a frequency analysis are presented in Appendix B.

Surface Water Inflow and Outflow

Most surface water in the LWC Planning Area is derived from rainfall. fhe exception to this is the Caloosahatchee River Canal (C-43), which also receives water from Lake Okeechobee. Historic flowways in the region were the natural drainage features consisting of a series of flat wetlands or swamps connected by shallow drainage ways or sloughs that were divided by low ridges. These features were dry for a portion of the year, and overtopped by water in periods of seasonal high rainfall (Nath, 1998). The majority of the canals in the LWC Planning Area were constructed as surface water drainage systems rather than for water supply purposes. The C-43 Canal is the only major canal used for water supply and it is maintained by releases from Lake Okeechobee. The amount of stored water is of critical importance to both the natural ecosystems and the developed areas in the LWC 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. Improved management of surface water drainage systems could have an extensive affect on the movement of water through the regional hydrologic cycle.

Ground Water Flow

Three aquifer systems, the Surficial Aquifer System (SAS), the Intermediate Aquifer System (IAS) and the Floridan Aquifer System (FAS), underlie the LWC Planning Area. Rainfall is the main source of recharge to the SAS. Ground water inflows from outside the LWC Planning Area from a much smaller portion of recharge to the SAS. The IAS is partially recharged from the SAS. The FAS receives its recharge from outside of the LWC Planning Area. Fairbank and Hohner (1995) present maps showing the spatial recharge rates into the SAS and the IAS.

SURFACE WATER RESOURCES

Prior to development, nearly level, poorly drained lands subject to frequent flooding characterized most of the LWC Planning Area. The natural surface drainage systems included large expanses of sloughs and marshes such as Telegraph Cypress Swamp, Corkscrew Swamp, Flint Pen Strand, Camp Keais Strand, Six Mile Cypress Slough, Okaloacoochee Slough and Twelve Mile Slough.

Lakes, Rivers, Canals, and Drainage Basins

Surface water bodies in the LWC Planning Area include lakes, rivers, and canals, which provide storage and conveyance of surface water. Lake Trafford and Lake

Hicpochee are the two largest lakes within the LWC Planning Area, but neither lake is considered a good source of water supply. **Plate 1** shows the lakes, rivers, canals and drainage basins (see below) in the LWC Planning Area.

The Caloosahatchee River is the most important source of surface water in the region and extends across seven of the ten drainage basins in the LWC Planning Area. The river is supplied by inflows from Lake Okeechobee and runoff from within its own basin. The freshwater portion of the river (C-43) extends eastward from the Franklin Lock and Dam (S-79) towards Lake Okeechobee and the cities of LaBelle and Moore Haven. West of S-79, the river mixes freely with estuarine water as it empties into the Gulf of Mexico.

The remaining rivers and canals in the LWC Planning Area drain either into Estero Bay, the Caloosahatchee River or the Gulf of Mexico. The majority of canals were constructed as surface water drainage systems rather than for water supply purposes. The C-43 Canal is the only major canal used for water supply and it is maintained by releases from Lake Okeechobee.

Drainage Basins

The LWC Planning Area is divided into 10 major drainage basins according to their respective hydrologic characteristics (**Plate 1**). These basins are the (1) North Coastal Basin, (2) Tidal Caloosahatchee Basin, (3) Telegraph Swamp Basin, (4) West Caloosahatchee Basin, (5) East Caloosahatchee Basin, (6) C-21 Basin, (7) S-236 Basin, (8) Estero Bay Basin, (9) West Collier Basin, and (10) East Collier Basin. The West Collier and East Collier basins have extensive wetland systems, which are described in Chapter 4 Natural Resources, in this document.

Some of the major rivers, and canals of the drainage basins have surface water bodies with regional water supply and include the Big Cypress Basin canal system and the Caloosahatchee River **(Figure 7)**. The LWC Planning Document (1994) recommended that the District identify opportunities to cooperatively evaluate the feasibility of using the Caloosahatchee River as a seasonal source of supply. The Caloosahatchee Water Management Plan (CWMP), completed in April 2000, addresses availability of water from the river. Recommendations from the CWMP are included in the 2000 LWC Water Supply Plan. Other regional recommendations in the 1994 LWC Planning Document include assisting Lee County in adopting the Lee County Surface Water Management Plan, which recommends increasing water supply within the county's basins; and working with public water suppliers and local governments in identifying additional sites for ASR projects.

North Coastal Basin

The North Coastal Basin is in southwestern Charlotte County and northwestern Lee County. There are numerous creeks within this basin. The basin drains via overland flow from the Fred C. Babcock/Cecil M. Webb Wildlife Management Area in Charlotte County into the Gator Slough watershed within northwestern Lee County. Most of this

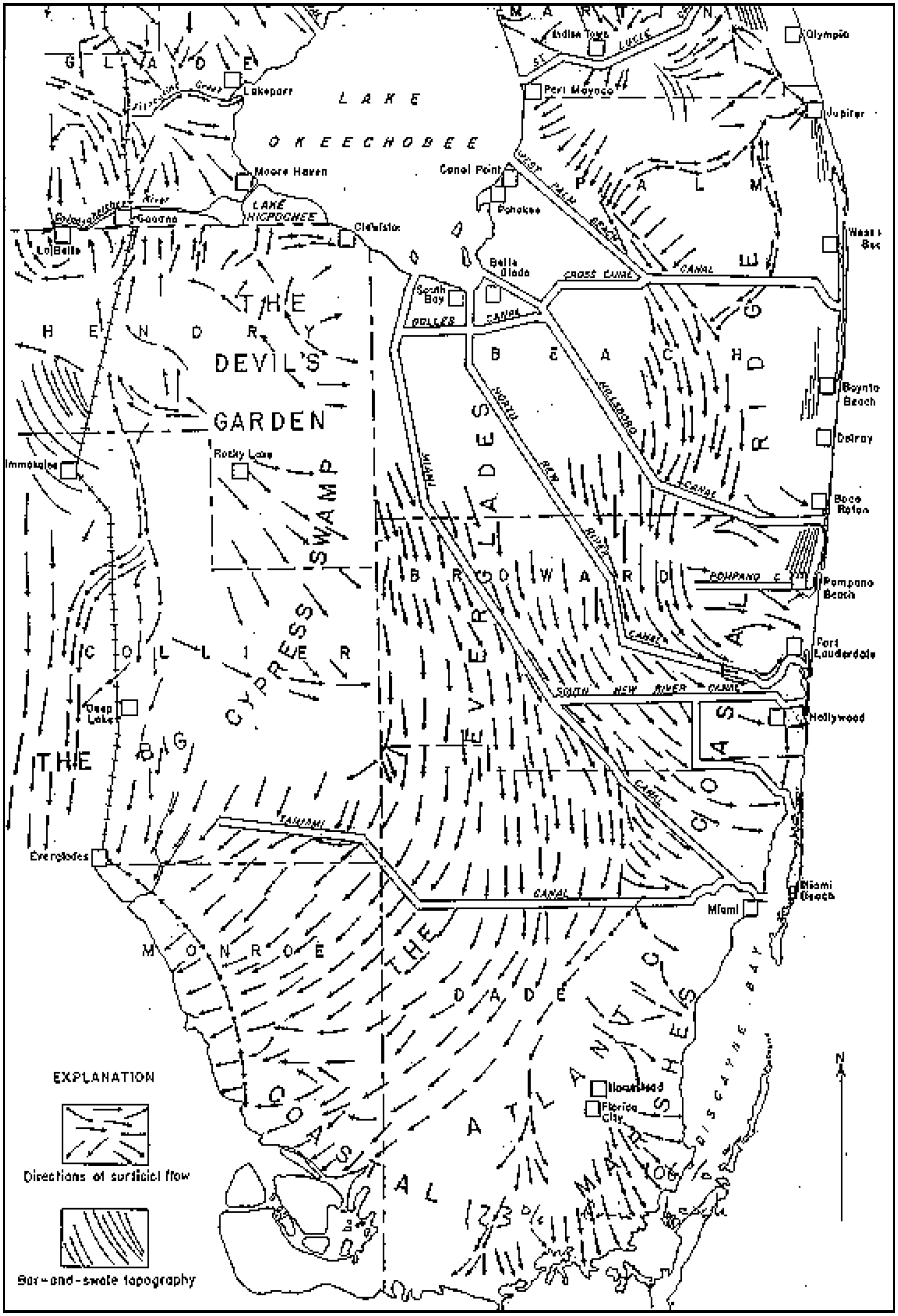


Figure 7. Historic Surface Water Drainage System in the South Florida (Parker, et. al, 1955).

basin drains through the Gator Slough Canal into the Cape Coral Canal System. Improvements were made in 1998 to divert water to Cape Coral for direct use or recharge.

Tidal Caloosahatchee Basin

The Tidal Caloosahatchee Basin extends on both sides of the saltwater portion of the Caloosahatchee Basin, northerly into Charlotte County. Numerous creeks drain into the Caloosahatchee River in this basin. These creeks are tidally influenced and are not currently suitable as a major source of surface water withdrawal. The Lee County Interim Surface Water Management Plan (Johnson Engineering et al., 1990) recommends putting weirs in several of the creeks to maintain water levels in the dry season. The report suggests that Trout Creek and the channelized portion of the Orange River have a potential for water supply. Trout Creek receives drainage from the Fred C. Babcock/Cecil M. Webb area via sheetflow and a large canal; placing a weir in the creek would enhance its water supply potential. In the Lehigh Acres area, the weirs in Able Canal (the channelized portion of the Orange River) provide recharge to the area. East County Water Control District is modifying internal weirs to retain more water on-site for ground water recharge.

Telegraph Swamp Basin

The Telegraph Swamp Basin extends from Charlotte County southward to the Caloosahatchee River. The major feature of this basin is the Telegraph Cypress Swamp which drains via sheetflow into Telegraph Creek in Lee County. Since this is a large watershed (approximately 92 square miles) with sheetflow discharge, there is a potential for this basin to be a good recharge area (Johnson Engineering et al., 1990).

West and East Caloosahatchee, C-21, and S-236 Basins

The West and East Caloosahatchee, C-21, and S-236 basins extend along the freshwater portion of the Caloosahatchee River (C-43 Canal), from S-79 (Franklin Lock and Dam) to S-77 at Lake Okeechobee. The basins include parts of Lee, Collier, Hendry, Glades, and Charlotte counties. The C-43 Canal is the major surface water resource within these basins. The primary purpose for the canal is to provide relief for regulatory releases of excess water from Lake Okeechobee. In the East Caloosahatchee Basin, Lake Hicpochee was severely impacted by the construction of the C-43 Canal. The canal was constructed through the lake's center, which resulted in lower lake water levels. The C-43 Canal provides drainage for numerous private drainage systems and local drainage districts within the combined drainage basins.

The C-43 Canal also provides water for agricultural irrigation projects within the basins and public water supply for the city of Fort Myers and Lee County. In 1998, the city of Fort Myers withdrew 8 MGD for the public water supply from the C-43, while approximately 3 MGD of the total public water supply of Lee County came from the C-43.

There are three structures (S-77, S-78 and S-79) which provide for navigation and water control in the C-43 Canal. These structures serve to control the water stages in C-43 from Lake Okeechobee (S-77) to Franklin Lock (S-79). Water levels upstream of S-78 are maintained at approximately 11 feet national geodetic vertical datum (NGVD), and 3 feet NGVD downstream. The S-79 Structure also serves as a saltwater barrier. The operation schedule for these structures is dependent on rainfall conditions, agricultural practices, the need for regulatory releases from Lake Okeechobee, and the need to provide water quality control for the public water supply facilities (SFWMD, 1987).

Estero Bay Basin

In the Estero Bay Basin in southern Lee County, there is a two-fold water management problem. Overdrainage is a problem in areas due to development. Conversely, lack of conveyance in other areas result in flooding. The basins include Hendry Creek, Mullock Creek/Ten Mile Canal/Six Mile Cypress Slough, Kehl Canal/ Imperial River, Estero River and Spring Creek. These waterways, with the exception of Ten Mile Canal and Kehl Canal, are all tidally influenced to some degree.

Several waterwork projects have been completed, or are underway, to increase water levels in the western part of the basin and to protect the water resources against saltwater intrusion (Hendry Creek has a saltwater barrier and weirs in Ten Mile Canal have been raised to increase the water levels within Six Mile Cypress Slough). Johnson Engineering (1990) concluded that the Estero Bay Basin does not have a major source of surface water available for water supply. However, because the basin has good recharge areas, saltwater barriers (weirs), could be used to increase water levels within the basin for recharge.

The Estero River east of U.S. 41 has slow conveyance and is considered a good recharge area, as is the Imperial River east of I-75. The Kehl Canal is connected to this river and drains the water levels within this basin in the dry season. The District and Lee County cost shared the replacement of the existing temporary Kehl Canal Weir, with a permanent structure containing two screw gates for water management. This weir increases water levels in the east Bonita area (a major recharge area). The new weir was designed to have the flexibility to add a cap to the weir structure to increase the water level to 12-13 feet NGVD for additional recharge capabilities in the area.

West Collier Basin

The West Collier Basin extends from State Road 29 westward to the Gulf of Mexico and northward to the Lee County border, and includes part of Hendry County. The basin does not have a major source of surface water for year round water supply. Lake Trafford, in the northern section of the basin, has a drainage area of approximately 30 square miles. The lake is relatively small (2.3 square miles) and is not considered a significant source of water storage for the region.

The Gordon and Cocohatchee rivers are the two remnant natural rivers in this basin. Both of these rivers are tidally influenced and connect to the extensive canal system within this basin. This basin flows into the Gulf of Mexico near the Ten Thousand Islands. This canal system, operated and managed by the Big Cypress Basin Board (BCBB), serves primarily as a drainage network. Since 1981, the BCBB has retrofitted many old weirs and constructed new water control structures in these canals to prevent overdrainage of the basin. Since the primary source of water for this system is rainfall, the canals have little or no flow during the dry season.

The West Collier Basin has extensive wetland systems. These systems include the Corkscrew Regional Ecosystem Watershed (CREW), Fakahatchee Strand State Preserve, and the Collier-Seminole State Park (**Plates 1 and 4**). An assessment of the CREW area was completed in September 1993. The assessment indicated that wellfield development and/or aquifer augmentation could affect the wetlands within the CREW boundaries. The assessment recommends detailed three-dimensional analyses prior to any proposed wellfield development.

East Collier Basin

The East Collier Basin extends from State Road 29 eastward to the LWC Planning Area boundary, north approximately three miles into southern Hendry County, and south into Monroe County. Sheetflow from this basin flows south into the Everglades National Park and the Gulf of Mexico. The Big Cypress National Preserve forms most of this basin (**Plate 1**). There are no major rivers or major sources of surface water for year-round water supply use in this basin.

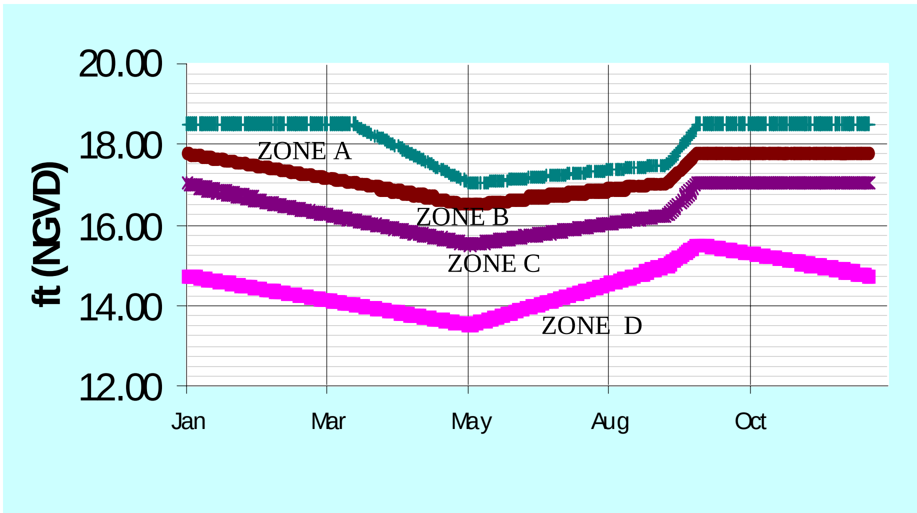
Lake Okeechobee

Lake Okeechobee is managed as a multipurpose freshwater resource in the C&SF Project. The primary tool for managing high lake water levels is the regulation schedule. This schedule defines the specific discharges that will be made to control excessive accumulation of water to protect 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 demonstrated in 1991, and formally adopted in 1994, 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 in place (**Figure 8**).

Run 25 contains three management zones: Zone C, Zone B and Zone A, as identified by individual lines of zones shown in **Figure 8**. Below Zone C is three “Pulse Release Zones,” identified as Level I, II, and III, which correspond to specific discharge volumes developed for the Caloosahatchee River and St. Lucie River estuaries, as shown in **Table 5**. When the lake stage falls below the Zone C line, no regulatory discharges are required. When lake stages reach any Zone (not just A, B, or C) releases of water are made by the USACE in accordance with the parameters shown below. 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, Zone B and Zone C are damaging to the downstream estuarine systems. The Pulse Release Zone D was developed to provide

Lake Okeechobee Regulation Schedule



Releases Through Lake Okeechobee Outlets

Zone	**Agricultural Canals to WCAs**	**Caloosahatchee River at S-77**		**St Lucie Canal at S-80**	
A	Pump Maximum Practicable	Up to Maximum Capacity		Up to Maximum Capacity	
B	Maximum Practicable Releases	***Normal to Very Wet:*** Up to 6,500 cfs	***Dry:*** Up to Maximum Pulse Release	***Normal to Very Wet:*** Up to 3,500 cfs	***Dry:*** Up to Maximum Pulse Release
C	Maximum Practicable Releases	***Wet to Very Wet:*** Up to 4,500 cfs ***Normal:*** Up to Maximum Pulse Release	***Dry:*** None	***Wet to Very Wet:*** Up to 2,500 cfs ***Normal:*** Up to Maximum Pulse Release	***Dry:*** None
D	As needed to minimize adverse impacts to littoral zone; no adverse impacts to the Everglades	***Very Wet:*** Up to Maximum Pulse Release	***Otherwise:*** None	***Very Wet:*** Up to Maximum Pulse Release	***Otherwise:*** None

Figure 8. Lake Okeechobee Regulation Schedule.

Table 5. 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, 1993, Lake Okeechobee SWIM Plan.

a buffer or safety factor for making early or pulsed releases of lake water to downstream estuaries. These release patterns mimic the hydrograph 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 Upper East Coast and Lower East 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 which 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 9**).

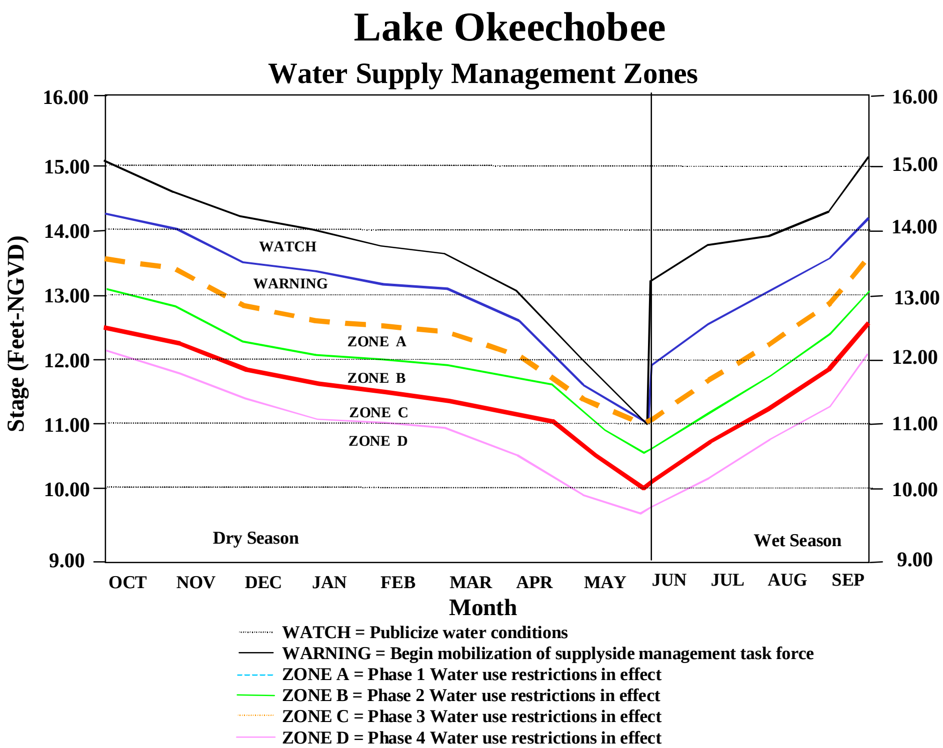


Figure 9. Lake Okeechobee Supply-Side Management Plan.

DRAINAGE DISTRICTS

Chapter 298, Florida Statutes governs local drainage districts **(Figure 8)**. These 298 districts are empowered to develop and implement a plan for draining and reclaiming the lands 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.

The District's past practice has been to issue consumptive use permits to the 298 districts for surface water use, while not requiring individual permits for users within these districts. Some 298 districts, however, may not have received a consumptive use permit; in these cases individual permits would be issued. The individual 298 district must still meet all conditions for issuance of a permit. The permit should indicate how water will be allocated, and should list the type and quantity of water use for each user.

