SOUTH FLORIDA WATER MANAGEMENT DISTRICT

CONSOLIDATED WATER SUPPLY PLAN
Support Document

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SOUTH FLORIDA WATER MANAGEMENT DISTRICT

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Consolidated Water Supply Plan SUPPORT DOCUMENT

Water Supply Department
South Florida Water Management District

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Acronyms and Abbreviations

ac-ft	acre-feet
ASR	aquifer storage and recovery
AWWA	American Water Works Association
BCBB	Big Cypress Basin Board
bls	below land surface
BGY	billion gallons per year
BMP	best management practice
BOD	biological or biochemical oxygen demand
C&SF	Central and Southern Florida
C&SF Project	Central and Southern Florida Flood Control Project
CAP	Continuing Authority Program
CERP	Comprehensive Everglades Restoration Plan
cfs	cubic feet per second
CIWQ	Comprehensive Integrated Water Quality
CMM	Capability Maturity Model
COD	Chemical Oxygen Demand
CREW	Corkscrew Regional Ecosystem Watershed
CUP	Consumptive Use Permitting
CWMP	Caloosahatchee Water Management Plan
DBHYDRO	SFWMD's corporate environmental database
DBP	Disinfectant/Disinfection By-Product
District	South Florida Water Management District
DSS	domestic self-supply
DWMP	District Water Management Plan
DWSA	Districtwide Water Supply Assessment
EAA	Everglades Agricultural Area
EAASR	Everglades Agricultural Area Storage Reservoirs
ECP	Everglades Construction Project
ED	Electrodialysis
EDR	Electrodialysis Reversal
EIS	Environmental Impact Statement

EPA	Everglades Protection Area
ERP	Environmental Resource Permit
ET	evapotranspiration
F.A.C.	Florida Administrative Code
FAS	Floridan Aquifer System
FDACS	Florida Department of Agriculture and Consumer Services
FDCA	Florida Department of Community Affairs
FDEP	Florida Department of Environmental Protection
FDOT	Florida Department of Transportation
FLUCCS	Florida Land Use and Cover Classification System
FPFWCD	Fort Pierce Farms Water Control District
FPL	Florida Power & Light
F.S.	Florida Statutes
FWC	Florida Fish and Wildlife Conservation Commission
GAC	Granular Activated Carbon
GIS	geographic information system
GPD	gallons per day
GPM	gallons per minute
IAS	Intermediate Aquifer System
IFAS	Institute of Food and Agricultural Sciences
IR	indicator region
IRL	Indian River Lagoon
IRLFS	Indian River Lagoon Feasibility Study
IRLN	Indian River Lagoon – North Feasibility Study
IRLS	Indian River Lagoon – South Feasibility Study
JSOC	Joint Statement of Commitment
KB	Kissimmee Basin
KB Plan	Kissimmee Basin Regional Water Supply Plan
LEC	Lower East Coast
LEC Plan	Lower East Coast Regional Water Supply Plan
LECSA	Lower East Coast Service Area
LFA	Lower Floridan Aquifer
LIMS	Laboratory Information Management System
LOER Plan	Lake Okeechobee & Estuary Recovery Plan

LOPA	Lake Okeechobee Protection Act
LOPP	Lake Okeechobee Protection Plan
LOWOD	Lake Okeechobee Works of the District
LOSA	Lake Okeechobee Service Area
LOWP	Lake Okeechobee Watershed Project
LWC	Lower West Coast
LWC Plan	Lower West Coast Water Supply Plan
MCL	Maximum Contaminant Level
MDCRC	Miami-Dade County Regional Canal
MDL	maximum developable limit
MFL	minimum flow and level
MGD	million gallons per day
mg/L	milligrams per liter
MIL	mobile irrigation laboratory
MISP	Master Implementation Sequencing Plan
mm	millimeter
MOA	memorandum of agreement
MSF	multistage flash
NGVD	National Geodetic Vertical Datum
NOAA	National Ocean and Atmospheric Administration
NBPSA	North Palm Beach Service Area
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRCS	Natural Resources Conservation Service
NSLRWCD	North St. Lucie River Water Control District
NSM	Natural System Model
NWFWMD	Northwest Florida Water Management District
NWI	National Wetlands Inventory
PDT	Program Delivery Team
PIR	Project Implementation Report
PLRG	pollutant load reduction goal
PMP	Project Management Plan
ppb	parts per billion
ppm	parts per million

psi	pounds per square inch
PSLSWU	Port St. Lucie Storm Water Utility
PWS	public water supply
RECOVER	Restoration Coordination Verification
Restudy	Central and Southern Florida Project Comprehensive Review Study
RO	reverse osmosis
RSM	Regional Simulation Model
SAS	Surficial Aquifer System
SDWA	Safe Drinking Water Act
SFER	South Florida Environmental Report
SFWMD	South Florida Water Management District
SFWMM	South Florida Water Management Model
SJRWMD	St. Johns River Water Management District
SMA	Square Mile Area
SOR	Save Our Rivers
SPF	Standard Project Flood
SRWMD	Suwannee River Water Management District
SSC	species of special concern
STA	stormwater treatment area
SWFFS	Southwest Florida Feasibility Study
SWFWMD	Southwest Florida Water Management District
SWIM	Surface Water Improvement and Management
TDS	total dissolved solids
THM	Trihalomethane
TMDL	total maximum daily load
TOC	total organic carbon
TTHM	total trihalomethanes
UEC	Upper East Coast
UEC Plan	Upper East Coast Water Supply Plan
UFA	Upper Floridan Aquifer
ULV	ultralow volume
U.S.	United States
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture

USDA-NRCS	United States Department of Agriculture - Natural Resources Conservation Service
USDW	Underground Source of Drinking Water
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UV	ultraviolet
VOCs	volatile organic chemicals
WaterSIP	Water Savings Incentive Program
WCA	Water Conservation Area
WMA	wildlife management area
WOD	Works of the District
WPA	Water Preserve Area
WRDA	Water Resources Development Act
WSE	Water Supply and Environmental
WWTP	Wastewater Treatment Plant

Planning South Florida's Water Supply Needs for Today and Tomorrow.

1
Introduction

The South Florida Water Management District (SFWMD or District) has undertaken the development of long-term comprehensive regional water supply plans to provide better management of south Florida's water resources. Chapter 373, Florida Statutes (F.S.), requires the District to prepare water supply plans for regions that have the potential for demands to exceed available supplies over a 20-year future time horizon. The District has committed to preparing water supply plans for each of its four planning regions (**Figure 1**), which cumulatively cover the entire District. Hydrologic divides define these regions.

The purpose of the water supply plans is to develop strategies to meet the future water demands of urban and agricultural uses, 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 shortfall.

This *2005–2006 Consolidated Water Supply Plan Support Document* includes information, assumptions and potential water source options to address statutory requirements through 2025. The Support Document provides characteristics of the SFWMD and its planning regions on topics related to the SFWMD's water supply planning and implementation activities.

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. The 1997 Florida Legislature adopted legislation specific to the role of the water management districts in water resource and water supply planning and development. The legislative intent was to provide for current and future human and environmental demands for a 20-year planning horizon.

Water supply planning was first required of the state's water management districts following adoption of the *Florida Water Resources Development Act of 1972* (Chapter 373, F.S.). The authors of *A Model Water Code* (Maloney *et al*. 1972), on which much of Chapter 373 is based, theorized that a statewide, coordinated planning framework is the best way to accomplish proper water resource allocation. The State Water Use Plan and the State Water Policy were the primary documents developed to meet this objective.

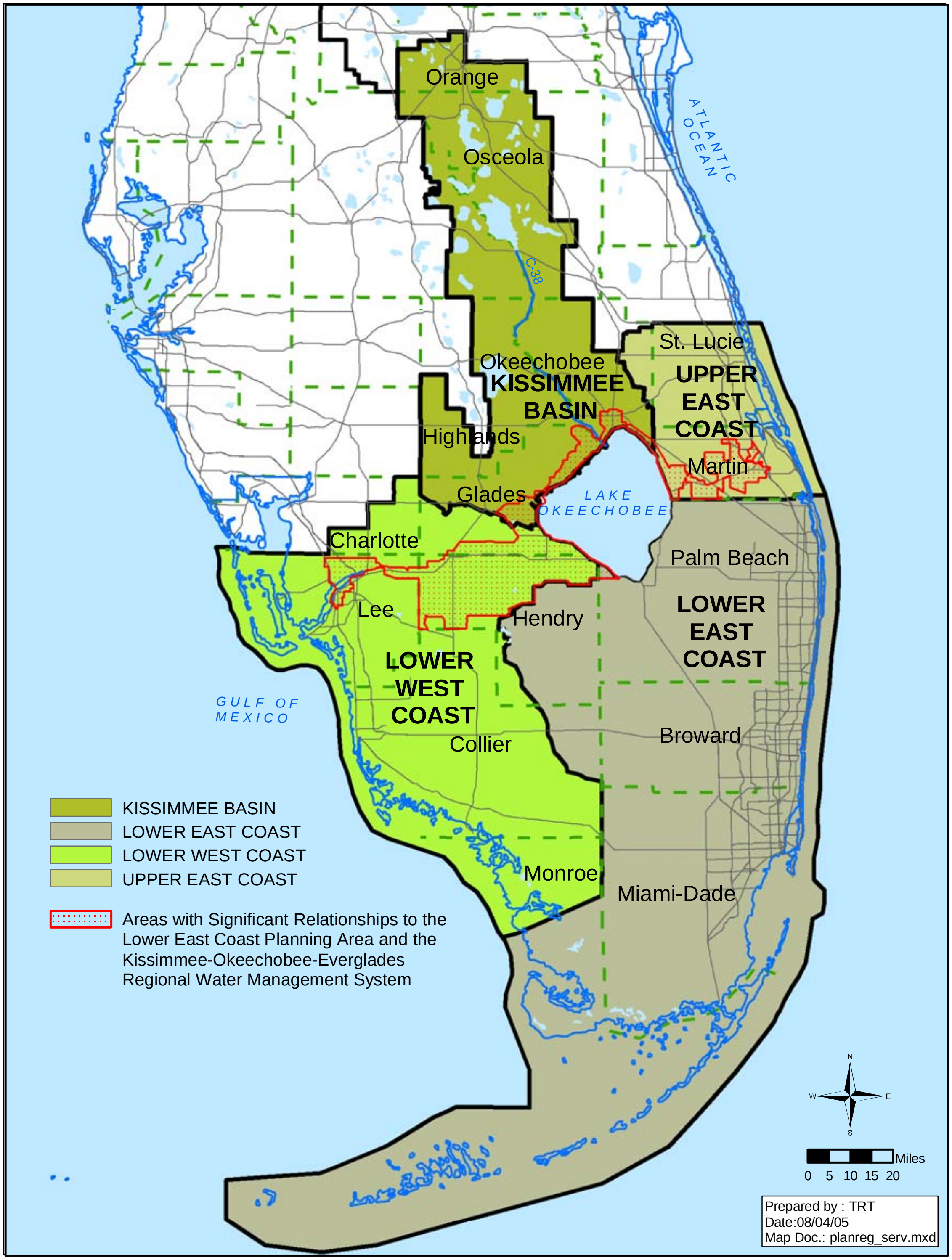


Figure 1. Planning Areas of the South Florida Water Management District.

With the passage of later legislative amendments, the Legislature eliminated the State Water Use Plan and called for developing the Florida Water Plan. The Florida Water Plan must include the Water Resource Implementation Rule (formerly known as the State Water Policy) and District Water Management Plans (DWMPs).

The Water Resource Implementation Rule [(Chapter 62-40 Florida Administrative Code (F.A.C.)] sets forth goals, objectives and guidance to develop and review water resource programs, rules and plans. 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.) prescribe these directives. These statutes provide the basic authorities, directives and policies for statewide water management, pollution control and environmental protection. **Figure 2** shows the current legal framework for water supply planning.

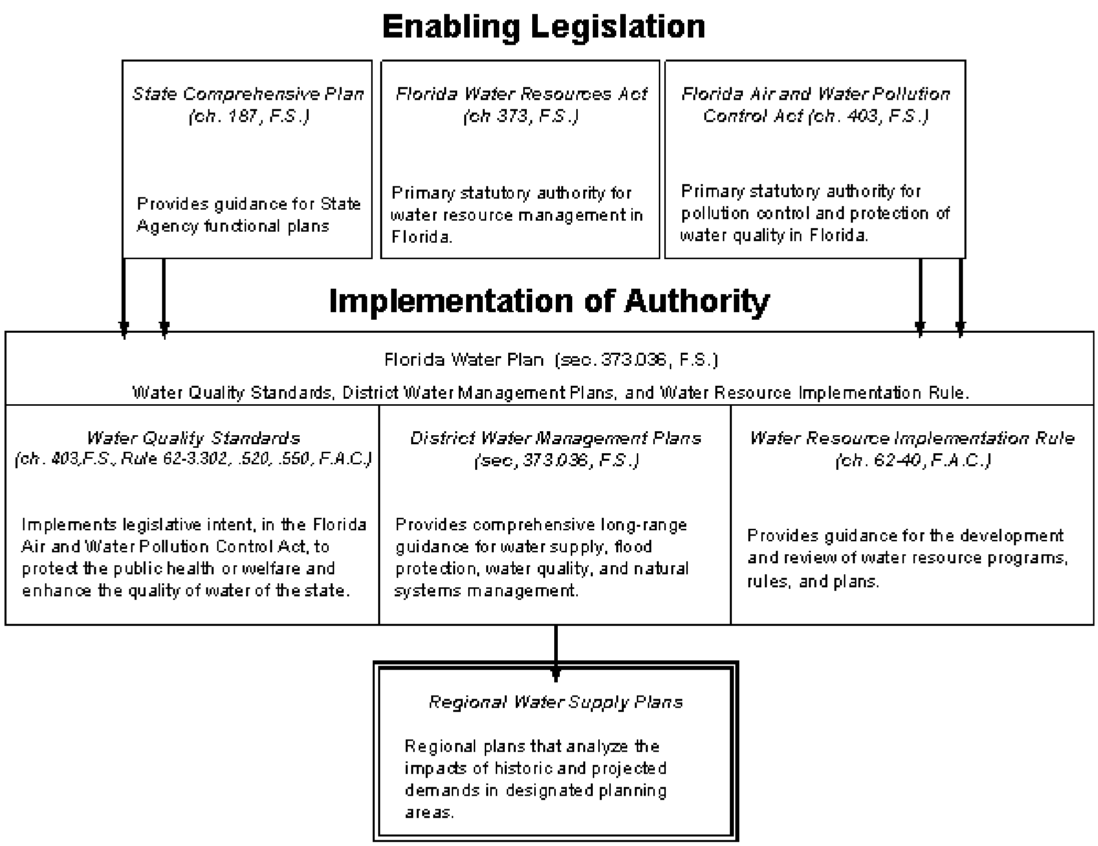


Figure 2. Legal Framework for Water Supply Planning.

The State Comprehensive Plan establishes the overall goal of water supply plans:

> 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 groundwater quality. Florida shall improve and restore the quality of waters not presently meeting water quality standards.

WATER SUPPLY PLANNING INITIATIVE

Water Supply Planning History

The SFWMD initiative in water supply planning began with the development of a *Water Supply Policy Document* (SFWMD 1991). Section 373.036, F.S., required water management districts to prepare assessments of water needs and supply sources. The District, through discussions with the Florida Department of Environmental Protection (FDEP), divided this process and prepared a Districtwide needs and sources analysis, followed by regional water supply plans. The *Water Supply Needs and Sources Document* (SFWMD 1992) provided a preliminary analysis of the District's water demand and available resources, as well as information to local governments (pursuant to Section 373.0391, F.S., and Section 373.0395, F.S.). It also helped to complete the *District Water Management Plan* (DWMP) in 1995 (SFWMD 1995). The District approved DWMPs in 1995 and 2000, as well as updates in 2001, 2002 and 2003 (SFWMD 2001, 2002a and 2003b), providing a comprehensive examination of the complex issues of water supply, flood protection, water quality and natural systems management in south Florida. In 2004, the DWMP was included in the District's 2005 *South Florida Environmental Report* (SFER), *Volume II*, Chapter 7. Since then, the DWMP has evolved into the SFWMD *Strategic Plan*.

Chapter 373 of the Florida Statutes contains statutory mandates for planning and development by the water management districts, in cooperation with the FDEP. Section 373.036(1), F.S., requires the FDEP to develop the Florida Water Plan in cooperation with the water management districts, regional water supply authorities and others. The Florida Water Plan includes, but is not limited to, the following items:

- The programs and activities of the FDEP related to water supply, water quality, flood protection and floodplain management and natural systems.
- The water quality standards of the FDEP.
- The district water management plans.
- Goals, objectives and guidance for the development and review of programs, rules and plans relating to water resources, based on statutory

policies and directives [the State Water Policy, renamed the Water Resource Implementation Rule pursuant to Section 373.019(20), F.S., shall serve as this part of the Plan (Chapter 62-40, F.A.C.)].

Regional water supply planning and development is mandated under Section 373.0361(1), F.S.:

> The governing board of each water management district shall conduct water supply planning for any water supply planning region within the district identified in the appropriate district water supply plan under s. 373.036, where it determines that existing sources of water are not adequate to supply water for all existing and future reasonable-beneficial uses and to sustain the water resources and related natural systems for the planning period. The planning must be conducted in an open public process, in coordination and cooperation with local governments, regional water supply authorities, government-owned and privately owned water utilities, multijurisdictional water supply entities, self-suppliers, and other affected and interested parties. The districts shall actively engage in public education and outreach to all affected local entities and their officials, as well as members of the public, in the planning process and in seeking input. During preparation, but prior to completion of the regional water supply plan, the district must conduct at least one public workshop to discuss the technical data and modeling tools anticipated to be used to support the regional water supply plan. The district shall also hold several public meetings to communicate the status, overall conceptual intent, and impacts of the plan on existing and future reasonable-beneficial uses and related natural systems. During the planning process, a local government may choose to prepare its own water supply assessment to determine if existing water sources are adequate to meet existing and projected reasonable-beneficial needs of the local government while sustaining water resources and related natural systems. The local government shall submit such assessment, including the data and methodology used, to the district. The district shall consider the local government's assessment during the formation of the plan. A determination by the governing board that initiation of a regional water supply plan for a specific planning region is not needed pursuant to this section shall be subject to s. 120.569. The governing board shall reevaluate such a determination at least once every 5 years and shall initiate a regional water supply plan, if needed, pursuant to this subsection.

Districtwide Water Supply Assessment

In 1997, Chapter 373, F.S., was modified, changing several water supply planning requirements. Among these was a requirement for each water management district to prepare a Districtwide Water Supply Assessment (DWSA). Part of the analysis completed in the DWSA was to identify areas that had the potential for demands exceeding available supplies (without causing unacceptable environmental impacts) over a 20-year future time horizon. For these areas, each District needed to prepare regional water supply plans. The Districtwide Water

Supply Assessment (SFWMD 1998a) confirmed the decision for the SFWMD to prepare water supply plans that cumulatively cover the entire SFWMD.

Regional Water Supply Plans

Regional water supply plans provide more detailed, region-specific information than the water supply assessments. Each water supply plan analyzes and evaluates the impacts of projected demands on available water resources and water resource-related natural systems. If projected impacts are more severe than a predefined threshold, the plan recommends increasing water resources to reduce impacts below the threshold.

Each regional water supply plan is based on at least a 20-year planning and development period and includes, but is not limited to, the following:

- A water supply development component.
- A water resource development component.
- A recovery and prevention strategy for addressing attainment and maintenance of minimum flows and levels (MFLs) in priority water bodies.
- A funding strategy for water resource development projects that shall be reasonable and sufficient to pay the cost of constructing or implementing all the listed projects.
- Consideration of how the options addressed serve the public interest or save costs overall by preventing the loss of natural resources or avoid greater public expense for water resource and water supply development in the future (unless adopted by rule, these considerations do not form final agency action).
- The technical data and information applicable to the planning area contained in the DWMP (SFWMD 2000b) and needed to support the regional water supply plans.
- The MFLs established for water resources within the planning area.
- Reservations of water adopted by rule pursuant to Section 373.223(4), F.S.
- An analysis of areas or instances in which the variance provisions of Subsection 378.212(1)(g), F.S., or Section 378.404(9), F.S., may be used to create water supply development or water resource development projects.

2
Natural Systems

OVERVIEW

The location of south Florida between temperate and subtropical latitudes, the expansive lake and wetlands of the greater Kissimmee – Lake Okeechobee – Everglades ecosystem, and the rainfall-driven, low-nutrient supply under which the Everglades evolved all combine to create a unique and species-rich flora and fauna mosaic.

South Florida Ecosystem

South Florida's largest natural feature is the Kissimmee – Lake Okeechobee – Everglades ecosystem (**Figure 3**), commonly referred to as the south Florida ecosystem. The Kissimmee – Lake Okeechobee – Everglades ecosystem consists of the Kissimmee Chain of Lakes, Kissimmee River, Lake Okeechobee and the Everglades, covering an area of about 9,000 square miles. This watershed once extended as a single hydrologic unit from present-day Orlando 250 miles south to Florida Bay. Water from lakes and wetlands in the Kissimmee Chain of Lakes overflowed natural drainage divides during wet periods and moved slowly southward through the Kissimmee River, snaking its way 90 miles to Lake Okeechobee. When water levels within Lake Okeechobee were high enough, water flowed over the southern rim of the lake into the extensive wetlands of the Everglades. These waters in turn moved slowly 100 miles south across vast sawgrass plains, aquatic sloughs and tree islands to the coastal estuaries of Florida Bay and the Ten Thousand Islands area.

The Kissimmee Chain of Lakes and Kissimmee River lie within the northern portion of the South Florida Water Management District's (SFWMD or District) boundaries. The Kissimmee Watershed contains an interconnected network of large lakes (Lake Tohopekaliga, Cypress Lake, Lake Hatchineha and Lake Kissimmee) that extends from Orlando south to the Kissimmee River. This area also contains many small streams and rivers, most of which are eventually tributaries to the lakes or the Kissimmee River.

The dominant lake within south Florida is Lake Okeechobee, often referred to as the "liquid heart" of south Florida. In its original condition, Lake Okeechobee was much larger and deeper than today and had a large littoral (wetland) zone that extended from the Kissimmee River to the Florida Everglades and a pelagic (open-water) zone. During periods of high rainfall, the littoral zone expanded far to the west.

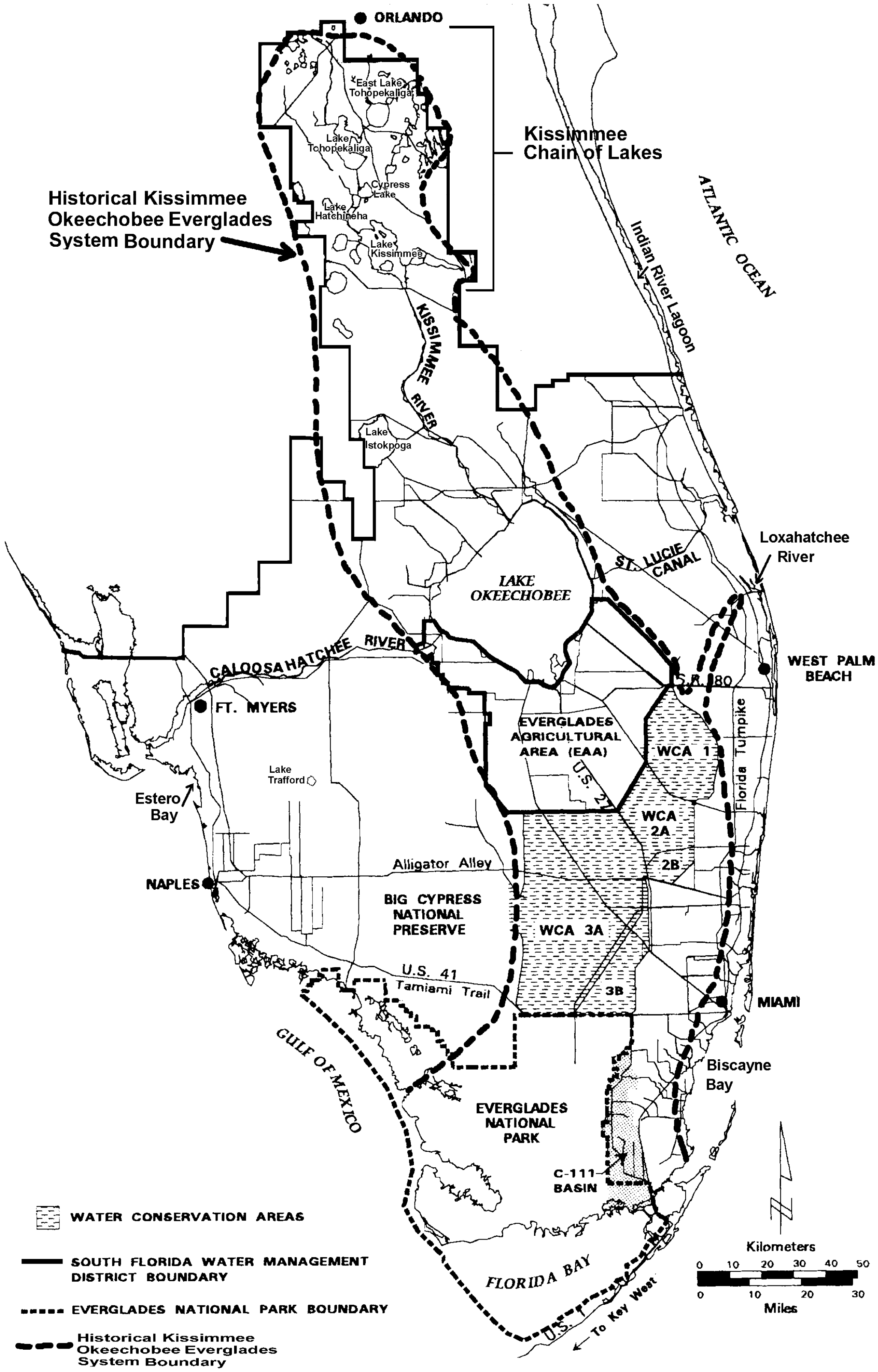


Figure 3. Kissimmee – Lake Okeechobee – Everglades Ecosystem.

Construction of the Herbert Hoover Dike and lowering the lake level reduced the lake to its present size (730 square miles), creating a littoral zone marsh community of about 98,000 acres inside the lake's levee system. These communities provide important habitat for fish, wading birds and migratory waterfowl, and are essential for maintaining the lake's ecological health.

Other major lakes found within the SFWMD include Lake Tohopekaliga in the Kissimmee Chain of Lakes, Lake Istokpoga in Highlands County and Lake Trafford in Collier County (**Figure 3**).

Historical Hoover Dike Poster

The three major rivers in south Florida are the Caloosahatchee, St. Lucie and Loxahatchee rivers, which support important freshwater communities upstream and feed into productive coastal estuaries (**Figure 3**).

Authorized by Congress in 1948, an extensive system of canals, structures and pumps, known as the Central and Southern Florida Flood Control Project (C&SF Project), was constructed to guard communities against hurricanes, floods, droughts and fires. When the project was designed in the 1950s, only about 500,000 people lived in the region, and it was estimated there might be 2 million people by 2000. Today's central and south Florida population of about 7 million people is more than three times the number of people the project was designed to serve. This strains the ability of the constructed system to perform its intended functions. When the C&SF Project was constructed, there was a lack of understanding about the environment, and the project has had unintended environmental implications.