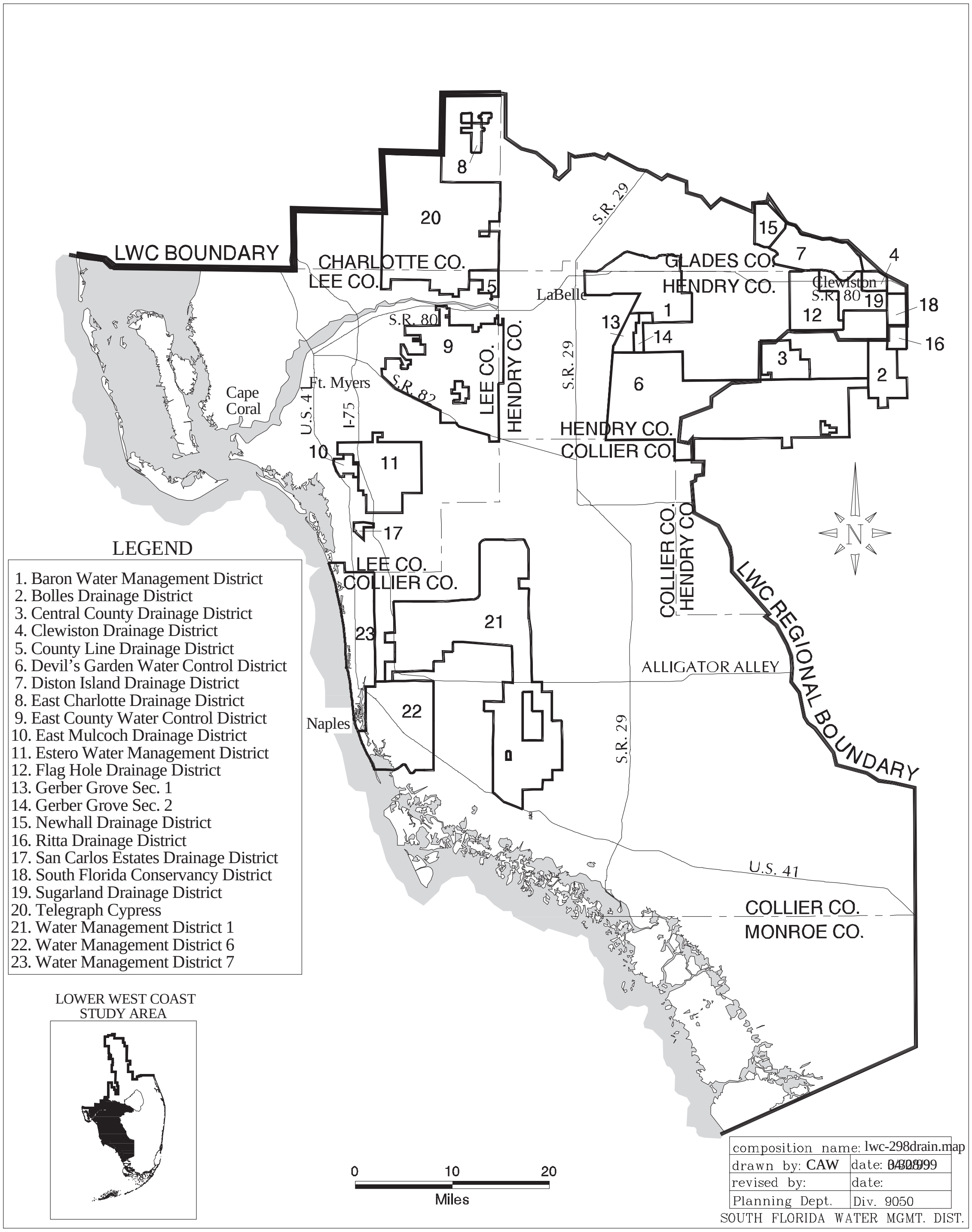


Figure 10. 298 Drainage Districts in the Lower West Coast Planning Area.

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 three major aquifer systems; the Surficial Aquifer System (SAS), the Intermediate Aquifer System (IAS) and the Floridan Aquifer System (FAS), are summarized in **Tables 6 - 10** for Charlotte, Collier, Glades, Hendry, and Lee counties. Appendix C includes a collection of ground water resources graphics. A stratigraphic cross section, and maps showing the elevation and thickness of each of the hydrogeologic units are provided in Appendix C. Information on ambient ground water quality, contamination sites, and saltwater intrusion is provided in Appendix G.

Table 6. Ground Water Systems in Charlotte County.

Aquifer System	Aquifer Unit	Thickness (feet)	Water Resource Potential
Surficial Aquifer System	Surficial Aquifer	0-70	Aquifer productivity is variable. Most wells yield less than 50 gpm, but can range as high as 600-700 gpm in wells tapping the Caloosahatchee marl in southeastern Charlotte County.
Intermediate Aquifer System	Sandstone Aquifer/ Mid-Hawthorn Aquifer	70-260	Important source of water for domestic and irrigation wells in southeastern Charlotte County.
Floridan Aquifer System	Lower Hawthorn Aquifer/ Upper Tampa Aquifer	150-300	Widely used for irrigation, but requires desalination treatment for potable use. Most productive zone lies at the contact between the Lower Hawthorn and Tampa formations.
	Suwannee Aquifer	200-300	Most productive aquifers in Charlotte County, but water requires desalination treatment for all uses. Water quality deteriorates from east to west.
	Ocala Group	200-300	

Table 7. Ground Water Systems in Collier County.

Aquifer System	Aquifer Unit	Thickness (feet)	Water Resource Potential
Surficial Aquifer System	Water Table Aquifer	20-100	The water table aquifer and the lower Tamiami aquifer are the most productive aquifers in the county. Yield High quality water except for isolated areas with high iron content. Potential for saltwater intrusion in coastal areas. In areas where the confining zone is absent, there is direct hydraulic connection of the Lower Tamiami and the water table aquifer.
	Lower Tamiami Aquifer	40-180	
Intermediate Aquifer System	Sandstone Aquifer	0-110	Yields large amounts of water in the northern portion of the county, but is absent south of Alligator Alley. Suitable for mostly agricultural uses.
	Mid-Hawthorn Aquifer	60-120	Aquifer is low yielding and produces poor quality water. Suitable only for microirrigation uses.
Floridan Aquifer System	Lower Hawthorn/ Suwannee Aquifer	Insufficient Data	Capable of high yields but requires desalination treatment. Some zones may be suitable for use in aquifer storage and recovery.

Table 8. Ground Water Systems in Glades County.

Aquifer System	Aquifer Unit	Thickness (feet)	Water Resource Potential
Surficial Aquifer System	Surficial Aquifer	20-100	Adequate in most areas for private domestic supply, but water quality is poor near Lake Okeechobee.
Intermediate Aquifer System	Sandstone Aquifer	90-230	Adequate in most areas for private domestic supply and to small to moderate irrigation
Floridan Aquifer System	Lower Hawthorn/ Suwannee Aquifer	500-1,400	Aquifer is under flowing artesian conditions throughout Glades County. The aquifer is highly productive. Productivity generally increases with depth: however, chloride, TDS, and sulfate concentrations increase with depth throughout the county. Aquifer is unsuitable for irrigation in southern Glades County.

Table 9. Ground Water Systems in Hendry County.

Aquifer System	Aquifer Unit	Thickness (feet)	Water Resource Potential
Surficial Aquifer System	Water Table Aquifer	0-100	Extensive throughout Hendry County. Productivity varies widely. Heavily used in isolated areas where other aquifers do not exist, or are low yielding.
	Lower Tamiami Aquifer	0-135	Most productive aquifer in Hendry County. Heavily used in the southeast county area. Thin or nonexistent in the northern and western portions of the county.
Intermediate Aquifer System	Sandstone Aquifer	0-120	Occurs in western Hendry County. Heavily used in areas where the lower Tamiami is thin or nonexistent. Moderately productive, water nonpotable in many areas.
	Mid-Hawthorn Aquifer	Insufficient data	Limited occurrence in Hendry County. Very low productivity; water quality not suitable for most irrigation uses.
Floridan Aquifer System	Lower Hawthorn/ Suwannee Aquifer	No Data	Little is known about the Floridan in Hendry County. It is believed to be capable of producing large volumes of water through flowing wells. Water is not suitable for irrigation.

Table 10. Ground Water Systems in Lee County.

Aquifer System	Aquifer Unit	Thickness (feet)	Water Resource Potential
Surficial Aquifer System	Water Table Aquifer	20-80	Yields moderate amounts of high quality water but already heavily allocated. Susceptible to saltwater intrusion near the coast.
	Lower Tamiami Aquifer	0-140	Absent from northern Lee County. Where present, yields moderate to large amounts of high quality water. The coast is susceptible to saltwater intrusion.
Intermediate Aquifer System	Sandstone Aquifer	0-110	Yields large quantities of good quality water in south central Lee County, but is absent in the north and east.
	Mid-Hawthorn Aquifer	40-120	Yields small quantities of good quality water in Cape Coral and north of C-43. Elsewhere suitable only for microirrigation uses
Floridan Aquifer System	Lower Hawthorn/ Suwannee Aquifer	Insufficient data	Capable of high yields but requires desalination treatment. Some zones may be suited for aquifer storage and recovery.

Surficial Aquifer System

The SAS may be divided into two aquifers, the water table and lower Tamiami, which are separated by leaky confining beds over much of the area. In northern Lee County, where the confining beds are absent or insignificant, the lower Tamiami is not a separate aquifer but part of the unconfined water table aquifer. The thickness of the SAS ranges from more than 200 feet in central and southern Collier County to four feet southwest of LaBelle in Hendry County. The SAS is further described by Bower et al., 1990, Smith and Adams, 1988; and Knapp et al., 1986.

The water table aquifer includes all sediments from land surface to the top of the Tamiami confining beds. Within Lee County, four major public water supply wellfields, all located in areas where the confining beds are absent, pump water from the water table aquifer. These are Lee County Utilities (Corkscrew Wellfield and Green Meadows Wellfield), Gulf Utilities, and the city of Fort Myers. The aquifer also furnishes irrigation water for many uses, including vegetables, berries, melons, nurseries, and landscape irrigation. In Hendry County, the water table aquifer is generally used only where no suitable alternative is available, though it may yield copious quantities of water in isolated areas. It produces good quality water, except in areas near LaBelle and parts of the coast, that have high concentrations of chlorides and dissolved solids, and isolated areas with high iron concentrations.

The lower Tamiami is the most prolific aquifer in Hendry and Collier counties. The lower Tamiami aquifer supplies water to Bonita Springs, Collier County, city of Naples, Immokalee, and North Naples, as well as many domestic self-suppliers and landscape and agricultural irrigation wells. Because of the large demands on the aquifer, it has been endangered by saltwater intrusion on the coast, and is frequently included in water shortage declarations.

Intermediate Aquifer System

The IAS consists of five zones of alternating confining and producing units which are further described in other District Publications (Wedderburn et al., 1982; Smith and Adams, 1988; and Knapp et al., 1984). The producing zones, which comprise the IAS, include the Sandstone and mid-Hawthorn aquifers.

The Sandstone aquifer has variable thickness. It averages over 100 feet near Immokalee and portions of central Lee County, but pinches out to the south around Alligator Alley, to the northwest in Cape Coral, and to the east in the middle of Hendry County.

The productivity of the Sandstone aquifer is highly variable. It provides all of the water withdrawn by the Lehigh Acres Public Water Supply Wellfield and a portion of that withdrawn by the Lee County Corkscrew and Green Meadows wellfields. In western Hendry County, where the lower Tamiami aquifer is absent, it is an important source of water for agricultural irrigation, but is not capable of supporting large-scale agricultural operations in most areas. Only marginally acceptable for potable uses in Hendry and Collier counties, water from the Sandstone aquifer is suitable for irrigation purposes throughout its extent, with the exception of the LaBelle area, where it has been contaminated by flowing Floridan wells.

Although present throughout the LWC Planning Area, the mid-Hawthorn Aquifer is not always productive. Its thickness is variable and relatively thin (it rarely exceeds 80 feet). This variability, combined with the presence of interbedded low permeability layers, results in low productivity of the aquifer. In addition to low productivity, the aquifer experiences degradation in water quality as it dips to the south and east, yielding only saline water in much of the LWC Planning Area.

The mid-Hawthorn aquifer formerly provided water for the city of Cape Coral and the Greater Pine Island water utilities. However, its limited water-producing characteristics made it an unreliable source. Both utilities have been forced to develop other sources. It is also used for domestic self-supply in those areas of Cape Coral not served by city water and for small water utilities north of the Caloosahatchee River. Elsewhere the aquifer is used only occasionally for agricultural irrigation.

Floridan Aquifer System

The FAS, which underlies all of Florida and portions of southern Georgia and Alabama, contains several distinct producing zones which are described by Wedderburn et al., 1982. Although it is the principal source of water in Central Florida, the FAS yields only nonpotable water throughout most of the LWC Planning Area. The quality of water in the FAS deteriorates southward, 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.

Developments in desalination technology have made treatment of water from the upper portion of the FAS feasible where chloride concentrations are not prohibitively high. The most productive zones are the lower Hawthorn and Suwannee aquifers. Currently, several utilities including the city of Cape Coral, Greater Pine Island, Collier County, Marco Island Utilities, and Island Water Association (Sanibel), obtain water from the lower Hawthorn or Suwannee aquifers. Elsewhere, the aquifers supply only a few agricultural irrigation wells. Improvements in desalination treatment technology will make development of these aquifers increasingly feasible; continuing increases in the demand for water in the LWC Planning Area, moreover, will make it necessary. Portions of the producing zones may also have potential for use in ASR projects.

In the deeper producing zones of the FAS, there are areas of extremely high transmissivity, known as “boulder zones.” Although they are not used as supply sources within the LWC Planning Area due to the high salinity and mineral content, these formations may serve other purposes. Some areas of the boulder zones have been used as disposal areas for treated wastewater effluent or residual brines from the desalination process.

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. Surface water management systems within the LWC Planning Area function primarily as aquifer drains, since the ground water levels generally exceed the surface water elevations within the LWC Planning Area. The Caloosahatchee River and the Gulf of Mexico act as regional ground water discharge points (Wedderburn et al., 1982). Ground water seepage represents 47 percent of the inflow to the Caloosahatchee River. During the wet season, after a rain event some recharge to the SAS may occur from drainage canals, small lakes such as Lake Trafford and low lying areas (Knapp, 1986; Smith and Adams, 1988). 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.

The Sandstone aquifer comes into direct contact with the SAS northeast of Immokalee (Smith and Adams, 1988). In those areas the Sandstone aquifer responds almost immediately to rain events, but the aquifer is receiving the water through the SAS and it does not have direct contact with surface water systems. The remainder of the IAS is not hydraulically connected to surface water.

The FAS is not hydraulically connected to surface water within the LWC 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 LWC Planning Area contains a variety of natural resources, ranging from coastal barrier islands, mangrove forests, bays, beaches and estuaries to inland freshwater-forested shrub, herbaceous wetlands, and upland habitats. 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 LWC Planning Area.

COASTAL RESOURCES

Southwest Florida has some of the most pristine and productive coastal waters within the state. Five of these areas are contained in aquatic preserves: Matlacha Pass, Pine Island Sound, Charlotte Harbor, Estero Bay, and Rookery Bay. Tourism, the major industry in Southwest Florida, is closely linked to its unique coastal resources. The coastal resources include areas such as estuarine systems, barrier islands and beaches.

Estuarine Systems

Coastal areas are dominated by large estuarine systems where the waters of the Gulf of Mexico mix with the freshwater inflows from numerous river systems, sloughs and overland sheetflow. These estuarine areas are characterized by shallow bays, extensive seagrass beds, and sand flats. Extensive mangrove forests dominate undeveloped areas of the shoreline. Two large open water estuarine systems, Charlotte Harbor and the Caloosahatchee River estuary, dominate the northwest portion of the LWC Planning Area. Other associated habitats are high salt marshes and riparian fringing marshes. More than 40 percent of Florida's rare, endangered or threatened species are found in Southwest Florida estuaries. One of the most renowned is the West Indian manatee, which depends on a healthy seagrass community as its major food source. The bald southern eagle also relies to a large extent on the estuary as its feeding grounds.

Coastal areas subject to tidal inundation support extensive mangrove forests and salt marsh areas. Coastal mangroves protect against erosion from storms and high tides, and assimilate nutrients from flowing water to produce organic matter (leaves), which forms the base of the estuarine food chain. Mangroves and salt marsh communities serve as important nursery and feeding grounds for many economically important species of finfish and shellfish, which in turn support migratory waterfowl, shore bird and wading bird populations. These brackish water communities were once commonly distributed along the entire coastline, but are now found in greatest abundance in Southwest Collier County and southern Lee County. The Ten Thousand Island region, which dominates the southern portion of Collier County, is the largest intact mangrove forest in the world.

Barrier Islands

Barrier islands form a chain from northern Lee County to southern Collier County. Barrier islands also protect the mainland from major storm events, act as a buffer for sensitive estuarine areas, and provide habitat for shorebirds and wildlife. These low lying, narrow strips of sand play an important role in the region's tourism economy by attracting visitors to the beaches.

Water Needs of the Coastal Resources

Maintenance of appropriate freshwater inflows is essential for a healthy estuarine system. Preliminary findings indicate that inflows to the Caloosahatchee Estuary ideally should have mean monthly values between 300 cfs and 2,801 cfs. Currently the mean daily flows range from 0 cfs to more than 13,652 cfs (Chamberlain and Doering, 1995). 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, water clarity, or rates of sedimentation may also adversely affect the estuarine community.

Estuarine biota are well adapted to natural seasonal changes in salinity. The temporary storage and concurrent decrease in velocity of flood waters within upstream wetlands aid in controlling the timing, duration and quantity of freshwater flows into the estuary. Upstream wetlands and their associated ground water systems serve as freshwater reservoirs for the maintenance of base flow discharges into the estuaries, providing favorable salinities for estuarine biota. During the wet season, upstream wetlands provide pulses of organic detritus which are exported down stream to the brackish water zone. These materials are an important link in the estuarine food chain.

Estuaries are important as nursery grounds for many commercially important fish species. Many freshwater wetland systems in the LWC Planning Area provide base flows to extensive estuarine systems in Lee, Collier, and Monroe counties. Wetlands as far inland as the Okaloacoochee Slough in Hendry County contribute to the base flows entering some of these estuarine systems. Maintenance of these base flows is crucial to propagation of many fish species that are the basis of extensive commercial and recreational fishing industries.

The estuarine environment is sensitive to freshwater releases, and disruption of the volume, distribution, circulation, temporal patterns of freshwater discharges could place severe stress on the entire ecosystem. “Such salinity patterns affect productivity, population distribution, community composition, predator-prey interactions, and food web structure in the inshore marine habitat. In many ways, salinity is a master ecological variable that controls important aspects of community structure and food web organization in coastal systems" (Myers and Ewel, 1990). Other aspects of water quality, such as turbidity, dissolved oxygen content, nutrient loads, and toxins, also affect functions of these areas (USFWS, 1990; USDA, 1989; Myers and Ewel, 1990).

INLAND RESOURCES

Inland portions of the LWC Planning Area include numerous freshwater swamps, sloughs, and marshes. A number of these systems are relatively pristine wetland areas and are recognized as having national and regional importance (e.g., Big Cypress National Preserve, Corkscrew Swamp Sanctuary, and Fakahatchee Strand). These wetland areas serve as important habitat for a wide variety of wildlife and have numerous hydrological functions. Before development of the region, inland areas were comprised of vast expanses of cypress and hardwood swamps, freshwater marshes, sloughs, and flatwoods. Scattered among these systems were oak/cabbage palm and tropical hammocks, coastal strand and xeric scrub habitats. A large portion of the area contained seasonally flooded wetlands which sheetflowed fresh water from the northeast to the southwest.

Water bodies within the LWC Planning Area include natural lakes, man-made surface water impoundments, rivers, and creeks.

Wetlands

Wetlands are transitional lands 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. In part, the Code 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 LWC Planning Area include swamps, marshes, bayheads, cypress domes and strands, sloughs, wet prairies, riparian 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 flow of 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 or freshwater wetlands within the LWC Planning Area can be grouped into three major categories based on hydroperiod: permanently flooded or irregularly exposed; seasonally or semipermanently flooded; temporarily flooded or saturated; and, upland. The Florida Land Use and Cover Classification System (FLUCCS) was used to delineate wetland systems with in the LWC Planning Area. The FLUCCS map was created in 1998 using 1994-1995 aerial photography and is the most accurate representation of the LWC Planning Area. The hydroperiod categories were created by combining FLUCCS coverage classifications with the National Wetlands Inventory hydrologic classifications. The hydrologic categories are broadly defined as:

- **Permanently Flooded or Irregularly Exposed.** Water covers the substrate throughout the year in all years or the substrate is exposed by tides less often than daily. Corresponds to lakes, reservoirs, embayments, and major springs.
- **Seasonally or Semipermanently Flooded.** Surface water persists throughout the rainy season and much of the dry season in most years. When surface water is absent, the water table is at or very near the land surface. Seasonally flooded soils are saturated. Corresponds to swamps, sloughs, mixed wetland hardwoods, cypress, wetland forest mixed, freshwater marshes, sawgrass and or cattail, wet prairies, emergent and submergent aquatic vegetation.
- **Temporarily Flooded or Saturated.** Surface water is present for brief periods during the rainy season, but the water table usually lies below the soil surface for most of the year. Plants that grow in both uplands and wetlands are characteristic of this water regime. The substrate is saturated to the surface throughout the rainy season or for extended periods during the rainy season in most years. Surface water is seldom present. Corresponds to

cypress - pine - cabbage palm, wet prairie - with pine, intermittent ponds, pine - mesic oak, Brazilian pepper, melaleuca, and wax myrtle - willow.

Distribution of Wetlands

The updated wetland systems map of the LWC Planning Area is shown on **Plate 3**. Although numerous man-made impacts have altered the landscape, significant wetland systems remain in the LWC Planning Area.

Charlotte County

In eastern Charlotte County, a portion of Fred C. Babcock/Cecil M. Webb Wildlife Management Area and Telegraph Cypress Swamp cover nearly 10,000 acres. Both systems are diverse with a mixture of hydric pine flatwoods, cypress strands and marshes.

Collier County

In Collier County, major wetland areas include the Okaloacoochee Slough, Fakahatchee Strand, the Big Cypress National Preserve, and the Corkscrew Regional Ecosystem Watershed (CREW lands).

Okaloacoochee Slough. This slough is one of the two most important surface water flowways in Collier County, with Lake Trafford-CREW being the other (Gore, 1988). This slough system is composed largely of herbaceous plants with trees and shrubs scattered along its fringes and central portions. It provides habitat for a wide variety of wildlife such as the endangered Florida panther.

Fakahatchee Strand. The strand is the southwest branch of the Okaloacoochee Slough. The strand contains a diversity of plant communities such as, mixed hardwood swamps, cypress forest, prairies, hammocks, pine forest, and pond apple sloughs. There are at least 30 species of plants and animals in the strand that are considered endangered, threatened, or species of special concern (U.S. Fish and Wildlife Service, 1984).

Big Cypress National Preserve. The preserve encompasses a vast area (570,000 acres) within Collier County. Habitats within the preserve are primarily cypress forest, pine flatwoods and marshes. There are in excess of 100 species of plants and 20 species of animals in the preserve listed by the state as endangered or threatened.

Corkscrew Regional Ecosystem Watershed (CREW). CREW is a 60,000 acre project in Lee and Collier counties, consisting of Corkscrew Sanctuary, Corkscrew Swamp, Camp Keais Strand, Flint Pen Strand, and Bird Rookery Swamp. CREW lands are dominated by cypress forest, low pine flatwoods, hardwood hammocks, marshes, mixed swamps and ponds. This system provides valuable habitat which supports at least 65 species of plants and 12 species of animals listed by the state as endangered or threatened.

Glades County

The major wetland in western Glades County is Fisheating Creek. Fisheating Creek is an extensive riverine swamp system that forms a watershed covering hundreds of square miles. Although Fisheating Creek is located in the Kissimmee Basin Planning Area, it delineates the northern boundary of the LWC Planning Area. Fisheating Creek is the only free flowing tributary to Lake Okeechobee. The creek attenuates discharges from heavy storm events and improves water quality before the storm water enters the lake. The creek also serves as a feeding area for wading birds such as the endangered wood stork, white ibis, and great egrets, when stages in the marshes surrounding Lake Okeechobee are too high.

Hendry County

The Big Cypress Swamp occupies a large section of southern Hendry County, including part of the Big Cypress Seminole Indian Reservation. The area is characterized by cypress forests, small pine hammocks, and marshes. The headwaters of the Okaloacoochee Slough are in northern Hendry County. The slough extends southward to Collier County, where it eventually branches to the Fakahatchee Strand

Lee County

Major wetland areas in Lee County include the Six Mile Cypress Slough and Flint Pen Strand, which is within CREW. Six Mile Cypress Slough encompasses 2,000 acres in Lee County and is dominated by cypress, interspersed with numerous ponds. The native plant communities which fringe the slough are pine flatwoods, hardwoods, and wet prairies. Heavy infestation of melaleuca has occurred in the southern one-third of the slough.

Uplands

Upland communities in the LWC Planning Area include flatwoods, tropical hammocks and xeric scrub communities, with flatwoods being the dominant upland habitat. Flatwood communities are divided into two types: dry and hydric. Dry flatwood communities are characterized by an open canopy of slash pine with an understory of saw palmetto. However, dry flatwoods are located in a slightly higher elevation in the landscape and are rarely inundated. Hydric flatwood communities (wetlands) are vegetatively similar to dry flatwoods.

Large areas of flatwoods are found throughout Hendry and Lee counties, as well as portions of Charlotte, Glades and Collier counties. Upland flatwoods are the native habitats most effected by the expansion of citrus into Southwest Florida. Flatwoods are important habitat for a number of threatened or endangered species, such as the Florida panther, eastern indigo snake, red-cockaded woodpecker and gopher tortoise. Pine flatwoods have greater richness of vertebrate species than either sand pine scrub or dry grass prairies (Myers and Ewel, 1990).

Tropical hammocks are scattered throughout the LWC Planning Area. This diverse woody upland plant community occurs on elevated areas, often on Indian shell mounds along the coast, or on marl or limestone outcroppings inland. Tropical hammocks are not widespread in occurrence, and as a result of conversion to other land uses, tropical hammocks are among the most endangered ecological communities in South Florida.

Xeric, sand pine scrub communities most commonly occur along sand ridges and ancient dunes. The southernmost of these communities was once found on Marco Island in Collier County, but has since been lost to development. Sand pine scrub is most often associated with relic sand dunes formed when sea level was higher than it is today. These well drained sandy soils are important areas of aquifer recharge for coastal communities. The sand pine scrub is the most endangered ecological community present within the LWC Planning Area. It is rapidly being eliminated by conversion to other land uses.

Upland plant communities (e.g., flatwoods, sand pine scrub) serve as recharge areas, absorbing rainfall into soils where it is distributed into plant systems 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 event. With few exceptions, the functions and values attributed to wetlands also apply to upland systems. Upland and wetland systems are ecological continuums, existing and adapting to geomorphic variation. The classification of natural systems is artificial and tends to convey a message that they survive independently of each other. In reality, wetland and upland systems are interdependent on each other. To preserve the structure and functions of wetlands, the linkage between uplands and wetlands must be maintained (Mazzotti et al., 1992).

Water Needs of the Inland Environment

Both the needs and functions of natural systems must be considered as part of the overall water supply planning process. Regional water supply plans are developed to identify sufficient water source options to meet the demands of urban and agricultural uses while meeting the needs of the environment. Wetland and upland communities play an integral role in maintaining regional water supplies by allowing for natural recharge of the aquifers.

Wetland Water Supply 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 LWC 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 that influence wetland systems, such as fire, geology and soils, and climate, is further discussed in Appendix E.

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. Shallow, low gradient wetlands, 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).

Studies of Southwest Florida wetland communities indicate that species composition and community type are largely determined by water depth and hydroperiod (Carter et al., 1973; Duever, 1984; Duever et al., 1986). Some wetland types contain water depths of three feet or more and are inundated year round, while other community types are characterized by saturated soils or water depths of less than a few inches that inundate the land for relatively short periods of time during the wet season. Wetland flora and fauna adapted to deep water and long periods of inundation are generally not well adapted to shallow water or a shortened hydroperiod. Complete drainage of a wetland severely alters wetland community organization and species composition. Partial drainage of wetlands can be caused by ground water withdrawals in adjacent upland areas. These withdrawals effectively lower underlying water tables and “drain” wetlands (Rochow, 1989). Drainage facilities such as canals and retention reservoirs constructed near wetlands have a history of draining and reducing hydroperiods of South Florida wetlands (Erwin, 1991). A major concern of reduced water depths and hydroperiod within wetlands is the invasion of exotic plants such as melaleuca and Brazilian pepper.

Rainfall, along with associated ground water or surface water inflows, is the primary source of water for the majority of wetlands in the LWC Planning Area. Rainfall in South Florida is highly variable. Although the region has a distinct wet and dry season, the timing and amount of rainfall which falls upon a particular wetland varies widely from year to year. As a result, wetland hydroperiod also varies annually. Hydroperiod information collected from a wetland during a series of wet years may vary considerably from data collected during a dry year. This wide variation in annual rainfall makes it difficult to determine what the appropriate water level or hydroperiod should be for a specific wetland ecosystem. Determining appropriate water level or hydroperiod conditions for a wetland often requires a data collection effort that spans a sufficient period of record. Hofstetter and Sonenshein (1990) suggest alterations that shorten hydroperiods may be detectable within 8 to 10 years.

Several attempts have been made by researchers to define annual inflows and water budgets for some of the larger wetland ecosystems present within the LWC Planning Area such as the Big Cypress Swamp (Klein et al., 1970; Freiberger, 1972; Carter et al., 1973; Duever et al., 1979, 1986), Corkscrew Swamp (Duever et al., 1974, 1975, 1976, 1978), Fakahatchee Strand (Burns, 1984), and Six Mile Cypress Slough (Johnson Engineering et al., 1990). However, no data currently exists which quantifies the environmental water demands for the region.

Computer modeling at the District has historically focused on predicting either ground water levels or surface water runoff. The utility of these modeling efforts for evaluating wetland hydroperiod has been quite limited. In recent years, however, the District's Wetland Drawdown Study has gathered sufficient data to calibrate integrated surface and ground water models capable of simulating wetland hydroperiod in a more realistic manner. Although the data requirements tend to limit these modeling efforts to a very local scale, they can be used to predict the effect of groundwater stresses on wetland hydroperiod, and aid in the evaluation of criteria for wetland protection. This knowledge could be utilized in determining appropriate flows from wetlands through tributaries to the different estuaries in the LWC Planning Area.

Upland Water Needs

The water supply needs of upland plant communities are not well known. It is assumed that the upper six to ten feet of the surficial aquifer is utilized by forest and herbaceous plant vegetation. Flatwoods are the dominant upland habitat within the LWC Planning Area. These plant associations are characterized by low, flat topography and poorly drained, acidic, sandy soils. In the past this ecosystem was characterized by open pine woodlands and supported frequent fires (Myers and Ewel, 1990). Three factors (fire frequency, soil moisture, and hydrology) play important roles in maintaining plant community structure and function and are also considered important as determinants of the direction of plant community succession. Fire is the factor which most strongly influences the structure and composition of upland plant communities.

Fire, under natural conditions, maintains flatwoods as a stable and essentially nonsuccessional plant association. However, when the natural frequency of fire is altered by drainage improvements, construction of roads, or other fire barriers, flatwoods can succeed to several other plant community types. The nature of this succession depends on soil characteristics, hydrology, available seed sources or other local conditions (Myers and Ewel, 1990). The hydrology of upland plant communities varies with elevation and topography. Seasonal variations as well as local withdrawals from ground water play an important role in determining the type of upland vegetation that will develop.

Wildlife Water Supply Needs

In South Florida, the dominant physical factors which influence the species composition, distribution and abundance of wildlife are the annual pattern of rainfall, water level fluctuations, and fire, as well as occasional hurricanes, frosts and freezes. Biological factors such as predation, competition and feeding habits also play important roles in configuring wildlife communities.

Alterations in water depth and/or hydroperiod that result in changes to vegetative composition densities and diversity may lead to the degradation of fish and wildlife habitat. One of the causes of melaleuca infestation is a decrease in water table levels which, when a seed source is present, can result in monotypic stands of tightly packed trees that have the potential to cause a localized decrease in biodiversity.

Wetland vegetative productivity usually exceeds that of other habitat types. Reduction in size of a wetland reduces food production at the bottom of the food chain. Alterations of the seasonal wet and dry pattern can also cause impacts. “The life cycle of many species are tied to this cycle. Wood storks, for example, are unable to successfully fledge their young without the dry season concentration of food. Anything that interferes with the cycle, too much water in the dry season or not enough in the wet season, tends to reduce fish and wildlife populations” (University of Florida, Center for Government Responsibility, 1982).

Flooding of wetlands during the summer months initiates the production of aquatic plants such as attached algae (periphyton) and macrophyte communities. These plants are consumed by small fish and invertebrates. Maximum numbers of fish and invertebrates occur near the end of the wet season. As marsh water levels decline during the dry season, these organisms are concentrated into smaller and smaller pools of water where they become easy prey for wading birds and other species of wildlife. Fish and invertebrates are the major dietary components of South Florida wading and water bird populations. Wading bird nesting success is highly dependent upon the natural seasonal fluctuations in hydroperiod of these marsh systems and the concentration of food resources. Kahl (1964) and SFWMD (1992) link the nesting success of wood storks and white ibis to the hydrologic status of regional wetland systems.

PROTECTION OF NATURAL RESOURCES

The District protects and enhances natural resources through its restoration activities and with integrated planning, regulation and land acquisition programs. Regulatory programs include rules to protect, enhance, mitigate, monitor wetlands and water resources and rules that address water quantity and quality.

Wetland Policies

The District prevents adverse impacts to wetlands from ground water withdrawals by implementing numerous state laws (Appendix A) through the consumptive use permitting process, which limits drawdown beneath wetlands. The permitting process is based on interpretation and implementation of the law to ensure that wetlands are protected. The obligation to leave enough water in natural areas to maintain their functions and protect fish and wildlife is central to water supply planning in the LWC Planning Area.

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 to protect wetlands from harm; and, develop the most reliable and cost effective water supply strategy.

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 ground water withdrawals.

Wellfield Impact Monitoring

The District 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) ground water modeling; and (3) a scientific wetland expert workshop. This phase was completed in November, 1995.

Phase II consisted of: (1) determining the extent and severity of impacts, if possible, using a historical approach to determine impacts from ground water drawdowns through aerial photointerpretation; and (2) identify wetland sites throughout the District for well installation and hydrobiological monitoring. This phase was completed April 1997.

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 ground water 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 ground water models used in the permit application process; and (e) symptoms of impact observed during drought.

Site characterization and well drilling contracts are presently underway in the LWC Planning Area. Biological studies will facilitate the characterization of biotic communities of the selected wetland sites and development of nondestructive long-term monitoring methods. To date, inventories of plant, fish, aquatic insect, bird, moss, algae and amphibian populations have been conducted. Various sampling methods are presently under investigation for incorporation into a long-term monitoring effort.

At Flint Pen Strand, there are currently 13 agricultural monitoring sites with 16 associated wells, with an additional 9 monitoring sites with 10 associated wells. At the Stairstep project site (Corkscrew Mitigation Bank) there are 3 reference sites with 5 associated wells. These sites are currently being surveyed and outfitted with the appropriate instrumentation. Full scale implementation began in the spring of 1999.

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, the 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 as follows:

- 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 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 water management districts and FDEP to adopt rules by 1994, that led to the state's mitigation banking rule (Chapter 62-342, F.A.C.), becoming effective January 1994. In 1996, the law was modified to further develop 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

Under the provisions of the Surface Water Improvement and Management (SWIM) Act, the SFWMD was required to develop and implement a SWIM plan to preserve protect and restore Lake Okeechobee. 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 Caloosahatchee Estuary occur when regulatory releases are made through the C-43 Canal for lake flood protection purposes. Large, unnatural freshwater releases from the Lake through the C-43 to the Caloosahatchee Estuary alter the estuarine salinity gradient and transport significant quantities of sediment to the estuary. Biota within the Caloosahatchee Estuary, and near-shore grass beds can be negatively affected by these high volume discharges.

Minimum Flows and Levels

The purpose of establishing minimum flows and levels (MFLs) is to avoid diversions of water that would cause significant harm to the water resources or ecology of an area. The Florida Legislature has mandated that all water management districts establish MFLs for surface waters and aquifers within their jurisdiction. Section 373.042(1) defines the minimum flow as “the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area.” It further defines the minimum level as 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 is further directed to use the best available information in establishing a minimum flow or a minimum level.

The overall purpose of Chapter 373 is to ensure the sustainability of water resources of the state (Section 373.016, F.S.). To carry out this responsibility, Chapter 373 provides the District with several tools, with varying levels of resource protection standards. MFLs play one part in this framework. Determination of the role of MFLs and the protection that they offer, versus other water resource tools available to the District, are discussed below.

The scope and context of MFLs protection rests with the definition of **significant harm**. The following discussion provides some context to the MFLs statute, including the significant harm standard, in relation to other water resource protection statutes.

Sustainability is the umbrella of water resource protection standards (Section 373.016, F.S.). Each water resource protection standard must fit into a statutory niche to achieve this overall goal. Pursuant to Parts II and IV of Chapter 373, surface water management and consumptive use permitting regulatory programs must prevent **harm** to the water resource. Whereas water shortage statutes dictate that permitted water supplies must be restricted from use to prevent **serious harm** to the water resources. Other protection tools include reservation of water for fish and wildlife, or health and safety (Section 373.223(3)), and aquifer zoning to prevent undesirable uses of the ground water (Section 373.036). By contrast, MFLs are set at the point at which **significant harm** to the water resources, or ecology, would occur. The levels of harm cited above, harm, significant harm, and serious harm, are relative resource protection terms, each playing a role in the ultimate goal of achieving a sustainable water resource.

Where does the significant harm standard lie in comparison to the consumptive use permitting and water shortage standards? The plain language of the standards of harm versus significant harm, although undefined by statute, implies that the minimum flow or level criteria should consider impacts that are more severe than those addressed by the consumptive use permitting harm standard, but less severe than the impacts addressed by the serious harm water shortage standard. The conceptual relationship among the terms harm, significant harm, and serious harm are shown in **Figure 11**.

Two water bodies within the LWC Planning Area are on the District's priority list for establishment of MFLs: the Caloosahatchee River and Estuary and the LWC aquifer system. Both of these are anticipated to be completed by the end of 2000. Additional information on these is provided in the Planning Document.

National Estuary Program

The Charlotte Harbor has been designated an estuary of national significance and is a component of the U.S. Environmental Protection Agency sponsored National Estuary

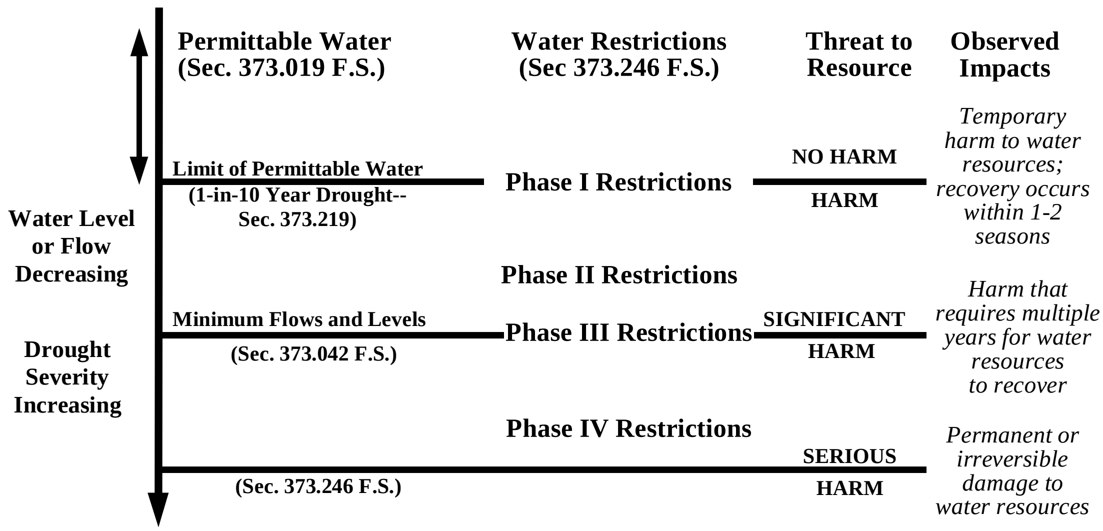


Figure 11. Conceptual Relationship among the Terms Harm, Significant Harm, and Serious Harm.

Program (NEP). The goals of the Charlotte Harbor National Estuary Program (CHNEP) include the following:

- Improve the environmental integrity of the Charlotte Harbor study area
- Preserve, restore, and enhance seagrass beds, coastal wetlands, barrier beaches, and functionally related uplands
- Reduce point and non-point sources of pollution to attain desired used of the estuary
- Provide the proper fresh water inflow to the estuary to ensure a balanced and productive ecosystem
- Develop and implement a strategy for public participation and education
- Develop and implement a strategy for public participation and education

Guided by these goals, the CHNEP published a Draft "Comprehensive Conservation and Management Plan (CCMP)" in November 1999. The CCMP details the actions needed to protect and improve the watershed while balancing human need with natural systems.

Land Acquisition and Preservation Programs

Natural resources in the LWC Planning Area that have been, or are proposed to be acquired for conservation/preservation purposes are shown on **Plate 4**. Ongoing acquisition programs in the LWC Planning Area are also discussed in Appendix E.

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 LWC Planning Area are shown on **Plate 4**.

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 LWC Planning Area are shown on **Plate 4**.

Local Programs

Several counties in the LWC Planning Area have initiated land preservation programs including Lee, Collier, and Charlotte counties.

Lee County

Lee County has acquired Six Mile Cypress Slough, a 2000-acre strand swamp, that parallels the course of the Caloosahatchee River. Acquisition was very much a grass roots effort. In the mid-1970s, after the slough failed to make the Environmentally Endangered Land (EEL) list, Six Mile Cypress Slough was enthusiastically adopted by students in the Lee County Environmental Education Program, under the direction of educator and former District Board member, William Hammond.

After a spirited campaign, voters approved a 0.2-mil, two-year tax for acquisition of the tract in November 1976. The acquisition effort moved slowly until the early 1980s, when $2 million of Save Our Rivers funds, administered by the District, were added. The acquisition area has since been expanded to 2,200 acres. One popular feature of the slough is the mile-long boardwalk, which is used by about 20,000 visitors annually. The Conservation 2020 Program adopted by voters in 1996, could generate as much as $77 million over a five-year period. Many of the lands being considered are already on the CARL lists.

Lee/Collier Counties

The Corkscrew Regional Ecosystem Watershed (CREW), created in 1989, is a 60,000-acre project surrounding the Corkscrew Sanctuary. In the mid-1980s, after several years of low rainfall, Lee County was motivated to apply for funds from the Save Our Rivers Program administered by the District to acquire the 15,000-acre Flint Pen Strand. The Corkscrew Sanctuary filed a separate application for lands within Collier County.

The District, hoping to acquire watershed lands in both counties as a unified project, created the CREW Trust, composed of representatives of several public and private agencies, to coordinate land acquisition, management, and public use. Approximately 21,000 acres have already been purchased from four major funding sources, including: the District (to become the ultimate project manager); Lee County; the Big Cypress National Preserve; and CARL (Lindblad, 1999). The Florida Wildlife Commission (FWC) is now preparing a management plan for the area. Recreation activities include a five-mile hiking trail, completed in 1994. A five-mile hiking trail was completed in 1994. Hunting may be permitted in the future, and four-wheeling will probably continue to be prohibited.

Charlotte County

The county has acquired 468 acres (former DRI known as Fairway Woodlands) adjacent to the Charlotte Harbor Flatwoods CARL project, Cedar Point. This project contains the following:

- An 88-acre peninsula next to Lemon Bay used for passive recreation and outdoor education
- Four eagle nests
- Tippicanoe Scrub
- Amberjack Slough

Charlotte County maintains conservation easements near Boca Grande and has conveyed easements to the FWC near the East Water Treatment Plant. These tracts were identified by the county's Environmental Lands Acquisition Advisory Council.