The effects of population and agricultural growth on south Florida's natural systems have been significant. Approximately half the Everglades have been lost to urban and agricultural development. The remaining Everglades, and the entire south Florida ecosystem, no longer exhibit the functions, richness and area that historically defined the pre-drainage system.

Today, resulting directly or indirectly from years of water management, drainage and development have substantially changed most of south Florida's native vegetation, altering hydrology, increasing nutrient loading and furthering the spread of exotics (USACE and SFWMD 1999).

Natural patterns of water flow and storage were altered by the C&SF Project. Water no longer follows the timing and duration of the natural ecosystem, nor can it move freely throughout the ecosystem. The entire south Florida ecosystem has suffered as a result.

The health and diversity of Lake Okeechobee are seriously threatened. Conditions in and around Lake Okeechobee changed dramatically due to agricultural development in the watershed to the north of the lake and construction of the C&SF Project. As a result of the system of canals and levees, all discharges into and out of the lake are artificially controlled. Operation of the C&SF Project for regional flood control has resulted in prolonged periods of high water levels in the lake. These high water levels have intensified the lake's phosphorus problems, which have led to declines in the lake's aquatic plant beds and juvenile fish.

Excess nutrient inputs from agriculture and delivery of storm water by the C&SF Project resulted in more than doubling in-lake total phosphorus concentrations. This increase in phosphorus has shifted the natural balance of nutrients in the lake, led to conditions favorable for blooms of undesirable blue-green algae, and contributed to accumulation of phosphorus-rich mud sediments over an extensive area of the lake bottom. Phosphorus loading in the Lake Okeechobee Watershed is far in excess of the amount considered acceptable for a healthy ecosystem. The lake's littoral zone has experienced a dramatic expansion of exotic and nuisance plants, displacing native vegetation (Lake Okeechobee Issue Team 1999).

The C&SF Project also included the construction of large canals linking Lake Okeechobee to the St. Lucie and Caloosahatchee estuaries. Discharges through these canals have severely influenced both estuaries—altering the quantity, quality and natural timing of fresh water entering the estuaries. These alterations, along with extreme salinity fluctuations, have resulted in the loss of critical habitats and biological communities, as seen by seagrass and oyster losses, placing the biotic integrity of these systems at risk.

Unsuitable flows to Florida and Biscayne bays and the Lake Worth Lagoon have adversely influenced salinity and physically altered fish and wildlife habitat. As with the Loxahatchee River and Estuary, problems are clear in areas where fresh water historically flowed from rivers, streams and wetlands into estuarine systems. Reduced freshwater flows have caused saltwater intrusion in some river systems, while coastal lagoons have experienced prolonged hypersaline conditions affecting water quality and estuarine biota.

Urban use has developed much of Florida's shoreline and nearby coastal ridges. The remaining natural hammock and dune communities along the beaches are unique subtropical ecosystems that have little protection and are rapidly disappearing. Continuing agricultural and urban development and rising sea levels threaten the remaining natural areas. Completely unimpaired coastal ecosystems are almost nonexistent in south Florida. Even the ecosystems within protected parks and preserves are impacted by changes in water management, development or other anthropogenic activities outside their boundaries.

Construction of the C&SF Project has significantly affected the Everglades that remain. The project has conveyed nutrient runoff from urban sources and the Everglades Agricultural Area (EAA) to natural areas, where undesirable shifts of flora and fauna have occurred. Detrimental hydrologic conditions in freshwater wetland habitats have negatively influenced plant and animal communities of the native Everglades. This and the loss of wetlands to urban development have adversely influenced food webs that support wading bird populations. The number of wading birds initiating breeding in south Florida, a key indicator of wetland ecosystem health, has steadily declined, with the exception of increased nesting since the late 1990s.

Agricultural use converted all the pond apple swamp forest and most of the sawgrass plain of the northern Everglades into farmland within the EAA. The eastern levee of the Water Conservation Areas (WCAs) cut off this community from the easternmost wetlands of the Everglades, largely converting these areas into agriculture and eliminating the band of cypress forest along the eastern fringe of the Everglades. Changes in hydrology, soil subsidence, exotic plant invasion and nutrient loads have further altered the remaining mosaic of sawgrass plains, aquatic slough and tree island areas found within the WCAs and Everglades National Park. Changes in hydrology have also altered the extent of naturally occurring fires and provided areas suitable for successful invasion of exotic species, such as melaleuca, Australian pine and Brazilian pepper.

The problems of the Everglades extend downstream to the mangrove estuary and coastal basins of Florida Bay, where the mangrove forest mosaic and submerged aquatic vegetation show the effects of diminished freshwater heads. Mangroves and other saline plants have migrated farther upstream to areas that were formerly freshwater marshes, swamps and prairie.

Altogether, these problems seriously threaten the natural and human environment of south Florida. In response, a number of precedent-setting initiatives are under way to protect and restore natural systems and to increase available water supplies. Many are directives from legislation and programs at the federal and state levels, while others have been initiated by the District. These efforts include: land purchase programs; the establishment of minimum flows and levels for water bodies; regulatory and construction projects to meet nutrient targets for areas, including the Everglades and Lake Okeechobee; restoration of the Kissimmee River; and, participation by the District as the local sponsor of the Comprehensive Everglades Restoration Plan (CERP)—the largest and most dynamic ecosystem restoration project of its kind in the world.

Overall, seriously degraded wetland systems will receive the most benefit from proposed restoration efforts. These systems include: the Everglades peat-forming marshes found within Water Conservation Areas 1, 2 and 3 and Shark River Slough located within Everglades National Park; the Everglades marl-forming wet prairies, including the rocky glades found within Everglades National Park; and, the mangrove estuaries and coastal basins of Florida Bay. Several other natural systems in south Florida already have restoration plans developed or under way. These systems include the Kissimmee River, where restoration is already in progress, and the Indian River Lagoon and the Northwest Fork of Loxahatchee River and Estuary, where restoration plans are being developed. In 2006, the SFWMD completed the document, entitled the *Restoration Plan for the Northwest Fork of the Loxahatchee River* (SFWMD 2006).

The following discussion describes south Florida's vital natural systems as they relate to water resources.

MAJOR SURFACE WATER FEATURES

Kissimmee Basin and Chain of Lakes

Kissimmee Chain of Lakes

Water bodies and wetlands together cover about a quarter of the Kissimmee Watershed. The major lakes of the Kissimmee Chain of Lakes include East Lake Tohopekaliga, Lake Tohopekaliga, Cypress Lake, Lake Hatchineha and Lake Kissimmee (**Figure 3**). Most wetland systems within the Kissimmee Basin drain into the Kissimmee River and subsequently into Lake Okeechobee. The Kissimmee Basin is divided at the outlet of Lake Kissimmee (S-65 Structure) into upper and lower basins. The Upper Kissimmee Basin, found largely within Osceola County, has hundreds of lakes, ranging in size from less than an acre to over 55 square miles (Lake Kissimmee). Shingle Creek Swamp, Reedy Creek and Boggy Creek are the headwaters of this system, feeding into Lake Tohopekaliga and East Lake Tohopekaliga. Most of the interconnected lakes are shallow, with mean depths varying from 6 feet to 13 feet. Outflows from Lake Tohopekaliga and the Alligator Chain of Lakes drain into Cypress Lake, which in turn flows into Lake Hatchineha and then into Lake Kissimmee. Large herbaceous marshes surround Cypress Lake, the north end of Lake Hatchineha and the entire shoreline of Lake Kissimmee. Large areas of forested cypress and mixed hardwood swamps, as well as smaller pockets of herbaceous marsh surround the Alligator Chain of Lakes.

The drainage basins within the SFWMD boundary of Polk County are divided into portions above and below Lake Hatchineha. Above this lake, the relatively low-lying flat prairies and shallow lake systems of Lake Marion and Saddlebag Lake drain into Lake Kissimmee. Lake Marion overflows through an extensive forested wetland system into Lake Hatchineha, which discharges into Lake Kissimmee. Water from Saddlebag Lake flows in a northwesterly direction through a series of small lakes into Big Gum Lake, which in turn overflows into Lake Pierce and subsequently into Lake Hatchineha.

Below Lake Hatchineha are the lake systems of Lake Weohyakapka and Arbuckle Lake. Surrounded by forested floodplains, Lake Weohyakapka flows into Lake Rosalie via Weohyakapka Creek. Lake Rosalie then drains in a southeasterly direction into Tiger Lake, which flows into Lake Kissimmee. Arbuckle Lake drains in a southerly direction into the Kissimmee River.

Lake Istokpoga, Florida's fifth-largest lake located in Highlands County, drains into both the Kissimmee River through the Istokpoga and C-41A canals and Lake Okeechobee via the C-40 and C-41 canals. Historically, extensive wetlands surrounded the lake, but now only remnant marshes remain. Pasture now surrounds a large portion of the lake, and residential development has taken place on the southwest shore.

Originally, small streams or seasonal wetlands connected the Kissimmee Basin lakes; therefore, substantial flow between lakes only occurred during major storm events. Today, canals and water control structures link most of these lakes together. Water control schedules now regulate the natural seasonal fluctuations in water levels.

The Lower Kissimmee Basin includes the tributary watersheds of the Kissimmee River between the outlet of Lake Kissimmee (S-65 Structure) and Lake Okeechobee. The Kissimmee River and Lake Istokpoga are the major surface water features in this basin.

Kissimmee River

The Kissimmee River (**Figure 3**) and floodplain have been highly altered from their original conditions by construction of a major canal and water control impoundments. The Kissimmee River was originally a meandering river and floodplain, with numerous oxbows extending 103 miles south from Lake Kissimmee to the north end of Lake Okeechobee. In the 1960s, the U.S. Army Corps of Engineers (USACE) channelized the river into a 56-mile canal to improve flood protection within the watershed. Today a series of combined locks and spillways divides the Kissimmee River into five pools (pools A–E). A regulation schedule controls water levels in each of these pools.

Efforts are under way to restore the river and its headwaters to achieve a more natural flow and improve water level conditions in the river and floodplain. Designed to restore 43 miles of the river, the Kissimmee River Restoration Project is redirecting flows through the historic river channel and restoring the ecological functions of the river/floodplain system. The project is expected to restore 27,000 acres of floodplain wetlands and will benefit over 320 species of fish and wildlife, including the endangered wood stork, snail kite and southern bald eagle. Environmental studies on the river are establishing a baseline for tracking expected changes and responses to the ecosystem as restoration projects move forward.

Kissimmee River Backfilled

Lake Okeechobee

Lake Okeechobee Pier

Located within south-central Florida, Lake Okeechobee and its watershed are key components of the Kissimmee – Okeechobee – Everglades ecosystem. The lake covers 730 square miles and represents the second-largest body of fresh water located wholly within the continental United States (**Figure 3**). The lake is shallow with a mean depth of only 9 feet, but has a surface water storage capacity of over 1 trillion gallons and represents the "liquid heart" of south Florida's water supply-flood control system. Major inflows to the lake include the Kissimmee River, Fisheating Creek and Taylor Creek/Nubbin Slough. Lake Okeechobee supports an extensive littoral zone (150 square miles) that provides important feeding and nesting habitat for fish, wading birds, migratory waterfowl, as well as the endangered Everglades snail kite. The lake is nationally renowned for its sportfishing (black bass and crappie) and supports a viable commercial fishing industry (SFWMD 2003c).

Lake Okeechobee is a direct source of drinking water for lakeside cities and towns and serves as a backup water supply for urban areas located along the Lower East Coast of Florida (**Chapter 9**). The lake provides irrigation water for the 700-square-mile EAA located south of the lake and represents a critical supplemental water supply for the Everglades during dry periods. Given these often-competing demands on the lake, management of this water resource is a major challenge.

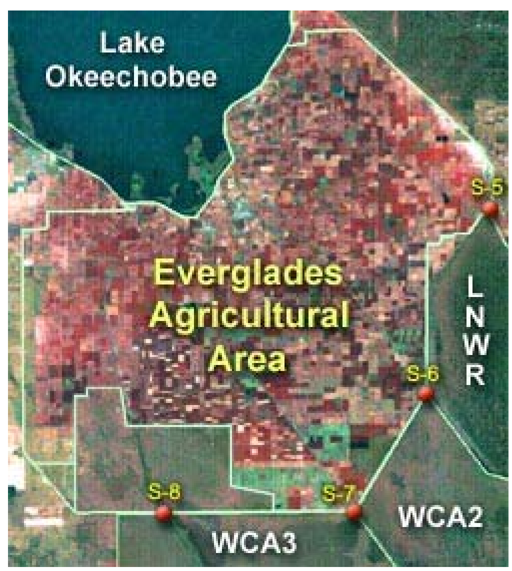
Lake Okeechobee, the heart of the C&SF Project, is a key water storage feature of the region's interconnected aquatic ecosystem. It has multiple functions, including flood protection, urban and agricultural water supply, navigation, fisheries, and wildlife habitat. As such, operation of the lake affects a wide range of environmental and economic issues. Lake operations must carefully consider the entire, sometimes conflicting, needs of the regional water management system.

A complex system of pumps and locks regulates the lake water levels. The primary tool for managing lake water levels is the regulation schedule. The USACE adopted the Water Supply and Environmental (WSE) Regulation Schedule in July 2000. Designed to provide environmental benefits to the lake and downstream systems while protecting the region's water supply, this schedule uses climate forecasting and tributary hydrologic conditions to determine the volumes of water to release from the lake.

For more information about Lake Okeechobee operations, including the regulation schedule, adaptive protocols, performance measures and water supply management, see **Chapter 10**.

The Everglades

Historically, during wet periods, Lake Okeechobee discharged water over its southern rim into the Everglades. Originally, this vast sawgrass marsh extended from Lake Okeechobee south to the peninsular tip of Florida, east to the coastal ridge and west to the Immokalee Ridge (roughly the border of the Big Cypress National Preserve), covering more than 4,500 square miles. Today, this vast mosaic of wetland plant communities has been reduced by almost 50 percent due to drainage and development. A large portion (more than 700,000 acres) of the original Everglades immediately south of Lake Okeechobee has been converted into agricultural lands, known as the Everglades Agricultural Area (EAA).



Map of Everglades Agricultural Area

Water Conservation Areas

South of Lake Okeechobee and the EAA, the C&SF Project has compartmentalized the Everglades into Water Conservations Areas (WCAs) 1, 2A, 2B, 3A and 3B located within Palm Beach, Broward and Miami-Dade counties (**Figure 3**). These five surface water impoundments (1,371 square miles) were developed to provide flood control, water storage and wildlife conservation benefits for the region. The WCAs contain the region's last remnants of the original sawgrass marshes, wet prairies and hardwood swamps located outside of Everglades National Park. Managed as surface water reservoirs, the WCAs have a combined storage capacity of 1,882,000 acre-feet. Water Conservation Areas 2B and 3B primarily recharge and maintain groundwater levels in coastal areas to the east (Light and Dineen 1994).

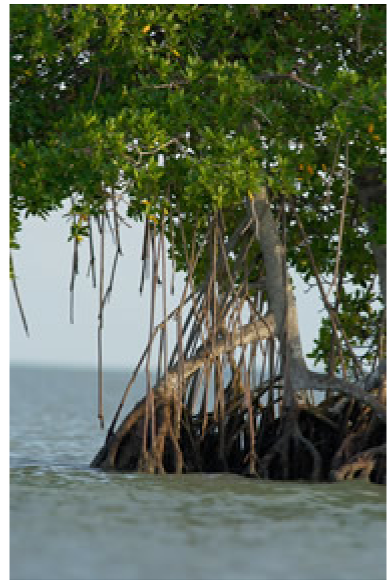
Everglades National Park

Flows from WCA-3A and WCA-3B enter the northern boundaries of Everglades National Park through a series of water management structures and culverts located under Tamiami Trail (US 41). Much of this water enters the park and flows in a southwest arc through Shark River Slough to Whitewater Bay and the Ten Thousand Islands area. Some of the water entering the park is diverted to the east into the South Miami-Dade Conveyance System and enters the park via the L-31N Canal and Taylor Slough. Water also enters from the C-111 Canal, where it flows south into northeastern Florida Bay.

Everglades National Park

Everglades National Park (**Figure 3**) is the largest remaining subtropical wilderness in the United States. The park contains both temperate and tropical plant communities, including sawgrass prairies, mangrove and cypress swamps, pinelands and hardwood hammocks, as well as marine and estuarine environments. Known for its abundant bird life, the park has large wading bird colonies of different species, such as the roseate spoonbill, wood stork, great blue heron and a variety of egrets. Rich in wildlife, the park is host to rare and endangered species, including the American crocodile, Florida panther and West Indian manatee. Everglades National Park was the first national park to be established to preserve purely biological resources—to protect the particular and primitive natural conditions of the subtropical Everglades ecosystem (Nordeen 1999). The park has been designated an International Biosphere Reserve, a World Heritage Site and a Wetland of International Importance, in recognition of its significance to all the peoples of the world (Ogden and Davis 1994).

Transitional wetlands that were historically located along the eastern border of the Everglades are now urban or agricultural areas. Human use has transformed about 2.9 million acres of the Everglades wetlands, severely reducing the size of three major wetland types. Construction and operation of the C&SF Project, a water management system of canals, structures and pumps that has altered natural patterns of water flow and storage, have significantly affected the Everglades that remain today. This and the loss of wetlands to developed areas have adversely affected the food webs supporting wading bird populations. The project has also conveyed nutrient runoff from the EAA and urban sources to natural areas, where undesirable shifts of biota have occurred. Changes in hydrology have altered both the extent and frequency of naturally occurring fires and provided suitable areas for the successful invasion of exotic species, such as melaleuca, Australian pine and Brazilian pepper. Hydrologic changes also have affected downstream estuarine systems that no longer receive historical quantities and timing of overland water flows.



Red Mangrove – Everglades National Park

Restoration of the remaining Everglades ecosystem requires research to gain an understanding of how the ecosystem functioned prior to man's intervention. Restoration focuses on improving upstream water quality and improving Everglades "hydropatterns"—the timing, depth and flow of surface water across these wetlands. Restoring these natural hydropatterns depends on knowledge of original pre-canal drainage conditions, as well as an understanding of the soil, topographic and vegetation changes that have taken place since canal drainage began in the 1880s (Ogden and Davis 1994).

Big Cypress National Preserve

The 729,000-acre Big Cypress National Preserve, located primarily within Collier County, lies to the west of WCA-3A. The Big Cypress Swamp occupies a large section of southern Hendry County, including part of the Big Cypress Seminole Indian Reservation. Cypress forests, small pine hammocks and marshes characterize the area. The name Big Cypress refers to the large size of this area, known for its vast stands of stunted pond cypress, as well as its cypress domes and strands that dominate this unique landscape. The Big Cypress Preserve was set-aside in 1974 to ensure the preservation, conservation and protection of the natural scenic, floral, faunal and recreational values of the Big Cypress Watershed.

The Big Cypress Preserve hosts in excess of 100 species of plants and 20 species of animals listed by the state as endangered or threatened, and nine federally listed species, including the bald eagle and peregrine falcon. Five endangered birds, the snail kite, wood stork, Cape Sable seaside sparrow and red cockaded woodpecker, nest in the preserve. The endangered West Indian manatee and Florida panther and the threatened eastern indigo snake and American alligator also live in the preserve. Six state-listed species include the white-crowned pigeon, Florida sandhill crane, least tern, Everglades mink, Big Cypress fox squirrel and the black bear.

From a hydrologic standpoint, the Big Cypress Preserve serves as a supply of fresh, clean water for the estuaries of the Ten Thousand Islands area.

Other Surface Water Features (by County)

Martin, St. Lucie and Okeechobee Counties

The area now known as the Allapattah Flats was historically a series of sloughs that flowed from St. Lucie County southwest into Martin County through Barley-Barber Swamp and into Lake Okeechobee. Highways, railroads and drainage projects have modified this drainage pattern.

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

The DuPuis Reserve and the Pal-Mar Project also contain significant wetland systems. The 21,875-acre DuPuis Reserve is located in southwestern Martin County and northwestern Palm Beach County. This site contains numerous ponds, wet prairies, cypress domes and remnant Everglades marsh. The Pal-Mar Project, which will total 35,600 acres when land acquisition is completed, consists primarily of wet prairies, high quality pine flatwoods and savanna.

Jonathan Dickinson State Park, consisting of 10,000 acres in southeast Martin County, contains a variety of native uplands and wetlands, including pine flatwoods, sand pine scrub, palmetto prairies, cypress sloughs and domes, marshes, and wet prairies. Acquisition efforts are under way in this area to purchase sufficient public lands to create a wildlife corridor that will connect Jonathan Dickinson State Park, the Pal-Mar Project, J.W. Corbett Wildlife Management Area (in Palm Beach County) and the DuPuis Reserve.

The few large remaining inland wetland systems in St. Lucie County include the Savannas; wetlands associated with Five Mile, Ten Mile, Cow, Cypress and Van Swearingen creeks; remnant portions of St. Johns Marsh; and, the floodplain of the North Fork of the St. Lucie River. The Savannas, a freshwater wetland system located west of the Atlantic Coastal Ridge, is one of the most endangered natural systems in south Florida. Historically, the Savannas formed a continuous system stretching the length of the county.

The Savannas State Preserve

Large tracts of forested and emergent wetlands are located in eastern Okeechobee County, creating a northwest to southeast system that continues into St. Lucie County.

Collier, Hendry and Lee Counties

Major wetland areas include the Okaloacoochee Slough, Fakahatchee Strand, the Big Cypress National Preserve and the Corkscrew Regional Ecosystem Watershed (CREW) lands. A number of these systems are relatively pristine wetland areas, 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 hydrologic functions. Before development of the region, inland areas were composed 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, with fresh water flowing from the northeast to the southwest.

Okaloacoochee Slough is one of the two most important surface water flowways in Collier County, with Lake Trafford-Corkscrew Regional Ecosystem Watershed (CREW) being the other. 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. Okaloacoochee Slough 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 contains diverse 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 considered endangered, threatened or species of special concern.


Barred Owl in CREW

The Lake Trafford-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. Cypress forest, low pine flatwoods, hardwood hammocks, marshes, mixed swamps and ponds dominate the CREW lands. This system provides valuable habitat supporting at least 65 species of plants and 12 species of animals listed by the state as endangered or threatened.

Major wetland areas in Lee County include the Six Mile Cypress Slough and Flint Pen Strand. The Six Mile Cypress Slough occurs in central Lee County and drains via the Ten Mile Canal into the Estero River and Estero Bay. Flint Pen Strand is part of the CREW in Lee and Collier counties. These wetlands are dominated by cypress and interspersed with numerous ponds. The native plant communities fringing the slough are pine flatwoods, hardwoods and wet prairies. Heavy infestation of melaleuca has occurred in the southern one-third of the slough.

Glades and Charlotte Counties

The major wetland in western Glades County is Fisheating Creek, an extensive riverine swamp system that forms a watershed covering hundreds of square miles. 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 egret, when stages in the marshes surrounding Lake Okeechobee are too high.

Significant wetland systems in eastern Charlotte County include the 10,000-plus-acre Telegraph Cypress Swamp and Jack's Fork, which are part of the Babcock Ranch Florida Forever project. Additionally, wetlands occupy a part of the Fred C. Babcock/Cecil M. Webb Wildlife Management Area, which is located in the Lower West Coast (LWC) Planning Area. These systems contain a diverse mixture of hydric pine flatwoods, cypress strands, wetland prairies and marshes.

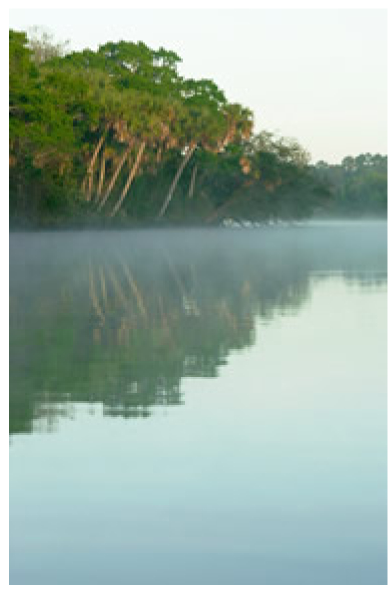
Major Rivers and Lakes

Rivers

The Kissimmee River was originally 103 miles in length until it was channelized in the 1960s into a 56-mile canal (C-38). A series of combined locks and spillways divides the Kissimmee River into five pools (pools A–E). A regulation schedule manages the water levels in each of these pools. The Kissimmee River Restoration Project, currently in progress, will backfill 22 miles of the C-38 Canal, directing flows through the historic river oxbows and restoring the ecological functions of the river/floodplain system. Backfilling of the canal began in the 1990s, midway between the S-65A and S-65B structures and will continue southward to the S-65D Structure.

The Caloosahatchee River was channelized in the 1800s and connected to Lake Okeechobee (**Figure 3**). Construction of a series of navigational locks and water control structures to manage water levels and flows has altered the river floodplain. Managing water levels in Lake Okeechobee involves the periodic release of large quantities of water into the estuary.

The St. Lucie River lies in Martin and St. Lucie counties and includes the North and South forks (**Figure 3**). These forks combine in the St. Lucie Estuary. Numerous creeks feed the St. Lucie River and Estuary in both Martin and St. Lucie counties. These include Danforth and Mapp creeks, which are tributaries of the South Fork of the St. Lucie River downstream of the St. Lucie Canal. The Five and Ten Mile creeks are the headwaters and tributaries to the North Fork of the St. Lucie River, and Willoughby, Bessey and Manatee creeks enter directly into the St. Lucie Estuary.



North Fork St. Lucie River

The Loxahatchee River (**Figure 3**) is located in southern Martin County and northern Palm Beach County. The Northwest Fork of the Loxahatchee River and North Fork of the Loxahatchee River drain into the Loxahatchee Estuary. The Northwest Fork originates in the Loxahatchee Slough. The slough receives discharges from the C-18 Canal and runoff and groundwater inflow from adjacent uplands. Downstream from the slough, the Northwest Fork receives additional input from three major tributaries: Cypress Creek, Hobe Grove Ditch and Kitching Creek. The North Fork originates in Jonathan Dickinson State Park. Limestone Creek and Simms Creek connect to the Loxahatchee River Estuary.

The Loxahatchee River and the North Fork of the St. Lucie River have been designated as aquatic preserves by the State of Florida. These designations are intended to preserve the biological, aesthetic or scientific values of these resources for the enjoyment of future generations.

The Northwest Fork of the Loxahatchee River was Florida's first Wild and Scenic River designated by the federal government. Natural tributaries to the Loxahatchee River system include the Loxahatchee Slough and North Fork of the river, Cypress Creek, Moonshine Creek, Kitching Creek, Limestone Creek, and Simms Creek.

In most of Palm Beach, Broward and Miami-Dade counties, the historical coastal rivers and streams, such as the Earman River, Hillsboro River, Snake Creek, Arch Creek, Miami River, Snapper Creek and Black Creek, were channelized by construction of major drainage canals. Only a few natural areas remain within these watersheds. A number of important river systems remain within Everglades National Park and the Ten Thousand Islands, including Taylor River, Shark River, Lostman's River and Turner River.