Chapter 5
RESOURCE REGULATION

There are several programs that the District, as well as federal, state, and local governments, may implement to protect water resources. The District's programs include permitting for both wetland protection and water resource allocation, and water shortage management.

The USEPA, through the reauthorization of the Safe Drinking Water Act, state agencies, through enacting administrative rules, and local governments, through implementing wellhead protection ordinances, strive to prevent ground water contamination. Of particular importance to the LWC Planning Area are the wellhead protection ordinances of the counties and cities in the region.

ENVIRONMENTAL RESOURCE PERMITTING

The Environmental Resource Permitting (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 (Basis of Review, Vol. IV). 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, and 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.

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 resources. 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 Lower West Coast Planning Area will have to be renewed. The current basin expiration date in the Lower West Coast Planning Area is December 15, 2001.

The District has issued 1,171 individual consumptive use permits in the LWC Planning Area (**Table 11**). Most of these permits are for agricultural uses.

Table 11. Individual Permit Allocations.

Water Use Category	Number of Permits	Daily Allocation (MGD)	Annual Allocation (MGY)	% of Total Allocations
Agriculture[a]	673	1358.9	496,000	50
Public Water Supply	44	154.8	56,491	6
Industrial	48	712.7	260,124	26
Recreation[b]	372	75.5	27,565	3
Mining and Dewatering	29	186.1	67,916	7
Other	5	238.8	87,164	9
Total	1,171	2726.7	995,260	100

a. Includes agriculture, aquaculture, livestock, and nursery.
b. Includes golf courses and landscape.
Source: SFWMD, 1999, Consumptive Use Permitting Program data.

Basis of Review Criteria

The consumptive use and permitting (CUP) 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 of the BOR, Water Resource Evaluations, address the evaluation of the potential impacts to the resource, existing legal users, the environment, saline water intrusion, and movement of pollution (SFWMD, 1994).

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 Water Resource Caution Areas (also known as Critical Water Supply Problem Areas).

Reduced Threshold Areas

The volume of usage that 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. The District has reduced this threshold to 10,000 GPD average or 20,000 GPD maximum in resource depleted areas, where there has been an established history of saline water movement into ground water and surface water bodies or should water be unavailable to meet projected needs of a region. These areas are referred to as Reduced Threshold Areas (RTAs). Three RTAs exist in the LWC Planning Area: Lee County, coastal Collier County, and the Muse/LaBelle area of Glades and Hendry counties. Under the District's current rulemaking effort, it is proposed to eliminate the RTA category.

Restricted Allocations Areas

Restricted Allocation Areas (RAAs) are areas designated within the District for which allocation restrictions are applied with regard to the use of specific sources of water. The water resources in these areas are managed in response to specific sources of water for which there is a lack of water availability to meet the demands of the region from that specific source of water. There are no RAAs within the LWC Planning Area; however, this designation exists in the other three planning areas.

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 previously designated Areas of Special Concern in the LWC 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. 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. All of the LWC Planning Area is designated as a Water Resource Caution Area. The Water Resource Implementation Rule requires that 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. (refer to Appendix A). 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. Few changes to the District's Water Shortage Plan have been made since that time. The District proposes to review the existing restrictions to determine whether these restrictions need updating, during the current rulemaking process. A history of the water shortages declared in the LWC Planning Area is presented in **Table 12**.

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). Lee and Collier counties have wellfield protection ordinances in effect.

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 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.

Federal Aquifer Protection

The first cohesive federal effort aimed at aquifer protection came in 1984, when the USEPA published its Ground Water Protection Strategy. This strategy recognized the need to prevent future ground water contamination and emphasized the protection of pubic water supply aquifers or those linked to unique ecosystems. As a result of this approach, federal provisions focused specifically at public water supply well protection, were adopted as part of the reauthorization of the Safe Drinking Water Act (SDWA) in 1986. This legislation established a nationwide policy to encourage states to develop systematic and comprehensive wellhead protection programs to protect public water supply areas from all man-made sources of contamination, which may cause or contribute to adverse health effects.

State, County, and City Wellhead Protection

State agencies, such as the FDEP, the Florida Department of Health (FDOH), the Department of Agriculture and Consumer Services (FDACS), and the water management districts have enacted a series of administrative rules directed towards aquifer protection. The FDEP has a number of regulations under the Florida Administrative Code which

Table 12. History of Water Shortages.

Year	Order #	Restrictions	Area Affected
1988	88-01-A 88-08	Phase I; Rescinded 88-01-A	Bonita Springs/North Naples (excluding the offshore Islands south to alligator alley)
1988	88-02 88-06	Phase I; Rescinded 88-02	Bonita Springs/North Naples (excluding the offshore Islands south to Pine Ridge Road
1988	88-03 88-07	Phase I; Rescinded 88-03	Coastal Lee County (excluding the offshore Islands south to Coconut Road)
1988	88-04 88-09	Phase I; Rescinded 88-04	At Marco Island, within the Fakahatchee South Water Use Basin, Collier County
1988	88-05 88-10	Phase I; Rescinded 88-05	At Marco Island, within the Fakahatchee South Water Use Basin, Collier County
1989	89-01 92-01	Phase I Rescinded	Lower West Coast – bounded to the North by Lee county line and to the south by Pine Ridge Rd. to the east by I-75, including the offshore Islands All areas
1989	89-02 92-01	Phase I	Marco Island, Collier County At Marco Island, within the Fakahatchee South Water Use Basin, Collier County
1989	89-03 92-01	Phase I; ground water	Portions of Lee County, Glades County, Hendry County, Collier County All areas
1989	89-04	Phase II	Bonita Springs/North Naples
1989	89-05 89-13	Phase I Rescinded 89-05 and 89-06	Fakahatchee South Water Use Basin
1989	89-06 89-13	Phase II Rescinded 89-05 and 89-06	At Marco Island, within the Fakahatchee South Water Use Basin, Collier County
1989	89-10	Phase I	South of Pine Ridge Rd. and east of I-75
1989	89-14 92-01	Phase I; ground and surface water	Hendry County All areas
1990	90-01	Phase III Agriculture	EAA/Lake Shore Perimeter
1990	90-02	Phase I; Nonagriculture	EAA/Lake Shore Perimeter (see also 90-10 & 90-27)
1990	90-04	Phase I; surface water	Portions of Hendry County Caloosahatchee Basin
1990	90-05	Phase I; ground water	Portions of Collier County (Bonita Springs); Caloosahatchee River Watershed
1990	90-06	Phase II; surface water	Portions of Hendry County Caloosahatchee River
1990	90-07 90-27	Phase I; ground and surface water Modified Phase I	Bonita Springs/North Naples; Portions of Lee and Collier County; Caloosahatchee River Watershed- South Water use Basin
1990	90-08	Phase I; ground water	Western Lee County; Caloosahatchee River Water Use Basin, including Watershed North and Watershed South Water Use Basins
1990	90-10	Modified previous orders to exclude the recirculating fountains	
1990	90-13	Phase II; agricultural uses of ground water	Portions of Glades and Hendry County in the Caloosahatchee River Watershed North Water Use Basin

Table 12. (Continued) History of Water Shortages.

Year	Order #	Restrictions	Area Affected
1990	90-14	Phase II; ground and surface water	Portions of Lee and Collier Counties including Coastal Collier County Water Use Basin and Caloosahatchee River Watershed - South Water use Basin; Bonita Springs/North Naples
1990	90-15 90-27	Phase I; ground and surface water Modified Phase I	Coastal Collier County; Caloosahatchee River Watershed-North and south Water Use Basin
1990	90-23	Phase II; ground and surface water	Lee County in the Caloosahatchee River Basin and its Watershed North and South Water Use
1990	90-24 90-27	Phase I; ground and surface water Modified Phase I	Portions of West Lee County in the Caloosahatchee River Basin and its Watershed North and South Water Use
1990	90-27 92-01		Modified 90-15, 90-24 and 90-07 to a Modified Phase I
1990	90-28	Rescinded 90-16 and 90-25	
1990	90-29 92-01		Modified WS Order 90-27 to change Golf Course Irrigation schedule Sept. 13, 1990
1991	91-01 92-01	Phase I; ground and surface water	Coastal Collier County Water Use Basin and Caloosahatchee River Watershed South Water Use Basin (Bonita Springs/ North Naples)
1991	91-04 92-01	Specific Restrictions	Order rescinding 92-01 and Declaring Modified Phase I Restriction within the coastal Collier County Water Use Basin and the Caloosahatchee River Watershed South Water Use Basin (92-01 rescinded 25 water shortage orders)
1992	92-03 93-45	Phase I; ground water and surface water Warning	Coastal Collier County (Bonita Springs and North Naples) and Caloosahatchee River Watershed South Water Use Basin Declaration of Water Shortage Warning within the coastal Collier County Water Use Basin, the Fakahatchee South Water Use Basin, the Fakahatchee North Water Use Basin, the Caloosahatchee River Water Use Basin, the Caloosahatchee River Watershed-North Water Use Basin, the Caloosahatchee River Watershed-South Water use Basin
1992	92-04	Phase I; ground water and surface water	Coastal Collier County Water Use Basin, Fakahatchee North and South Water Use Basin
1997	97-30	Phase I; Surficial Aquifer System	
1999	99-29	Phase I; ground water and surface water	Caloosahatchee River Water Use Basin, Caloosahatchee River Watershed South, Caloosahatchee River Watershed North, South-Hendry County/L-28 Gap Water Use Basin, Fakahatchee North Water Use Basin, Fakahatchee South Water Use Basin, Coastal Collier County Water Use Basin

function to regulate activities, such as hazardous and solid waste, storm water discharge, storage tank systems, etc. The primary goal of these legislative policies, aimed at aquifer protection, is to prevent problems before they occur as contrasted to correcting or providing remedial action for preexisting problems.

The intent of these ordinances is to protect and safeguard the health, safety, and welfare of the public by providing criteria for regulating and prohibiting the use, handling, production and storage of certain harmful substances which may impair present and future public water supply wells and wellfields.

Chapter 6
DEMAND ESTIMATES AND PROJECTIONS

Demand assessments for 1995 and projections for 2020 were obtained from the Districtwide Water Supply Assessment (July 1998), for two major categories of water use, urban and agricultural (**Figure 12**). Urban use is further subdivided into five subcategories: (1) public water supply; (2) domestic self-supplied; (3) commercial and industrial self-supplied; (4) recreation self-supplied; and (5) thermoelectric self-supplied. The subcategory of public water supply refers to all potable water supplied by regional water treatment facilities with pumpage of 0.5 million gallons per day (MGD) or more to all types of customers. The other five subcategories of urban water use are self-supplied. Commercial and industrial refers to operations using over 0.1 MGD. 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 0.1 MGD. The golf course subcategory includes those operations not supplied by a public water supply or regional reuse facility. Domestic self-supplied is used to designate those households whose primary source of water is private wells and water treatment facilities with pumpages of less than 0.5 MGD. Thermoelectric self-supplied for power generation includes water used by electric power generating facilities for cooling purposes.

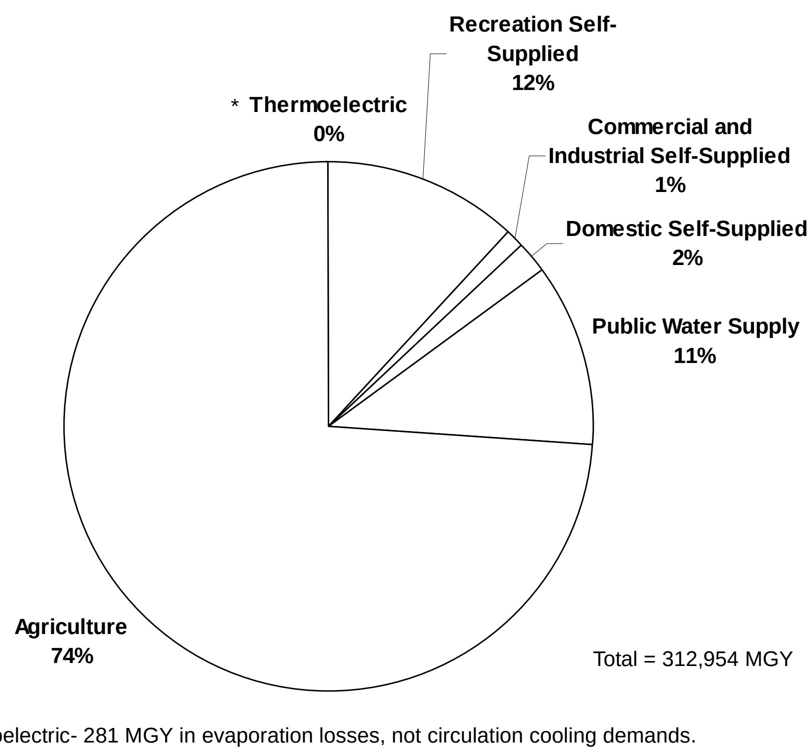


Figure 12. Overall Water Demands for 1995 in the Lower West Coast Planning Area.

Although electric power generation facilities withdraw large amounts of water, virtually all of this water is returned to the hydrologic system near the point of withdrawal. Agriculture includes water used to irrigate crops, cattle watering, and aquaculture. For 1995, the total assessed water demand for the LWC Planning Area was 312,954 million gallons for the year (**Figure 13**).

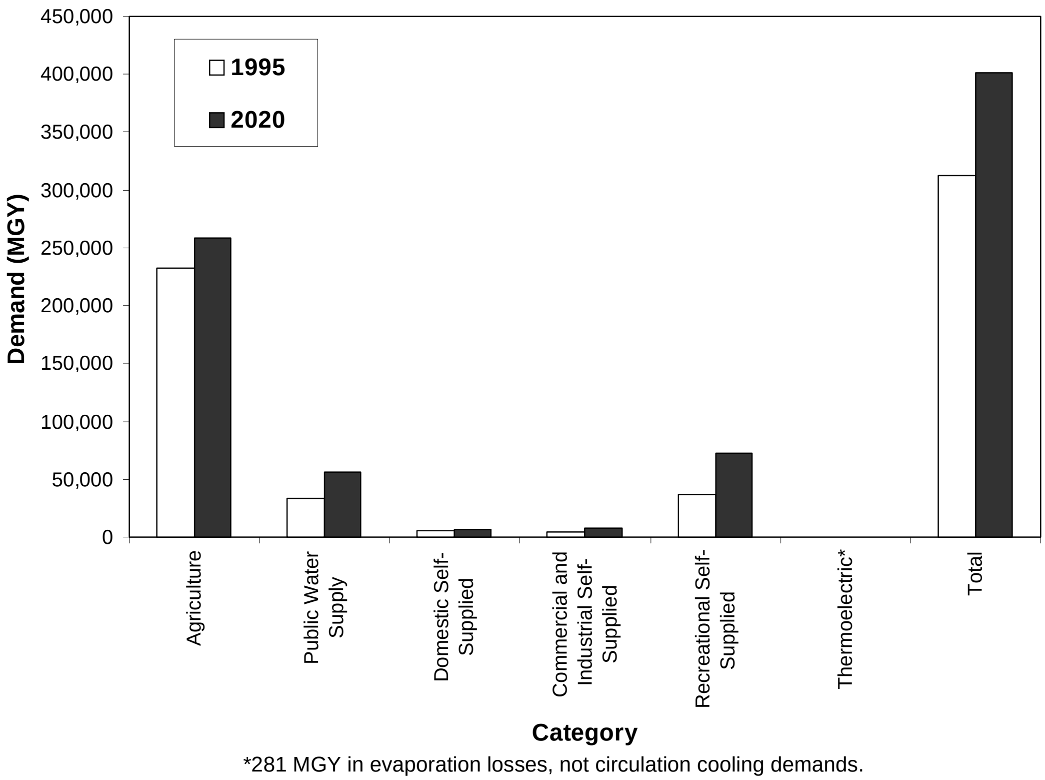


Figure 13. Comparison of 1995 and 2020 Water Demands (MGY).

From 1995 to 2020, the total average water demand is projected to increase by 28 percent from 312,954 to 401,548 million gallons per year (MGY), as shown in **Table 13** and **Figure 13**. Recreational self-supplied has the largest projected increase of 94 percent. However, agricultural water demand is projected to remain the single largest category of use. In 1995, agriculture accounted for 74 percent of the total demand. Agricultural demands are projected to increase by 11 percent by 2020, accounting for 64 percent of the total demand in that year.

URBAN WATER DEMAND

Recreation water supply was the largest component (46 percent) of urban water demand in 1995, followed by public water supply (42 percent), domestic self-supplied (6 percent) and commercial and industrial self-supplied (5 percent). Urban water demand in 1995 was estimated to be about 79,913 MGY which is equivalent to 219 MGD; this is projected to increase to almost 142,761 MGY (391 MGD) in 2020. One-in-ten urban demand in 2020 is projected at 158,222 MGY.

Table 13. Overall Water Demands for 1995 and 2020 (MGY).

Category	Estimated Demands 1995	% of Total	Projected Demands 2020	% of Total	% Change 1995-2020	Projected 1-in-10 Demand 2020
Agriculture	233,041	74	258,787	64	11	306,978
Public Water Supply	33,438	11	56,615	14	69	60,545
Domestic Self-Supplied	4,942	2	6,428	2	30	6,816
Commercial and Industrial Self-Supplied	4,155	1	7,289	2	75	7,289
Recreational Self-Supplied	37,097	12	72,148	18	94	83,591
Thermoelectric	281	0	281	0	0	281
Total	312,954	100	401,548	100	28	465,500

The major driving force behind urban demand is population. Population estimates for 1995 were taken from the U.S. Census. Population projections for the year 2020 were obtained from the Bureau of Economic and Business Research at the University of Florida, adjusted to the portions of the counties within the LWC Planning Area (**Table 14**), and used to develop urban demand projections. The total population of the LWC Planning Area for 1995 was 590,939 and is projected to increase 68 percent to 992,805 in 2020.

Urban demand is projected for the Lee, Collier, Glades, and Hendry county areas. The Charlotte County Area is not included in the urban water demand analysis because the portion of the county within the LWC Planning Area has very small demands for urban uses. Urban demands are concentrated in Lee and Collier counties, with these two counties accounting for approximately 95 percent of the LWC Planning Area urban population.

Public Water Demand

The estimated water demand for PWS and domestic self-supplied users was 38,380 MGY in 1995. These water demands are projected to increase 64 percent from 1995 to 2020 to a total water demand of 63,043 MGY. About 13 percent of the 1995 population were self-supplied and this is projected to be 10 percent in 2020 (**Table 15**). The figures in **Table 15** are presented both in millions of gallons per year (MGY) and

Table 14. Population in the Lower West Coast Planning Area 1995-2020.

County Area	1995			2020		
	Total	Public Water Supplied	Domestic Self-Supplied	Total	Public Water Supplied	Domestic Self-Supplied
Lee	375,238	317,451	57,787	594,300	517,506	76,794
Collier	182,933	158,708	24,225	349,200	322,919	26,281
Hendry	27,714	18,617	9,097	39,999	28,365	11,634
Glades	4,409	2,122	2,287	7,560	3,710	3,850
Charlotte	645	0	645	1,746	0	1,746
LWC Planning Area	590,939	496,898	94,041	992,805	872,500	120,305

millions of gallons per day (MGD). 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 F.

Table 15. Public Water Supply and Domestic Self-Supplied Demand (MGY/MGD).

County Area	1995				2020				% Change between 1995 and 2020	
	Public Water Supplied		Domestic Self-Supplied		Public Water Supplied		Domestic Self-Supplied			
	MGY	MGD	MGY	MGD	MGY	MGD	MGY	MGD	PWS	DSS
Lee	15,662	42.91	2,197	6.02	24,319	66.63	3,153	8.64	+55	+43
Collier	16,213	44.42	1,971	5.40	29,930	82.00	2,171	5.95	+85	+10
Hendry	1,456	3.99	631	1.73	2,182	5.98	828	2.27	+50	+31
Glades	105	0.29	113	0.31	182	0.50	189	0.52	+72	+68
Charlotte	0	0.00	29	0.08	0	0.00	83	0.23	0	+188
Total	33,437	91.61	4,942	13.54	56,615	155.11	6,427	17.61	+69	+30

Commercial and Industrial Self-Supplied

Commercial and industrial demands supplied by public utilities are included in the PWS demands. The Lee and Collier county areas are the only portions of the LWC Planning Area with reported commercial and industrial self-supplied demands (**Table 16**). Estimates are provided both in terms of millions of gallons per year (MGY) and millions of gallons per day (MGD). The projection methodology for commercial and industrial self-supplied demand is discussed in Appendix F.

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

County Area	1995		2020	
	MGY	MGD	MGY	MGD
Lee	1,974	5.40	3,126	8.60
Collier	2,181	6.00	4,163	11.40
Hendry	0	0.00	0	0.00
Glades	0	0.00	0	0.00
Charlotte	0	0.00	0	0.00
Total	4,155	11.4	7,289	20.00

Landscape and Recreational Self-Supplied Demand

Recreational demands supplied by utilities are included in the PWS demands. Demand projections for this section include irrigated acreage permitted for landscaping and recreation, including golf course irrigation, in the LWC Planning Area. Results are presented both in terms of millions of gallons per year (MGY) and millions of gallons per day (MGD). The Collier County Area has the highest demand (**Table 17**). Projection methodology is discussed in Appendix F.

Table 17. Landscape and Recreational Self-Supplied Demand (MGY/MGD).

County Area	1995		2020	
	MGY	MGD	MGY	MGD
Lee	15,370	42.10	27,048	74.00
Collier	21,413	58.70	44,786	122.70
Hendry	281	0.80	281	0.80
Glades	33	0.10	33	0.10
Charlotte	0	0.00	0	0.00
Total	37,097	101.60	72,148	197.70

AGRICULTURAL WATER DEMAND

Summary of Agricultural Demand

There are seven subcategories of agricultural water demand analyzed in this section: (1) citrus; (2) tropical fruit; (3) vegetables; (4) field crops; (5) sod; (6) greenhouse and nursery; and (7) cattle and fish production. Field crops include sugarcane, seed corn, rice, and soybeans. Agricultural water demand was estimated for 1995 to be approximately 233 billion gallons (**Table 13**). Citrus has by far the largest 1995 agricultural water demand (48 percent) and is followed by field crops (31 percent).

Vegetables, sod, and greenhouse/nursery combined account for about 15 percent of agricultural water demand. Tropical fruit production accounts for approximately one percent of agricultural demand. The combined water demand for cattle watering, irrigation of improved pasture, and aquaculture account for less than 0.5 percent of total agricultural demand.

Agricultural water demand is forecast to increase by 11 percent to 258,787 MGY in the year 2020 (**Table 13**). More than half of the agricultural water demand in the year 2020 is anticipated to be for citrus (56 percent) and field crops (28 percent). Vegetables, sod, and greenhouse/nursery combined account for about 14 percent of projected 2020 agricultural water demand. Tropical fruit production accounts for approximately one percent of projected 2020 agricultural demand.

The LWC Planning Area continues to experience growth in irrigated agricultural acreage, especially citrus. The irrigated crops in this region are citrus, sugarcane, vegetables, sod, and greenhouse/nursery. Growth in citrus acreage is usually on land that was formerly pasture. Pasture is seldom irrigated in the LWC 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 which are associated with the total number of cattle. Descriptions of the agricultural acreage in each county, projection methodology, and the calculation of irrigation requirements and other agricultural water use, including data sources, are detailed in Appendix F.

Agricultural irrigation requirements vary by season, especially for crops such as vegetables that are grown only at specific times of the year. Therefore, agricultural requirements vary by month for each crop in each county, and the summations for the LWC Planning Area are presented as millions of gallons per year and millions of gallons per day. **Figure 14** presents a graphical comparison of agricultural demand by crop type for 1995 and 2020. **Table 18** shows the annual average agricultural irrigation demand by crop.

These projected crop acreages are consistent with the Caloosahatchee Water Management Plan (CWMP). Apparent differences between the plans occur because of differences in geographic extents and the fact that the LWC Water Supply Plan uses net acres while the CWMP uses gross acres. Lands irrigated by ground water are consistent in both plans.

During the public participation process, agricultural interests on the CWMP Advisory Committee indicated that known future projects would result in increases to citrus and sugarcane acreages beyond the historical based acreage projections. As a result, an additional 12,748 acres of citrus and 45,210 acres of sugarcane were incorporated in the analysis for the CWMP. To prevent misrepresentation, gross acreages and net acreages are not combined in the above figure and table (**Figure 14** and **Table 18**).

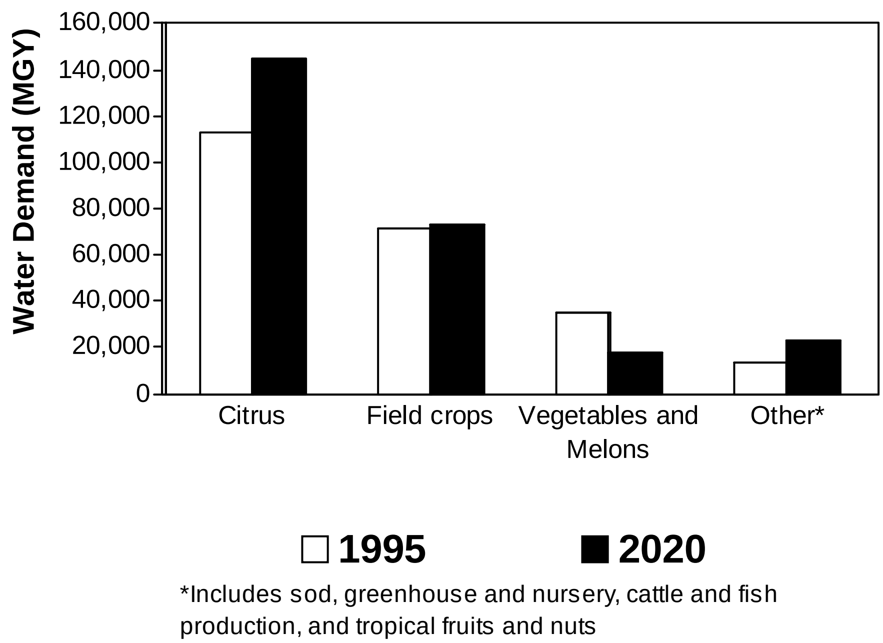


Figure 14. Comparison of 1995 and 2020 Agricultural Demands (MGY).

Table 18. Water Demand (MGY) and Irrigated Acreage by Crop Type[a].

Category	Estimated Demands 1995 (MGY)	Total Irrigated Ac./(head cattle) 1995	Projected Demands 2020 (MGY)	Total Irrigated Ac./ (head cattle) 2020	% Change in Demands 1995-2020	% Change in Acreage 1995-2020	Projected 1-in-10 Demands 2020
Citrus and Citrus Nursery	112,724	128,259	145,206	166,739	29	30	172,339
Tropical Fruit and Nuts	2,103	1,930	3,465	3,180	65	65	4,394
Vegetables and Melons	34,951	44,231	18,103	22,427	-48	-49	20,949
Field Crops	71,707	55,038	72,963	57,122	2	4	86,971
Sod	1,128	650	1,128	650	0	0	1,330
Greenhouse and Nursery	9,610	6,089	17,170	10,627	79	75	20,043
Cattle and Fish Production	818	86,113	752	75,583	-8	-12	752
Total Planning Area	233,041	236,197	258,787	260,745	11	10	306,778

a. Because of differences in units, acreage total excludes cattle and fish production.

Citrus

Citrus is by far the dominant agricultural crop in the LWC Planning Area, and occupies approximately one-half of the irrigated agricultural acreage in the region. Between 1968 and 1980 acreage remained at about the same level. From about 1984 until about 1992, acreage grew rapidly, associated with the inter-regional movement of citrus acreage southward from Central Florida following several severe winter freezes in the mid-1980s. Since approximately 1992, citrus growth has slowed in the area.

Citrus acreage in the LWC Planning Area is projected to grow from 128,259 acres in 1995 to 166,739 acres in 2020. This growth in acreage represents an increase in average irrigation requirements from 112,724 MGY in 1995 to 145,206 MGY in 2020. The 1-in-10 demands estimated for 2020 are 172,339 MGY.

Tropical Fruits and Nuts

Tropical fruits (primarily avocados and mangos) and nuts are produced only in the Lee County portion of the LWC Planning Area. In 1995, there were 1,930 acres of tropical fruits and nuts in Lee County; this acreage is projected to increase to 3,180 acres in 2020. Average irrigation requirements for this acreage are estimated at 2,103 MGY in 1995 and 3,465 MGY in 2020. The projected 2020 1-in-10 irrigation requirement is 4,394 MGY.

Vegetables and Melons

Vegetable crops grown in the LWC Planning Area include cucumbers, peppers, tomatoes, squash, eggplant, watermelons, Latin vegetables, snap beans, and potatoes. There is no significant berry production in the area. Different types of vegetables are often grown interchangeably, and in 1995 there were 44,231 acres of land used for vegetable production. This is projected to decrease to 22,427 acres in 2020. The average irrigation requirement for vegetable crops is 34,951 MGY in 1995 and 18,103 MGY in 2020. The 1-in-10 irrigation requirement for the 2020 vegetable acreage is 20,949 MGY.

FIELD CROPS

Sugarcane

Hendry and Glades county areas are the only parts of the LWC Planning Area where sugarcane is produced. As a result of the cultivation practices used for sugarcane (ratoon and fallow), 25 percent of the land used for sugarcane production is fallow in any given year. This fallow land does not require irrigation and is not included in the demand projections presented here.

In 1995, a total of 35,443 acres of sugarcane were produced in the Hendry County Area, with an average irrigation requirement of 46,616 MGY. The historical projection of acreage and irrigation demand is to remain relatively constant through 2020. The 1-in-10 irrigation requirement for 2020 is 56,466 MGY.

Sugarcane acreage in the Glades County Area is also projected to remain constant at 16,295 acres through 2020. The associated acreage irrigation requirement is 23,134 MGY. The 1-in-10 irrigation requirement for 2020 is 27,710 MGY.

Other Field Crops

The seed corn production in southeastern Charlotte County varies from year to year, based primarily on the demand for seed corn, which in turn is dependent on seed corn production in other parts of the country. This variation in production is more a fluctuation than a trend. The estimate for seed corn production is 2,100 acres and 1,000 acres for soybeans. While fluctuations are anticipated, the magnitude of this acreage is typical. These combined acreages have average irrigation requirements of 1,782 MGY, and 1-in-10 year drought irrigation requirements of 2,020 MGY.

Rice in southern Glades County is grown during the summer months in rotation with sugarcane or winter vegetables, and takes place on land that would otherwise be fallow. Rice acreage in southern Glades County was assessed at 200 acres in 1995, and is projected to increase to 800 acres by 2020. Average demands are 175 MGY for 1995 and 699 MGY for 2020. The 1-in-10 demands in 2020 are 775 MGY.

Sod

In 1995, there were a total of 650 acres of irrigated sod production in the LWC Planning Area. There is additional sod harvested from pastureland, but this is rarely irrigated. Sod production is projected to remain fairly constant through 2020, with an associated average irrigation requirement of 1,128 MGY in both 1995 and 2020. The 1-in-10 irrigation requirement for sod for 2020 is estimated at 1,330 MGY.

Greenhouse and Nursery

In 1995, there were 6,089 acres of greenhouse/nursery operations in the LWC Planning Area, and this is projected to increase to 10,627 acres by the year 2020. Average demands by greenhouse/nurseries in the LWC Planning Area are projected to increase from 9,610 MGY in 1995 to 17,170 MGY in 2020. The 1-in-10 irrigation requirement associated with the projected 2020 acreage is 20,043 MGY.

Cattle and Fish Production

Demand for cattle watering and barn washing is associated with cattle production (which is in turn associated with pasture acreage). However, these demand results are somewhat conservative since range cattle are also included in the calculations. Aquaculture, associated with fish production is only located in Collier County. Combined cattle and fish production was assessed at 818 MGY in 1995, and is projected to decline slightly to 752 MGY in 2020. This decline is related to the displacement of pastureland by other agricultural or urban land uses.

Chapter 7
WATER SOURCE OPTIONS

Water source options are options that make additional water available from existing or new sources, such as reclaimed water or the Floridan aquifer, or options that reduce water use, such as conservation. This section discusses options that increase water availability.

WATER CONSERVATION

In the late 1980's, the District experienced severe drought conditions. As a result of the drought, the District examined its rules concerning drought management and made changes to the Basis of Review (BOR) for Water Use Applications. These changes included water conservation requirements for all classes of water use. Examples of requirements such as adoption of ordinances that affect irrigation hours, landscaping and plumbing fixture ordinances, leak detection, rate structures, and public education are discussed in detail in this chapter. These changes have, over the years since adoption, largely been incorporated into existing water use permits. Consequently, every day water use has become more “efficient.”

Water conservation refers to any beneficial reduction in water use losses. Practices and technologies that provide the services desired by the users, while using less water, help 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, 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 historic rates and patterns of water use in the modeling of the LWC 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 potable public water supply permit must submit a water conservation plan at the time of permit application. Utilities operated by private entities and those public utilities providing service to an area beyond their political boundary are required to document the fact that they requested local governments within their service area to adopt conservation ordinances.

The conservation plan must address the following elements:

- Adoption of an irrigation hours ordinance
- Adoption of a Xeriscape™ landscape ordinance
- Adoption of an ultra-low volume fixtures ordinance
- Adoption of a rain sensor device ordinance
- Adoption of a water conservation based rate structure
- Implementation of a leak detection and repair program
- Implementation of a water conservation public education program
- An analysis of reclaimed water feasibility

The mandatory water conservation program requires that each utility evaluate and take applicable action on all elements. The elements consist of a combination of water conservation ordinances and water conservation activities. Utilities must rely on local governments to codify the water conservation ordinances. Depending on the demographics and location of the service area, utilities can choose to demonstrate which water conservation activities are more cost effective for the situation and emphasize implementation of those activites in their conservation plan.

The implementation status of the water conservation measures within regional public water supply utility service areas in the LWC Planning Area are indicated in **Table 19**. Analysis for reclaimed water feasibility is omitted from this table. All utilities that have an associated wastewater treatment facility have conducted a study. Generally, because of the autonomy of local governments in the LWC Planning Area, each ordinance has to be adopted by each unit of local government for the measure to be fully implemented. Positive responses in **Table 19** reflect the adoption of the appropriate ordinance by the applicable local government, within the majority of the utility's service area.

Adoption of an Irrigation Hours Ordinance

The ordinance limits all lawn and ordinance irrigation to the hours, of 4:00 P.M. to 10:00 A.M. at a minimum. Irrigation during daytime hours is generally less efficient. The sunlight and increased winds during the daytime hours cause some of the water to evaporate before hitting the ground or to blow onto impervious surfaces such as

Table 19. Implementation Status of Mandatory Water Conservation Measures.

Utility Service Area	Ordinance Required				Ordinance Not Required			
	Irrigation Hours	**Xeriscape / Landscape**	**Ultra Low Vol. Plumbing Fixture**	**Rain Sensor Device**	**Conservation Rate Structure**	**Utility Leak Detection /Repair**	**Water Conservation Public Education**	**Reclaimed Water Feasibility**
Lee County								
Lee County Utilities	Yes	No	Yes	No	Yes	Yes	Yes	Yes
Bonita Springs	Yes	No	Yes	No	Yes	Yes	Yes	Yes
Island Water Assoc.	Yes	Yes	Yes	No	Yes	Yes	Yes	No
Fort Myers	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
Greater Pine Island	Yes	No	Yes	No	Yes	No	Yes	No
Cape Coral	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Gulf Corkscrew/San Carlos	Yes	No	Yes	No	Yes	Yes	Yes	Yes
Lehigh	Yes	No	Yes	No	Yes	No	Yes	Yes
Collier County								
Immokalee	No	Yes	Yes	Yes	Yes	No	Yes	Yes
Naples	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Marco Island Utilities	No	Yes	No	Yes	No	Yes	Yes	Yes
Golden Gate	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Everglades City	Yes	No	No	Yes	Yes	No	No	Yes
Collier County Utilities	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Port of the Islands	No	Yes	Yes	Yes	No	No	Yes	No
Hendry County								
Clewiston	No	No	No	No	No	Yes	No	Yes
LaBelle	No	No	Yes	No	No	Yes	No	Yes
Port LaBelle	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Glades County								
Moore Haven	No	Yes	Yes	No	No	Yes	No	No
Charlotte County								
No Public Water Supply Systems in Planning Area								

Yes: Water Conservation Measure Used; No: Measure Not used.

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 should 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.

The permit applicant or enacting local government may adopt an ordinance that includes exemptions from the irrigation hour restrictions for the following circumstances, irrigation systems and/or users:

- Irrigation using a micro irrigation system
- Reclaimed water end users
- Preparation for or irrigation of new landscape
- Watering in of chemicals, including insecticides, pesticides, fertilizers, fungicides, and herbicides when required by law, recommended by the manufacturer, or constituting best management practices
- Maintenance and repair of irrigation systems
- Irrigation using low volume hand watering, including watering by one hose attended by one person, fitted with a self-canceling or automatic shut off nozzle or both
- Users irrigating with 75% or more water recovered or derived from an aquifer storage and recovery system

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 nature 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.

The District finds that the implementation and use of Xeriscape™ landscaping, as defined in Section 373.185, F.S., contributes to the conservation of water. The District further supports adoption of local government ordinances as a significant means of achieving water conservation through Xeriscape™ landscaping.

Adoption of an Ultra Low Volume Fixture Ordinance

This measure requires adoption of an ordinance that 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; showerheads, 2.5 gal/min.; and faucets, 2.0 gal/min. The previous standard for plumbing devices (before September 1983) included: toilets, 3.5 gal/flush; showerheads, 3.0 gal/min.; and faucets, 2.5 gal/min. These District regulations are consistent with the maximum water use allowed for showerheads and faucets manufactured after January 1, 1994 (US Code: title 42, Section 6295 of the Energy Policy Act) and conform to current Building Construction Standards (Chapter 553.14, F.S.).

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

Adoption of a Rain Sensor Device Ordinance

This measure requires adoption of an ordinance that 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 rate structure used by utilities that provides a financial incentive for users to reduce demands. Water conservation rates generally involve the following:

- Increasing the block rate, where the marginal cost of water to the user increases in two or more steps as water use increases
- 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
- Quantity based surcharges
- Time of day pricing

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 infield leak detection and repair efforts. The program description should include the number of man hours devoted to leak detection, the type of leak detection equipment being used and an accounting of the water saved through leak detection and repair.

Implementation of a Water Conservation Public Education Program

Public information, as a water conservation measure, involves a series of reinforcing activities 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 that control a wastewater treatment plant, an analysis of the economic, environmental, and technical feasibility of making reclaimed water available is required.

Commercial/Industrial Users

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

Conservation plans must include the following:

- An audit of water use
- Implementation of cost effective conservation measures
- An employee water conservation awareness program
- Procedures and time frames for implementation
- 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 hour's 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 existing 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 showerheads 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 rest rooms and other facilities that 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 control devices.

Utilities and other water management agencies generally implement audits. 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 20** and **21**. In addition, the cost and water savings for irrigation system conversion for agricultural uses are discussed. The information in this section should not be interpreted as a cost-benefit analysis of these conservation measures, since no discounting is applied to the streams of costs and benefits.

Table 20. Representative Water Use and Cost Analysis for Retrofit Indoor Water Conservation Measures.

Representative Water Use	Toilet	Showerhead
Cost/unit ($)	$200.00	$20.00
Flushes/day/person	5	--
Gallons saved/flush	1.9	--
Minutes/day	--	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/1,000 gallons saved	$0.58	$0.22

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 the implementation of retrofit programs can be significant. For example, if 10,000 showerheads were retrofitted in an

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

Representative Water Use	Rain Switch	Mobile Irrigation Lab
Cost/unit or visit ($)	$68.00	$50.00[a]
Acres/unit	0.11	0.11
Water savings (inches/year)	70	70
Water savings (gallons/year)	209,070	209,070
Life (years)	10 years	7 years
Water savings/life (gallons)	2,090,700	1,463,493
Cost/1,000 gallons saved ($)	$0.033	$0.034

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

area, this could result in a water saving 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.

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. 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 reuse potential 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 that conserve water. To assist growers with agricultural irrigation, the federally funded Mobile Irrigation Laboratory that operates in the LWC Planning Area carries out audits. Agriculture is a major water user in the LWC 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 projects container nursery projects. 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. The percentages of crops irrigated by micro irrigation systems (drip and trickle) during 1995 are discussed in Appendix F.

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

Initial cost ($/acre)	$1,000.00
Operating cost ($/acre	$25.00
Water savings (inches/yr)	8,519
Water savings (gallons per year)	230,805
Life (years)	20
Cost over life ($)	$1,500.00
Water savings over life (gallons)	4,616,100
Cost/1,000 gallons saved ($)	$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 50 percent efficiency to micro irrigation with 85 percent efficiency could result in water saving of approximately 6 BGY or 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.

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 LWC Planning Area are currently being revised. Until this information becomes available, less recent cost information is provided in **Table 23**. The costs were based on a 16-inch diameter well and a maximum Surficial Aquifer well depth of 200 feet and maximum Floridan Aquifer well depth of 900 feet.

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.

Table 23. Well Costs for Aquifer Systems.

Aquifer System	Drilling Cost (per well)	Equipment Cost (per well)	Engineering Cost (per well)	Operations and Maintenance Cost (per 1,000 gallons)	Energy Cost (per 1,000 gallons)
Surficial	$45,185	$61,501	$16,317	$.004	$.025
Intermediate[a]	$43,930	$61,501	$16,317	$.004	$.030
Intermediate[b]	$62,757	$61,501	$15,062	$.004	$.035
Floridan	115,472	$65,267	$17,572	$.004	$.040

a. In northern Lee and Hendry County, the average depth is 200'.
b. In Collier, southern Lee and Highlands County, the average depth is 300'.
Source: PBS&J, 1991, Water Supply Cost Estimates. Cost were converted to 1999 dollars.

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. 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. Additionally, large user agreements are taken into account in calculating water use allocations. 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.

RECLAIMED WATER

Encouragement and promotion of the use of reclaimed water and water conservation are formal state objectives. The Water Resource Implementation Rule (Chapter 62-40 F.A.C.) 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 Water Use permits. Statutory and rule provisions for reuse of reclaimed water are included in Appendix A.

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 H.

Reclaimed Water 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 include the following:

- 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 Chapter 5 of the LWC Planning Document.

Existing Treatment Facilities

There are 22 existing regional wastewater treatment facilities in the LWC Planning Area with a FDEP permitted capacity equal to or greater than 0.50 MGD. These facilities treated an average of 58 MGD in 1997. Nineteen of the facilities used reuse for all or a portion of their disposal needs in 1997 resulting in 37 MGD being reused. Reuse included irrigation of residential lots, medians, green space, golf courses, and ground water recharge via percolation ponds. In addition to reuse, 5 MGD was disposed of by deep well injection and 16 MGD was disposed of by surface water discharge. The volume of treated wastewater is projected in increase to 97 MGD by 2020. Summarized wastewater facility information is provided in Appendix D.

SURFACE WATER STORAGE

Surface water storage could be used by pumping surface water runoff and ground water seepage into regional storage systems during periods of excessive rainfall to provide additional water supply and flood protection. The capture of surface water runoff and ground water seepage in canals of the primary water management system, and storage of these waters in existing or new surface water reservoirs or impoundments, provides an opportunity to increase the supply of fresh water during subsequent dry periods. The primary problems associated with surface water storage are the expense of constructing and operating large capacity pumping facilities, the cost of land acquisition, appropriate treatment costs, the availability of suitable locations, and the high evaporation rates of surface water bodies (**Table 24**).

Table 24. Reservoir Costs.