Major Lakes

Lake Istokpoga

Lake Okeechobee, which spans 467,200 acres, is the largest lake within the SFWMD. Lake Kissimmee covers an area of 34,948 acres and represents the second-largest lake within the District. Lake Kissimmee serves as the primary source of water for the Kissimmee River. Lake Istokpoga, at 27,692 acres, is the third-largest lake within the District and provides flows to both the Kissimmee River and Lake Okeechobee. Some of the other major lakes located within the District include Lake Tohopekaliga (18,810 acres); East Lake Tohopekaliga (11,968 acres); Lake Weohyakapa (7,532 acres); and, Lake Hatchineha (6,665 acres)—all located within the Kissimmee Basin (KB) Planning Area—and Lake Trafford (1,494 acres), which is located in Collier County in the Lower West Coast (LWC) Planning Area.

Natural lakes within the Upper East Coast (UEC) Planning Area include Lake Eden in the Savannas State Preserve, Mile Lake, which is west of the North Fork of the St. Lucie River in southern Port St. Lucie, and Banner Lake, which is south of State Road 708 in Hobe Sound. These lakes provide habitat for aquatic plants and animals and other wildlife that rely on open water during some portion of their life, but are not important sources of water supply for urban and agricultural uses within the planning area.

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

COASTAL RESOURCES

Coastal resources include barrier islands, the Florida Keys, coastal ridges, wetlands and estuarine systems.

Barrier Islands

Barrier islands play important roles in providing habitat for a wide variety of tropical, native and endemic plants, and shorebird and wildlife species. Barrier islands protect the mainland from major storm events and act as a buffer for sensitive estuarine areas. These low-lying, narrow strips of sand also play an important role in the region's tourism economy by attracting visitors to the beaches.

Barrier islands are typically low-lying areas of sand, mangrove peat deposits and coral rock that exist adjacent to the Atlantic Ocean or Gulf of Mexico. Along the east coast of Florida, these islands form an almost continuous chain that extends from the state line north of Jacksonville to Biscayne Bay and continues south through the Florida Keys to the Dry Tortugas. On the west coast of Florida, barrier islands also form a chain that extends from northern Lee County to southern Collier County, where it merges with the Ten Thousand Islands area of coastal mangrove forests and islands that continues southward to Florida Bay. The seaward edges of the islands generally support a coastal dune community, which includes salt- and drought-tolerant species. Behind the dune community, cabbage palm, saw palmetto, oak and sea grape are present. The shoreward edge of the islands typically supports mangrove wetlands. Much of the natural plant and animal communities of these islands has been lost to development.

Hutchinson Island is a low barrier island located along the eastern shoreline of Martin and St. Lucie counties. The eastern edge of the island supports a coastal dune community, which includes salt- and drought-tolerant species. West of the dune community, cabbage palm, saw palmetto, oak and sea grape are present. The western edge of the island supports mangrove wetlands.

Florida Keys

The Florida Keys consist of a limestone island archipelago extending southwest over 200 miles from the southern tip of the Florida mainland to the Dry Tortugas, 70 miles west of Key West. The Keys are bounded on the north and west by the relatively shallow waters of Biscayne Bay, Barnes and Blackwater sounds, Florida Bay—all areas of extensive mud shoals and seagrass beds—and the Gulf of Mexico. Hawk Channel lies to the south, between the mainland Keys and an extensive reef tract 5 miles offshore. The Straits of Florida lie beyond the reef, separating the Keys from Cuba and the Bahamas.

Florida Keys

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

Coastal Ridge and Wetlands

Coastal mangrove forests and salt marshes largely dominated the coastline of south Florida prior to development. Immediately behind the mangrove fringe, a coastal ridge is present along the edge of the mainland that forms a 1- to 3-mile-wide area dominated by sand pine, saw palmetto, scrub oaks and other xeric plant species. Wetland depressions often occurred farther west of the coastal ridge, frequently forming continuous systems that extended for many miles. The Savannas, a remnant freshwater coastal wetland system, is located immediately west of the coastal ridge in Martin and St. Lucie counties. Similar systems of interconnected freshwater lakes and wetlands existed historically throughout much of the length of Palm Beach County.

Estuarine Systems

Coastal areas are dominated by large estuarine systems where the waters of the Atlantic Ocean or Gulf of Mexico mix with the freshwater inflows from numerous river systems, sloughs and overland sheet flow. Shallow bays, extensive seagrass beds, and sand or mud flats characterize these estuarine areas. Extensive mangrove forests dominate undeveloped areas of the shoreline.

Governor Crist with Ken Pruitt, Michael Sole and Carol Ann Wehle – Proposing Funding for Northern Everglades Estuary Protection

Several large open water estuarine systems—Charlotte Harbor, Pine Island Sound, the Caloosahatchee Estuary, Estero Bay, St. Lucie Estuary, Indian River Lagoon, Lake Worth Lagoon, Biscayne Bay, Whitewater Bay and Florida Bay—exist within the SFWMD. Other associated habitats include high salt marshes and riparian fringing marshes. These estuaries provide important habitat for threatened and endangered species and support commercial and recreational fisheries. More than 40 percent of Florida's rare, endangered or threatened species are found in south 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 southern bald eagle and American crocodile also rely largely on the estuary as their 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 dominates the southern portion of Collier County and represents one of the world's largest remaining intact mangrove forests.

Many of south Florida's estuary areas are contained in aquatic preserves, such as Matlacha Pass, Pine Island Sound, Charlotte Harbor, Estero Bay, Rookery Bay, St. Lucie River, Loxahatchee River, Lake Worth Creek and Biscayne Bay. Florida Bay is within Everglades National Park, and southern Biscayne Bay is part of Biscayne National Park.

Indian River Lagoon / St. Lucie Estuary

Manatees – Indian River Lagoon

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

An estimated 4,300 species of plants and animals have been documented in the Indian River Lagoon, making it the most diverse estuary in North America (SFWMD and SJRWMD 2002).

The St. Lucie Estuary is located in the southern region of the Indian River Lagoon in Martin and St. Lucie counties. The St. Lucie Watershed encompasses about 781 square miles and is divided into five major basins and several small basins. Land use of the western basins is predominantly agricultural with about 70 percent of the land in citrus and improved pasture. The two eastern basins (North St. Lucie and Tidal) are urban with about 45 percent of the land devoted to agricultural activities.

The St. Lucie Estuary is divided into three sections: the North Fork, the South Fork and the middle estuary. The North Fork is about 4 miles long with a surface area of 4.5 square miles. Depths range from 10 feet in the central portion to 20 feet at its juncture with the South Fork. The North Fork is designated as an aquatic preserve. The South Fork has about half the surface area of the North Fork, and is relatively shallow, except for an 8-foot navigation channel. This channel is part of the Okeechobee Waterway, which links Stuart with Fort Myers through Lake Okeechobee and the Caloosahatchee River. The middle estuary begins at the confluence of the North and South forks and continues to Hell Gate Point near the Indian River Lagoon proper.

Loxahatchee River and Estuary

Loxahatchee River

The Loxahatchee River and Estuary and its upstream watershed are located along the southeastern coast of Florida within the Lower East Coast (LEC) and UEC planning areas. This watershed encompasses approximately 210 square miles within northern Palm Beach and southern Martin counties, and connects to the Atlantic Ocean via the Jupiter Inlet, near Jupiter.

The Loxahatchee River and upstream floodplain are unique regional resources in several ways. The river has often been referred to as the "last free-flowing river in southeast Florida." In May 1985, based on its natural scenic qualities, diverse native plant and wildlife communities, and in order to preserve the natural landscape, a 7.5-mile reach of the Northwest Fork of the Loxahatchee River was federally designated as Florida's first Wild and Scenic River. In addition, different portions of the river and estuary are designated as aquatic preserves, Outstanding Florida Waters and a state park. The Northwest Fork represents one of the last vestiges of native cypress river-swamp within southeast Florida. Large sections of the river's watershed and river corridor are included within Jonathan Dickinson State Park, which contains outstanding examples of the region's natural habitats.

This unique watershed contains a number of natural areas that are essentially intact and in public ownership. These areas include the J.W. Corbett Wildlife Management Area; Jonathan Dickinson State Park; Hungryland Slough Natural Area; Loxahatchee Slough Natural Area; Hobe Sound National Wildlife Refuge; Juno Hills Natural Area; Jupiter Ridge Natural Area; Pal-Mar; Cypress Creek; and, the Atlantic Coastal Ridge. These natural areas contain pinelands, xeric oak scrub, hardwood hammocks, freshwater marshes, wet prairies, cypress swamps, mangrove swamps, seagrass beds, tidal flats, oyster beds and coastal dunes. A total of 267 animal species has been observed in and along the river and estuary (FDEP and SFWMD 2000). Along the river and within Jonathan Dickinson State Park can be found coastal sand pine scrub, a biological community so rare it is designated "globally imperiled." The Cypress River Swamp community supports a number of species that have been identified as endangered, threatened or species of special concern by the Florida Fish and Wildlife Conservation Commission (FWC), or listed as threatened or endangered by the U.S. Fish and Wildlife Service (USFWS). The Loxahatchee River Watershed also contains managed agricultural lands and urban areas.

Flows in the Loxahatchee River have been highly altered due to drainage—specifically, construction of the C-18 Canal and drainage of the Loxahatchee

Slough. The long-term decline of the extent and health of the freshwater floodplain swamp community along the upstream portion of the Northwest Fork appears to be linked to hydrologic alterations of the river and its watershed, as well as past dredging activities in the estuary and Jupiter Inlet. Combined, these two factors have resulted in reduced freshwater flows to the river, the lowering of the groundwater table and increased saltwater intrusion of the floodplain swamp community during dry periods. Sufficient freshwater flows are required during the dry season to protect the existing cypress community from further degradation and loss of natural function.

Several water management, environmental water supply and/or ecosystem restoration projects are completed, under way or planned for the Loxahatchee River and Estuary. These include the: *Northern Palm Beach County Comprehensive Water Management Plan*; CERP North Palm Beach County Project; the *Restoration Plan for the Northwest Fork of the Loxahatchee River* (SFWMD 2006); initial water reservations for the Northwest Fork of the Loxahatchee River; minimum flows and levels (MFLs) for the Northwest Fork of the Loxahatchee River; and, MFLs for the Northwest Fork of the Loxahatchee River tributaries.

Lake Worth Lagoon

Lake Worth Lagoon is a long, narrow body of brackish water located along the Intracoastal Waterway in Palm Beach County. Historically, Lake Worth Lagoon was a freshwater lake fed by drainage from swamps along the western edge. Creation of permanent inlets to the lagoon, beginning in the late 19th and early 20th centuries, changed its character from fresh water to estuarine. The cumulative impact of the anthropogenic activities over the past 100 years has significantly altered the Lake Worth Lagoon environment, although regionally important natural resources remain. Alterations affecting the hydrology of the lagoon include construction and development of major drainage canals (C-51, C-17 and C-16), shoreline bulkhead construction, causeway construction, filling, channel dredging and port development. In particular, discharges from the C-51 Canal to the lagoon have produced episodic releases of large amounts of fresh water that have adversely influenced estuarine biological communities within the lagoon.

Lake Worth Lagoon flow targets have been recommended and made available for use in the sediment transport component of the CERP North Palm Beach County Project. The purpose of this restoration project is to improve water quality and allow for the re-establishment of sea grasses and benthic communities within the lagoon. The elimination of organically enriched sediment from the C-51 Canal discharge will enable long-term improvements to the lagoon.

Caloosahatchee River and Estuary

Caloosahatchee River

The Caloosahatchee River and Estuary and its upstream watershed are located within Lee, Hendry and Glades counties (**Figure 3**). The watershed drains an area of over 1,300 square miles extending 66 miles from Lake Okeechobee to the mouth of the Caloosahatchee Estuary (San Carlos Bay). The Caloosahatchee River (C-43), along with the St. Lucie Canal (C-44) are important components of the Central and Southern Florida Flood Control Project (C&SF Project), and are used primarily for regulatory releases from Lake Okeechobee when lake levels exceed the lake regulation schedule. In addition to regulatory discharges for flood protection, the river also receives water deliveries from the lake for river navigation and water supply for urban and agricultural users.

The Caloosahatchee Estuary is a large estuarine ecosystem where the waters of the Gulf of Mexico mix with the freshwater inflows from the river, sloughs and overland sheet flow from the upstream basin. A shallow bay, extensive seagrass beds and sand flats characterize the estuary. Extensive mangrove forests dominate undeveloped areas of the shoreline. The tidal portion of the river includes portions of Lee and Charlotte counties. Bordered by Fort Myers on the south shore and Cape Coral on the north shore, the estuary length between the Franklin Lock and Shell Point is 26 miles. The estuary is an important nursery ground for many commercially and recreationally important fish and shellfish species. The estuary also provides foraging areas and wetland habitat for a large number of Florida's rare, endangered and threatened species. Hydrologic alterations of the watershed have dramatically changed the natural quantity, quality, timing and distribution of flows delivered to the downstream estuary. Large, unnatural freshwater releases from the lake through the C-43 Canal have altered the estuarine salinity gradient and transport significant quantities of sediment to the estuary. Biota within the Caloosahatchee Estuary and near-shore seagrass beds has been impacted by these high-volume discharges.

Estero Bay

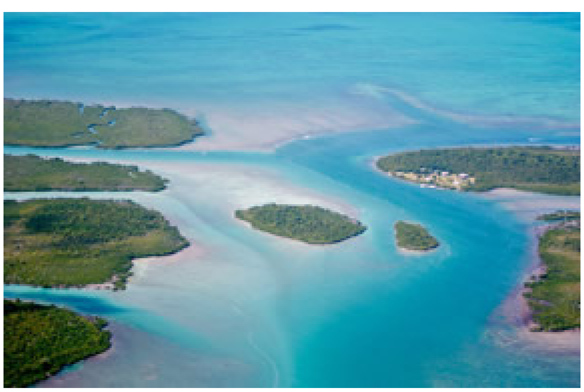
The Estero Bay Watershed covers an area of 462 square miles and includes central and southern Lee County and parts of northern Collier and western Hendry counties. The principal freshwater inflows come from Hendry Creek, Mullock Creek, Estero River, Spring Creek and the Imperial River. Coastal portions of the watershed are urbanized and include the cities of Fort Myers, Bonita Springs and Fort Myers Beach. The watershed includes all of Estero Bay, most of which is located within the Estero Bay Aquatic Preserve and adjacent barrier islands. Hendry Creek, Mullock Creek, the Estero River, areas of Corkscrew Swamp, Spring Creek and the Imperial River are major surface water features in the basin.

Estero Bay (**Figure 3**) is a long, narrow and very shallow body of water whose northwestern border begins at Bowditch Point on Estero Island and reaches as far south as Bonita Beach. Estero Island, Black Island, Long Key, Lover's Key and Big Hickory Island are the barrier islands that separate the bay from the Gulf of Mexico. The flora and fauna of the bay and its watershed are varied and abundant and include many state- and federal-listed species, such as the West Indian manatee, loggerhead sea turtle, Florida panther, bald eagle, Big Cypress fox squirrel, red-cockaded woodpecker and snowy plover. The mangrove-lined shores and islands of the bay contain five rookeries or roosting areas that support brown pelicans, frigate birds, herons, egrets, cormorants and ibis.

Water quality is a primary concern for Estero Bay, and will be addressed by the Florida Department of Environmental Protection's (FDEP) Impaired Waters and Total Maximum Daily Load (TMDL) programs.

Population growth in the Estero Bay Watershed has been rapid, posing a threat to sensitive natural resources in the bay and watershed. Urban land use in the basin is primarily located in the western developed corridor, the areas around Florida Gulf Coast University, Bonita Springs and western Immokalee. The major wetland and associated upland systems are located within the central and eastern parts of the basin, while the agricultural uses are located on the boundaries and between the large wetland systems.

Biscayne Bay



Biscayne Bay

Located along the coast of Miami-Dade County and northeastern Monroe County, Biscayne Bay comprises a marine ecosystem of about 428 square miles and a watershed area of about 938 square miles. This subtropical estuary is designated as an "Outstanding Florida Water and an Aquatic Preserve" under Florida Statutes.

The bay is divided into three general areas: north, central and south Biscayne Bay. The north Biscayne Bay extends from Dumfoundling Bay south to the Rickenbacker Causeway. This area of the bay retains the most estuarine habitat found in the bay, but it is also the most altered by dredging and bulkheading. Roughly 40 percent of the area is too deep or too turbid to support a productive estuarine ecosystem. The remaining shallow areas contain highly productive seagrass beds. Manatee grass is extensive and serves as habitat for a diverse and popular fishery.

In contrast, central Biscayne Bay, which extends from Rickenbacker Causeway south to Black Point, is more of a marine system that is heavily influenced by daily tidal flushing. Estuarine areas are limited to near-shore areas close to major sources of freshwater inflow (canals). Seagrass meadows, in which turtle grass is dominant, are extensive. This is a highly productive pink shrimp area, supporting a commercial fishing industry. A narrow band of mangrove-forested coastal wetlands begins at Matheson Hammock Park and extends southward along the shoreline.

Southern Biscayne Bay extends from Black Point to Jewfish Creek and includes Biscayne National Park, a sanctuary for the Florida spiny lobster. Card and Barnes sounds are part of the Florida Keys National Marine Sanctuary. This area is profoundly affected by a reduction in historical freshwater flows, and tends to become hypersaline during periods of low rainfall. Freshwater wetlands have been significantly reduced and a transition to mangrove species is occurring.

Historically, the bay's clear water and diverse and productive communities of seagrass, coral and sponge characterized Biscayne Bay. Prior to settlement, mangroves and coastal wetlands rimmed the bay. Freshwater flowed through transverse glades, over shallow falls of the coastal ridge. Groundwater flow was sufficient to cause upwelling fresh enough to drink. Oyster bars and estuarine species, such as red and black drum, were common.

Overall, Biscayne Bay shows increasing signs of distress, such as declines in fisheries, increased pollution and dramatic changes in near-shore vegetation. Intensive development of the watershed has altered the natural cycle of freshwater inflows into the bay. The northern and central portions of Biscayne Bay are strongly affected by the urban development associated with the growth of Miami. Southern Biscayne Bay is influenced by drainage from the Everglades, which has been altered by canals and agricultural activities. The opening of inlets and further channelization has contributed to the bay's transition from a freshwater estuary to a marine lagoon. Today, the bay is a pulsed system that alternates between marine conditions and extreme low salinities near the discharges of 19 major canals. Scientists have observed changes in fish diversity and abundance with a shift toward marine species over time. Red and black drum populations are no longer sustainable and oysters are not common. Restoration and preservation of Biscayne Bay and Biscayne National Park are dependent on a comprehensive understanding of the linkages between the hydrologic system and the bay ecosystem, and of the natural versus human-induced variability of the ecosystem.

Florida Bay and Ten Thousand Islands

Florida Bay

Between the southern edge of the Everglades and the Florida Keys lies a large, shallow, subtropical estuary called Florida Bay. This triangular shaped estuary, about 850 square miles, is the largest estuary in Florida and the largest body of water within Everglades National Park. Because the average depth of the bay's mud flats is only about 3 feet, sunlight reaches the bottom and supports the growth of seagrass beds. Plants, such as turtle grass, horned pondweed and manatee grass, stabilize the mud flats. Seagrass beds serve as nursery areas, feeding grounds and refuges for many species. A number of different species of algae also live there. Exposed at low tide, the mud flats of Florida Bay provide a valuable feeding area for a number of birds.

More than 25 years ago, this subtropical estuary was noted for its clear, warm waters, lush seagrass beds and outstanding fishing. However, starting in the late 1980s, dramatic changes in the ecology of Florida Bay became evident. These changes included the widespread death of seagrass beds, turbid water associated with this die-off, large and sustained blooms of algae, and population reductions in pink shrimp, sponges, lobster, recreational game fish and wading birds. The Comprehensive Everglades Restoration Plan (CERP) Florida Bay/Florida Keys Feasibility Study (discussed later in this chapter) will ultimately provide a recommended plan of action to restore Florida Bay.

Florida Bay and Ten Thousand Islands

Ten Thousand Islands is a maze of hundreds, not thousands, of mangrove islands and waterways that extend from just south of Marco Island to Flamingo and Florida Bay. Most of the mangrove islands consist of clumps of mangrove trees rising out of coral reefs, oyster beds and sandy shoals. Some of the islands are actually land-masses called keys. A series of sloughs through the Big Cypress Swamp, as well as a series of tidal creeks, channels, and surface and subsurface sheet flow provide a supply of fresh water to western Florida Bay and the Ten Thousand Island estuaries.

Two-thirds of the area lies within Everglades National Park, while Cape Romano Ten Thousand Islands Aquatic Preserve and Ten Thousand Islands National

Wildlife Refuge protect the areas outside the national park boundaries. Ten Thousand Islands National Wildlife Refuge is part of the largest expanses of mangrove forest in North America. Most of the refuge is mangrove forest, while the northern reaches of the refuge consist of brackish marshes and interspersed ponds, small coastal hardwood hammocks, and cabbage palms.

The seagrass beds and mangrove bottoms serve as a vital nursery for marine life. Roughly 200 species of fish and over 189 species of birds have been documented in the area. Notable threatened and endangered species include the West Indian manatee, bald eagle, peregrine falcon, wood stork, and Atlantic loggerhead, green and Kemp's Ridley sea turtles.

Threatened and Endangered Species

The USFWS has identified 18 federally listed plant and animal species that would likely be affected by changes in water management practices (**Table 1**). Of the listed species, critical habitat has been designated for the West Indian manatee (*Trichechus manatus*), the snail kite (*Rostrhamus sociabilis plumbeus*), the Cape Sable Seaside Sparrow (*Ammodramus maritimus mirabilis*) and the American crocodile. For a description of these critical habitat geographic designations and a complete species description, taxonomy, distribution, habitat requirements, management objectives and recovery status, see the USFWS Web site available from: http://www.fws.gov. A complete listing of all the federally listed threatened and endangered plant and animal species occurring or thought to occur within the study area is also available from this Web site. The FWC provides information about state-listed species (**Table 1**).


Wood Storks

Appropriate hydrology is not just an issue for the plant communities, but also for the associated wildlife, including endangered and threatened species and species of special concern. Species composition, distribution and abundance are influenced by the annual pattern of rainfall, water level fluctuations, fire, occasional hurricanes, frosts and freezes.

Alterations in water depth and/or hydroperiod resulting 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. A reduction in the size of a wetland reduces food production at the bottom of the food chain. Alterations in the seasonal wet and dry patterns can also cause impacts. "The life cycle of many species is 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 1982.)

Flooding of wetlands during the summer months initiates the production of aquatic plants, such as attached algae (periphyton) and macrophyte communities. Small fish and invertebrates consume these plants. 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 on the natural seasonal fluctuations in hydroperiod of these marsh systems and the concentration of food resources. Biological factors, such as predation, competition and feeding habits, also play important roles in configuring wildlife communities.

Table 1. Threatened and Endangered Plant and Animal Species Found in the SFWMD.

Scientific Name	Common Name	USFWS[a]	FWC[a]
Mammals			
Trichechus manatus	West Indian Manatee	E[b]	E[b]
Felis concolor coryi	Florida panther	E	E
Mustela vison evergladensis	Everglades mink		T
Birds			
Rostrhamus Sociabilis plumbeus	snail kite	E[b]	E
Mycteria americana	wood stork	E	E
Ammodramus maritimus mirabilis	Cape Sable seaside sparrow	E[b]	E
Ammodramus savannarum floridanus	Florida grasshopper sparrow	E	E
Picoides borealis	red-cockaded woodpecker	E	T
Haliaeetus leucocephalus	bald eagle	T	T
Polyborus plancus (borealis)	Audubon's crested caracara	T	T
Aphelocoma coerulescens	Florida scrub jay	T	T
Grus canadensis pratensis	Florida sandhill crane		T
Ajaia ajaia	roseate spoonbill		SSC
Aramus guarauna	limpkin		SSC
Egretta caerula	little blue heron		SSC
Egretta thula	snowy egret		SSC
Egretta tricolor	tricolored heron		SSC
Eudocimus albus	white ibis		SSC
Falco peregrinus tundrius	Arctic peregrine falcon		SSC
Speotyto cunicularia	burrowing owl		SSC
Reptiles and Amphibians			
Crocodylus acutus	American crocodile	E[b]	E
Drymarchon corais couperi	Eastern indigo snake	T	T
Gopherus polyphemus	gopher tortoise		SSC
Pituophis melanoleucus mugitus	Florida pine snake		SSC
Tantilla oolitica	Miami black-headed snake; rimrock crowned snake		SSC
Rana capito	gopher frog		SSC
Invertebrates			
Liguus fasciatus	Florida tree snail		SSC
Heraclides aristodemus ponceanus	Shaus swallowtail butterfly		E
Plants			
Cucurbita okeechobeensis	Okeechobee gourd	E	
Amorpha crenulata	crenulate lead plant	E	
Chamaesyce deltoidea	deltoid spurge	E	
Galactia smallii	Small's milkpea	E	
Polygala smallii	tiny polygala	E	
Chamaesyce garberi	Garber's spurge	T	

[a] E=Endangered; T=Threatened; SSC=Species of special concern
[b] Designated critical habitat

PROTECTION OF NATURAL SYSTEMS

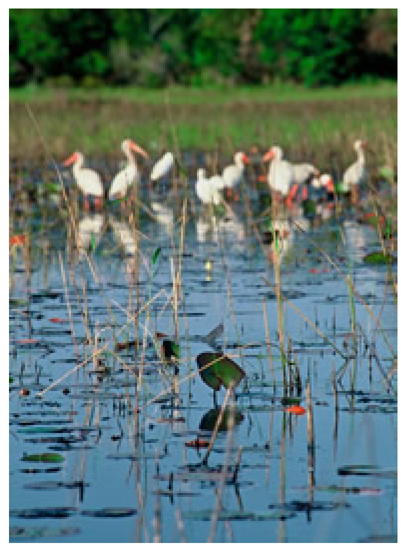
Wetlands

Wetlands are transitional lands between uplands and aquatic systems (water bodies) and are typically defined by vegetation, soils and hydrology. Chapter 62-340, Florida Administrative Code (F.A.C.), provides the statewide methodology for delineating wetlands in Florida. Rule 62-340.200(19), F.A.C., provides the following definition:

> Wetlands means those areas that are inundated or saturated by surface water or groundwater 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.

Functions and Values of Wetlands

Wetlands within the SFWMD planning regions include swamps, marshes, bayheads, cypress domes and strands, sloughs, wet prairies, riparian wetland hardwoods, and mangrove swamps. Wetlands perform a number of valuable hydrologic and biological functions. Hydrologic functions performed by wetlands include receiving and storing surface water runoff. This is important in controlling flooding, erosion and sedimentation. Surface water entering 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.