Reservoir Type	Construction Cost $/Acre	Engineering Design Cost[a] $/Acre	Construction Administration $/Acre	Land $/Acre	Operations and Maintenance $/Acre
Minor Reservoir	3,567	505	399	5,648	148
Major Reservoir	10,016	1,135	566	5,648	132

a. Engineering costs include the permitting process, hydrogeologic investigation, monitoring during well construction, and design. Costs were converted to 1999 dollars.

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. **Table 25** presents the status of the ASR wells in the LWC Planning Area.

Aquifer Storage and Recovery Costs

Estimated project costs for ASR consisting of a 900-foot, 16-inch well, with two monitoring wells using treated water 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. 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 additional treatment capacity to meet peaks in demands. Water for ASR should be reflected in the water use permit. The costs related to aquifer storage and recovery in the LWC Planning Area are currently being revised. Until this information becomes available, less recent cost information is provided in **Table 26**.

Table 25. Aquifer Storage and Recovery Facilities in Southwest Florida.

Facility Name	ASR Type	Pre-application	Construction Application Received	Construction Permit Received	Well Constructed	Operational Testing	Operation Permit
San Carlos Estates (Bonita Springs Utilities)	TDW		X				
Kehl Canal (Bonita Springs Utilities)	PTS		X				
Fort Myers	TDW		X				
Collier County	TDW						X
North Reservior (North Fort Myers)	TDW	X					
Olga	RSW	X					
Corkscrew (Lee County)	TDW						
Well 1					X		
Wells 2-6		X					
Marco Lakes	PTS						
Well 1						X	
Wells 2-9			X				

ASR types: TDW- potable through drinking water plant; RSW- raw surface water; PTS- partially treated surface water; RGW- raw ground water; RCW- reclaimed water. Source: 1999 personal communication with utility representatives.

Table 26. Aquifer Storage and Recovery System Costs.

System	Well Drilling Cost (per well)	Equipment Cost (per well)	Engineering Cost[a] (per well)	Operations and Maintenance Cost (per 1,000 gallons)	Energy Cost (per 1,000 gallons)
Treated Water at System Pressure	$251,026	$37,654	$451,847	$.005	$.08
Treated Water Requiring Pumping	$251,026	$125,513	$502,052	$.008	$.08

a. Engineering costs include the permitting process, hydrogeologic investigation, monitoring during well construction, and design.

Source: PBS&J, 1991, Water Supply Cost Estimates. Costs were converted to 1999 dollars.

Existing ASR Facilities

There are many ASR facilities in operation in the United States, including New Jersey, Nevada, California, and Florida. In Florida, there are numerous ASR projects in operation, under construction, or in permitting. Operational facilities include: Collier County, Manatee County, Peace River, Cocoa, Port Malabar, and Boynton Beach. All but the Marco Island facility use treated water. Marco Island uses raw surface water from a borrow pit. Collier County uses potable water. Lee County has completed their ASR well and is in the testing phase. Bonita Springs is in the permitting/design phase while several other entities are evaluating the feasibility of ASR. Additional information on ASR can be found at www.sfwmd.gov.

FLORIDAN AQUIFER SYSTEM (FAS)

In the LWC Planning Area, there has been increased use of the FAS for public water supply. The FAS yields nonpotable water throughout the LWC 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 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 LWC 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 three major aquifer systems of the LWC 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. For the period from 1985-1990, the common value for TDS in the upper portion of the FAS was 1,093 mg/L to 7,425 mg/L. For this same period, chloride ranged from 167 mg/L to 3,785 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.

SEAWATER

While seawater is plentiful and obtainable from the Gulf of Mexico, costs associated with the construction and operation of seawater reverse osmosis and distillation systems can be high. As with all surface waters, the Gulf of Mexico is also vulnerable to discharges or spills of pollutants which could impact a water treatment system. However, recent proposals to construct and operate a seawater desalination water supply for Tampa

Bay Water indicate these facilities can be constructed at a dramatically lower cost (as much as half) than previous experience. Four proposals to construct a 25 MGD seawater desalination water supply state water could be produced for less than $2.30 per thousand gallons, with one estimate as low $1.71 per thousand gallons for the first year (Tampa Bay Water Press Release, 1999).

Chapter 8
WATER QUALITY AND TREATMENT

There are water quality standards that must be met for different types of uses. These standards are generally 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. Human activities, such as waste disposal or pollution spillage, have the potential of degrading ground and surface water quality.

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 G.

The U.S. Environmental Protection Agency (USEPA) is developing a ground water rule that specifies the appropriate use of disinfection to assure public health protection. The ground water rule proposal is anticipated to be established by the end of the year 2000. More information on the ground water rule can be obtained from the USEPA; internet access is also available at the following site: http://www.epa.gov/OGWDW/standard/gwr.html.

Large surface water systems must comply with the Stage 1 Disinfectants and Disinfection By-products Rule (D/DBPR) by December 2001. Ground water systems and small surface water systems must comply by December 2003. The new total trihalomethanes MCL may have an impact on public water supplies in the LWC Planning Area. Most systems in the LWC Planning Area have been able to meet the current TTHM standard of 0.10 mg/L by modifying or optimizing operation of their treatment and/or disinfection processes. TTHM concentrations in some cases are close to the current MCL of 0.10 mg/L. Some utilities in the LWC Planning Area will have difficulty in meeting more stringent TTHM standards without some plant modification. TTHM MCL information is given in Appendix G.

The Interim Enhanced Surface Water Treatment Rule (IESWTR) (December, 1998) will strengthen protection against microbial contaminants, especially *Cryptosporidium* (Federal Register CFR 40, Parts 9, 141, and 142). The IESWTR applies to public water systems that use surface water or ground water under the direct influence of surface water (GWUDI) and serve at least 10,000 people. States must conduct surveys on smaller systems (USEPA, 1998). This rule will come into affect with the Stage I D/DBPR. This rule contains new standards for turbidity. For more information, internet access is available at the following site: http://www.epa.gov/OGWDW/mdbp/ieswtr.html.

Nonpotable Water Standards

Water for potable and nonpotable water uses have different treatability constraints. 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 which 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 G.

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 H). 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 (WSTB, 1996).

GROUND WATER CONTAMINATION AND IMPACTS TO WATER SUPPLY

Ground Water Contamination Sources

The Surficial Aquifer System is easily contaminated by activities occurring at land's surface in the LWC Planning Area. Once a contaminant enters the aquifer, it may be difficult 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. Saltwater intrusion also presents a potential threat to aquifers in the LWC Planning Area.

Solid Waste Sites

Landfills and old dumps within the boundaries of the LWC Planning Area are listed and displayed in Appendix G, with an accompanying location map. In addition to landfills and dumps there are also sludge spreading sites; 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 monitoring began in the early 1980's for all the landfills listed in Appendix G. No contamination problems were noted in any of these sites. The active landfills in the LWC Planning Area are lined; any unlined cells at the same sites have been closed (Krumbholz, 1998).

Contaminants from landfills are called leachates. Leachates often contain high concentrations of nitrogen and ammonia compounds, iron, sodium, 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 the following:

- Landfill size and age
- Types and quantities of wastes produced in the area
- Local hydrogeology
- 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 hazardous waste site cleanup. There are many potential hazardous waste sites in the LWC Planning Area. Many older gas stations and dry cleaning facilities require some cleanup. Not all the potential hazardous waste sites actually contain contamination. The potential hazardous waste sites include locations in the Early Detection Incentive (EDI) Program, the Petroleum Liability and Restoration Program (PLIRP), the Abandoned Tank Restoration Program (ATRP), the Petroleum Cleanup Participation Program (PCPP), Pre-approved Advanced Cleanup Program (PACP) and other 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 USEPA to identify and remediate uncontrolled or abandoned hazardous waste sites. The National Priorities List (NPL) targets sites considered to have a high health and environmental risk. There are no NPL sites in the LWC Planning Area. The U.S. Environmental Protection Agency has a web site with more information about the Superfund program sites at http://www.epa.gov/superfund/sites.

Petroleum Contaminant Sites

Sites are reported to the FDEP, if contamination was noticed in the soil, surface water, ground water or monitoring wells. For more information on the petroleum clean up program, please refer to Florida Department of Environmental Protection world wide web site at http://www.dep.state.fl.us/dwm/programs/pcp/default.html.

Septic Tanks

Septic systems are a common method of on-site waste disposal. There are approximately 81,000 septic tanks in the LWC Planning Area (estimated from data in Marella, 1994, 1998 and SFWMD, 1998). Septic tanks may threaten ground water resources used as drinking water sources.

Saltwater Intrusion

Saltwater intrusion along the coast of the LWC Planning Area has been advanced by canal excavation and aquifer development for public water supplies and agriculture. In some channels, salinity control structures have been installed to limit saltwater encroachment by maintaining freshwater heads on the inland side. The greatest threat from saltwater intrusion lies where ground water and surface water gradients are lowest. Saltwater intrusion has been most evident in the lower Tamiami aquifer in the Naples Coastal Ridge and Bonita Springs/North Naples areas, and also in the water table aquifer in the area of Marco Island's public water supply withdrawals.

The SFWMD maintains a saltwater intrusion database called SALT that collects information on chloride, specific conductance, and water levels from the District's monitoring network. The monitoring network consists of data supplied from monitoring wells by the public water supply utilities and the USGS. Selected data acquired from this network, the USGS, and the District's DBHYDRO database were used to construct maps of average chloride concentrations in monitor wells in the water table, lower Tamiami, and mid-Hawthorn aquifers. These maps are intended to serve as an aid in visualizing the distribution of known values, rather than as an absolute indicator of saltwater intrusion. Appendix G includes maps containing well locations and average chloride concentrations.

In addition to saltwater intrusion from coastal waters, overdevelopment of aquifers which overlie more saline aquifers increases the possibility of upconing and contamination from the poorer quality layers. This potential exists throughout the LWC Planning Area. Although upconing of saline water is not considered to be true seawater intrusion, it is a significant threat because of its potential to degrade potable water supplies.

Cross contamination of shallow aquifers has also occurred from many of the Floridan aquifer wells in the LWC Planning Area. Numerous artesian wells were drilled into the highly mineralized Floridan Aquifer System from the 1930s through the 1950s for agricultural water supply and oil exploration. Many of these wells were short-cased, meaning the casings extended to less than about 200 feet below land surface, which exposed the shallower zones to invasion by the more saline Floridan water. Additionally, steel casings may have corroded, allowing inter-aquifer exchange through the casings. Often, if a well was abandoned, it was either plugged improperly, or simply left open, free-flowing on the land surface, and recharging the surficial aquifer with saline water. The result is the existence of localized sites throughout the shallow aquifers containing anomalously high concentrations of dissolved minerals.

In 1981 the Florida Legislature passed the Water Quality Assurance Act which required the water management districts to plug abandoned FAS wells. Under this program, many known wells in the LWC Planning Area were plugged. The federal government is currently offering a well abandonment program through the Soil Conservation Service for wells on specific agricultural lands.

Another source of localized pockets of mineralized water is connate water, theorized to be ancient seawater remaining from periods of inundation, entrapped within the aquifer, and relatively unexposed to freshwater flushing.

The effects of seawater intrusion, upconing, aquifer cross contamination, and connate water can create a complex and somewhat unpredictable scenario of local ground water quality. Monitor wells provide a great deal of information where they exist, but there are limits as to how many wells can be installed and monitored. Where more detailed information is required, additional methods may be needed to monitor the saltwater interface. In 1993, the District participated in a cooperative study in Broward County which utilized a surface geophysical method for delineating saltwater intrusion.

Geophysical surveys can provide extremely useful information about the extent of saltwater intrusion at relatively low cost (Benson and Yuhr, 1993).

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. Many of the major contamination sources identified in the LWC Planning Area can generate contaminants that are not easily treated. For example, nitrate is generated by septic systems or by fertilizer application, benzene from leaking gasoline tanks, and volatile organic compounds from various hazardous waste contamination sites. Water quality treatment methods for potable and nonpotable uses are described in the remaining portions of this section.

WATER TREATMENT TECHNOLOGIES

Several water treatment technologies are currently employed by the regional water treatment facilities in the LWC Planning Area. Chlorination, lime softening and membrane processes warrant discussion. The United States Environmental Protection Agency (USEPA) and Florida Department of Environmental Protection regulate water treatment plants. 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.

Disinfection

Disinfection, the process by which pathogenic microorganisms are destroyed, provides essential public health protection. All potable water requires disinfection as part of the treatment process prior to distribution. Chlorination is the only method of disinfection used in the LWC Planning Area.

Chlorination

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. 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. Chlorine is a common disinfectant used in the United States. The use of free chlorine as a disinfectant often results in the formation of levels of Trihalomethanes (THMs) and other disinfectant by-products (DBP) when free chlorine combines with naturally occurring organic matter in the raw water source. In December of 1998, President Clinton announced more stringent regulations in the D/DBPR for TTHMs, and water borne pathogens. The rule also regulates for the first time, *Cryptosporidium.* This may require facilities that 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), enhanced coagulation, membrane systems, and switching from chlorine to chlorine dioxide (Jack Hoffbuhr, American Water Works Association Memorandum [December, 1998] regarding the Interim Enhanced Surface Water Treatment Rule).

The only disinfectant used in the LWC Planning Area is chlorination or chlorine used with ammonia to form chloramine. The rate of disinfection depends on the concentration and form of available chlorine residual, contact time, pH, temperature, and other factors. Current disinfection practice is based on establishing an amount of chlorine residual during treatment and, then, maintaining an adequate residual to the customer's faucet. Chlorine is also effective at reducing color. Chlorination has widespread use in the United States.

Capital and construction costs of a chlorination system are 70 to 80 percent less than a comparable ozonation system, while the operating costs are 25 to 50 percent less. Capital, operation, and maintenance costs for chlorination are presented in **Table 32**.

Table 32. Chlorination Treatment Costs.

Facility Size (MGD)	Capital Cost (per gallon/day capacity)	Engineering Cost (per gallon/ day capacity)	Operations and Maintenance Cost (per 1,000 gallons)
1	$.0638	$.00954	$.0577
3	$.0276	$.00414	$.0264
5	$.0216	$.00324	$.0207
10	$.0141	$.00211	$.0151
20	$.0100	$.00151	$.0126

Source: PBS&J, 1991 Water Supply Cost Estimates converted to 1999 dollars.

Ozonation

The use of ozone reduces unwanted disinfection by-products. However, ozone does not leave a residual like chlorine and chloramine which are persistent and can be measured. Ozone is an unstable gas that is produced on-site. After it is generated, the ozone gas is transferred into the water being treated. Contact times required for disinfection by ozone are short (seconds to several minutes) when compared to the longer disinfection time required by chlorine. Ozone, however, does not produce trihalomethanes as does chlorine and it is also effective at reducing color. Ozonation has widespread use in Europe and Canada, and limited use in the United States (Montgomery, 1985).

Disadvantages of ozone disinfection include its inability to maintain a persistent residual and unknown health effects associated with ozonation by-products. None of these by-product compounds have been shown to have potential health significance but only limited information is available on this subject. Compared to chlorine, ozone appears to generate less mutagenic by-products. A mutagenic compound is one which has the ability to produce a change in the DNA of a cell. Ozone by-products appear to be generally more biodegradable than their precursors. As a result, water receiving ozone treatment may promote regrowth of bacteria in the distribution system. Capital, operation, and maintenance costs for ozonation are presented in **Table 33**.

Table 33. Ozonation Costs.

Facility Size (MGD)	Capital Cost (per gallon/day capacity)	Engineering Cost (per gallon/day capacity)	Operations and Maintenance Cost (per 1,000 gallons)	Energy Cost (per 1,000 gallons)
1	$.1644	$.0251	$.0602	$.0157
3	$.1167	$.0176	$.0330	$.0157
5	$.0936	$.0138	$.0246	$.0013
10	$.0773	$.0113	$.0166	$.0105
20	$.0575	$.0088	$.0133	$.0105

Source: PBS&J, 1991 Water Supply Cost Estimates converted to 1999 dollars.

Aeration

Aeration is used by 5 of the 31 regional water treatment facilities in the LWC Planning Area. This treatment process is used in areas with high quality raw water which only needs to be aerated to remove hydrogen sulfide, which causes tastes and odors, or the removal of carbon dioxide, which can reduce the lime demand in lime softening treatment. Aeration also adds oxygen to the water. More recently, aeration has been used to remove trace volatile organic contaminants from water, which are believed to cause adverse health effects.

Aeration Process

In most water treatment aeration process applications, air is brought into contact with water in order to remove a substance from the water, a process referred to as desorption or stripping. This can be accomplished through packed towers, diffused aeration, or tray aerators.

A packed tower consists of a cylindrical shell containing packing material. The packing material is usually individual pieces randomly placed into the column. The shapes of the packing material vary and can be made of ceramic, stainless steel, or plastic. Water is introduced at the top of the tower and falls down through the tower as air is passing upward.

Diffused aeration consists of bringing air bubbles in contact with a volume of water. Air is compressed and then released at the bottom of the water volume through bubble diffusers. The diffusers distribute the air uniformly through the water cross section and produce the desired air bubble size. Diffused aeration has not found wide spread application in the water treatment field.

Cascading tray aerators depend on surface aeration that takes place as water passes over a series of trays arranged vertically. Water is introduced at the top of a series of trays. Aeration of the water takes place as the water cascades from one tray to the other.

Aeration Costs

The cost of aeration is relatively low. Costs decrease with facility size as shown in **Table 34**.

Table 34. Aeration Treatment Costs.

Facility Size (MGD)	Capital Cost (per gallon/day capacity)
1	$.0113
3	$.0083
5	$.0075
10	$.0053
20	$.0050

Source: PBS&J, 1991 Water Supply Cost Estimates converted to 1999 dollars.

Lime Softening

Lime softening is used at 18 of the 31 regional water treatment facilities in the LWC 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, TTHM precursors, and others (Hamann et al., 1990).

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 MCL 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 TTHMs and 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 35**). The cost advantages of lime softening are in operating and maintenance expenses, where costs are typically 20 percent less than for comparable membrane technologies. 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.

Membrane Processes

Membrane technology has continued to improve in anticipation of the more stringent water quality regulations that the USEPA announced in December 1998. Membrane processes can remove dissolved salts, organic materials that react with chlorine DBP precursors as well as provide softening. Several membrane technologies are used to treat drinking water: reverse osmosis (RO), nanofiltration, ultrafiltration, and microfiltration. Each membrane process has a different ability in processing drinking water.

Table 35. Lime Softening Treatment Costs.

Facility Size (MGD)	Capital Cost (per gallon/ day capacity)	Engineering Cost (per gallon/ day capacity)	Land Requirements (Acres)	Operations and Maintenance Cost (per 1,000 gallons)	Energy Cost (per 1,000 gallons)
3	$1.63	$.25	1.5	$.60	$.023
5	$1.57	$.24	2.5	$.56	$.023
10	$1.53	$.23	4.0	$.50	$.021
15	$1.26	$.19	6.0	$.41	$.020
20	$1.13	$.16	8.0	$.38	$.020

Source: PBS&J, 1991 Water Supply Cost Estimates converted to 1999 dollars.

Reverse Osmosis

Reverse Osmosis (RO) technology has been used in Florida for a number of years. Major public water supply RO facilities include Cape Coral, Collier County, Greater Pine Island, Marco Island, and Island Water Association (Sanibel) in the LWC Planning Area.

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 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 36**). 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 TTHMs and other 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.

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

Table 36. Reverse Osmosis Operating Pressure Ranges.

System	Transmembrane Pressure Operating Range (psi)	Feed Water TDS Range (mg/L)	Recovery Rates (%)
Ocean water	800-1,500	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 site (letter dated December 12, 1990 from B.D. DeGrove, Point Source Evaluation Section, FDEP, 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 37** and **38**. 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 37. Reverse Osmosis Treatment Costs.

Facility Size (MGD)	Capital Costs (per gallon/ day capacity)	Engineering Cost (per gallon/ day capacity)	Land Requirements (Acres)	Operations and Maintenance Cost (per 1,000 gallons)	Energy Cost (per 1,000 gallons)
3	$1.76	$.26	.40	$.58	$.29
5	$1.59	$.24	.40	$.54	$.29
10	$1.47	$.23	.50	$.51	$.29
15	$1.43	$.21	.63	$.50	$.29
20	$1.40	$.20	.78	$.38	$.29

Source: PBS&J, 1991 Water Supply Cost Estimates converted to 1999 dollars.

Methods of determining capital and operations and maintenance 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

Table 38. Concentrate Disposal Costs.

Deep Well Disposal Facility (MGD)	Capital Cost (per gallon/ day capacity)	Engineering Cost (per gallon/ day capacity)	Land Requirements (Acres)	Operations and Maintenance Cost (per 1,000 gallons)
3	$.73	$.109	0.5	$.040
5	$.55	$.083	0.5	$.030
10	$.50	$.075	1.0	$.028
15	$.46	$.070	2.0	$.025
20	$.38	$.056	3.0	$.020

Source: PBS&J, 1991 Water Supply Cost Estimates converted to 1999 dollars.

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.

The recent improvements in low pressure membranes has reduced the electrical costs associated with reverse osmosis systems. Because reverse osmosis pump power consumption is directly proportional to pressure, the low pressure systems can provide significant reductions in power consumption. The reverse osmosis treatment costs presented herein do not reflect the recent improvements in membrane technology.

Membrane Softening

Membrane softening or nanofiltration is an emerging technology that is currently in use in Florida. Membrane softening differs from standard reverse osmosis 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 TTHM 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 the LWC Planning Area, including the city of Fort Myers, Collier County, and Gulf Corkscrew.

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 39**.

Table 39. Membrane Softening Costs.

Facility Size (MGD)	Capital Costs (per gallon/day capacity)	Engineering Cost (per gallon/ day capacity)	Land Requirements (Acres)	Energy Cost (per 1,000 gallons)	Operations and Maintenance Cost (per 1,000 gallons)
3	$1.67	$.25	0.40	$.200	$.55
5	$1.52	$.23	0.40	$.200	$.53
10	$1.41	$.21	0.50	$.200	$.50
15	$1.38	$.21	0.63	$.200	$.48
20	$1.33	$.20	0.78	$.200	$.46

Source: PBS&J, 1991 Water Supply Cost Estimates converted to 1999 dollars.

Ultrafiltration

Ultrafiltration is a pressure driven processes that removes nonionic matter, higher molecular weight substances and fractions colloids. Colloids are extremely fine sized suspended materials that will not settle out of the water column.

Microfiltration

Microfiltration is also a pressure driven process but it removes coarser materials than ultrafiltration. Although this membrane type removes micrometer and submicrometer particles it allows dissolved substances to pass through.

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. However, ED/EDR is generally not considered to be an efficient and cost effective organic removal process and therefore is usually not considered for TTHM 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 reverse osmosis treatment (Boyle Engineering, 1989).

Distillation

The distillation treatment process is based on evaporation. Saltwater is boiled and the dissolved salts, which are nonvolatile, 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. Capital construction costs and operation and maintenance expenses are three to five times as expensive as brackish water reverse osmosis systems and/or EDR (Buros, 1989).

WATER TREATMENT FACILITIES

Potable Water Treatment Facilities

Potable water in the LWC Planning Area is supplied by three main types of facilities: (a) regional public water supply treatment facilities, municipal or privately owned; (b) small developer/home owner association or utility owned public water supply 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.

The Florida Department of Environmental Protection (FDEP) regulates regional public water supply systems in the LWC Planning Area. The local health department is required to regulate the smaller facilities, as described; (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 (Chapter 62-550, F.A.C.). The LWC Plan reports on the FDEP regulated facilities with a permitted average daily flow of 0.5 million gallons per day (MGD) or greater.

There are 31 regional water treatment facilities within the LWC Planning Area. These facilities primarily use raw ground water, and most are considering ground water sources to meet future demands. Fort Myers and Lee County use surface water from the Caloosahatchee River, while Clewiston uses surface water from Lake Okeechobee. Wellfield and surface water withdrawal locations for these facilities are shown in **Figures 15 - 17**.

Other detailed information provided in Appendix D include the source, aquifer or surface water name and pump capacity for each of the wells or surface pumps; existing, proposed, and future sources of raw water; and water treatment methods for each facility. The existing treatment technologies employed by the facilities are chlorination, reverse osmosis, aeration, and lime or membrane softening.

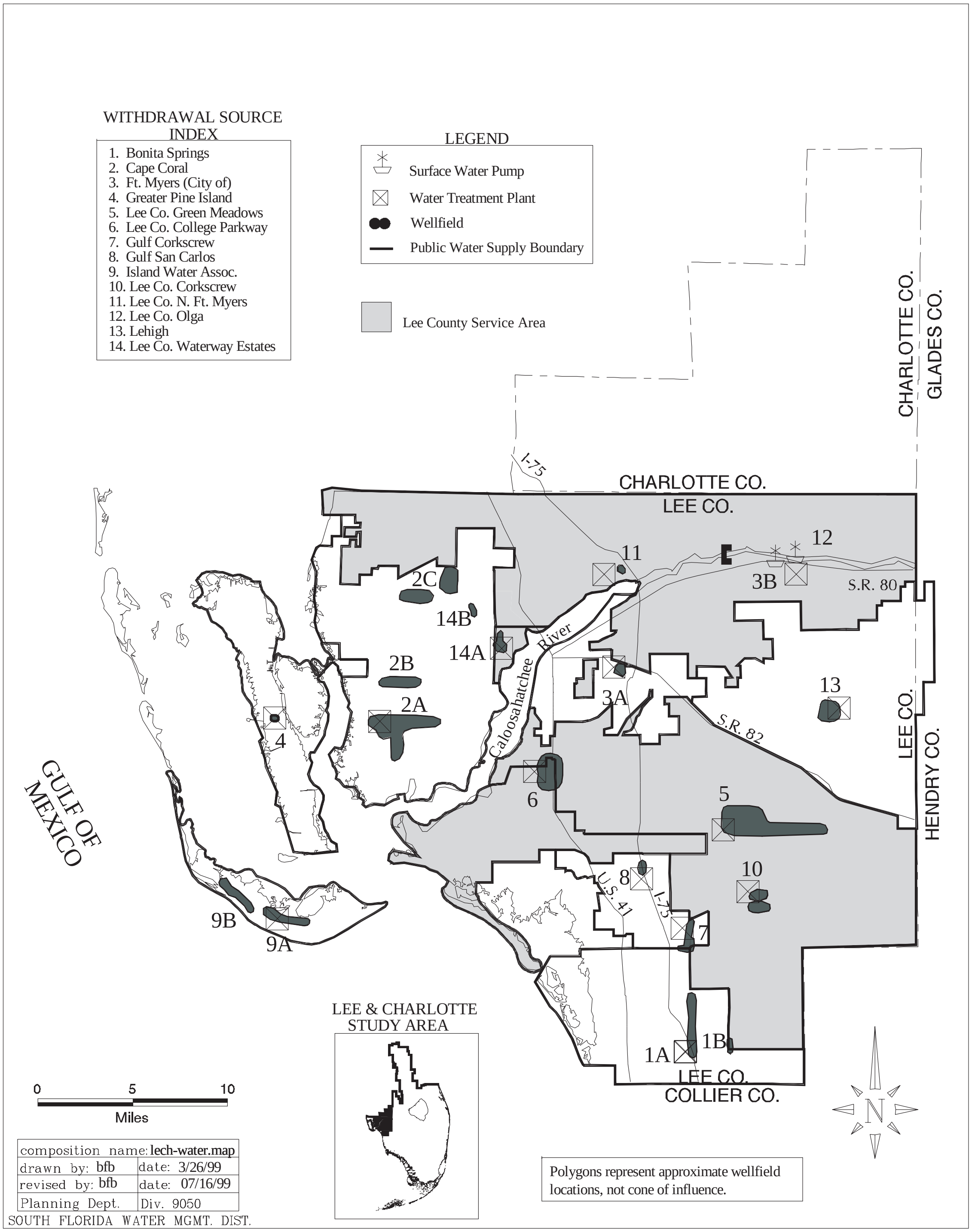


Figure 15. Lee County and Charlotte County Potable Water Treatment Facilities, Service Areas, and Source Locations.

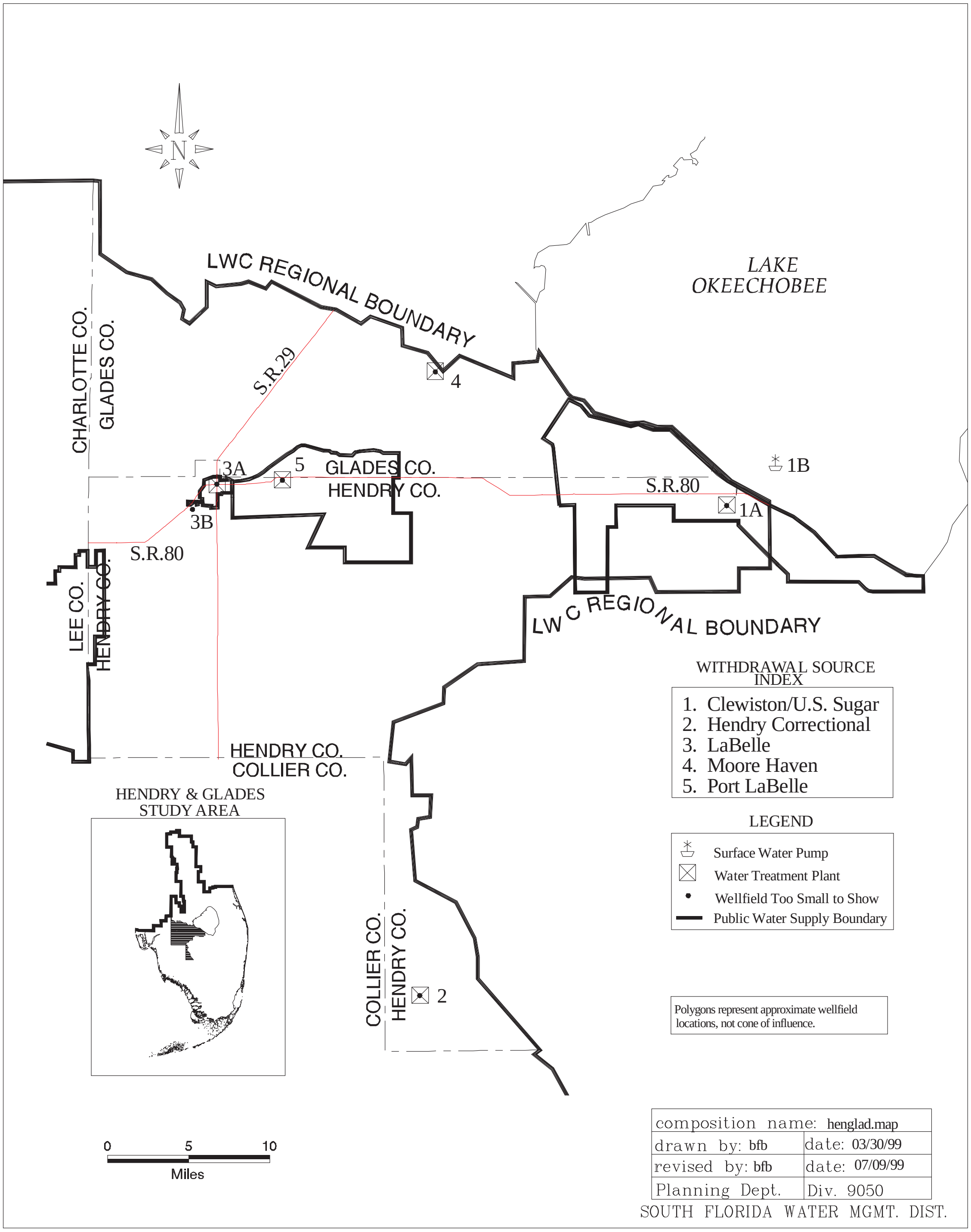


Figure 16. Hendry County and Glades County Potable Water Treatment Facilities, Service Areas, and Source Locations.

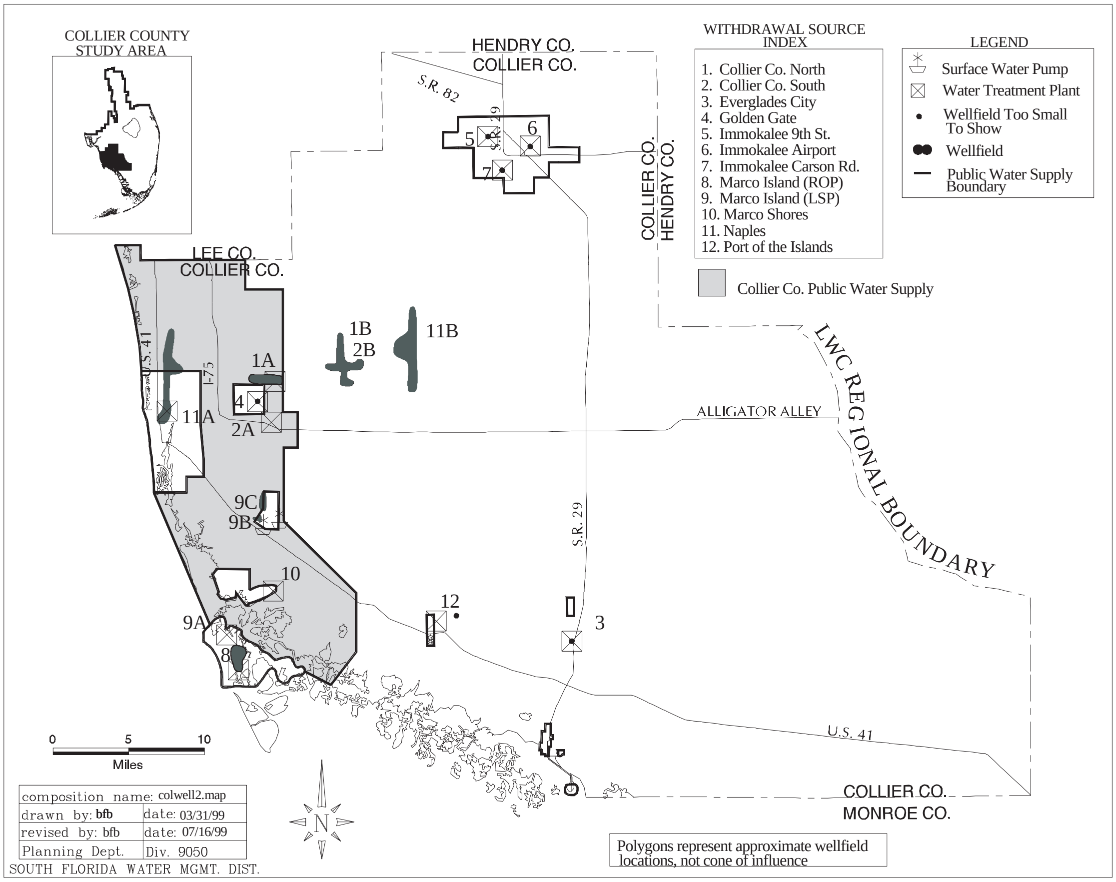


Figure 17. Collier County Potable Water Treatment Facilities, Service Areas, and Source Locations.

Wastewater Treatment Facilities

Wastewater treatment in the LWC Planning Area is provided by (a) regional wastewater treatment facilities, municipal or privately owned; (b) small developer/home owner association or utility owned wastewater treatment facilities; and (c) septic tanks.

Many of the smaller facilities are constructed on an interim basis until regional wastewater facilities become 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 18**. Wastewater treatment in the LWC Planning Area is regulated by the FDEP for all facilities. The following wastewater treatment facilities are exempt from FDEP regulation and are regulated by the local health department for each county: (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 drain field systems and other on-site sewage systems with subsurface disposal and a design capacity of 10,000 GPD or less, which serve the complete wastewater disposal needs of a single establishment (Chapter 62-600, F.A.C.). The LWC Water Supply Plan

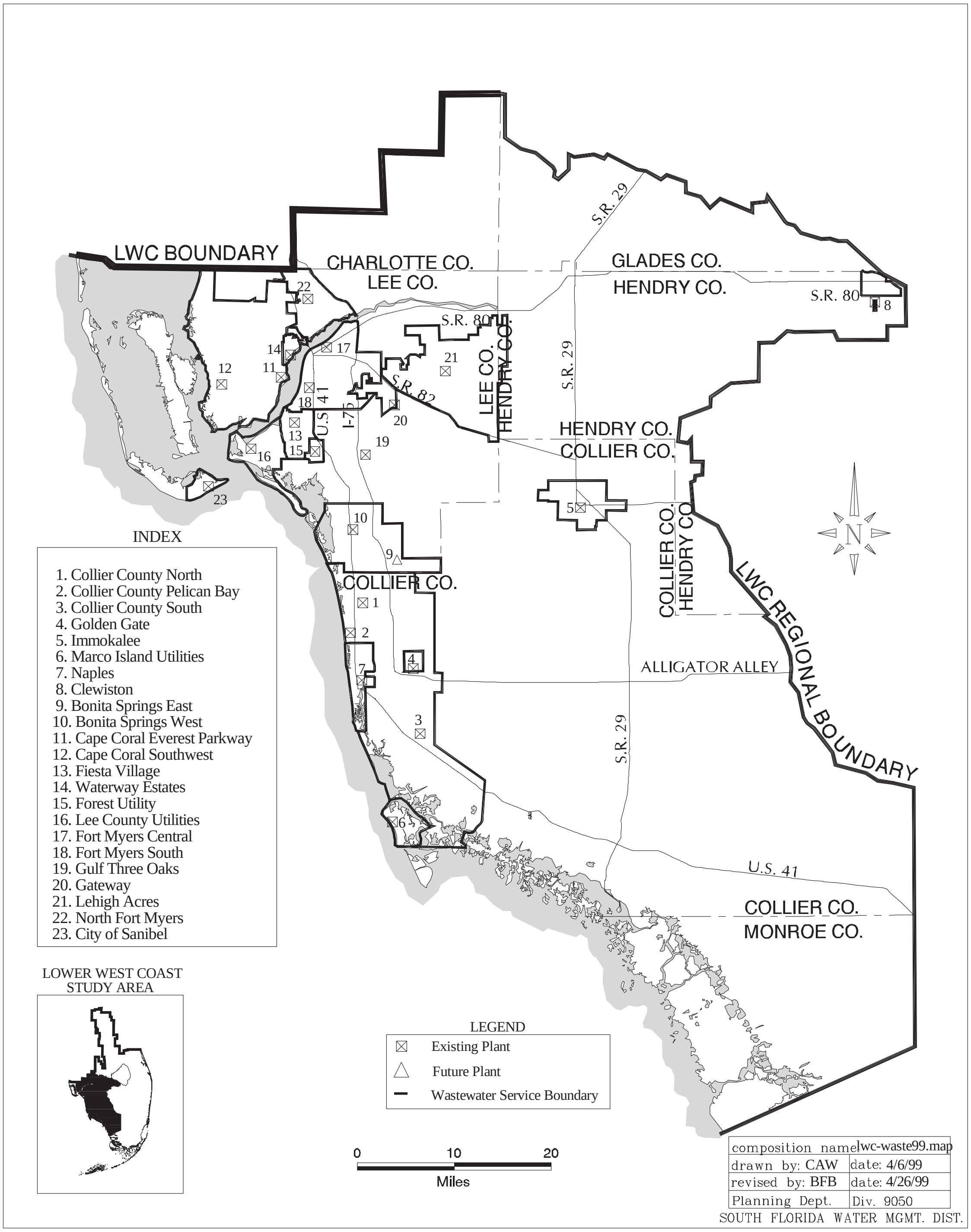


Figure 18. Regional Wastewater Treatment Facility Locations.

reports on the FDEP regulated facilities with a permitted average daily flow of 0.5 million gallons per day (MGD) or greater.

All the FDEP regulated facilities use the activated sludge treatment process. The methods of reclaimed water/effluent disposal include surface water discharge, reuse, and deep well injection. Six facilities are permitted to use surface water discharge and six facilities use deep well injection systems.

There are 22 existing regional wastewater treatment facilities in the LWC Planning Area with a FDEP permitted capacity equal to or greater than 0.50 MGD. These facilities treated an average of 58 MGD in 1997. Nineteen of the facilities used reuse for all or a portion of their disposal needs in 1997 resulting in 37 MGD being reused. Reuse included irrigation of residential lots, medians, green space and golf courses and ground water recharge via percolation ponds. In addition to reuse, 5 MGD was disposed of by deep well and 16 MGD was disposed of by surface water discharge. The volume of treated wastewater is projected to increase to 97 MGD by 2020.

Specific information on each of the wastewater treatment facilities is provided in Appendix D. 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 known future plans are also discussed.

GLOSSARY

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

Application Efficiency The ratio of the volume of irrigation water available for crop use to the volume delivered from the irrigation system. This ratio is always less than 1.0 because of the losses due to evaporation, wind drift, deep percolation, lateral seepage (interflow), and runoff that may occur during irrigation.

Aquifer A portion of a geologic formation or formations that yield water in sufficient quantities to be a supply source.

Aquifer Compaction The reduction in bulk volume or thickness of a body of fine-grained sediments contained within a confined aquifer or aquifer system. The compaction of these fine-grained sediments results in subsidence, and sometimes fissuring, of the land surface.

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 heterogeneous body of intercalated permeable and less permeable material that acts as a water-yielding hydraulic unit of regional extent.

Artesian When ground water is confined under pressure greater than atmospheric pressure by overlying relatively impermeable strata.

Available Supply The maximum amount of reliable water supply including surface water, ground water and purchases under secure contracts.

Average-day Demand A water system's average daily use based on total annual water production (total annual gallons or cubic feet divided by 365).

Average Irrigation Requirement Irrigation requirement under average rainfall as calculated by the District's modified Blaney-Criddle model.

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

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 is a division of the University of Florida, with programs in population, forecasting, policy research and survey.

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

BOR Basis of Review (for Water Use Applications with the South Florida Water Management District).

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

Budget (water use) An accounting of total water use or projected water use for a given location or activity.

Central and Southern Florida Project Comprehensive Review Study (Restudy) A five-year study effort that looked at modifying the current C&SF Project to restore the greater Everglades and South Florida ecosystem while providing for the other water-related needs of the region. The study concluded with the Comprehensive Plan being presented to the Congress on July 1, 1999. The recommendations made within the Restudy, that is, structural and operational modifications to the C&SF Project, are being further refined and will be implemented in the Comprehensive Everglades Restoration Plan (CERP).

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

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

Conservation (water) Any beneficial reduction in water losses, wastes, or use.

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.

Consumptive Use Use that reduces an amount of water in the source from which it is withdrawn.

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.

Demographic Relating to population or socioeconomic conditions.

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

Domestic Use Use of water for the individual personal household purposes of drinking, bathing, cooking, or sanitation.

Drawdown The distance the water level is lowered, due to a withdraw at a given point.

DWMP District Water Management Plan. Regional water resource plan developed by the District under Ch. 373.036, F. S.

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.

Evapotranspiration Water losses from the surface of soils (evaporation) and plants (transpiration).

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.

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

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.

Florida Water Plan State-level water resource plan developed by the FDEP under Ch. 373.036, F.S.

Governing Board Governing Board of the South Florida Water Management District.

Ground Water Water beneath the surface of the ground, whether or not flowing through known and definite channels.

Harm *(Term will be further defined during proposed Rule Development process)* An adverse impact to water resources or the environment that is generally temporary and short-lived, especially when the recovery from the adverse impact is possible within a period of time of several months to several years, or less.

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, that is the agricultural branch of the University of Florida, performing research, education, and extension.

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

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

Irrigation The application of water to crops, and other plants by artificial means.

Irrigation Audit A procedure in which an irrigation systems application rate and uniformity are measured.

Irrigation Efficiency The average percent of total water pumped or delivered for use that is delivered to the root zone. of a plant.