Wading Birds – Wetlands

Wetlands also function hydrologically as groundwater recharge-discharge areas. Wetlands may recharge the groundwater when the water level of a wetland is higher than the water table. Conversely, groundwater 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 semiaquatic and terrestrial organisms use wetlands during some part of their life cycle. Their dependence on wetlands may be for overwintering, residence, feeding and reproduction, nursery areas, den sites, or corridors for movement. Wetlands are an important link in the aquatic food web, and 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 planning regions are grouped into three major categories based on hydroperiod: permanently flooded or irregularly exposed; seasonally or semipermanently flooded; and, temporarily flooded or saturated. The Florida Land Use and Cover Classification System (FLUCCS) was used to delineate wetland systems within the regional planning areas (FDOT 1995). The hydroperiod categories were created by combining FLUCCS coverage classifications with the National Wetlands Inventory (NWI) hydrologic classifications. The NWI, a service of the U.S. Fish and Wildlife Service, is a nationwide wetland mapping system. 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. The category 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. The category corresponds to swamps, sloughs, mixed wetland hardwoods, cypress, wetland forested mixed, freshwater marshes, sawgrass and/or cattail, wet prairies, and 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. The category corresponds to cypress-pine-cabbage palm, wet prairie-with pine, intermittent ponds, pine-mesic oak, Brazilian pepper, melaleuca and wax myrtle-willow.

Inland wetlands within the District can be grouped into three major categories: forested, scrub shrub and herbaceous wetlands. These classes were generalized from the NWI.

Freshwater-forested wetland communities include cypress, cabbage palm, mixed hardwood and bayheads. Scrub shrub wetland communities can be found in a number of different habitat and hydroperiod ranges. Shrubs, such as wax myrtle and St. Johns wort, which are indicative of temporarily flooded soil, often border the wetter herbaceous marshes and prairie ponds. In the wetter areas, willow and small bay are the dominant shrub species. Herbaceous (emergent) wetlands can generally be referred to as marsh. There are also sloughs, wet prairies and prairie ponds.

Uplands

Native uplands are nonwetland areas with intact ground cover, understory and canopy. Native uplands include longleaf and slash pine forests, live oak hammocks, sand pine scrub, cabbage palm, turkey oak, hardwood forest, palmetto prairies, xeric oak and hardwood hammocks, and dry prairie grasslands. 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 the systems survive independently of each other. In reality, wetland and upland systems are interdependent. To preserve the structure and functions of wetlands, the linkage between uplands and wetlands must be maintained.

Function and Values of Uplands

Uplands serve as recharge areas, absorbing rainfall into soils to be used by plants or stored underground within the aquifer. Groundwater 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. Uplands often have groundwater storage available in the Surficial Aquifer System (SAS). Rainfall infiltrates the surface soils and becomes partly used by plants through evapotranspiration, and the remainder percolates to groundwater storage. Upland vegetative areas also provide climate moderation, noise barriers, wildlife habitat and recreational resources.

Pine flatwoods are an important upland community throughout the region. These plant associations are characterized by a low, flat topography and poorly drained, acidic, sandy soils. Under natural conditions, fire maintains flatwoods as a stable plant association. However, when the natural

Wet Prairie Pine Flatwoods

frequency of fire is altered by increased drainage and the construction of roads and other fire barriers, flatwoods can succeed to other community types. The nature of this succession depends on soil characteristics, hydrology, available seed sources or other local conditions. 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 a greater variety of vertebrate species than either sand pine scrub or dry grass prairies. Upland communities, particularly pine flatwoods, are seriously threatened by development in the UEC Planning Area.

The upland pine and hardwood hammock communities throughout south Florida have historically had little protection and have been the primary areas where development has occurred. Significant natural upland areas still exist in the Lake Wales Ridge, along the northwestern edge of the SFWMD boundary. Pinelands of the Atlantic Coastal Ridge were historically interspersed with wet prairies and cypress domes and bisected by "finger glades," watercourses that flowed from the Everglades to the coast. These remain only in small and isolated patches and protected from urban development.

Flatwood communities are divided into two types, dry and hydric. An open canopy of slash pine with an understory of saw palmetto characterizes dry flatwood communities. 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 in portions of Charlotte, Glades and Collier counties. Upland flatwoods are the native habitats most affected by the expansion of citrus into southwest Florida.

The longleaf pine-turkey oak hills ecological community only exists within the SFWMD in eastern Polk and northern Highlands counties. This sandhill ecosystem occurs on rolling land, where water moves rapidly through the soils. There are several variations of this community. In mature natural stands of trees, the overstory consists of longleaf pine trees. In areas where pines have been removed, turkey oaks and/or sand live oak trees grow. Ground cover is scattered with numerous bare areas. This community is influenced by fire, heat and drought. The natural vegetation is adapted to withstand the effects of occasional fire. Without the occurrence of fire, the longleaf pine cannot withstand the invasion of hardwood species and would change into an upland hardwood hammock. In this habitat, water moves rapidly through the soil to the aquifer with little runoff and minimal evapotranspiration.

The Kissimmee Prairie Ecosystem, located in Okeechobee County, east of the Kissimmee River (C-38), is a dry prairie ecosystem. Characterized by flat terrain, sandy soil and grasslands, the dry prairie becomes desert-like during the spring dry season. In central Florida, the dry prairie ecosystem includes the 46,000-acre Kissimmee Prairie Preserve State Park and the 7,315-acre National Audubon

Ordway-Whittell Kissimmee Prairie Sanctuary, constituting one of the largest remaining blocks of dry prairie in Florida. Preserved through the efforts of the Kissimmee Prairie Ecosystem Restoration Project, the ecosystem provides breeding habitat for numerous wildlife species.

Xeric sand pine scrub communities are most commonly found along sand ridges and ancient dunes, and were formed when the sea level was higher than it is today. These well-drained sandy soils are important areas of aquifer recharge for coastal communities. Although not as diverse as pine flatwood communities, xeric sand pine scrub communities contain more endangered and threatened plants and animals than any other south Florida habitat. It is the most endangered ecological community in the LWC Planning Area, and is seriously threatened in the UEC Planning Area. Xeric pine scrub communities are rapidly being eliminated by conversion to other land uses. The southernmost of these communities was once found in Marco Island in the LWC Planning Area, but has since been lost to development. The area of concern in the UEC Planning Area comprises a 1- to 3-mile-wide ancient dune along the eastern edge of the coastal ridge in Martin and St. Lucie counties.

Tropical hammocks are multilayered, dense forests with both tropical and temperate vegetation, found only in the southern counties. The canopy of hardwoods and palms is entangled with clinging vines, ferns and epiphytes. This diverse, woody upland plant community occurs in elevated areas, often on Indian shell mounds along the coast, or on marl or limestone outcroppings inland. Tropical hammocks are among the most endangered ecological communities in south Florida, having rapidly declined due to conversion to other land uses.

Estuaries

An estuary is defined as a partially enclosed body of water formed where fresh water from rivers and streams flows into the ocean, mixing with the salty seawater. Estuaries and the lands surrounding them are places of transition from land to sea, and from fresh to salt water. Although influenced by the tides, estuaries are protected from the full force of ocean waves, winds and storms by the reefs, barrier islands, or fingers of land, mud or sand that define an estuary's seaward boundary.

Functions and Values of Estuaries

Estuaries are important as nursery grounds for many recreationally and commercially important species, such as spiny lobster, penaeid shrimp, blue crab, oyster, spotted sea trout and stone crab. Estuaries serve as important habitat for a number of state and federally listed species, provide flood protection and shoreline protection during major storms, and act as natural filters for water quality improvement.

Many freshwater wetland systems within the District provide base flows to extensive estuarine systems. Classic examples are Shark River Slough and the Taylor Slough/C-111 basins (Everglades National Park), which provide significant freshwater base flows to Whitewater Bay, the Ten Thousand Islands area and Florida Bay. 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. Maintaining these base flows is crucial to the breeding of many fish species that are key to extensive commercial and recreational fishing industries. Due to the sensitive nature of these systems, estuaries are highly vulnerable to human development and drainage activities, and present some unique sustainability challenges to protect these systems against habitat loss and alteration.

Coastal estuaries associated with south Florida watersheds include the southern reaches of the Indian River Lagoon, the St. Lucie River and Estuary, the Loxahatchee River and Estuary, Lake Worth Lagoon, Biscayne Bay, Florida Bay and the Florida Keys, the Caloosahatchee River and Estuary, and Estero Bay. Ecosystem restoration is discussed later in this chapter.

One of the District's water management goals is to manage freshwater discharges to south Florida's estuaries in a way that preserves, protects and, where possible, restores essential estuarine resources. The District seeks to ensure that estuaries receive not only the right amount of water at the right time, but also clean, quality water.

Ecosystem Protection Programs

Key elements of the District's ecosystem protection programs include such activities as the establishment and implementation of minimum flows and levels (MFLs) for priority water bodies (major lakes, rivers, estuaries and wetland systems located within the SFWMD); wetlands protection; regulation polices; and, the District's Land Acquisition Program.

Minimum Flows and Levels

The overall purpose of Chapter 373, F.S., is to ensure the sustainability of water resources of the state (Section 373.016, F.S.). To carry out this responsibility, Chapter 373, F.S., provides the District with several tools, with varying levels of resource protection standards. The Minimum Flow and Level (MFL) Program plays a role in this framework.

The purpose of establishing 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), F.S., 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 groundwater 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 was further directed to use the best available information in establishing a minimum flow or a minimum level.

The scope and context of minimum flow and level protection rest 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.

Under Chapter 373, F.S., surface water management and consumptive use permitting (CUP) regulatory programs must prevent harm to the water resource. 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 the reservation of water for fish and wildlife or health and safety. By contrast, MFLs are set at the point at which significant harm to the water resources or ecology would occur. The levels of harm—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.


Ospreys – Loxahatchee River

Minimum flows and levels were developed in 2000 for the Caloosahatchee River and in 2001 for the Lower West Coast aquifers; the Everglades (Holey Land and Rotenberger wildlife management areas, Water Conservation Areas 1, 2 and 3, and Everglades National Park); Lake Okeechobee and the northern portion of the Biscayne Aquifer; and, the St. Lucie River and Estuary. In 2003, MFLs were developed for the Northwest Fork of the Loxahatchee River. In 2005, MFLs were developed for Lake Istokpoga, and in 2006, MFLs were developed for Florida Bay. The District's MFL Priority List identifies the water bodies scheduled to have MFLs developed during the next five years.

Water Reservations

Water reservations are rules that set aside quantities of water in specified locations and seasons of the year for protection of fish and wildlife, or public health and safety. District staff recommends that the Governing Board initiate rule development for initial reservations of water for the Everglades system within the District, pursuant to Section 373.223(4), Florida Statutes (F.S.). By adopting a reservation rule, the reserved water cannot be allocated under consumptive use permits issued by the District and is protected under the District's water shortage plan. When establishing a reservation, an existing legal use is protected so long as such use is not contrary to the public interest.

Initial reservations of water, the subject of this rule development, set aside the water available under current conditions for protection of fish and wildlife. Current conditions include existing operation of the Central and Southern Florida Flood Control Project (C&SF Project) and existing consumptive use and land use. Initial reservations are distinct from project reservations, which will be adopted in the future to protect additional water made available by each CERP project for protection of fish and wildlife, or public health or safety.

The District is developing initial reservations for the protection of fish and wildlife in key areas of the SFWMD. Adoption of initial reservations for the Everglades system is the first major regulatory component to prevent existing water for the protection of fish and wildlife from being allocated in consumptive use permits. The base level of protection for natural system water supplies provided by the initial reservations will be complemented by CERP projects and associated project reservations, which will make additional water available to restore the Everglades.

Wetland Protection Policies

The District protects and enhances natural resources through its restoration activities and integration of planning, regulatory and land acquisition programs. Regulatory programs include rules to protect, enhance, mitigate and monitor wetlands and water resources, and also develop and enforce rules that address water quantity and quality.

The District prevents adverse impacts to wetlands from groundwater withdrawals by implementing numerous state laws 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 wetlands are protected. The obligation to leave adequate water in natural areas to maintain system functions and protect fish and wildlife is essential to water supply planning in the regional planning areas.

The State Comprehensive Plan states in Section 187.201(7), F.S.:

> *Goal.*-- 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.
>
> *Policies.*-- Reserve from use that water necessary to support essential nonwithdrawal demands, including navigation, recreation, and the protection of fish and wildlife.

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

Wetland Protection and Consumptive Use

District rules protect wetlands from harm caused by consumptive water use, meaning any use of water that reduces the supply from which it is withdrawn or diverted. Each consumptive use permit application is reviewed for the potential influence on wetlands. Wetlands are identified that will be affected by a proposed water use where the wetland occurs near a producing well. Groundwater models are used to define the cone of influence and determine the potential drawdown, or to lower water levels around a well, within any particular wetland. The evaluation of potential harm to wetlands includes an analysis of the applicant's proposed withdrawal, as well as a cumulative analysis of the proposed withdrawal combined with all other permitted uses and pending applications within the cone of depression of the applicant's proposed use. The cone of depression is the depression of the water table due to pumping from a well within its area of influence.

While the District has had narrative criteria for wetland protection since the late 1980s, new rules adopted in September 2003 provide a numerical drawdown standard for wetlands where appropriate. A narrative standard was adopted for wetlands and other surface waters with differing needs and constraints. The updated rules were developed after several years of research, wetland monitoring, data analysis and groundwater modeling of drawdowns near wetlands.

Proposed uses of water that could cause harm to wetlands must be modified to eliminate and/or reduce the harm to the extent feasible. Modifications include developing alternative water supply sources, modifying pumpage, relocating withdrawal facilities, implementing water conservation measures and creating hydrologic barriers.

In cases where the proposed harm to wetlands cannot be eliminated or reduced to a permittable level, an applicant can propose mitigation to offset harm to the wetland.

Environmental Resource Permitting

The *Florida Environmental Reorganization Act of 1993* consolidated dredge and fill permitting and surface water management permitting activities into one program implemented through Chapter 373, F.S. The Environmental Resource Permit (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: agricultural, commercial and residential. Developed sites, containing more impervious surfaces or altered topography, must provide a way to direct storm water to water management areas for water quality treatment and flood attenuation.

During the ERP application review 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. If the proposed wetland impacts are determined to be allowable, an applicant will need to provide compensation for the loss of the wetland functions. Generally, this is accomplished through mitigation. Mitigation consists of the restoration or enhancement of existing wetlands, the creation of new wetland habitat, or a combination of these methods. 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 ensure an upland buffer exists, adequate amounts of water will be available, wetlands will not be inundated for prolonged periods, and a conservation easement is provided to ensure long-term protection.

Florida Department of Environmental Protection – Dredge and Fill Delegation

Changes in the regulatory program were implemented under the terms of an operating agreement, approved in 1992, between the SFWMD and FDEP. In November 1992, the SFWMD began reviewing certain dredge and fill activities proposed in FDEP jurisdictional wetlands. The operating agreement specified the type of projects in which the SFWMD could authorize dredging or filling activities in FDEP jurisdictional wetlands. The delegation agreement was the first step toward achieving a one-stop permitting program in Florida.

Environmental Compliance Program

In 1989, the District completed an internal study assessing the ability of its regulatory program to manage and protect wetland resources. An independent company analyzed the program. As a result of those studies, a major initiative to develop a post-permit compliance program was undertaken in 1990, and the District has supported a wetland mitigation compliance work unit since 1992. This group reviews submitted monitoring reports and verifies success criteria on-site. Mitigation sites are monitored for five years; thereafter, site inspections are completed annually.

Land Resources Programs

Florida Forever Program

Camping – Florida Forever Land

Approved in 1998, the *Florida Forever Act* (Section 259.105, F.S.) authorizes the state to sell bonds to support and protect environmentally sensitive land and water resources. Florida Forever uses a strategic, science-based planning and management process to acquire and manage land and water areas, ensuring biodiversity by establishing natural corridors and protecting ecological connections. Florida Forever also provides a means to protect and restore natural systems and associated water resources.

All lands acquired with Florida Forever funding are to be used for "multiple-use" purposes, including outdoor recreational activities, water resource development projects and sustainable forestry management. Water resource or water supply projects may be allowed only if the following specified conditions are met: minimum flows and levels (MFLs) have been established for those waters that may incur significant harm to water resources; the project complies with permitting requirements; and, the project is consistent with the regional water supply plan.

In 2006, the State of Florida took ownership of nearly 74,000 acres of the historic and environmentally sensitive Babcock Ranch, located in Charlotte and Lee counties. This purchase brings to near completion the largest natural land corridor in Florida, from Lake Okeechobee to the Gulf of Mexico, preserving important habitat for some of Florida's most endangered species, while protecting a valuable water-recharge area for southwest Florida.

Save Our Rivers

The Save Our Rivers (SOR) Program began in 1981 with the legislative enactment of the Water Management Lands Trust Fund, Chapter 373.59, F.S. This legislation enabled the five water management districts to buy lands needed for water management, water supply, and the conservation and protection of water resources, and to make them available for appropriate public use.

Acquisition of lands for SOR projects is accomplished in concert with other District initiatives under the Florida Forever Work Plan. The District currently accomplishes the acquisition of SOR lands primarily using mitigation and Florida Forever funds. Although the majority of Florida Forever expenditures are used to purchase lands for water resource projects, such as reservoirs and stormwater treatment areas, the purchase and management of several SOR lands are funded through Florida Forever.

Land Stewardship Program

The Land Stewardship Program is responsible for the planning and management of SOR lands, as well as the implementation and administration of mitigation banks and regional off-site mitigation areas. A major thrust of the Land Stewardship Program is to protect and restore the flowways, watersheds and wetlands, all of which are critical to the water resources of the SFWMD. The major goals of the program are to restore the hundreds of thousands of acres of SOR lands to their natural state and condition; manage the land in an environmentally acceptable manner; and, provide public recreational opportunities compatible with natural resources protection. Program objectives include:

- Complete/update management plans for all SOR projects.
- Restore native communities.
- Implement and administer mitigation banking projects.
- Control invasive exotics.
- Restore natural fire regime (prescribed burning).
- Public use and education of SOR lands.

The program is implemented by SFWMD staff located in five service centers and at headquarters in West Palm Beach.

Horseback Riding - DuPuis

Public Use and Environmental Education on SOR Lands

The District encourages use of its lands for appropriate outdoor recreational activities. All SOR lands are available for public use, except in rare instances where there is no legal public access or where lease restrictions prohibit public access. The vast majority of SOR lands are managed as semi-wilderness areas, with very limited vehicular access other than off-road parking. Opportunities include hiking, primitive camping, canoeing, fishing and horseback riding, with volunteers from various user groups maintaining the trails and wilderness campsites. Cooperative agreements with the FWC allow high quality, low impact hunting on much of the land. Acquisition and management partners from several counties have constructed environmental education centers, boardwalks and interpretive trails, all at no cost to the District, that are used annually by thousands of school children and adults.

Wetland Mitigation Banking

Under Chapter 373, F.S., the District is authorized to participate in and encourage the development of private and public mitigation banks and regional off-site mitigation areas. Furthermore, the state's mitigation banking rule, Chapter 62-342, F.A.C., encouraged each water management district to establish two mitigation banks. The use of mitigation and mitigation banking offers opportunities to supplement funding of the District's land acquisition, restoration and management programs. The District's mitigation bank sites include the Loxahatchee Mitigation Bank in Palm Beach County and the Corkscrew Regional Mitigation Bank in Lee County. The District is developing each bank in a public-private contractual agreement. Private bankers obtain permits, restore the land, reimburse the District for its land acquisition and staff costs, and then generate a revenue stream for future projects.

As of late 2006, the Loxahatchee Mitigation Bank was completing its fourth year of monitoring toward attainment of the success criteria, and in May 2006, the third revenue disbursement, amounting to $410,000, was provided by the private mitigation banker, TetraTech EC, Inc., to the SFWMD. This will be used to offset previous land acquisition and associated project costs. During 2006, at the Corkscrew Regional Mitigation Bank, restoration of the pasture grass continued, along with exotic treatment and prescribed burn of the upland areas. The District also manages three regional mitigation sites, including Pennsuco in Miami-Dade County, Corkscrew Regional Ecosystem Watershed (CREW) in Lee and Collier counties, and Shingle Creek in Orange and Osceola counties, expending funds that provide for the acquisition, restoration and management of lands within these areas.

Cooperative Management Agreements

In addition to agreements with the FWC, the District has entered into cooperative agreements with other state agencies, local governments and the private sector for assistance in the management of certain SOR lands. In most cases, the SFWMD has a Memorandum of Agreement (MOA) and an annual work plan that detail services and compensation. The cooperators provide many services for which the SFWMD does not pay, including managerial, planning and administrative support from the organization's headquarters staff and specialized services, such as law enforcement and management of public hunting.

Modeling and Scientific Support

District programs depend on scientific support and computer modeling for all aspects of water management. The District provides modeling support to evaluate both regional and subregional water management plans and projects through the development of standard models and related tools, and application of regional scale models. The District's Strategic Plan calls for the development and implementation of and migration to the next-generation Regional Simulation Model (RSM), replacing current regional models. The RSM accommodates the extreme hydrologic complexities of south Florida, by incorporating new technology and data, providing a modular and easily modified model. The RSM Model also provides flexibility in scenario investigation using the hydrologic simulation engine and the management simulation engine. In addition, the Capability Maturity Model (CMM), a development standard, is being applied to all model development and implementation, modeling oversight, peer review, scope review and model library, and dataset creation.

An extensive program of environmental monitoring spans the entire District. Monitoring sites extend from Kissimmee Chain of Lakes, through the Kissimmee River to Lake Okeechobee. From coast to coast, the network spans the peninsula from Fort Myers to Fort Pierce and south through the Everglades to Florida Bay. The network supports many water quality, quantity, meteorological, hydrologic and hydrogeologic monitoring programs designed to collect, process, manage and disseminate. These data are used for permitting, water management, water supply planning, environmental protection, ecosystem restoration, flood control, legal requirements and other information.

The District designs, installs, maintains and constantly improves its infrastructure to record environmental and operational data and support the monitoring network. Intensive quality assurance and control provide oversight, as well as laboratory data validation, to ensure compliance with state-set acceptable levels for data quality, and provide legally defensible environmental and operational data. The majority of data are archived in the corporate environmental database

(DBHYDRO) after being processed through the Laboratory Information Management System (LIMS) operated by the District's analytical laboratory.

The District uses the archived data to prepare reports mandated by state and federal agency permits and agreements, and to analyze the present data that describe hydrologic and water quality conditions within the District for decision-making purposes. The monitoring programs also report on the status of efforts to meet Florida water quality standards throughout the District.

ENVIRONMENTAL WATER NEEDS

Water Needs of Coastal Resources

Natural systems on coastal ridges and barrier islands depend primarily on groundwater levels and rainfall as their primary sources of fresh water. Therefore, these communities can be affected by lowering of the groundwater table due to withdrawals for landscape irrigation and consumptive use.

Maintaining appropriate freshwater inflows is essential for a healthy estuarine system. Flow regimes are typically defined in terms of total mean monthly inflows and a suitable range of acceptable minimum and maximum flow rates. 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 due to flood control activities can significantly reduce salinities and introduce stormwater contaminants. In addition to the immediate impacts associated with dramatic changes in freshwater inflows, long-term cumulative changes in water quality constituents or water clarity may also adversely affect the estuarine community.

Estuarine flora and fauna are well adapted to natural seasonal changes in salinity. The temporary storage and concurrent decrease in velocity of floodwaters within upstream wetlands aid in controlling the timing, duration and quantity of freshwater flows into the estuary. Upstream wetlands and their associated groundwater 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 downstream to the brackish water zone. These materials are an important link in the estuarine food chain.

The estuarine environment is sensitive to freshwater releases. Disruption of the volume, distribution, circulation and 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. Other aspects of water quality, such as turbidity, dissolved oxygen content, nutrient loads and toxins, also affect functions of these areas.

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. 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

Wetland Drawdown Study

Maintaining appropriate wetland hydrology (water levels and hydroperiod) is the single most critical factor in maintaining a viable wetland ecosystem. Rainfall, along with associated groundwater and surface water inflows, is the primary source of water for the majority of wetlands in the regional planning areas. 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, and are influenced by and reflect regional processes and impacts, as well as local ones.

James Gosselink stated 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 groundwater drawdowns affect wetlands. An adverse environmental impact can be defined as: 1) a change in surface or shallow groundwater 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 groundwater tables in areas adjacent to wetland communities appear to have decreased wetland surface water depths and shortened 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 the drawdown occurs). Shallow, low gradient wetlands may be 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 may: 1) induce a shift in community structure toward species characteristic of drier conditions; 2) reduce rates of primary and secondary aquatic production; 3) increase the destructiveness of fire; 4) cause the subsidence of organic soils; and, 5) allow for exotic plant invasion.

Some wetland types contain water depths of 3 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 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 groundwater withdrawals in adjacent upland areas. These withdrawals effectively lower underlying water tables and "drain" wetlands. Drainage facilities, such as canals and retention reservoirs constructed near wetlands, have a history of draining and reducing hydroperiods of south Florida wetlands. A major concern of reduced water depths and hydroperiod within wetlands is the invasion of exotic plants, such as melaleuca and Brazilian pepper. The Comprehensive Everglades Restoration Plan (CERP) Melaleuca Eradication and Other Exotic Plants Project is a plan to enhance efforts to control invasive exotic plant species in south Florida.

Determining appropriate water level or hydroperiod conditions for a wetland often requires a data collection effort spanning a sufficient period of record. The SFWMD completed a Wetland Drawdown Study, which gathered data sufficient to calibrate integrated surface and groundwater models capable of simulating wetland hydroperiod. The models were used to predict the effect of groundwater stresses on wetland hydroperiod, and aid in the evaluation of criteria for wetland protection. A rule implementing the findings of the study became effective in 2003. The rule establishes the criteria for the protection of wetlands from harm caused by consumptive use withdrawals of water.

Upland Water Needs

Seasonal variations play an important role in determining the type of upland vegetation that will develop. It is generally thought that plant communities located in uplands are better able to adapt to dry season hydroperiod fluctuation in comparison to plants in wetlands. The water supply needs of upland plant communities are not well known. It is assumed that the upper 6 feet to 10 feet of the Surficial Aquifer is used by forest and herbaceous plant vegetation. 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. Fire frequency, soil moisture and hydrology play important roles in maintaining plant community structure and function. These three factors are considered important to determine the direction of plant community succession. Fire most strongly influences the structure and composition of upland plant communities.

Fire, under natural conditions, maintains flatwoods as a stable and essentially non-successional plant association. However, when the natural frequency of fire is altered by drainage improvements and 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 and other local conditions. The hydrology of upland plant communities varies with elevation and topography. Seasonal variations, as well as local withdrawals from groundwater influence the type of upland vegetation that will develop.

Water Needs of Native Vegetation

Historically, a combination of factors creates a unique and species-rich flora and vegetation mosaic: the location of south Florida between temperate and subtropical latitudes; the state's proximity to the West Indies; and, the expansive wetland system of the greater Everglades with low levels of nutrient inputs. Today, most of south Florida's native vegetation has been altered substantially by drainage and development directly or indirectly from a century of water management, resulting in hydrologic changes, nutrient inputs and the spread of exotics (USACE 1999).

Riparian plant communities of the Kissimmee River and its floodplain are recovering from channelization and drainage. The macrophyte communities of the diminished littoral zone of Lake Okeechobee are now contained within the Hoover Dike. They remain essential for the ecological health of the lake, but are stressed by extreme high and low lake levels and by the spread of exotics.

Below Lake Okeechobee, all of the pond apple swamp forest and most of the sawgrass plain of the northern Everglades have been converted to the Everglades Agricultural Area (EAA). In addition, the band of cypress forest along the eastern fringe of the Everglades was largely converted into agricultural land after the eastern levee of the Water Conservation Areas (WCAs) cut off this community from the remaining Everglades. The mosaic of macrophytes and tree islands within the WCAs and Everglades National Park is altered by changes in hydrology, exotic plant invasion and nutrient inputs.

The problems of the Everglades extend to the mangrove estuary and coastal basins of Florida Bay, where the forest mosaics and submerged aquatic vegetation show the effects of diminished freshwater heads and flows upstream are exacerbated by a rise in sea level. The upland pine and hardwood hammock communities of the Atlantic Coastal Ridge were historically interspersed with wet prairies and cypress domes and dissected by "finger glades," watercourses that flowed from the Everglades to the coast. These remain only in small and isolated patches, which are protected from urban development.

More detailed documentation of existing vegetation focuses on wetland systems that have been seriously degraded and that will receive the most benefits from the implementation of the components recommended in the *Central and Southern Florida Project Comprehensive Review Study Final Feasibility Report and Programmatic Environmental Impact Statement* (known as the Restudy) (USACE and SFWMD 1999). These systems include the Everglades peatland; the Everglades marl prairie and rocky glades; and, the mangrove estuaries and coastal basins of Florida Bay. Other natural systems in south Florida already have restoration plans and have had lesser impacts from man. These systems include the Kissimmee River, where restoration is already in progress; Lake Okeechobee, for which a revised regulation schedule is planned to protect littoral, macrophyte communities; and, the Big Cypress National Preserve, where vegetation impacts and fixes are relatively minor compared to the Everglades. The Atlantic Coastal Ridge pinelands and hardwood hammocks, as well as the hammock and dune communities along the beaches, are unique subtropical ecosystems that have very little protection and are rapidly disappearing.

Water Needs of Fish and Wildlife

The life cycles, community structures and population densities of the fauna of south Florida are intricately linked to regional hydrology. The status of fish and wildlife has been strongly influenced by the cumulative effects of drainage activities early this century, the Central and Southern Florida (C&SF) Project, and ensuing urban and agricultural development. The major emphasis in this section is on those faunal groups that appear to have declined due to hydrologic changes caused by the C&SF Project. The major linkages between hydrologic alterations and fauna emphasized in this section include the decline of aquatic food webs and populations; higher level consumers that depend on them; shifts in habitats to those less favorable to faunal

Great Egret

communities; and, the reduction in the spatial extent of the Everglades wetland system.

A critical link in the aquatic food webs, and one that appears to have been impacted by hydrologic alterations, is the intermediate trophic level of the small aquatic fauna. The small marsh fishes, macro-invertebrates, amphibians and reptiles, which form the link between the algal and detritus food web bases of the Everglades and the larger fishes, alligators and wading birds that feed upon them, are diminished due to loss of habitat and changes in hydrology.

Included in the freshwater aquatic community of south Florida are the larger sport species, such as the largemouth bass (*Micropterus salmoides*), sunfishes and black crappie (*Lepomis nigromaculatus*). Lake Okeechobee is renowned for the trophy bass from its littoral zone and for an abundant black crappie fishery. Largemouth bass also naturally inhabit the deepwater sloughs and wet prairies of the Everglades.

The American alligator (*Alligator mississippiensis*) is a keystone species in the Everglades. Holes created by alligators form ponds in which aquatic fauna survive droughts. Mounds of sediment excavated from the holes create higher-elevation habitat for willow and other swamp forest trees. In addition to modifying topography, the American alligator is the top predator in the Everglades and feeds on every level of the food chain, from small fishes to wading birds, at various stages in its life.

The most conspicuous indicators of ecosystem health in the Everglades are the plummeting populations of wading birds. At present, nesting birds have declined to only 10 percent of their historical number and they continue to decline. The food bases for these species are mostly contained in the freshwater marsh fish assemblage of the Everglades and the low salinity mangrove fish assemblage of the estuarine transition zone.

Tree Islands in WCA-1

Due to diminished freshwater heads and flows upstream, habitats for the American crocodile (*Crocodylus acutus*) and migratory waterfowl, and nursery grounds of estuarine and marine sport fishes and pink shrimp (*Penaeus duorarum*), were also degraded.

In contrast, the deer population has benefited from lower water levels. More white-tailed deer (*Odocoileus virginianus*) presently live in the Everglades than during pre-drainage conditions. However, during high water periods, large-scale mortality can occur when the deer are stranded on overbrowsed tree islands.

REGIONAL RESTORATION EFFORTS

History of the Central and Southern Florida Flood Control Project

After years of severe hurricanes, then drought and fires, then more deadly storms, Florida asked the federal government for a master plan to guard against hurricanes, floods, droughts and fires.

Dragline 1955

In 1948, the U.S. Congress authorized the largest civil works project in the country. In 1949, the Florida Legislature created the Central and Southern Florida Flood Control District, predecessor to today's South Florida Water Management District (SFWMD or District), to manage the huge project. Design and subsequent construction followed and continued for over 20 years as the U.S. Army Corps of Engineers (USACE) built a massive plumbing system called the Central and Southern Florida Flood Control Project (C&SF Project). The project was authorized to provide flood protection and water supply, prevent saltwater intrusion, preserve fish and wildlife, and make available recreation and navigation.

S-65 Lock Construction 1965

The C&SF Project stretches from just south of Orlando to Florida Bay. It consists of over 1,000 miles of canals, 700 miles of levees, hundreds of gate and water control structures, and dozens of pump stations. The system drains regional floodwaters during times of abundant rainfall, tropical storms and hurricanes. The network connects to hundreds of small local and community drainage districts to manage floodwaters. It moves water throughout the region for use by cities, farms and natural ecosystems; recharges drinking water supply wellfields; and, is essential to the region's development.

In the 1970s, as more habitats showed signs of distress, environmental restoration became increasingly important. In 1972, pursuant to the *Florida Water Resources Act* (Chapter 373, F.S.), the state created five water management districts with expanded responsibilities for regional water resource management and environmental protection. The boundaries for the state's five water management districts are based on watersheds and other natural, hydrologic and geographic features, rather than political boundaries. In 1976, voters approved a constitutional amendment giving the districts the authority to levy property taxes to help fund these activities.

Over the past half-century, the effects of population and agricultural growth on natural ecosystems have been significant in south Florida. The remaining Everglades are about half the size they were 100 years ago. Due to water management system limitations, discharges to the Everglades and estuaries are often too much or too little, and frequently occur at the wrong time of the year. As a result, the remaining south Florida ecosystem no longer exhibits the functions and species that defined the pre-drainage system. There have been significant wildlife impacts; large areas have become infested with invasive plants; and, harmful algae blooms have occurred in Lake Okeechobee, Florida Bay and other lakes and estuaries.


Aquatic Tractor 1952

Comprehensive Everglades Restoration Plan

In 1992, Congress authorized a Comprehensive Review Study (Restudy) of the C&SF Project. The purpose of the Restudy was to develop modifications to the C&SF Project to restore the Everglades and Florida Bay ecosystems, while providing for the other water-related needs of the region. A wide range of modification options and proposed alternatives to the C&SF Project were studied for feasibility to recommend the most appropriate environmental improvement options. A conceptual master plan was developed for ecosystem restoration in south Florida. In addition to environmental benefits, other aspects have been considered, such as urban and agricultural water supply needs.

The *Water Resources Development Act of 1996* required that a comprehensive plan be submitted to Congress by July 1, 1999. The resulting Comprehensive Everglades Restoration Plan (CERP) was designed to capture, store and redistribute fresh water previously lost to tide and to regulate the quality, quantity, timing and distribution of water flows.

The CERP's efforts, which affect 16 counties within an 18,000-square-mile area, include 68 components that will take more than 30 years to construct at an estimated cost of $8.4 billion. The major components of the CERP are:

- Surface Water Storage Reservoirs.
- Water Preserve Areas.
- Management of Lake Okeechobee as an Ecological Resource.
- Improved Water Deliveries to the Estuaries.
- Underground Water Storage.
- Treatment Wetlands.
- Improved Water Deliveries to the Everglades.
- Removal of Barriers to Sheet Flow.
- Storage of Water in Existing Quarries.
- Reuse of Wastewater.
- Pilot Projects.
- Improved Water Conservation.
- Additional Feasibility Studies.

Together, these components are expected to benefit the ecological functioning of more than 2.4 million acres of the south Florida ecosystem, while improving regional water quality conditions, deliveries to coastal estuaries, urban and agricultural water supply, and maintaining existing levels of flood protection.

Critical Restoration Projects

In 1966, prior to the CERP, seven projects were determined to be critical to the restoration of the south Florida ecosystem and were authorized for implementation. These comparatively small Critical Restoration projects are currently being implemented along with the CERP projects by the USACE and the SFWMD.

Acceler8 Projects

The CERP was designed as a 50-50 partnership between the state and federal governments. Since the *Water Resources Act of 2000*, authorization of projects for the federal partner, the USACE, has not occurred as anticipated. In 2004, the state chose to fund $1.5 billion for eight restoration projects, called Acceler8, through the SFWMD's issuance of "Certificates of Participation" bond revenue to expedite the funding, design and construction of 14 restoration components consistent with the CERP Master Implementation Sequencing Plan (MISP). Some of the benefits of Acceler8 are achieving restoration goals sooner, increasing storage capacities for additional flood control and water supply options, providing water flows and hydrology, and improving water quality.

Acceler8 includes the following restoration projects:

- C-44 (St. Lucie Canal) Reservoir/ Stormwater Treatment Area (STA). Ground was broken for the reservoir/STA test cell on March 24, 2006.
- C-43 (Caloosahatchee River) West Reservoir. Ground was broken for the reservoir test cell on Feb. 24, 2006.
- Everglades Agricultural Area (EAA) Reservoir - Phase 1 with Bolles and Cross canals improvements. Ground was broken for the reservoir test cell on Jan. 14, 2005, and Phase 1 construction began Aug. 2, 2006.
- Everglades Agricultural Area (EAA) Stormwater Treatment Areas (STAs) Expansion. Ground was broken for the expansion on Feb. 9, 2006.

Governor Bush – Restoring the Everglades is a Top Priority

- Water Preserve Areas (Fran Reich Preserve, C-9, C-11, Acme Basin B, WCA-3A/3B). Ground was broken on the Acme B Basin Project on June 20, 2006.
- Picayune Strand Restoration Project. *The Draft Basis of Design Report* was completed in July 2006.
- Biscayne Bay Coastal Wetlands - Phase 1. *The Draft Basis of Design Report* was completed in January 2006.
- C-111 Spreader Canal. *The Draft Basis of Design Report* was completed in May 2006.
- Lake Okeechobee Fast Track (LOFT). This group of facilities is designed to capture and treat stormwater runoff north of Lake Okeechobee to remove phosphorus before it enters the lake. Preliminary design began in January 2007.

Restoration Coordination and Verification

As implementation of the CERP moves forward, a program known as "REstoration, COordination and VERification" (RECOVER) ensures a systemwide focus throughout the ongoing planning and implementation of the plan. The RECOVER Program is designed to organize and supply scientific and technical support during the implementation of the plan. The RECOVER Program links science and the tools of science to a set of systemwide planning, evaluation and assessment tasks. These links provide RECOVER with the scientific basis for meeting overall program objectives, which are to evaluate and assess plan performance; refine and improve the operational criteria of the plan; measure and interpret actual responses of human and natural systems as projects are implemented; and, maintain a systemwide perspective throughout the restoration program.

The RECOVER Program accomplishes its activities through partnerships with interagency and interdisciplinary teams of federal, state and local agencies and tribal governments. The program offers stakeholders the opportunity to participate in the assessment and refinement of the CERP and in the review of RECOVER work products. Additionally, RECOVER welcomes the public to attend meetings and provide comment.

The RECOVER Leadership Group comprises three technical teams that align with its mission areas. The Assessment Team is primarily responsible for measuring the actual performance of implemented projects and interpreting that performance based on the analysis of information obtained from research, monitoring, modeling or other relevant resources. The Evaluation Team is primarily responsible for forecasting the performance of plans and the designs relative to desired objectives by using predictive modeling and other tools. The Planning Team is primarily responsible for developing recommendations to improve plan performance and integrating RECOVER with the appropriate planning and operations planning activities of the USACE and the SFWMD.

Feasibility Studies

The time frame of the C&SF Project Restudy did not permit a thorough investigation of all the regional water resource problems of south Florida. Subsequent to the completion of the feasibility study, a number of new feasibility studies were proposed. The *Water Resources Development Act of 1996* authorizes the continuation of studies and analyses needed to further the CERP.

Some of these studies have investigated or will continue to investigate conceptual designs developed under the C&SF Project Restudy and make regional recommendations for meeting the future needs of agricultural, urban and environmental users.

Comprehensive Integrated Water Quality Feasibility Study

The Comprehensive Integrated Water Quality (CIWQ) Feasibility Study is a study cosponsored by the USACE and the Florida Department of Environmental Protection (FDEP). The study is the result of a recommendation of the Restudy, which recognized the need for a comprehensive water quality plan that would integrate the CERP projects and other federal, state and local government programs.

The study area for the project is the SFWMD boundary plus the study area for the Indian River Lagoon – North Feasibility Study (IRLN). The IRLN project is within the St. Johns River Water Management District (SJRWMD) boundary.

The CERP includes a number of construction features, such as stormwater treatment areas (STAs), specifically designed to improve water quality conditions for the purpose of south Florida ecosystem restoration. Furthermore, the CIWQ Plan includes other construction features, such as water storage reservoirs, that could be designed to maximize water quality benefits to downstream water bodies. Optimizing the design and operation of construction features of the recommended plan to achieve water quality restoration targets is essential for achieving overall ecosystem restoration goals for south Florida.

Degradation of water quality throughout the study area is extensive, particularly in urban and agricultural coastal areas. The FDEP listed approximately 160 use-impaired water bodies in south Florida in its 1998 Section 303(d) list. There are several ongoing water quality restoration programs in the study area, such as National Pollutant Discharge Elimination System (NPDES) point and nonpoint source regulatory programs; total maximum daily loads (TMDLs) development and remediation programs; and, Surface Water Improvement and Management (SWIM) planning efforts. Point sources include sewage and industrial wastes, while nonpoint sources include pollutants that enter water bodies in indirect ways.

The overall goal of the CIWQ Plan is to develop a comprehensive plan for linking these water quality improvement programs and water quality restoration targets with the ongoing CERP ecosystem restoration effort. It is also recognized that achieving all of the water quality goals for ecosystem restoration in all use-impaired water bodies within the study area will depend on actions outside the scope of the CERP.

The SFWMD, the FDEP, the U.S. Environmental Protection Agency (USEPA) and other agencies have developed or are developing water quality improvement programs for several of the impaired water bodies within the study area. The most notable example is the *Everglades Forever Act*, which focuses on achieving adequate water quality in the Everglades. Other examples include the SWIM planning efforts for the Indian River Lagoon, Lake Okeechobee, Biscayne Bay and the Florida Keys National Marine Sanctuary Water Quality Protection Program.

The FDEP has agreed to participate in the Project Management Plan (PMP) phase of the feasibility study as the local sponsor. The USACE and the FDEP will work together with other federal, state and local agencies to identify problems, opportunities and potential solutions for ecosystem restoration as they relate to water quality issues.

Water Preserve Areas Feasibility Study

Everglades National Park

Accomplished in conjunction with the CERP, the Water Preserve Areas (WPAs) Feasibility Study re-examined the portions of the C&SF Project specific to Lake Okeechobee, the Everglades Agricultural Area (EAA), Water Conservation Areas (WCAs), Everglades National Park, Big Cypress National Preserve and Native American tribal lands. The study determined the feasibility of structural or operational modifications needed to restore the Everglades and Florida Bay ecosystems, as well as other related needs as mentioned previously.

The WPAs are located within Palm Beach, Broward and Miami-Dade counties east of the WCAs and generally west of existing developed areas. Ecological restoration of the Everglades will require a significant increase in water quantity. The WPAs provide a critical source for this new water by: a) reducing undesirable losses from the natural system through seepage, and b) providing a means of backpumping stormwater runoff previously discharged to tide, providing a new source of water.

Furthermore, development continues to encroach on the remaining natural areas adjacent to the Everglades. These remaining wetland areas could serve a critical role in the restoration of the Everglades by increasing the overall spatial extent.

The WPA Feasibility Study investigated concepts to capture and store excess surface waters by backpumping water normally discharged to tide via the C&SF Project canal system from urban areas in the Lower East Coast (LEC) Planning Area. The reconnaissance and feasibility phase of the C&SF Restudy demonstrated that the WPA concept is an integral part of the CERP.

The study also focused on other water-related needs, such as urban and agricultural water supply, water quality, and flood control. The WPAs provide a mechanism for increased aquifer recharge and surface water storage capacity to enhance regional water supplies for the urban areas in the LEC Planning Area, reducing demands on an already degraded natural system.

From the study's findings, restoration plans were developed to address ecosystem and water-related needs. The Acceler8 WPA Project involves the construction of aboveground impoundments, a wetland buffer strip, pump stations, culverts, canals, water control structures and seepage control systems. Five project components will be located adjacent to the Everglades WCAs in Palm Beach, Broward and Miami-Dade counties. The Acceler8 WPA Project will reduce seepage of water from the WCAs into urban areas; reduce the amount of excess water discharged to tide; improve Everglades water quality; improve hydropatterns in the WCAs; improve flows to the Everglades National Park; enhance and increase the spatial extent of wetlands adjacent to the remaining Everglades; provide a buffer between natural and developed areas; and, provide supplemental water supply deliveries and aquifer recharge to urban areas—reducing demands on Lake Okeechobee and the WCAs.

The CERP Broward County Water Preserve Areas Project comprises the C-9 and C-11 impoundments and a WCA-3A/3B levee seepage management system. The seepage management system will focus on seepage reduction by allowing higher water levels in the L-33 and L-37 borrows. The impoundment areas will provide groundwater recharge and adequate water supply to urban areas. These areas will also prevent saltwater intrusion and aid in reducing seepage from the WCA seepage management area.

Southwest Florida Feasibility Study

The Southwest Florida Feasibility Study (SWFFS) was authorized by Congress in the *2000 Water Resources Development Act* as part of the CERP. The SWFFS is being conducted by the USACE and the SFWMD.

The study area includes all of Lee County, most of Collier and Hendry counties, and portions of Charlotte, Glades and Monroe counties, encompassing approximately 4,300 square miles and two major drainage basins. The northern boundary corresponds to the Caloosahatchee River Watershed, which is also the SFWMD/Southwest Florida Water Management District (SWFWMD) jurisdictional boundary in Charlotte County. The eastern boundary delineates the divide between the Big Cypress Swamp and the Everglades system.

The Restudy of the C&SF Project concluded that southwest Florida needed a separate assessment of all the water issues it faces, not only those related to the C&SF Project. Water quality and hydrologic data do not exist for much of the region, and this lack of information, assessments and monitoring data is a fundamental gap that hinders southwest Florida's long-term water resources management opportunities.

The SWFFS, however, is an important first step and offers the opportunity to use USACE and SFWMD resources to plan for appropriate infrastructure either before or as development occurs. The study will develop a water resources plan for the entire southwest Florida area and provide for ecosystem and marine/estuary restoration and protection, environmental quality, flood protection, water supply, and other water-related purposes. In addition, it will provide a framework to address the health of aquatic ecosystems, water flows, water supply, wildlife, biological diversity and natural habitats, the region's economic viability, and property rights.

The following activities for this study have been completed: a predevelopment vegetation map; development of four subregional MIKE SHE models; a 2000 and 2050 land use map and demand projections; water quality data assessment; identified ecological-estuarine performance measures and targets, and hydrologic stages and flows; and, identification of an initial array of alternatives. It is anticipated that this study will be completed by late 2008.

Indian River Lagoon – South Feasibility Study

The SFWMD, in cooperation with the USACE, conducted the Indian River Lagoon – South Feasibility Study (IRLS) to address water quality issues in the St. Lucie Estuary and Indian River Lagoon. The purpose of the study was to evaluate methods to improve surface water management in the C-23, C-24, C-25 and C-44 basins by providing increased storage and reducing the need for periodic high-volume freshwater discharges to the estuarine system.

The Final Indian River Lagoon – South Feasibility Study, completed in 2003, recommended a plan in Martin, St. Lucie and Okeechobee counties to improve water quality within the St. Lucie Estuary and the Indian River Lagoon by reducing the damaging effects of watershed runoff; reducing high peak freshwater discharges to control salinity levels; and, reducing nutrient loads, pesticides and other pollutants. The project will also provide water supply for agriculture to offset reliance on the Floridan Aquifer.

Indian River Lagoon – South

The final CERP Project Implementation Report (PIR) and Environmental Impact Statement (EIS) were completed in March 2004, and the final report was submitted to Congress in the fall of 2005 for authorization by a future *Water Resources Development Act*. This legislation will move the CERP Indian River Lagoon South Restoration Project one-step closer to implementation. Appropriation of federal funds is needed, and land for this project must be purchased. The Indian River Lagoon South Restoration Project includes approximately 130,000 acre-feet of storage in reservoirs for runoff from the C-23, C-24, C-25 and C-44 canals; provides storage on approximately 90,000 acres of natural storage areas; and, removes 7.9 million cubic yards of muck from the St. Lucie River and Estuary.

Through Acceler8, the SFWMD is moving forward with the design and construction of the C-44 Reservoir and stormwater treatment areas of the plan. The project, located in southern Martin County directly north of the C-44 Canal, consists of a 3,400-acre, 15-foot-deep aboveground reservoir that will hold 50,600 acre-feet of water, and a 6,300-acre STA to capture and treat stormwater runoff before it enters the St. Lucie Canal and, ultimately, the St. Lucie Estuary and Indian River Lagoon. The SFWMD initiated test cell construction in 2006 and expects to begin major construction activities in 2007. Construction of the Acceler8 components is expected to be completed by the end of 2009.

The Ten Mile Creek Water Preserve Area, located just south of the Ten Mile Creek in St. Lucie County, also addresses regional storage and freshwater flows from the watershed. This Critical Restoration Project was completed in 2006, with the exception of storm damage repairs and improvements. These projects are expected to be completed in 2008.

Information about other CERP components of the Indian River Lagoon South Restoration Project and anticipated completion dates are available from: http://www.evergladesplan.org/pm/program_docs/proj_status_reports.cfm.

A separate feasibility study effort is ongoing to investigate the northern portions of the Indian River Lagoon. This feasibility study will investigate water resource problems in Brevard, Volusia and Indian River counties associated with the existing C&SF Project system. A multiagency, interdisciplinary team was formed to perform this study. The local sponsor is the St. Johns River Water Management District (SJRWMD).

Florida Keys/Florida Bay Feasibility Study

Florida Bay

Florida Bay is located at the southern tip of the Florida peninsula and covers about 850 square miles, including 700 square miles within Everglades National Park. The bay is relatively shallow, with average depths less than 3 feet. The Florida mainland is located to the north, and the Florida Keys lie to the southeast. Sheet flow across marl prairies in the southern Everglades and numerous creeks fed by Taylor Slough and the C-111 Canal provide fresh surface water inflows into the bay and groundwater recharge. Surface water from the Shark River Slough system flows into Whitewater Bay and may provide groundwater recharge for central and western Florida Bay.

At least 22 commercially and/or recreationally important aquatic species are known to use Florida Bay as a nursery ground. A guide boat industry in the Florida Keys operates within Florida Bay. Target species of this industry include snook, tarpon, permit, bonefish, spotted seatrout and mangrove snapper. The bay is also a nursery for young spiny lobsters and several species of snappers, grunts and sparids. Florida Bay and nearby coastal embayments are the principal nursery habitat for pink shrimp, which is the basis of a multimillion-dollar fishery in the Tortugas. Pink shrimp are an important species commercially and form a prey base for higher trophic-level organisms.

During the summer of 1987, approximately 100,000 acres of seagrass (primarily *Thallassium testudinum*) "died off" in western Florida Bay. Phytoplankton blooms and sponge die-offs followed this seagrass die-off. Conditions within Florida Bay have continued to visibly decline since 1987, including losses of seagrass habitat; diminished water clarity; micro-algal blooms of increasing intensity and duration; and, population reductions in economically significant species, such as pink shrimp, sponges, lobster and recreational game fish. In addition to these problems, populations of wading birds, forage fish and juvenile game fish species have been reduced.

Recognizing Florida Bay's ecological changes, the State of Florida and the federal government made a commitment to improve environmental management in order to restore the bay toward a more natural state. A collaborative interagency research program was initiated in 1994 to document the history of the bay, monitor status and trends, understand human impacts on the bay, and provide a scientific basis for restoration. With partners from other state and federal agencies and the academic community, the District has initiated a comprehensive investigation of the bay and its upstream watershed to better understand the ecological consequences of alternative water management actions.

The CERP Florida Keys/Florida Bay Feasibility Study will ultimately provide a recommended plan of action to restore Florida Bay. As part of the feasibility study, data are being synthesized and assessed to better understand the effects of the C&SF Project on historic freshwater flow pathways, volumes of freshwater flow delivered to the bay and their effect on salinity, and the biological response of estuarine organisms to these changes in salinity.

A key component of this project is the development of a hydrodynamic model for Florida Bay to simulate water movement patterns in the bay. Among other things, the model will support salinity predictions from varying temporal and spatial freshwater inflows, and in the future, will be linked with water quality and ecological models. For example, the model will accept output from surface and groundwater hydrologic models to predict the impacts that C&SF Project restoration alternatives will have on Florida Bay.

The SFWMD is in the process of developing a hydrodynamic model to simulate water movement and salinity patterns within Florida Bay. This model will be linked to a water quality model that can predict water clarity and potential algal bloom conditions. New models have been developed by the U. S. Geological Survey (USGS) and the District to simulate upstream wetland hydrology to determine the role that freshwater inflows play in regulating salinity levels within Florida Bay. The District has developed a seagrass model that can predict changing seagrass habitat in response to changes in salinity, temperature and nutrients. Ecological models are also under development for higher trophic-level organisms present within the bay. These models will be used to assess how various restoration alternatives will affect Florida Bay. The models will provide a foundation for the development of indicators for measuring the success of restoration efforts. In addition to these modeling efforts, a number of experiments are under way to determine how changes in salinity affect nutrient cycling within the bay. This nutrient research is coordinated with experiments on plants, including mangrove trees and seagrasses.

One of the District's Acceler8 projects, the C-111 Spreader Canal Project, located in south Miami-Dade County, will provide more natural sheet flow to Florida Bay by eliminating point sources of freshwater discharges through C-111 to the estuarine systems of Manatee Bay and Barnes Sound. Project works include pump stations, culverts, a spreader canal, water control structures and a stormwater treatment area. In addition, an existing canal and levee will be degraded to enhance sheet flow across the restored area.

Additional Water for Everglades National Park and Biscayne Bay Reconnaissance Study

Biscayne Bay Lighthouse

The Additional Water for Everglades National Park and Biscayne Bay Reconaissance Study was completed in June 2003. This study investigated the need for providing additional water to Everglades National Park and Biscayne Bay, the quantity needed, the timing and distribution, and the impacts and benefits associated with the CERP implementation. The Reconnaissance Study confirmed that federal participation is warranted to proceed to a feasibility-level study; however, a non-federal sponsor for the feasibility phase has not yet been identified. The report also recommends deferral of the feasibility phase until completion of the technical documentation report to be prepared for the Initial CERP Update Project currently under way by RECOVER.