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

Lake Okeechobee Largest freshwater lake in Florida. Located in Central Florida, the lake measures 730 square miles and is the second largest freshwater lake wholly within the United States.

Leakance Movement of water between aquifers or aquifer systems.

Leak Detection Systematic method to survey the distribution system and pinpoint the exact locations of hidden underground leaks.

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

Level of Certainty Probability that the demands for reasonable-beneficial uses of water will be fully met for a specified period of time (generally taken to be one year) and for a specified condition of water availability, (generally taken to be a drought event of a specified return frequency). For the purpose of preparing regional water supply plans, the goal associated with identifying the water supply demands of existing and future reasonable beneficial uses is based upon meeting those demands for a drought event with a 1-in-10 year return frequency.

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

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, a nationally established references for elevation data relative to sea level.

NRCS The Natural Resources Conservation Service is a federal agency that provides technical assistance for soil and water conservation, natural resource surveys, and community resource protection

One-in-Ten Year Drought Event A drought of such intensity, that it is expected to have a return frequency of 10 years (see Level of Certainty).

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

Overhead Sprinkler Irrigation A pressurized system, where water is applied through a variety of outlet sprinkler heads or nozzles. Pressure is used to spread water droplets above the crop canopy to simulate rainfall.

Per Capita Use Total use divided by the total population served.

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

Potable Water Water that is safe for human consumption (USEPA, 1992).

Potentiometric Head The level to which water will rise when a well is drilled into a confined aquifer.

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

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

Projection Period The period over which projections are made. In the case of this document, the 25 year period from 1995 to 2020.

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

Rapid-Rate Infiltration Basin (RIB) An artificial impoundment that provides for fluid losses through percolation/seepage as well as through evaporative losses.

Rationing Mandatory water-use restrictions sometimes used under drought or other emergency conditions.

Reasonable-Beneficial Use Use of water in such quantity as is necessary for economic and efficient utilization for a purpose and in a manner which is both reasonable and consistent with the public interest.

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

RECOVER A comprehensive monitoring and adaptive assessment program formed to perform the following for the Comprehensive Everglades Restoration Program: restoration, coordination, and verification.

Reduced Allocation Areas Areas in which a physical limitation has been placed on water use.

Reduced Threshold Areas (RTAs) Areas established by the District for which the threshold separating a General Permit from an Individual Permit has been lowered from the maximum limit of 100,000 GPD to 20,000 GPD. These areas are typically resource-depleted areas where there have been an established history of sub-standard water quality, saline water movement into ground or surface water bodies, or the lack of water availability to meet projected needs of a region.

Regional Water Supply Plan Detailed water supply plan developed by the District under Ch. 373.0361, F.S.

Retrofit The replacement of existing equipment with equipment that uses less water.

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

Restudy Shortened name for C&SF Restudy.

Reverse Osmosis (RO) Process used to produce fresh water from a brackish supply source.

Saline Water Water with a chloride concentration greater than 250 mg/L, but less than 19,000 mg/L.

Saline Water Interface The hypothetical surface of chloride concentration between fresh water and saline water, where the chloride concentration is 250 mg/L at each point on the surface.

Saline Water Intrusion This occurs when more dense saline water moves laterally inland from the coast, or moves vertically upward, to replace fresher water in an aquifer.

Sea Water Water which has a chloride concentration equal to or greater than 19,000 mg/L.

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 horizontal flow, and restrict the vertical flow of water from one aquifer to another. The rate of vertical flow is dependent on the head differential between the aquifers, as well as the vertical permeability of the sediments in the semi-confining layer.

Sensitivity Analysis An analysis of alternative results based on variations in assumptions (a "what if" analysis).

Serious Harm (*Term will be defined during proposed Rule Development process)* An extremely adverse impact to water resources or the environment that is either permanent or very long-term in duration. Serious harm is generally considered to be more intense than significant harm.

Significant Harm *(Term will be defined during proposed Rule Development process)* An adverse impact to water resources or the environment, when the period of recovery from the adverse impact is expected to take several years; more intense than harm, but less intense than serious harm.

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 surface of a surface water body.

Storm Water Surface water resulting from rainfall that does not percolate into the ground or evaporate.

Subsidence An example of subsidence is the lowering of the soil level caused by the shrinkage of organic layers. This shrinkage is due to biochemical oxidation.

Surface Water Water that flows, falls, or collects above the surface of the earth.

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

SWIM Plan Surface Water Improvement and Management Plan, prepared according to Ch. 373, F. S.

TAZ Traffic analysis zone; refers to a geographic area used in transportation planning.

Transmissivity A term used to indicate the rate at which water can be 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.

Ultra-low-volume Plumbing Fixtures Water-conserving plumbing fixtures that meet the standards at a test pressure of 80 psi listed below.

Toilets - 1.6 gal/flush

Showerheads - 2.5 gal/min.

Faucets - 2.0 gal/min.

Uplands Elevated areas that are characterized by non-saturated soil conditions and support flatwood vegetation.

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 Resource Caution Areas Areas that have existing water resource problems or where water resource problems are projected to develop during the next 20 years (previously referred to as critical water supply problem areas).

Water Resource Development The formulation and implementation of regional water resource management strategies, including: the collection and evaluation of surface water and ground water data; structural and nonstructural programs to protect and manage the water resource; the development of regional water resource implementation programs; the construction, operation, and maintenance of major public works facilities to provide for flood control, surface and underground water storage, and ground water recharge augmentation; and, related technical assistance to local governments and to government-owned and privately owned water utilities.

Water Shortage Declaration *Rule 40E-21.231, Fla. Admin. Code:* "If …there is a possibility that insufficient water will be available within a source class to meet the estimated present and anticipated user demands from that source, or to protect the water resource from serious harm, the Governing Board may declare a water shortage for the affected source class." Estimates of the percent reduction in demand required to match available supply is required and identifies which phase of drought restriction is implemented. A gradual progression in severity of restriction is implemented through increasing phases. Once declared, the District is required to notify permitted users by mail of the restrictions and to publish restrictions in area newspapers.

Water Supply Plan District plans that provide an evaluation of available water supply and projected demands, at the regional scale. The planning process projects future demand for 20 years and develops strategies to meet identified needs.

Water Supply Development The planning, design, construction, operation, and maintenance of public or private facilities for water collection, production, treatment, transmission, or distribution for sale, resale, or end use.

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.

Wetland Drawdown Study Research effort by the South Florida Water Mangement District to provide a scientific basis for developing wetland protection criteria for water use permitting.

Xeriscape™ Landscaping that involves seven principles: proper planning and design; soil analysis and improvement; practical turf areas; appropriate plant selection; efficient irrigation; mulching; and appropriate maintenance.

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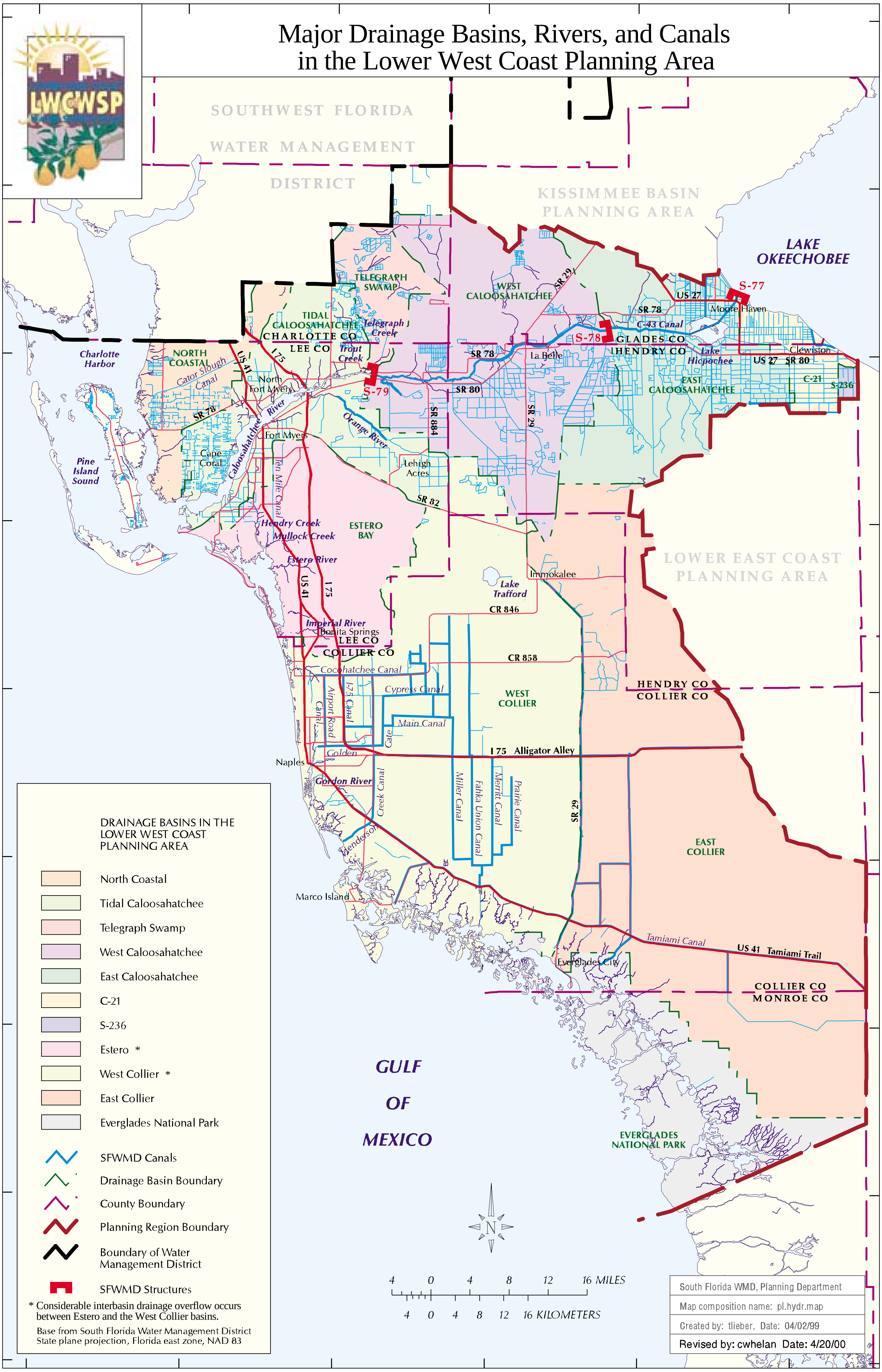

Plate 1. -- Major Drainage Basins, Rivers, and Canals
in the Lower West Coast Planning Area

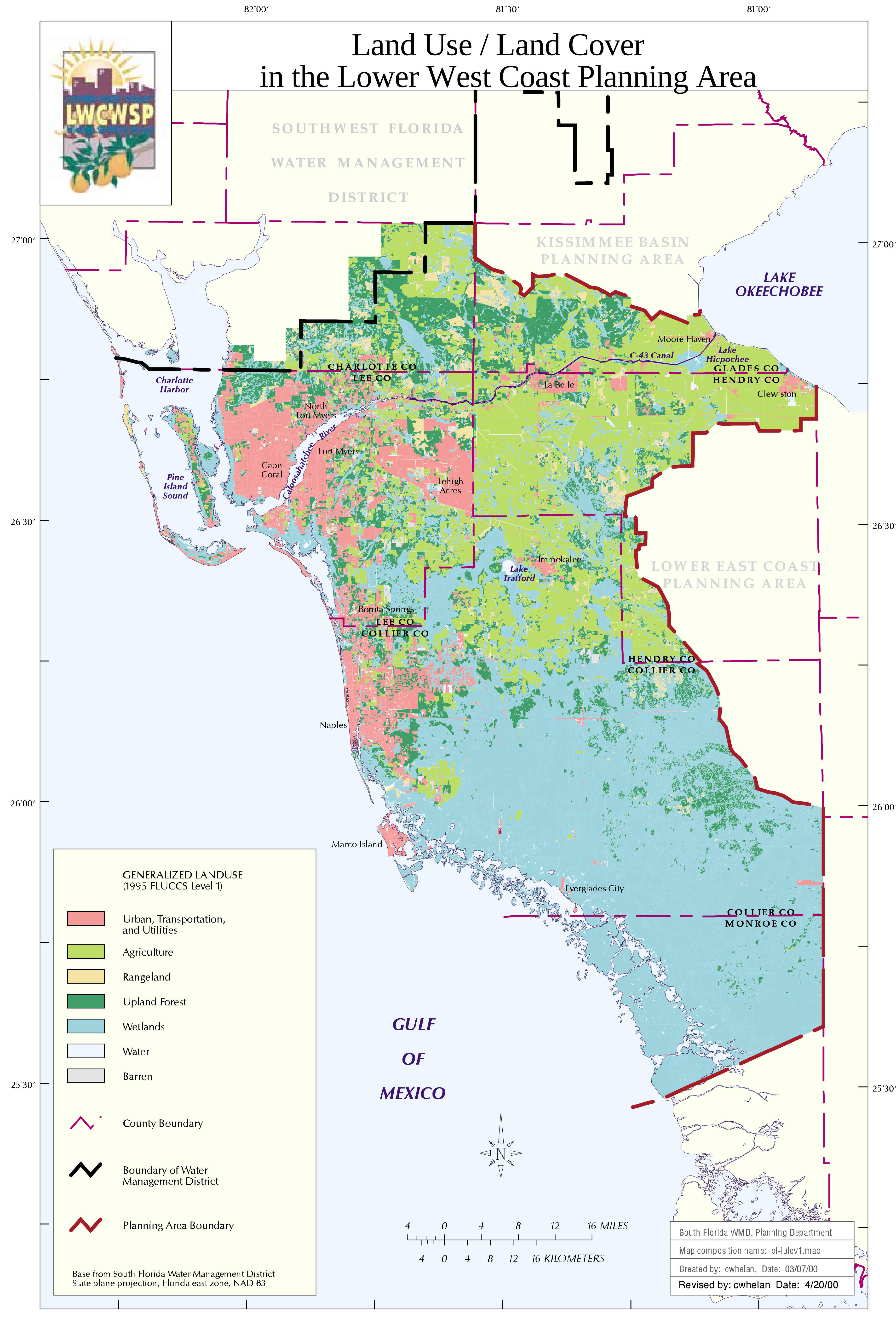

Plate 2. -- Land Use / Land Cover in the
Lower West Coast Planning Area.

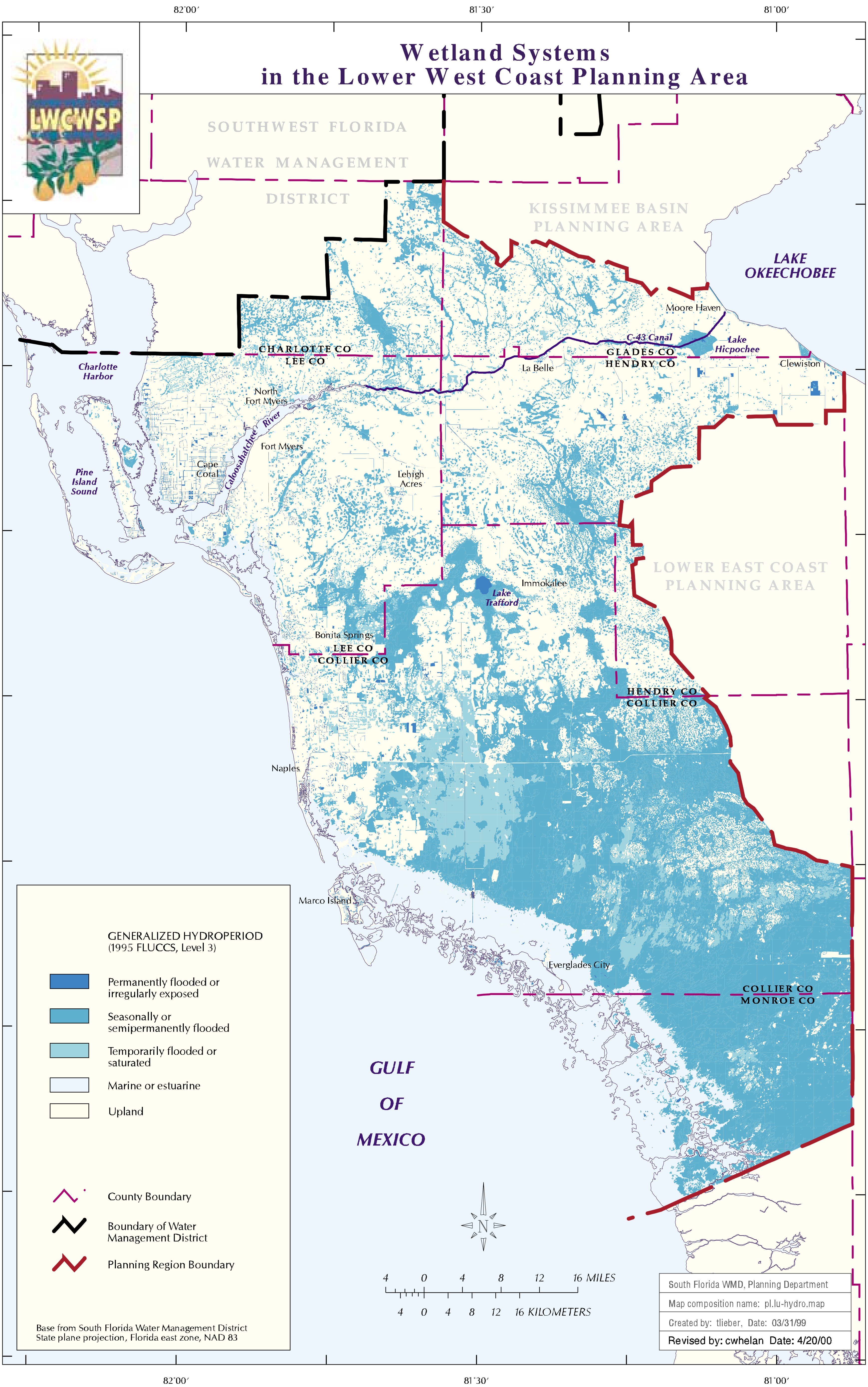

Plate 3. -- Wetland Systems in the
Lower West Coast Planning Area.

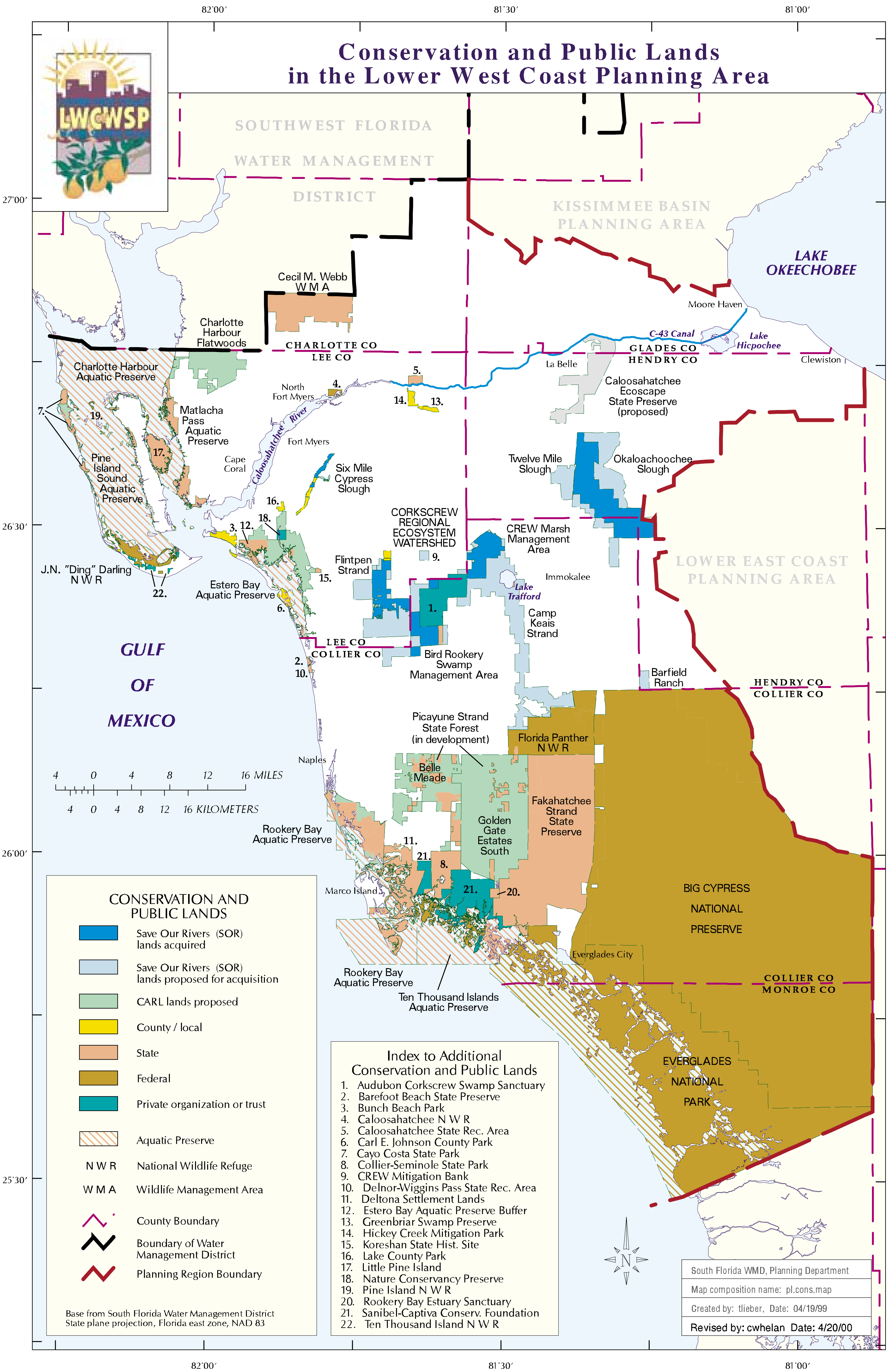

Plate 4. -- Conservation and Public Lands in the Lower West Coast Planning Area.