Lake Okeechobee Protection Program

Lake Okeechobee's natural resources have been threatened in recent decades by three environmental impacts: 1) excessive phosphorus loads; 2) harmful higher and lower water levels; and, 3) the spread of exotics vegetation. In recognition of these issues, the Florida Legislature enacted the *2000 Lake Okeechobee Protection Act* and the subsequent Lake Okeechobee Protection Program (LOPP). The LOPP sets forth a series of activities and deliverables to reduce phosphorus loads and implement long-term solutions in Lake Okeechobee consistent with total maximum daily loads (TMDLs).

The LOPP components are designed and implemented—with public input—by an interagency team of scientists, engineers and other environmental restoration experts. The coordinating partners include the SFWMD, the FDEP, the Florida Department of Agriculture and Consumer Services (FDACS), the Florida Fish and Wildlife Conservation Commission (FWC), the U.S. Department of Agriculture–Natural Resources Conservation Service (USDA–NRCS), the Institute of Food and Agricultural Sciences (IFAS), and other agencies, organization and landowners.

Eight distinct components comprise the LOPP:

1. Lake Okeechobee Protection Plan.
2. Lake Okeechobee Construction Project.
3. Lake Okeechobee Watershed Phosphorus Control Program.
4. Lake Okeechobee Research and Water Quality Monitoring Program.
5. Lake Okeechobee Exotic Species Control Program.
6. Lake Okeechobee Internal Phosphorus Management Program.
7. Annual Progress Report.
8. Lake Okeechobee Permits and the Works of the District programs.

Lake Okeechobee & Estuary Recovery

The Lake Okeechobee & Estuary Recovery (LOER) Plan involves the continued implementation of the Lake Okeechobee Protection Program (LOPP) and the CERP Lake Okeechobee Watershed Project (LOWP), the latter of which includes Critical Restoration projects for the Taylor Creek/Nubbin Slough Basin in cooperation with the USACE, as authorized by the *Water Resources Act of 1996*. The LOER Plan has been developed to improve water quality, expand water storage, facilitate land acquisition and enhance the ecological health of Lake Okeechobee and the St. Lucie and Caloosahatchee estuaries. State agencies charged with carrying out this plan include the SFWMD, the FDEP, the FDACS and the Florida Department of Community Affairs (FDCA).

The LOER Plan includes five "fast-track" capital projects and numerous interagency initiatives to provide short-term relief and long-term protection. Areas targeted for construction projects include the S-154 Basin, S-133 Basin, Taylor Creek Reservoir, Nubbin Slough Stormwater Treatment Areas (STA) Expansion and Lakeside Ranch STA. Since the establishment of the LOER Plan, the Lake Okeechobee Fast-Tack (LOFT) projects are being constructed as part of Acceler8. Additional components of the LOER Plan include revisions to environmental resource permit (ERP) criteria for new development in the Upper and Lower Kissimmee basins, Lake Okeechobee, and St. Lucie and Caloosahatchee estuary basins; establishment of TMDLs for the St. Lucie and Caloosahatchee tributaries and estuaries; mandatory fertilizer best management practices (BMPs); alternative storage/disposal of excess surface water; innovative land use planning; and, revisions to the Lake Okeechobee regulation schedule.

In conjunction with the LOER Plan, the Critical Project Pilot STAs at Nubbin Slough and Taylor Creek were completed in 2006. The USACE is expediting modifications to the Lake Okeechobee regulation schedule, and the SFWMD is developing rules to modify its water shortage plans. Four pilot projects are moving forward to store water on private land, and a water storage assessment on public land in northern and southern Lake Okeechobee watersheds has been completed. Information from this assessment is being used to develop preliminary designs, costs and schedules for implementation. Temporary pumps have been purchased to address water supply concerns associated with low Lake Okeechobee levels, while permanent forward pumps and structures are under design. The SFWMD has initiated a rule revision process to develop additional water quality and quantity criteria for environmental resource permits.

Additionally, in April 2006, an engineering study assessing the condition of the Herbert Hoover Dike around Lake Okeechobee was completed for the District. The study's findings included an opinion that the dike does not meet current dam safety standards, and that internal erosion caused by seepage through the earthen structures is affecting the dike. High lake levels are believed to significantly increase this internal erosion. Recommendations for addressing these conditions include fast-tracking repairs to the dike by the USACE and lowering lake levels to minimize seepage. Lower lake levels have the potential to improve water quality and habitat conditions in the lake.

Other South Florida Restoration Projects

Several south Florida ecosystem restoration projects were not authorized by the CERP; however, these efforts are interrelated to the overall effects to restore the south Florida ecosystem.

Kissimmee River Restoration

Prior to the CERP, Congress authorized the Kissimmee River Restoration Project in the *Water Resources Development Act of 1992*. The overall goal of this project is to restore over 40 square miles of river/floodplain ecosystem, including 43 miles of meandering river channel and 27,000 acres of wetlands. The restoration project is a partnership between the SFWMD and USACE. The Kissimmee River Restoration Project is among the largest ecosystem restoration projects in the world, and has been studied worldwide by scientists, engineers and policy makers.

Kissimmee River

To achieve this goal, the physical form and the historic hydrology of the system must be re-created. The two primary components of the restoration project are the headwaters revitalization and the backfilling of the Lower Kissimmee Basin. The headwaters revitalization will modify the way water is released to the river in an effort to simulate historic flow conditions. The lower basin backfilling will fill the middle portion (22 miles) of the Kissimmee River (C-38 Canal) and re-create the river's physical form and flow patterns.

In 2001, the first of the project's four phases was completed, which filled in 7.5 miles of the flood control canal and restored flow to about 15 miles of historic river channel and associated floodplain. In April 2006, the SFWMD approved the purchase of the last parcels of land to complete the final phases of the project. The 12,000 acres complete the total acquisition of the 102,061 acres needed for construction of the project. The next phase of construction began in May 2006 and involves backfilling about 2 miles of canal, beginning at the northern end of the Phase 1 project area, as well as reconnecting about a half mile of continuous river channel. Completion of this phase is expected in 2007. Future phases in the 2007–2011 time frame will focus on backfilling an additional 12.5 miles of canal and reconnect additional river channels. Two water control structures will be removed, restoring more than 8,000 acres of the river/floodplain ecosystem. The system will continue to be monitored for five years when construction is completed to ensure restoration success.

As restoration efforts proceed, positive changes have been observed. Emerging sandbars and sandy bottom show signs of improvement in the river's hydrology. In formerly isolated sections of the river, oxbows are flowing again. Emergent and shoreline vegetation has reappeared and is thriving. Waterfowl are returning to the floodplain, and water quality is improving. The project is re-establishing the physical form of the river with its historical water levels and flows, while ensuring existing flood protection is maintained.

In April 2003, the SFWMD Governing Board adopted a resolution directing SFWMD staff to work with the USACE and stakeholders to develop a long-term management plan for the Kissimmee Chain of Lakes (SFWMD 2004). The purpose of this initiative was to provide a comprehensive review and analysis of the water resources of the Upper Kissimmee Basin and to provide a detailed surface water management plan for the basin that best addresses environmental restoration/protection, plant management, flood control, water supply and other needs in and downstream of the basin. The final draft, *Proposed Scope for the Kissimmee Chain of Lakes Long-Term Management Plan*, was completed in March 2004. This document is available from the District's Web site at: http://www.sfwmd.gov.

Miami-Dade County Regional Canal Study

The purpose of the Miami-Dade County Regional Canal Study is to determine whether modifications should be made to the existing C&SF Project to provide flood damage reduction and solutions to other related water resource problems within Miami-Dade County. In 2002, the USACE was directed to perform a reconnaissance study to determine federal (USACE) interest in participating in a cost-shared feasibility phase study to provide flood damage reduction and solutions to other water resource problems within Miami-Dade County. Based on the study's findings, it was recommended that the Miami-Dade County Regional Canal (MDCRC) Study proceed to the feasibility phase and be divided into three interim reports:

- Interim Report 1: Basins C-2, C-3, C-4 and C-5.
- Interim Report 2: Basins C-6, C-7, C-8 and C-9.
- Interim Report 3: Basins C-1, C-100, C-102, C-103, C-111 and L-31E.

This recommendation was based on the large geographic area associated with the study; the need to prioritize basins severely impacted by flooding; and, the potential cost savings resulting from information generated in the first interim feasibility study. The C-7, C-8, and C-9 basins are being studied under the Continuing Authority Program (CAP).

However, due to budgetary constraints under the CAP, the studies have been temporarily suspended. Close coordination between the MDCRC project team and the C-7, C-8 and C-9 team will occur when preparing Interim Report No. 2, which is scheduled to begin in 2009–2010. The USACE and the SFWMD, in cooperation with Miami-Dade County, are the implementing entities.

Florida Keys Water Quality Improvements Program

On December 21, 2001, Public Law 106-554 authorized the USACE to provide technical and financial assistance to carry out projects for the planning, design and construction of treatment works to improve water quality in the Florida Keys National Marine Sanctuary. The primary purpose of this effort is to improve water quality in the Florida Keys, by implementing several wastewater and stormwater master plans previously prepared for Monroe County and various municipalities within Monroe County.

A Program Delivery Team (PDT) has been formed to ensure effective and coordinated actions are undertaken for successful implementation of the Florida Keys Water Quality Improvements Program. Members of the team consist of one representative from each municipal governmental agency in Monroe County, as well as state and federal agency representatives. Meeting records of the PDT are available for review. The SFWMD is coordinating and facilitating interaction with the USACE for the municipalities of Monroe County.

Modified Water Deliveries to Everglades National Park and C-111 Project

The Modified Water Deliveries (ModWaters) Project consists of structural modifications and additions to the existing C&SF Project, which are needed to enable water deliveries for the restoration of more natural hydrologic conditions in Everglades National Park. The ModWaters Project must be completed as a precondition for construction of the Phase I Decompartmentalization. Completion of the ModWaters Project will provide the first major improvement in the timing, distribution and volume of water flows to Everglades National Park.

The ModWaters Project is composed of three interrelated subprojects: Tamiami Trail Flow modifications, Seepage and Conveyance, and the 8.5 Square Mile Area (SMA). The objectives of the project are to:

- Restore natural hydrology of Everglades National Park, to the extent practicable.
- Mitigate additional potential flooding of the 8.5 SMA resulting from ModWaters implementation.
- Restore and enhance ecological functions.

Structures S-355 A and B were completed in 1998 as part of the original authorized design for improved conveyance of water through WCA-3B. Environmental Impact Statements (EIS) have been completed for the Tamiami Trail and the 8.5 Square Mile Area Mitigation Plan, outlining the recommended federal plan. Design work has been initiated for the 8.5 SMA Mitigation Plan. The EIS for the Seepage and Conveyance and Combined Structural and

Operating Plan was completed in May 2003. Part of the required funding for construction activities has been appropriated to the Department of Interior. Additional funding appropriations will be needed from Congress to meet the anticipated deadlines for project completion.

Everglades Construction Project

Stormwater Treatment Area 4

The Everglades Construction Project (ECP) is an integral part of the Restudy and just one element of the Everglades Program. The SFWMD is responsible for projects that include, but are not limited to, the construction of stormwater treatment areas (STAs), hydropattern restorations, water diversions and other improvements. Comprising 12 interrelated construction projects between Lake Okeechobee and the Everglades, the ECP includes six large constructed wetlands totaling over 47,000 acres. These stormwater treatment areas (STAs) will use naturally occurring biological processes to reduce the levels of phosphorous entering the Everglades to an interim goal of 50 parts per billion (ppb).

The primary objectives of the plan are: a) to reduce the phosphorus levels in water entering the northern Everglades ecosystem to an interim target of 50 ppb, and b) to improve the volume, timing and distribution of water entering the Everglades.

The secondary objectives are to:

- Reduce the volume of harmful discharges to sensitive estuarine systems, including the Caloosahatchee Estuary, the St. Lucie Estuary and Lake Worth.
- Reduce the volume of poor quality of water discharged to Lake Okeechobee from special drainage districts adjacent to the lake.
- Improve the flood protection in the C-51 West Basin located in central Palm Beach County.
- Restore more desirable water levels in the 25,000-acre Rotenberger Wildlife Management Area. Provide a source of clean water for the 35,500-acre Holey Land Wildlife Management Area.

The scope and time frames of the ECP were incorporated into the *1994 Everglades Forever Act*, which recognized that constructed wetlands are the best available means to achieve the interim water quality goals of Everglades restoration. The conceptual design for the ECP was completed in 1994, and final design was completed for most of the ECP projects by 1997. Land acquisition began in 1994 and continued through 2001. Construction began in 1997 and the last of the STAs was completed in October 2003. The first STA constructed, STA 6-Section 1, is located in southeastern Hendry County and was completed in October 1997. Other ancillary construction continued through 2006. Operation and maintenance of the STAs and other features of the ECP will commence upon completion of the individual projects.

The *Everglades Protection Area Tributary Basins: Long-Term Plan for Achieving Water Quality Goals* (Burns & McDonnell 2003), revised in 2006, is a comprehensive set of water quality improvement measures designed to ensure that all waters entering the Everglades Protection Area (EPA) achieve compliance with water quality standards. These measures include enhancements to the existing STAs, expanded best management practices (BMPs), and integration with the CERP projects. Additional information about the Long-Term Plan and approved revisions to the plan are available from the District's Web site at: http://www.sfwmd.gov/org/erd/longtermplan/index.shtml.

Best Management Practices

Best management practices (BMPs) are the best available land, industrial and waste management techniques or processes that reduce pollutant loading from land use or industry, or that optimize water use. One of the cornerstones to improving the long-term ecological health of the Everglades is a strong and effective Best Management Practices Program. The SFWMD is required to develop and implement BMP regulatory programs under the *1994 Everglades Forever Act*. In 2003, the *Everglades Forever Act* was modified to incorporate the *Everglades Protection Area Tributary Basins: Long-Term Plan for Achieving Water Quality Goals* (Burns & McDonnell 2003). The Long-Term Plan objective for the tributary basins is to further develop and strengthen BMP initiatives in these basins.

The *Everglades Forever Act* mandated the creation of the Everglades Program to achieve water quality standards in the Everglades. A major component of the program focuses on controlling phosphorus in discharges through a combination of BMPs in the tributary basins and STAs. The BMP Program is known as the Everglades Regulatory Program. In addition, the *Everglades Forever Act* includes other source control initiatives, such as District monitoring of the effects of BMPs on the Everglades Protection Area hydroperiod, landowner-sponsored

BMP research, and expansion of the BMP Program to the *Everglades Forever Act* specified Chapter 298 diversion area basins.

The BMPs are implemented through a permitting process. When appropriate BMPs are in place, records are kept to ensure accurate implementation and measurements are taken to monitor how well BMPs are working. The permit also requires the submittal of an annual report describing the Everglades Program performance to the FDEP for review, which is included in the District's annual *South Florida Environmental Report* (SFER).

Since 1994, BMPs and STAs together have prevented more than 2,200 tons of phosphorus from reaching the Everglades.

In addition to reducing phosphorus discharges to the Everglades from farms, other structural and nonstructural BMPs are used within the District to improve water quality, and minimize the use of pesticides, fertilizers and irrigation water. Within south Florida, there are agricultural, cow/calf, citrus, turf, vegetable and agronomic crops, plant nursery, aquaculture, stormwater and other BMP programs that help promote low-impact development and conservation design.

Rapid urbanization has an impact on natural flowways and affects water quality and quantity. The increase in stormwater runoff disrupts the natural balance of physical, chemical and biological processes; causes pollution in natural systems; results in soil erosion that causes damage downstream; and, reduces the infiltration of water into the ground. In addition, the increase in runoff discharging through exiting drainage systems may cause flooding.

Stormwater BMPs use three principles to improve water quality—prevention, reduction and treatment. Florida's growth management and urban stormwater management programs rely on both nonstructural and structural BMPs for preventing pollution and protecting designated uses of water bodies from Florida's rapid urbanization.

Nonstructural BMP practices can be used to prevent the generation of nonpoint source pollutants (water pollution from stormwater runoff and indirect sources, such as septic tanks and atmospheric deposition) or to limit their transport off-site. Florida requires the use of nonstructural BMPs, such as land management and the preservation of wetlands and floodplains. Other nonstructural BMPs include street sweeping, proper use and disposal of fertilizers and pesticides, and public education programs.

Technology-based structural BMPs are also required for all new developments and redevelopments to lessen the stormwater peak discharge rate, volume and pollutant loading that accompanies urbanization. The most widely used structural BMPs in developing areas include retention or infiltration areas, detention ponds, constructed wetlands, sand filters, bio-retention areas, and vegetated buffer strips along streams and swales.

The Lake Okeechobee Watershed Phosphorus Control Program includes: 1) continued implementation of existing regulations and voluntary agricultural and nonagricultural BMPs; 2) development and implementation of improved BMPs; 3) improvement and restoration of hydrologic function of natural and managed systems; and, 4) use of alternative technologies for nutrient reduction.

Dairy Farm Water Retention

In February 2001, the SFWMD, FDEP and FDACS entered into an interagency agreement to address how to implement the programs and coordinate with existing regulatory programs [Lake Okeechobee Works of the District (LOWOD), Dairy Rule, and *Everglades Forever Act* restoration programs]. Under the *Lake Okeechobee Protection Act* (LOPA), Section 373.4595, F.S., the FDACS is charged with implementing a voluntary BMP Program (Rule 5M-3) on all agricultural lands within the Lake Okeechobee Watershed. In general, farmers are eligible to receive between 75 percent and 87.5 percent in cost-share funds, through either the FDACS or a combination of FDACS and Natural Resources Conservation Service (NRCS). The FDEP is responsible for developing nonagricultural nonpoint source BMPs. The implementation of phosphorus-reduction projects and large-scale regional projects, research and monitoring, and exotic plant control is the responsibility of the SFWMD.

New Florida legislation has been introduced that would create a plan for restoring the northern Everglades, including the coastal estuaries. The Northern Everglades and Estuaries Protection Plan would direct the FDEP, SFWMD and FDACS to implement best management practices, acquire land and create water treatment and storage areas north of Lake Okeechobee to reduce pollutant loads to the lake and estuaries.

Surface Water Improvement and Management Program

In the late 1980s, it was determined that Florida had to do more to protect and restore its priceless surface waters. While point sources were being controlled, nonpoint sources were still a major concern. In 1987, the Florida Legislature created the Surface Water Improvement and Management Program (SWIM Program) to address these nonpoint pollutant sources.

The SWIM Program addresses a water body's needs as a system of connected resources, rather than isolated wetlands or water bodies. The state's five water management districts and the FDEP are directly responsible for the SWIM Program, but the water management districts work in concert with federal, state and local governments, and the private sector. All the partners contribute in the form of funding or in-kind services. Several water management districts have put more resources into SWIM than they receive from the state, and SWIM dollars have been used as a match to secure federal grants.

The SWIM Program develops carefully crafted plans for at-risk water bodies, and directs the work needed to restore damaged ecosystems, prevent pollution from runoff and other sources, and educate the public. The SWIM plans are used by other state programs, such as Save Our Rivers, to help make land buying decisions and by local governments to help make land use management decisions.

Since its inception, the SWIM Program has made great strides toward improving the quality of a number of troubled water bodies and increasing the understanding of healthy water bodies. The initial legislation identified specific water bodies that would fall under the SWIM Program. Today, 29 water bodies are on the SWIM water body priority list.

Initially, money for the SWIM Program came from state general revenues, matched by funds raised by the water management districts. However, the Legislature's original commitment of $15 million per year began to erode by 1990. In many cases, the SWIM Program's shrinking funding has meant that water management districts have had to increase their share of dollars to continue successful protection and restoration programs.

The ecosystems within the SFWMD possess unique hydrologic, biologic and anthropogenic features, and include both land (watershed) and water (estuary, lagoon, river, etc.) components. These ecosystems are the: St. Lucie Estuary/ Indian River Lagoon, Loxahatchee River, Lake Worth Lagoon, Biscayne Bay, Florida Keys, Estero Bay, Caloosahatchee Estuary and Florida Bay. Work efforts for these water bodies support the SWIM Program, as well as the CERP, the *Florida Watershed Restoration Act*, and development of Minimum Flows and Levels (MFLs) for specified water bodies. The SFWMD is required by Chapter 62-40, Florida Administrative Code (F.A.C.), to establish regional stormwater management policies for watersheds by determining pollutant load reduction goals. The SWIM Program funds help pay for the collection and analysis of valuable data on water quality, land cover and ecological communities. The data are used to design and implement management strategies to protect the natural resources within the watersheds. More information about the SWIM Program is available from: http://www.dep.state.fl.us/Water/watersheds/swim.htm.

3

Water Conservation and Water Source Options

Water conservation and water source options are measures that reduce water use or make additional water available from existing or alternative sources. When implemented together, conservation of water and development of water source options provide optimal use of water resources by reducing water use and extending water supplies.

Conservation, also known as demand management, is essentially permanent water use efficiencies at the point of demand. Water conservation does not apply to short-term water restrictions that are used during a water shortage. Examples of year-round methods to reduce water consumption include retrofitting homes, businesses and agricultural operations with water-saving devices. Water conservation measures also include public education, local government ordinances, changes in rate structures to encourage conservation and mobile irrigation labs (MILs) that help participants use water more efficiently. There are numerous ways to save water, which are described in the Water Conservation section of this chapter.

Water Conservation through Efficient Irrigation

Water source options, also referred to as supply management, are a means to diversify the water resources. Supply management involves increasing the availability of the resource at the point of supply. Water reclamation or reuse, after one or more uses, is an example. Reclaimed water can be used for golf course, urban landscape or agricultural irrigation, cooling towers for power plants, or manufacturing. Another option may involve treating lower quality or brackish water for use in the water treatment process, minimizing freshwater use.

Supply management is the purview of the water suppliers in selecting and implementing appropriate water sources based on particular characteristics of the utility, availability of sources for water supply and cost-effectiveness of treatment options. Improved technology can also change the feasibility of alternative water supplies. In many cases, yesterday's costly alternative source is widely used today. For example, reverse osmosis (RO) was once far too expensive for utilities to consider unless they had no other alternative; today, there are numerous RO plants throughout the District, treating water from brackish aquifers, such as the Floridan, to provide potable water to utility customers. Numerous water source options are discussed in the Water Source Options section of this chapter.

ROLES IN REGIONAL WATER SUPPLY PLANS

Long-term conservation provides a basis for adjusting historic rates and patterns of water use in projecting future water demands in the regional water supply plans. Reducing future water demands before expanding water supplies is a prudent way to manage water resources. Water source options are developed to meet the demands, while not harming the environment. The optimal solution is to employ water conservation measures and develop water source options.

Within the existing legislative framework, the South Florida Water Management District (SFWMD or District) is increasing efforts in conservation. These efforts include funding to promote conservation practices (demand management) and development of alternative sources of water supply (supply management). Regional water supply plan updates, as well as consumptive use permitting are being used to promote and require conservation of water resources. Supply and demand management can help extend water supplies and reduce water use.

FLORIDA WATER CONSERVATION INITIATIVE

Following the 1999–2001 drought, the Florida Department of Environmental Protection (FDEP) led a statewide Water Conservation Initiative with a simple goal: Florida can and must do more to use water more efficiently. The *Florida Water Conservation Initiative, April 2002* (FDEP 2002), identifies ways to improve efficiency in all categories of water use. In addition to policy and regulatory measures, the following are the six highest ranked Water Conservation Initiative alternatives:

AGRICULTURAL IRRIGATION presents many opportunities for improved efficiency. Key among these are cost-share programs to implement irrigation best management practices (BMPs), increased use of MILs to evaluate irrigation efficiency, improvements in recovery and recycling of irrigation water, and greater use of reclaimed water for irrigation.

LANDSCAPE IRRIGATION for watering lawns, ornamental plants and golf courses can be significantly reduced through more efficient irrigation system design, installation and operation, and by reducing the amount of landscaping that requires intensive irrigation.

WATER PRICING or rate structures, informative utility billing and other techniques can send appropriate price signals to encourage water users to conserve water.

INDUSTRIAL, COMMERCIAL AND INSTITUTIONAL users can improve water use efficiency through certification programs for businesses that implement industry-specific BMPs, and by water use audits, improved equipment design and installation, and greater use of reclaimed water.

INDOOR WATER USE is a growing water use sector. The greatest potential for conserving water in this sector is by increasing the number of Florida homes and businesses that use water-efficient toilets, clothes washers, showerheads, faucets and dishwashers.

REUSE OF RECLAIMED WATER can be used more efficiently through pricing and metering. Metering of reclaimed water use and implementation of volume-based rates for reclaimed water is a major strategy contained in the *Water Reuse for Florida – Strategies for Effective Use of Reclaimed Water Report* to promote efficient use of reclaimed water (Reuse Coordinating Committee 2003).

Table 2 presents detailed information about the 51 recommendations from the *Florida Water Conservation Initiative*. It shows the tables of selected water conservation alternatives that six work groups summarized and ranked.

Table 2. Recommended Water Conservation Alternatives.

Water Conservation Alternative[a]	**Priority**	**Respon-sible Entity**	**Total Score**	**Amount of Water Saved (1 to 5)[b]**					**Cost-Effectiveness (1 to 3)[c]**			**Ease of Implementing (1 to 3)[d]**		
AGRICULTURAL IRRIGATION														
AI-1: Cost-share and other incentives	High	F, S, W, I	10	💧	💧	💧	💧	💧	$	$	$	√	√	
AI-2: More mobile irrigation labs to achieve water conservation BMPs	High	F, S, W, I	10	💧	💧	💧	💧	💧	$	$	$	√	√	
AI-3: Increase rainfall harvesting and recycling of irrigation water	High	S, W	9	💧	💧	💧	💧	💧	$	$	$	√		
AI-4: Increase the reuse of reclaimed water	High	S, I	9	💧	💧	💧	💧	💧	$	$	$	√		
AI-5: Improve methods for measuring water use and estimating agricultural water needs	Med.	S, W, I	8	💧	💧	💧	💧		$	$		√	√	
AI-6: Conduct additional research to improve agricultural water use efficiency	Med.	S, W	8	💧	💧	💧	💧		$	$		√	√	
AI-7: Increase education and information dissemination	Med.	S, W	8	💧	💧	💧			$	$		√	√	√
AI-8: Amend WMD rules to create incentives for water conservation	Med.	S, W	8	💧	💧	💧	💧		$	$		√	√	

<u>Legend</u>
F = Federal agencies or Congress
S = State agencies or Congress
W= Water Management Districts
L = Local governments (city, county; includes public water supply utilities, both public/investor owned)
I = Industry businesses or organizations with standard-setting ability

[a] Bolded alternatives from FDEP Basic List of Water Conservation Alternatives to be considered (FDEP 2003).
[b] A score of 1 indicates the least water saved, 5 the most.
[c] A score of 1 indicates the least cost-effective, 3 the most cost-effective.
[d] A score of 1 indicates relatively difficult to implement, 3 relatively easy.

Table 2. Recommended Water Conservation Alternatives (Continued).

Water Conservation Alternative[a]	Priority	Respon-sible Entity	Total Score	Amount of Water Saved (1 to 5)[b]					Cost-Effectiveness (1 to 3)[c]			Ease of Implementing (1 to 3)[d]		
LANDSCAPE IRRIGATION														
LI-1: Develop and adopt state irrigation design & installation standards and require inspection	High	S, L	10	♦	♦	♦	♦	♦	$	$	$	√	√	
LI-2: Expand and coordinate educational/ outreach programs on water-efficient landscaping	High	S, W, L	9	♦	♦	♦	♦		$	$	$	√	√	
LI-3: Establish a statewide training and certification program for irrigation design and installation professionals	High	S, I	9	♦	♦	♦	♦		$	$	$	√	√	
LI-4: Develop environmentally sound guidelines for the review of site plans	Med.	S, L	8	♦	♦	♦	♦		$	$	$	√		
LI-5: Conduct applied research to improve turf and landscape water conservation	Med.	S, I	8	♦	♦	♦	♦		$	$		√	√	
LI-6: Establish a training and certification program for landscape maintenance workers	Med.	S, W, I	7	♦	♦	♦	♦		$	$		√		
LI-7: Evaluate the use of water budgeting as an effective water conservation practice	Low	W, L	6	♦	♦	♦	♦		$			√		
LI-8: Evaluate the need to establish consistent statewide watering restrictions for landscape irrigation	Low	W, L, I	6	♦	♦	♦			$	$		√		

[a] Bolded alternatives from FDEP Basic List of Water Conservation Alternatives to be considered (FDEP 2003).
[b] A score of 1 indicates the least water saved, 5 the most.
[c] A score of 1 indicates the least cost-effective, 3 the most cost-effective.
[d] A score of 1 indicates relatively difficult to implement, 3 relatively easy.

Table 2. Recommended Water Conservation Alternatives (Continued).

Water Conservation Alternative[a]	Priority	Respon-sible Entity	Total Score	Amount of Water Saved (1 to 5)[b]					Cost-Effectiveness (1 to 3)[c]			Ease of Implementing (1 to 3)[d]		
WATER PRICING														
WP-1: Phase in conservation rate structures	High	S, W, L	10	♦	♦	♦	♦	♦	$	$	$	√	√	
WP-2: Require drought rates as part of utility conservation rate structures	Med.	S, W, L	8	♦	♦	♦			$	$	$	√	√	
WP-3: Consider using market principles in the allocation of water, while still protecting the fundamental principles of Florida water law	Med.	S, W, I	7	♦	♦	♦			$	$	$	√		
WP-4: Improve cost-effectiveness in the next cycle of regional water supply plans	Med.	W	7	♦	♦				$	$	$	√	√	
WP-5: Phase in informative billing	Med.	S, W, L	7	♦	♦				$	$	$	√	√	
WP-6: Require more measurement of water use, including metering and sub-metering		S, W, L												
a) Sub-metering of new multifamily residences	Med.	S, L	7	♦	♦	♦			$	$		√	√	
b) Sub-metering retrofit of existing multifamily residences	Low	S, L	6	♦	♦	♦	♦		$			√		
WP-7: Adopt additional state guidance on water supply development subsidies	Low	S, W	6	♦	♦				$	$		√	√	

[a] Bolded alternatives from FDEP Basic List of Water Conservation Alternatives to be considered (FDEP 2003).
[b] A score of 1 indicates the least water saved, 5 the most.
[c] A score of 1 indicates the least cost-effective, 3 the most cost-effective.
[d] A score of 1 indicates relatively difficult to implement, 3 relatively easy.

Table 2. Recommended Water Conservation Alternatives (Continued).

Water Conservation Alternative[a]	**Priority**	**Respon-sible Entity**	**Total Score**	**Amount of Water Saved (1 to 5)**[b]					**Cost-Effectiveness (1 to 3)**[c]			**Ease of Implementing (1 to 3)**[d]		
INDUSTRIAL/ COMMERCIAL/ INSTITUTIONAL														
ICI-1: Consider establishing a "Conservation Certification" Program	High	S, W, I	10	💧	💧	💧	💧		$	$	$	√	√	√
ICI-2: Consider a range of financial incentives and alternative water supply credits	High	F, S	10	💧	💧	💧	💧		$	$	$	√	√	√
ICI-3: Consider cooperative funding for the use of alternative technologies to conserve water	High	I	9	💧	💧	💧	💧		$	$	$	√	√	
ICI-4: Implement additional water auditing programs	Med.	S, W	8	💧	💧	💧	💧		$	$		√	√	
ICI-5: Promote use of reclaimed water	Med.	S, W, L, I	8	💧	💧	💧	💧		$	$		√	√	
ICI-6: Investigate methods of assuring that large users from public suppliers have the same conservation requirements as users with individual permits	Low	W, L	6	💧	💧	💧			$	$		√		
INDOOR WATER USE														
IWU-1: Expand programs to replace inefficient toilets	High	W, L	10	💧	💧	💧	💧	💧	$	$	$	√	√	
IWU-2: Require that inefficient plumbing fixtures be retrofitted at time of home sale	High	S, L, I	9	💧	💧	💧	💧		$	$	$	√	√	
IWU-3: Provide incentives to retrofit inefficient home plumbing fixtures	High	W, L	9	💧	💧	💧	💧		$	$	$	√	√	

[a] Bolded alternatives from FDEP Basic List of Water Conservation Alternatives to be considered (FDEP 2003).
[b] A score of 1 indicates the least water saved, 5 the most.
[c] A score of 1 indicates the least cost-effective, 3 the most cost-effective.
[d] A score of 1 indicates relatively difficult to implement, 3 relatively easy.

Table 2. Recommended Water Conservation Alternatives (Continued).

Water Conservation Alternative[a]	Priority	Respon-sible Entity	Total Score	Amount of Water Saved (1 to 5)[b]					Cost-Effectiveness (1 to 3)[c]			Ease of Implementing (1 to 3)[d]		
IWU-4: Support national dishwasher and clothes washer standards; offer incentives for purchasing efficient washers	High	S, W, L	9	💧	💧	💧	💧		$	$	$	√	√	
IWU-5: Create a water auditor inspection program for the sale of new and existing homes, supported by a refundable utility service fee	Med.	S, L	8	💧	💧	💧	💧		$	$	$	√		
IWU-6: Coordinate and expand the statewide water conservation campaigns	Med.	S, W, L	8	💧	💧	💧	💧		$	$		√	√	
IWU-7: Evaluate the potential for gray water use	Low	S	5	💧	💧	💧			$			√		
IWU-8: Investigate the potential for cisterns	Low	L	4	💧	💧				$			√		
REUSE OF RECLAIMED WATER														
RW-1: Encourage metering and volume-based rate structures for reclaimed water service	High	S, W	10	💧	💧	💧	💧	💧	$	$	$	√	√	
RW-2: Education and Outreach	High	S, W, L	9	💧	💧	💧	💧		$	$		√	√	√
RW-3: Facilitate seasonal reclaimed water storage (including ASR)	High	S, W, L	9	💧	💧	💧	💧		$	$	$	√	√	
RW-4: Link reuse to regional water supply planning	High	S, W	9	💧	💧	💧	💧		$	$	$	√	√	
RW-5: Implement viable funding programs	High	S, W	9	💧	💧	💧	💧	💧	$	$		√	√	

[a] Bolded alternatives from FDEP Basic List of Water Conservation Alternatives to be considered (FDEP 2003).
[b] A score of 1 indicates the least water saved, 5 the most.
[c] A score of 1 indicates the least cost-effective, 3 the most cost-effective.
[d] A score of 1 indicates relatively difficult to implement, 3 relatively easy.

Table 2. Recommended Water Conservation Alternatives (Continued).

Water Conservation Alternative[a]	Priority	Respon-sible Entity	Total Score	Amount of Water Saved (1 to 5)[b]					Cost-Effectiveness (1 to 3)[c]			Ease of Implementing (1 to 3)[d]		
RW-6: Promote agency support of groundwater recharge and indirect potable reuse	High	S, W	9	♦	♦	♦	♦	♦	$	$		√	√	
RW-7: Encourage reuse in southeast Florida	High	S, W	9	♦	♦	♦	♦	♦	$	$		√	√	
RW-8: CUP incentives for utilities that implement reuse programs	Med.	S, W	8	♦	♦	♦	♦		$	$		√	√	
RW-9: Encourage use of supplemental water supplies	Med.	S, W, L	7	♦	♦	♦			$	$		√	√	
RW-10: Assist in ensuring economic feasibility for reuse utilities and end users	Med.	W, L, I	7	♦	♦	♦			$	$		√	√	
RW-11: Encourage reuse system interconnects	Med.	S, W	7	♦	♦	♦			$	$		√	√	
RW-12: Enable redirection of existing reuse systems to more desirable reuse options	Low	S, W	6	♦	♦	♦			$	$		√		
RW-13: Facilitate permitting of backup discharges	Low	S	6	♦	♦				$	$		√	√	

[a] Bolded alternatives from FDEP Basic List of Water Conservation Alternatives to be considered (FDEP 2003).
[b] A score of 1 indicates the least water saved, 5 the most.
[c] A score of 1 indicates the least cost-effective, 3 the most cost-effective.
[d] A score of 1 indicates relatively difficult to implement, 3 relatively easy.

Statewide Comprehensive Water Conservation Program

A statewide, comprehensive water conservation effort was initiated to implement the recommendations of the Water Conservation Initiative, including incorporation of conservation into the water supply planning, regulatory and utility facilities planning processes.

Known as the Joint Statement of Commitment for the Development and Implementation of a Statewide Comprehensive Water Conservation Program for Public Water Supply, or Joint Statement of Commitment, the agreement outlines the responsibilities of the state, through FDEP, in overseeing a statewide Comprehensive Water Conservation Program, as well as the roles of the water management districts and utilities.

The signatories of the Joint Statement of Commitment (JSOC) include the FDEP; the SFWMD; the St. Johns River Water Management District (SJRWMD); the Southwest Florida Water Management District (SWFWMD); the Northwest Florida Water Management District (NWFWMD); the Suwannee River Water Management District (SRWMD); the Florida Public Service Commission; the Utility Council of the American Water Works Association, Florida Section; the Utility Council of the Florida Water Environment Association; and, the Florida Rural Water Association.

A copy of the Joint Statement of Commitment may be obtained from the Florida Department of Environmental Protection Office of Water Policy, available from: http://www.floridadep.org/water/waterpolicy/conservation.htm.

The goal of the entire effort is to produce a statewide program consisting of measurable, accountable and goal-based conservation activities appropriate for each utility's user profile. Although state policy promotes water conservation and the water management districts exercise regulation and offer incentives, local utilities and their customers implement the conservation measures and track results.

Subsequent to the signing of the JSOC, the 2004 Florida Legislature enacted House Bill 293, creating Section 373.227 of the Florida Statutes (F.S.). This legislation encourages the use of efficient, effective and affordable water conservation measures, and states that goal-based, accountable, tailored water conservation programs should be emphasized for public water supply utilities. The legislation identifies the goals to be addressed as part of the program, encourages conservation by utilities, and gives the statewide program legislative backing.

Based on the principles of the JSOC, the signatories, along with other interested stakeholders, developed a work plan for the statewide Comprehensive Water

Conservation Program, which became known as "Conserve Florida." The work plan provides tasks, milestones and completion dates for the three main program elements established in the original JSOC. These elements, which are further validated by the creation of Section 373.227, F.S., are:

- Develop and implement standardized public water supply conservation definitions and standardized quantitative and qualitative performance measures for an overall system of assessing and benchmarking the effectiveness of water conservation programs and practices. (Completed March 2005.)
- Establish a clearinghouse and pilot applications for water conservation programs and practices that will provide an integrated statewide database for the collection, evaluation and dissemination of quantitative and qualitative information about water conservation programs and practices and their effectiveness. (Under contract with the FDEP and the University of Florida.)
- Develop and maintain a Florida-specific water conservation guidance document, including a standardized process to assist public water suppliers in the design and implementation of goal-based, utility-specific water conservation plans. (Completed May 2006.)

The Conserve Florida Program seeks to improve statewide water management programs and policies by developing a water conservation performance measurement system and integrating that system with strategic planning and consumptive use permitting. The work plan recommends a complete performance management system consisting of both goal-based performance measures and task-based performance indicators. Goal-based performance measures correlate to water-use efficiency, whereas task-based indicators evaluate the conservation effort and the effects of that effort in achieving conservation goals.

The goal-based approach stresses accountability. The program is available to any utility in the state that wants to participate. As provided in Section 373.227(4), F.S., (enacted in House Bill 293), a water management district must approve a goal-based water conservation plan as part of a consumptive use permit if a utility provides reasonable assurance the plan will achieve effective water conservation, at least as well as the water conservation requirements adopted by the appropriate water management district, and is otherwise consistent with the statute.

The Water Conservation Clearinghouse, hosted by the Department of Engineering Sciences at the University of Florida, provides information and associated online resources, such as the Water Conservation Guide. The mission of the clearinghouse is to collect, analyze, catalog and make available research information. In addition, the clearinghouse provides technical assistance to public water supply utilities and water managers for use in developing effective and efficient water conservation programs. The clearinghouse evaluates conservation programs, promotes continuous, long-term improvement in water conservation practices, and provides potential methods to utilities seeking to implement conservation programs.

The Water Conservation Guide is the foundation of the Conserve Florida Program and essential to its success. The guidance document aids utilities in developing goal-based, alternative water conservation programs that will conserve water at least as effectively as traditional regulatory requirements. The guide includes a standard methodology for developing a utility water use profile and a process for developing utility-specific conservation goals and minimum requirements based on utility size. Additionally, the guidance document defines a standard process to measure and report results, evaluate effectiveness, and refine the program if goals are not met.

To ensure the long-term viability of the Conserve Florida Program, the work plan recommends a permanent revenue source, not subject to annual budget processes of the Legislature, the FDEP or the water management districts. A copy of the JSOC Work Plan may be obtained from the FDEP Office of Water Policy: http://www.floridadep.org/water/waterpolicy/conservation.htm.


Xeriscaping™

Also required by House Bill 293 and included in the Conserve Florida Program are guidelines that address Xeriscape™ landscaping and the development of a statewide model ordinance to increase landscape irrigation efficiency. In addition, the 2004 legislation allows water management districts to require the use of reclaimed water, if feasible, and to encourage metering of newly implemented reuse projects, enabling utilities to charge for the actual volume used. See Chapters 367, 373, 403, 570 of the Florida Statutes for specific legislative authority on the statewide Comprehensive Water Conservation Program.

WATER CONSERVATION

Water conservation refers to reductions in water use. Practices and technologies that provide water uses are broken down into two categories: 1) long-term, permanent reductions, and 2) short-term, temporary reductions. Long-term reductions require implementation of technologies, such as ultralow flow devices, that reduce water use, while satisfying the needs of consumers. This distinguishes them from the short-term water conservation measures and cutbacks required of users during water shortage situations, or from situations when short-term problems with the supply system capacity occur.

Water conservation, also known as demand management, addresses permanent water use efficiencies at the point of demand. The permanent water use reductions resulting from long-term conservation technologies provide many benefits, such as reducing impacts on the environment and water resources.

Mandatory Water Conservation Measures

The District's consumptive use permitting rules require planning and implementation of water conservation measures by public water supply utilities (and associated local governments), commercial/industrial users, landscape and golf course users, and agricultural users. Examples of requirements include adoption of local government ordinances that affect irrigation hours, landscaping and plumbing fixtures, leak detection, rate structures, and public education. All of these requirements apply to users required to obtain individual water use permits. Water use (consumptive use) permitting is further discussed in **Chapter 4** (Regulation).

Public Water Supply Utilities

All 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 their request to local governments within their service area to adopt conservation ordinances.

The conservation plan must address:

- Adoption of an irrigation hours ordinance.
- Adoption of a Xeriscape™ landscape ordinance.
- Adoption of an ultralow 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 each utility to evaluate or plan and implement all elements where applicable. Utilities must rely on local governments to codify water conservation ordinances. Depending on the demographics, housing characteristics and location of the service area, utilities can choose to demonstrate which water conservation activities are more cost-effective for their situation and emphasize implementation of those activities in their conservation plan.

Adoption of an Irrigation Hours Ordinance

The ordinance limits all lawn irrigation to the hours of 4:00 p.m. to 10:00 a.m. because irrigation during daytime hours is less efficient. Sunlight and increased winds during daytime hours cause water to evaporate before reaching the ground or to blow onto impervious surfaces, such as sidewalks, roads and driveways. Wind also causes the water that reaches the plants to be unevenly applied. In addition to changing the time of irrigation, users should water more deeply, but less frequently. Public education programs also contribute to the effectiveness of irrigation ordinances by informing irrigators how to reduce applications, while still meeting the water requirements of plants.

The permit applicant or enacting local government may adopt an ordinance that includes exemptions from the irrigation time restrictions for the following circumstances:

- Irrigating with a microirrigation system.
- Reclaimed water end users.
- Preparing for irrigation of new landscape.
- Watering-in of chemicals, including insecticides, pesticides, fertilizers, fungicides and herbicides, when required by label, recommended by the manufacturer or implementing best management practices (BMPs).
- Maintenance and repair of irrigation systems.
- Irrigating with 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.
- Irrigating with 75 percent or more water recovered or derived from an aquifer storage and recovery (ASR) system.

Adoption of a Xeriscape™ Landscape Ordinance

Xeriscape™ is defined in Subsection 373.185(1)(b), F.S.:

> "Xeriscape™" or "Florida-friendly landscape" means quality landscapes that conserve water and protect the environment and are adaptable to local conditions and which are drought tolerant. The principles of Xeriscape™ include planning and design, appropriate choice of plants, soil analysis which may include the use of solid waste compost, efficient irrigation, practical use of turf, appropriate use of mulches, and proper maintenance.

The legislation requires that 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 natural vegetation; and, require a rain sensor for automatic sprinkler systems. District rules, as mandated by the Legislature, require all local governments to consider a Xeriscape™ ordinance and adopt an ordinance 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 that require a building permit.

The District has found 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 Ultralow Volume Fixtures Ordinance

Mandatory water conservation measures require adoption of an ultralow volume (ULV) fixtures ordinance for all new construction. The SFWMD'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, 2.2 gal/min. at 60 psi. 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, (U.S. Code: Title 42, Section 6295 of the federal *Energy Policy Act*) and conform to current Building Construction Standards (Chapter 553, F.S.).

Ultralow volume fixtures save water by using less water, while providing a sufficient level of service to the user. An estimated savings of 8,670 gallons per toilet per year can be made by installing ULV fixtures. By comparison, 9,125 gallons per shower per year can be saved (**Table 3**).

Table 3. Representative Water Use and Cost Analysis for Ultralow Volume Fixtures.

Housing Stock Characteristic	Conservation Measure	Water Savings per Retrofit	Cost per Device	Cost per 1,000 Gallons
Housing Built before 1984	Showerhead Retrofit	3.5 Gallons/Minute	$20	$.06/1,000
Pre-1992 Outdoor Irrigation Systems Without Rain Sensors	Rain Sensor Installation	74 Gallons/Day	$68	$1.07/1,000
Housing Built before 1984	Toilet Retrofit	4.4 Gallons/Flush	$200	$.25/1,000

Source: Hampton Roads Water Efficiency Team, Water Wise Guide 2000. Available from: http://www.hrwet.org
Source: U.S. General Accounting Office: "Water Infrastructure: Water-Efficient Plumbing Fixtures Reduce Water Consumption and Wastewater Flows" 2000. Available from: http://www.gao.gov
Source: U.S. Department of Energy Plumbing Manufacturers Institute, "How to Buy a Water-Saving Replacement Toilet" 2000. Available from: http://www.eere.energy.gov

Adoption of a Rain Sensor Device Ordinance

The water conservation plan involves adoption of a rain sensor device ordinance requiring 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.

As with ULV fixtures, rain sensor devices save water by using less water, while providing a sufficient level of service to the user. An estimated 26,882 gallons per housing unit per year can be saved by installing rain sensor devices (**Table 4**).

Table 4. Representative Water Use and Cost Analysis for Rain Sensor.

Representative Water Use	Rain Sensor
Cost/Unit or Visit ($)	$68.00
Acres/Unit	0.11
Water Savings (inches/year)	42.50
Water Savings (gallons/year)	12,702.00
Life (years)	5.00
Water Savings/Life (gallons)	63,510.00
Cost/1,000 Gallons Saved ($)	$1.07

Note: These savings are based on 180 ¾-inch irrigations per year and an unpublished District study of rain sensor performance by Morris Rosen and Wayne Hermann showing 32 percent efficiency for rain sensors. An analysis of 37 years of daily rain data from NOAA at Fort Pierce and Stuart show 10 percent of the days had greater than or equal to ½-inch of rain. These savings are independent of turf irrigation requirements.

Adoption of a Conservation Rate Structure

A conservation rate structure is used by utilities to provide users with a financial incentive to reduce demands. Water conservation rates generally involve:

- 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.

Users faced with higher rates will often achieve water conservation by implementing a number of the conservation measures discussed in this chapter. Increasing block rates is the most frequently used conservation rate structure employed by utilities. 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, the customer base and their water uses.

Adoption of a Utility Leak Detection and Repair Program

The SFWMD requires implementation of leak detection programs by utilities with unaccounted for water losses greater than 10 percent. The Leak Detection Program must include water auditing procedures and an infield leak detection and repair program. The program description should include the number of labor hours devoted to leak detection, the type of leak detection equipment 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 and/or messages to educate citizens about water conservation. The program informs citizens how to reduce water use; establishes awareness of water use behavior and the benefits of water conservation; and, educates users on water-saving concepts, actions and technology-based alternatives, which will save water and make a difference.

Successful outreach and education efforts usually consist of cooperation between many agencies and organizations. For example, outreach through school education can provide a foundation for long-range acceptance of the conservation message and resulting conservation action by future generations. Public water supply utilities can play an important role through their customer service and billing processes. The District and other participating state agencies have consistently provided assistance to a wide range of water users through outreach and education programs.

All users can be brought to an educated level of awareness about local and regional conservation efforts. These efforts are typically targeted at the users with the most potential for participation, including domestic indoor and outdoor uses. This gives the public a means to take action in implementing conservation behavior and techniques, such as installing and maintaining water-saving devices.

Although quantification of a specific amount of water saved because of an outreach and education effort is not as readily measured, as with water-saving devices or technology, outreach and education are crucial to any successful conservation program.

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

The SFWMD's regulations require that all individual commercial/industrial permit applicants submit a conservation plan.

Conservation plans must include:

- 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 Xeriscape™ to be cost-effective. 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, exceptions to the irrigation hour limitations in the rule, which provide for protection of the landscape during stress periods and help to assure the proper maintenance of irrigation systems.

Agricultural Users

Citrus, vegetable and container nursery permittees are required by the SFWMD to use microirrigation or other systems of equivalent efficiency. This applies to new installations, or upon modification, to existing irrigation systems. The permittees are also required to analyze the feasibility of using reclaimed water.

Microirrigation Systems

Microirrigation 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 is limited to areas not underlain by the root zone. Installation of microirrigation systems, or systems of equivalent efficiency, is required under SFWMD permitting rules for new citrus and container nurseries. Additional water savings can be achieved by using microirrigation systems on crops (such as vegetables), and by retrofitting irrigation systems for existing citrus and nursery crops.

Conversion of existing seepage irrigated citrus to microirrigation is a significant source of water savings (**Table 5**). **Table 5** summarizes the cost and potential water savings of 1 acre of conversion. Water savings of approximately 6 billion gallons per year (BGY) or 15.8 million gallons per day (MGD) can be realized by converting 25,000 acres of citrus from flood irrigation with 50 percent efficiency to microirrigation with 85 percent efficiency. 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) are often extremely cost-effective compared to the costs of developing additional water supplies.

It is estimated by the Institute of Food and Agricultural Sciences (IFAS), University of Florida that the initial cost to install a microirrigation system for citrus is $1,000 per acre, and that the system would have estimated annual maintenance costs of $25 per acre per year (IFAS 1993).

Table 5. Irrigation Costs and Water Use Savings Associated with Conversion of Citrus from Seepage Irrigation to Low Volume Irrigation.

Initial Cost ($/acre)	$1,000.00
Operating Cost ($/acre)	$25.00
Water Savings (inches per year)	8,519.00
Water Savings (gallons per year)	230,805.00
Life (years)	20.00
Cost over Life ($)	$1,500.00
Water Savings over Life (gallons)	4,616,100.00
Cost/1,000 Gallons Saved ($)	$0.33

Source: Institute of Food and Agricultural Sciences 1993.

Supplementary Water Conservation Measures

Supplementary water conservation measures have water reduction benefits, but are not required by the District's water conservation rule. Supplementary measures enhance the mandated conservation measures by further reducing water demands.

Rain Sensor

Urban Users

Outdoor water use is often the largest component of urban water use; therefore, supplementary measures for urban users may include outdoor conservation measures since those are usually the most cost-effective.

The savings per unit of cost associated with the outdoor conservation measures are generally greater than those for indoor conservation measures, primarily due to the larger volumes of water used.

Indoor Audits and Water-Efficient Technology

The *1992 Energy Policy Act* stipulated national maximum allowable water-flow rates for indoor plumbing fixtures. These fixtures were required for new construction from the inception of the act. However, existing housing can significantly reduce water use by switching to the more efficient fixtures.

Indoor audits provide information and services directly to households and other urban water users to achieve greater efficiency of appliances that use indoor water. This option generally includes inspections to locate leaks, determine if plumbing devices are operating properly, repair minor problems, and provide information about conservation measures and devices. In some cases, a retrofit program will include installation of ULV showerheads and toilet devices.

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, generally older housing, with high water consuming fixtures.

The cost-effectiveness of retrofitting older homes is enhanced by the fact that many of these homes have fewer bathrooms and fixtures. The greater the number of people using a water-saving device, the more cost-effective and water conserving 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 particularly suitable targets for retrofit programs are public rest rooms and other facilities with high use rates.

Landscape Audits and Water-Efficient Technology

Landscape audits are measures that improve the efficiency of irrigation systems, and include services to determine if the irrigation system is operating properly. Improving the efficiency of irrigation systems may include adjusting irrigation timers (to assure that a water conserving schedule is being followed); replacing sprinkler heads (to assure that the system is providing adequate coverage and not wasting water by irrigating impervious surfaces); recalibrating irrigation systems; and, installing rainfall sensing/irrigation control devices.

Utilities and water management agencies generally implement landscape audits. Because of the large outdoor component of water use in south Florida, irrigation audits can be especially effective. Outdoor water audits are particularly important due to the peaking of outdoor demand during periods of low rainfall, with maximum stress on water resources.

Landscape retrofit measures provide information and incentives for users to implement physical changes to landscapes and irrigation systems. Devices suitable for landscape retrofits include those that prevent unneeded 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.

To assist homeowners in reducing outdoor irrigation, mobile irrigation laboratories (MILs) perform audits to evaluate the potential for saving water. An urban MIL typically performs 140 evaluations per year (**Table 6**), for a potential savings of 0.08 MGD. Saving water also results in saving money ($2.25 per 1,000 gallons). The program is maintained by a partnership between the SFWMD, the U.S. Department of Agriculture–Natural Resources Conservation Service (USDA–NRCS), the Florida Department of Agriculture and Consumer Services (FDACS), and various soil and water conservation districts. Audits are provided at no cost to the homeowner.

Table 6. Costs and Water Savings Associated with Urban Mobile Irrigation Labs.

Representative Water Use	Mobile Irrigation Lab
District Cost (/lab/year)	$56,700.00
Evaluations (/lab/year)	140.00
Water Savings (MGD/lab/year)[a]	0.08

a. Based on 2004–2005 evaluation data from all south Florida urban MILs.

Public Water Supply Utilities

Filter Backwash Recycling

Filter backwash recycling is a conservation measure that 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.

Distribution System Pressure Control

Pressure control measures in potable water distribution systems reduce water use, while providing acceptable water pressures to 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 stabilize, overall operating pressure. Unlike the pressure reduction efforts during water shortages, which call for reductions in pressures to levels needed to meet minimums for fire flow, these changes target reductions at locations where pressures are inconsistently high within the system.

There are numerous benefits to an optimized or stabilized pressure system. High pressures increase loss of water through leaks, and increase use by the end user, especially when water use is prescribed by 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, resulting 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 involves estimating and detecting infiltration of groundwater or surface water into wastewater collection systems. Repair efforts reduce infiltration. Reducing infiltration of groundwater prevents waste by allowing the groundwater to be used for other purposes.

Agricultural Users

Agricultural Audits and Water-Efficient Technology

Growers are encouraged to adopt irrigation management practices that conserve water. Irrigation management practices and technology are interdependent. For instance, a change in the type of irrigation system will generally require a change in irrigation scheduling to achieve water conservation, while maintaining crop yield and economic return. An additional factor in agricultural water conservation is potential energy savings. Costs for diesel fuel or electricity used for pumping water are energy related and will be reduced if water conservation management practices are employed.

To assist growers, MILs perform audits on irrigation systems. An agricultural MIL typically performs 110 evaluations per year (**Table 7**), for a potential savings of 0.41 MGD. The program is maintained by a partnership between the SFWMD, the USDA–NRCS, the FDACS, and various soil and water conservation districts. Audits are provided at no cost to the grower.

MIL Technician Evaluating Irrigation System

Table 7. Costs and Water Savings Associated with Agricultural Mobile Irrigation Labs.

Representative Water Use	Mobile Irrigation Lab
District Cost (/lab/year)	$104,000.00
Evaluations (/lab/year)	110.00
Water Savings (MGD/lab/year)[a]	0.41

a. Based on 2004-2005 evaluation data from all south Florida agricultural MILs.

Water Savings Incentive Program

The SFWMD offers a cooperative funding program for the implementation of technology-based water conservation projects that save water through urban water demand reduction. Known as the Water Savings Incentive Program, or WaterSIP, the program focuses on funding noncapital projects, such as installation of rain shut-off devices for irrigation systems and plumbing retrofits. Millions of gallons of water are being saved every day because utilities, local governments, homeowner associations and nonprofit organizations have been instrumental in installing water conservation devices funded through this program.

WATER SOURCE OPTIONS – SUPPLY MANAGEMENT

As previously mentioned, water source options are also referred to as supply management. Supply management consists of water source options that could be used to meet a specific demand. In some areas, these options are considered conventional sources, while in other areas they would be considered alternative water supply sources. For example, the Floridan Aquifer is the primary source of water in the Kissimmee Basin (KB) Planning Area, where its quality is fresh. However, in most of the other areas in the District, the Floridan Aquifer is considered an alternative source because its water quality is brackish and requires desalination treatment or blending with a freshwater source prior to treatment or use.

Some sources that have historically been considered alternative sources are now becoming commonplace. For instance, the use of brackish water from the Floridan Aquifer in many regions of the District is regarded as a public water supply source, as in the Lower West Coast (LWC) Planning Area, where use of freshwater aquifers has been maximized in much of the coastal portions of the region. Over 50 percent of the water allocated for public water supply in this region is brackish water from the Floridan Aquifer. Depending on the region, a variety of water source options can be used to meet water demands.

Water Source Option Cost Information

Cost information is included for most of the following water sources options. Treatment technologies and their associated costs are presented in **Chapter 5** of this document. Unless otherwise noted, cost information presented in **Chapters 3** and **5** is updated information from the St. John's River Water Management District's (SJRWMD) Special Publication SJ97-SP3, entitled *Water Supply Needs and Sources Assessment—Alternative Water Supply Strategies Investigation—Water Supply and Wastewater Systems Component Cost Information* (SJRWMD 1997). The cost information contained in the SJRWMD document was updated to project 2005 dollars using a FDEP and water management district agreed-upon projected 2005 Construction Cost Index. The cost information provides a consistent set of definitions and criteria for the development of comparable planning level life cycle cost estimates for water supply and water treatment alternatives. The following are definitions of the cost terms used in this cost information.

Construction Costs

The construction costs developed for each of the water supply and wastewater treatment systems are the total amounts expected to be paid to a qualified contractor to build the required facilities. These values include all material costs, equipment costs, installation costs and taxes. Unless otherwise noted, the construction costs for treatment components do not include factors for peak flow.

Nonconstruction Capital Costs

The nonconstruction costs are 45 percent of the construction costs and account for engineering design, permitting, administration and construction contingency associated with the constructed facilities. The 45 percent nonconstruction costs are divided into three parts: an engineering cost of 15 percent of the construction costs; an administrative cost of 10 percent of the construction cost; and, a general contingency of 20 percent of the construction cost.

Land and Acquisition Costs

Recommended values are used for the purpose of land cost estimations and are in the form of dollars per acre or dollars per square foot. A $100,000 per acre value for land was used unless otherwise noted. The land area required and the cost associated with the land is included as a part of the total capital cost for each of the water supply and wastewater system components. In addition to the cost of the land, a land acquisition cost of 25 percent of the land value is included to account for the cost of engineering, administrative and legal services associated with the land acquisition process.

Total Capital Costs

The total capital costs for each of the water supply and wastewater system components are the sum of the construction costs, nonconstruction costs, land value and land acquisition costs.

Operation and Maintenance Costs

The operation and maintenance costs are the estimated costs of operating and maintaining the water supply or wastewater treatment system components each year. These costs include all energy costs, chemical costs, labor costs, etc. The operation and maintenance costs are based on annual average flow conditions.

Equivalent Annual Costs

The equivalent annual costs are the total life cycle costs of the system component based on the service life of the component and the time value of money. The time value of money used for the purpose of this investigation is 7 percent, and the service lives of the components are presented in the document referenced previously. The annual operation and maintenance costs associated with the system component are also included in the equivalent annual cost.

Unit Costs

Unit costs include the portion of the annual operation and maintenance costs that vary with the production rate, such as energy costs and chemical costs. The unit costs are expressed in terms of dollars per 1,000 gallons.

Cost Study

The *Draft Water Supply Cost Estimation Study*, which is expected to be completed in early 2007, will provide an updated evaluation of various water treatment technologies where applicable. When finalized, this cost study will be posted on the South Florida Water Management District's (SFWMD or District) Web site. However, given the rapidly rising costs of land and construction, these costs must not be viewed as a substitute for the detailed evaluation that should accompany utility-specific feasibility and design studies needed to assess and construct such facilities.

Over time, with the implementation and reporting of alternative water supply projects, and the information in the *Draft Water Supply Cost Estimation Study*, cost estimating relationships and curves for various water withdrawal facilities, technologies, by-product disposal methods, and surface storage and aquifer storage and recovery (ASR) systems can be updated and refined.

Groundwater Sources

Significant amounts of water demands within the District are met with groundwater sources, especially urban demands. The hydrogeology of south Florida is best defined as a series of layered aquifers and aquitards that vary in thickness and depth. This includes both semi-confined and unconfined aquifers. There are three primary water producing aquifer systems from which groundwater is withdrawn in each of the planning regions: the Surficial Aquifer System (SAS), the Intermediate Aquifer System (IAS) and the Floridan Aquifer System (FAS). These systems typically do not extend over the entire District, are not present in all regions and vary from region to region. The FAS exists throughout the District. Within an individual aquifer, hydraulic properties and water quality may vary vertically and horizontally.

Surficial Aquifer System

The SAS is typically found at depths from land surface to 200 feet below land surface. This includes the SAS in the Upper East Coast (UEC) and KB planning areas, the Biscayne Aquifer in the Lower East Coast (LEC) Planning Area, and the Water Table and Lower Tamiami aquifers in the LWC Planning Area.

Intermediate Aquifer System

The IAS is a confining unit in most of the District producing very little water. The IAS is used for water supply on a very limited basis, except in the LWC Planning Area. In the LWC Planning Area, the IAS includes two producing zones, the Sandstone and Mid-Hawthorn aquifers. These aquifers can be found from 50 feet to almost 400 feet below land surface, depending on the location.

Floridan Aquifer System

The FAS is the deepest of the aquifers used for water supply in the SFWMD. The water quality in the FAS decreases significantly from Orlando to Miami or Naples. Within the FAS, multiple permeable intervals, or producing zones, are sandwiched between low permeability confining materials. The quality of water in the FAS deteriorates to the south, increasing in hardness and salinity. Salinity also increases with depth, making the deeper producing zones less suitable for development than do those near the top of the system. In the KB Planning Area, the FAS is the primary source of fresh water for all uses. However, water from the FAS requires desalination treatment south of central Okeechobee County. In addition, the FAS is artesian (flows at land surface without a pump) in some portions of the District. The water producing formations of the FAS in the Orlando area can be found between 80 feet and 1,500 feet below land surface (bls). The water producing formations of the FAS currently used for water supply south of central Okeechobee County can be found from 600 feet to over 1,800 feet bls, depending on the location.

In 2003, over 25 regional water suppliers in south Florida were using reverse osmosis to treat brackish water from the Floridan Aquifer to meet potable water demands. These utilities and several others plan to use the Floridan to meet future water needs. In addition, several golf courses in south Florida have also tapped the Floridan Aquifer, using reverse osmosis to meet irrigation needs. Many

Floridan Well – Okeechobee County

citrus growers in the UEC Planning Area also depend on the Floridan Aquifer when surface water availability becomes limited. Currently, use of a brackish water source is exempt from District water shortage declarations.

Groundwater Estimated Costs

Expansion of an existing public water supply wellfield is usually selected by a utility when additional raw water is required. Groundwater supply systems are composed of wellfields and their related features, such as wells and pumps. The cost of a well is a function of diameter and depth. **Figures 4** and **5** provide the well drilling construction costs and the well drilling construction and nonconstruction costs combined for different diameters and depths. These costs include drilling, casing to District standards, minimal logging, pump testing and the final wellhead. Well equipment costs are presented in **Table 8** and include pumps, valves, fittings, metering, a well house structure and electrical controls, as well as installation and taxes. The operation and maintenance costs include normal maintenance of the well, including equipment, energy and labor.

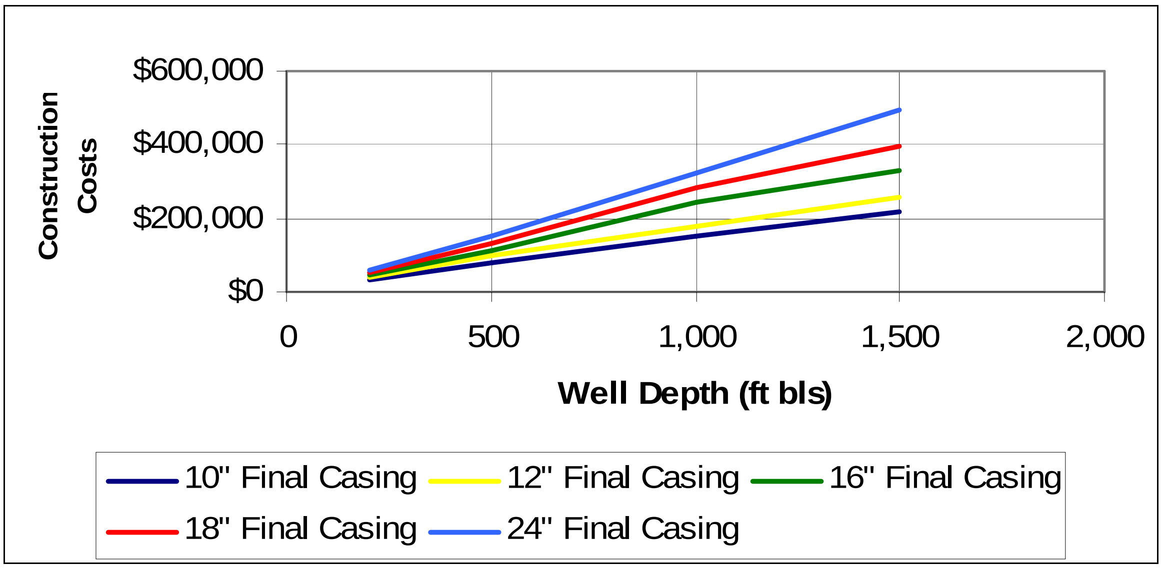


Figure 4. Well Drilling Construction Costs.
Source: Diversified Drilling Corporation. Fax dated October 23, 2003.

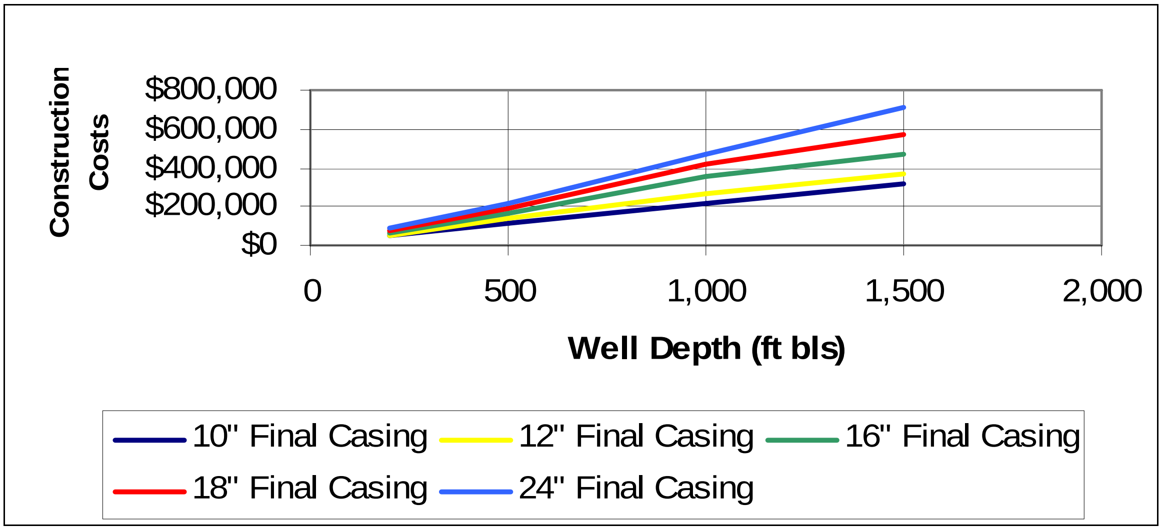


Figure 5. Well Drilling Construction and Nonconstruction Combined Costs.
Source: Diversified Drilling Corporation. Fax dated October 23, 2003.

Table 8. Well Equipment Cost Estimates.

Capacity (MGD)	Construction Cost	Non-Construction Cost	Total Capital Cost	Annual O & M Cost	Equivalent Annual Cost	Cost ($/1,000 gal)
1	$49,429	$22,243	$71,671	$27,628	$34,393	$0.09
2	$59,946	$26,976	$86,921	$43,231	$51,435	$0.07
3	$69,788	$31,404	$101,192	$64,424	$73,975	$0.07
4	$80,442	$36,199	$116,641	$86,306	$97,316	$0.07
5	$90,846	$40,881	$131,727	$103,433	$115,867	$0.06

Groundwater 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 to ensure satisfactory future water supply.

Reclaimed Water

Reclaimed water is wastewater that has received at least secondary treatment and is reused after flowing out of a wastewater treatment plant (WWTP) [Chapter 62-610, Florida Administrative Code (F.A.C.)]. Reuse is the deliberate application of reclaimed water for a beneficial purpose, in compliance with the FDEP and water management district rules. Potential uses of reclaimed water include landscape (e.g., medians, residential lots and golf courses) and agricultural irrigation, groundwater recharge through percolation ponds, industrial uses, environmental enhancement, and fire protection.

In addition to the more common uses of reclaimed water, Chapter 62-610, F.A.C., also addresses the use of high-quality reclaimed water for groundwater recharge using injection wells for indirect potable use.

The State of Florida encourages and promotes the use of reclaimed water. 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. The District requires all water use permit applicants to use reclaimed water unless the applicant can demonstrate it is not feasible to do so.

In 2005, in the SFWMD service area, there were 110 wastewater facilities that reused about 232 MGD of reclaimed water for a beneficial purpose (FDEP 2006). This reuse accounted for 28 percent of the total 823 MGD of wastewater treated in the SFWMD. The remaining 590 MGD of treated wastewater was disposed of by deep well injection and discharge to the ocean. **Table 9** presents the percent of wastewater reuse for each of the District's water supply planning areas in 2005.

Reuse needs to be encouraged in some parts of the District, while conservation and efficient use of reclaimed water needs to be promoted in other parts. Reclaimed water is not as widely used in the LEC Planning Area as in other regions of south Florida. The Florida Department of Environmental Protection's (FDEP) *2005 Reuse Inventory Report* (FDEP 2006) indicates that of the 640 MGD in wastewater flows in 2005, the average percentage of reused water was only 11 percent across the LEC Planning Area. In Miami-Dade and Broward counties, the percentage ranged from 6 percent to 7 percent of the combined 515 MGD in wastewater flows. In comparison, Palm Beach County reuses 28 percent of the 125 MGD of wastewater it generates (FDEP 2006). Furthermore, Palm Beach County has adopted a mandatory reuse ordinance requiring all new development in the area defined in the ordinance to use reclaimed water for irrigation. The SFWMD continues to work with local governments and utilities in Broward and Miami-Dade counties to explore reuse options.

In the KB and LWC planning areas, which reuse 100 percent and 90 percent of wastewater flows, respectively, supplemental sources are being investigated and developed to augment reclaimed water flows. Several utilities in these regions have waiting lists for reclaimed water. Conservation of reclaimed water is also being explored in these regions.

Encourage Reclaimed Water Conservation

Effluent Pumps Reuse System

In parts of the District where there is limited availability of fresh water and reclaimed water supplies are committed, the conservation of reclaimed water is being recognized as a tool to extend supplies of reclaimed water for additional uses as part of a larger water supply strategy. One of the most effective tools for promoting water use reductions in any water system is a water conserving rate structure. Many reclaimed water utilities in Florida continue to charge a flat monthly fee for reclaimed water service. This is because many systems began implementing reuse as a means of wastewater disposal and as an incentive to attract customers to its use for irrigation. In addition, there was generally a much greater volume of reclaimed water available than the customer base could support and overuse was not discouraged.

As a reuse system matures and the customer base expands, shortages of reclaimed water can become an issue. Droughts intensify the potential for shortages of reclaimed water. Many utilities have sought approval for supplemental water supplies from the FDEP and the water management districts to increase the supply of reclaimed water.

Table 9. 2005 SFWMD Reuse by Planning Region.

Planning Region / County	WWTF Capacity (MGD)	WWTF Flow (MGD)	Reuse Capacity (MGD)	Reuse Flow (MGD)	Percent Reuse[b]
Lower East Coast (LEC)					
Broward	257.33	211.68	20.85	12.58	6
Miami-Dade	358.81	298.69	23.67	20.60	7
Monroe	12.13	5.66	1.21	0.33	6
Palm Beach	162.28	125.92	66.53	35.81	28
LEC Total	790.55	641.95	112.26	69.32	11
Lower West Coast (LWC)					
Collier	50.92	28.95	33.58	23.59	81
Hendry	2.86	1.92	2.86	1.92	100
Lee	71.90	50.25	58.52	47.35	94
LWC Total	128.68	81.12	94.96	72.86	90
Upper East Coast (UEC)					
Martin	13.15	6.84	9.29	4.84	71
St. Lucie	19.46	12.23	10.01	4.35	36
UEC Total	32.61	19.07	19.30	9.19	48
Kissimmee Basin (KB)					
Okeechobee	1.30	1.01	1.50	1.01	100
Orange	91.50	58.99	134.02	58.98	100
Osceola	28.35	20.08	54.27	20.03	100
Polk	1.40	1.18	1.14	1.18	100
KB Total	122.55	81.26	190.93	81.20	100
District Totals	1,071.39	823.40	417.45	232.57	28
State Totals	2,297.89	1,611.18	1,325.06	659.67	41

a. Data obtained from FDEP 2005 Reuse Inventory.
b. Reuse Flow divided by WWTF Flow times 100.

Observations made in the Southwest Florida Water Management District (SWFWMD) indicate that, before efficiency standards were implemented, when a customer switches from potable water to reclaimed water for irrigation, the volume used for irrigation is as much as four times greater than observed for potable water. This is due to the cost differential between the two sources, and the fact that there is often no additional cost to the customer for using greater amounts. Overwatering carries fertilizers, pesticides and herbicides off-site and results in more frequent applications of these materials.

The installation of meters and the implementation of volume-based rate structures are two ways to curtail excessive use of reclaimed water. Studies done by the SWFWMD (SWFWMD 2002a) have concluded that simply providing meters can reduce the residential use of reclaimed water by about 50 percent.

Utilities implementing metering will incur increased costs associated with the purchase of the meters and for routine reading of the meters. These costs are typically recovered from the utility's customers as part of their rates for reclaimed water service.

A volume-based rate structure assesses a charge for the water in proportion to the amount of water used. Since customers are billed for reclaimed water actually used, volume-based rates discourage overuse and waste of this water resource. Metering of reclaimed water use is needed to implement volume-based reclaimed water rates. The SWFWMD gathered information from 14 reclaimed water systems in the Tampa Bay Area to determine the average amount of reclaimed water used by single-family residential irrigation customers. The data reveal that metered, single-family residential customers use an average of 534 gallons per day (GPD) of reclaimed water. The average amount of reclaimed water used by unmetered, flat-rate single-family residential customers was 980 GPD, almost double the amount of comparable metered customers. The data also reveal that the amount of potable-quality water offset by both the metered and the unmetered was approximately 300 GPD; therefore, the metered customers are approximately 56 percent efficient (based on potable quality water offset), while the unmetered, flat-rate customers are only 30 percent efficient (SWFWMD 2002b). Reuse systems show that with unmetered, flat-rate customers, systems can be severely limited in developing a customer base to full potential due to overuse of the reclaimed water by a flat-rate structure.

Water Meter

In addition to volume-based rate structures as a means of system management and conservation, there are several means of promoting water conservation in reclaimed water systems. Most of these follow methods employed by potable water systems. In June 2003, the Reuse Coordinating Committee, consisting of members of the FDEP, five water management districts and other state agencies, collaborated on a report entitled, *Water Reuse for Florida – Strategies for Effective Use of Reclaimed Water* (Reuse Coordinating Committee 2003). This report provides a list of options for improving efficient use of water in reclaimed systems. Supported methods include development of storage and supplemental sources, education programs, water audits of irrigation systems, ordinances on irrigation system efficiencies, and encouragement of aquifer recharge and indirect potable reuse.

Reclaimed Water Estimated Costs

The costs associated with implementation of a reuse program vary depending on the size of the reclamation facility, facility equipment needed, extent of the reclaimed water transmission system and 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, reducing fertilization costs for the end user. Costs of several items listed previously are contained in this chapter and **Chapter 5** of this document.

Seawater

Seawater as a water source option involves using seawater from the Atlantic Ocean or Gulf of Mexico as a raw water source. From a quantitative perspective, seawater appears to be an unlimited source of water. However, removal of salts is required before potable or irrigation uses are feasible. Seawater averages about 3.5 percent dissolved salts, most of which is sodium chloride, with lesser amounts of magnesium and calcium. To accomplish salt removal, a desalination treatment technology would have to be used, such as distillation, reverse osmosis (RO) or electrodialysis reversal (EDR). As with all surface waters, seawater is also vulnerable to discharges or spills of pollutants that can affect a water treatment system.

A 2001 feasibility study for co-locating seawater or brackish RO treatment facilities with electric power plants recommended a more detailed evaluation and cost analysis. As part of the 2005–2006 water supply planning process, it was concluded that seawater desalination is a potential alternative supply that merits future consideration. In December 2006, the District completed a feasibility study for co-locating seawater treatment facilities with once-through cooling power plants in south Florida (Metcalf & Eddy 2006). The study recommended three sites co-located with Florida Power & Light's (FPL) facilities in Fort Myers, Fort Lauderdale and Port Everglades.

Seawater Estimated Costs

The cost of seawater desalination can be several times the cost of brackish groundwater desalination due to higher salt content, intake facilities and concentrate disposal. The higher salt content reduces the efficiency of the treatment facility (less gallons of potable water are produced from water pumped) and results in increased concentrate/reject water disposal needs compared to brackish groundwater desalination. Cost information from seawater desalination studies shows that costs can be significant for seawater desalination. For example, in Singapore, a 36-MGD desalination plant was estimated to cost between $7.52 and $8.77 per thousand gallons. However, seawater treatment costs are declining due to improvements in membrane technologies and energy recovery research.

The cost of seawater desalination appears to be reduced when the desalination facility is co-located with power generating facilities that use seawater for cooling. There are many benefits of co-locating desalination facilities with electric power plants, and one benefit is sharing facility components. Cost savings are also associated with using the existing intake and discharge structures of the power plant to provide raw water to the desalination plant and to provide a means for concentrate disposal. It is possible to dispose of the desalination process concentrate by blending it with the power plant's cooling water discharge. Another significant advantage of using power plant cooling water as a source is that the temperature of the water is elevated, which reduces the pressure and associated energy needed to produce the product water.


Reverse Osmosis Plant

The wholesale cost for the desalinated water over the next 30 years is projected to average $2.49 per thousand gallons. Advances in membrane technologies have substantially reduced the cost of RO treatment, creating recent interest in the implementation of RO in the coastal United States, including Florida, Texas and California. The 25-MGD Tampa Bay Water RO plant, co-located with the Tampa Electric Company's Big Bend power plant, is undergoing pretreatment modifications and expected to start producing water shortly.

When considering costs for using seawater, the proximity to a major potable water transmission system or network must be considered. Depending on its location, it could be a considerable distance from the seawater treatment facility to a major transmission main to get the treated water into the distribution system. In most areas of the SFWMD, these coastal areas are very urbanized.

Storage

Storage is an essential component of any supply system experiencing variability in the availability of supply. With 60 percent to 75 percent of the 50-plus inches of average rainfall occurring during the rainy season, storage is required to keep this water in the system instead of discharging it to tide. The three major types of potential storage options are aquifer storage and recovery (ASR), regional and local retention, and reservoirs.

Aquifer Storage and Recovery

Aquifer storage and recovery (ASR) is the underground storage of storm water, surface water or reclaimed water, which is appropriately treated to potable standards and injected into an aquifer through wells during wet periods. The aquifer (typically the Floridan Aquifer System in south Florida) acts as an underground reservoir for the injected water, reducing water loss to evaporation. The water is stored with the intent to later recover the water for treatment and reuse in the future during dry periods. Current regulations require injected water to meet drinking water standards when the receiving aquifer is classified as an Underground Source of Drinking Water (USDW) aquifer, unless an aquifer exemption is obtained from the U.S. Environmental Protection Agency (USEPA). Obtaining an aquifer exemption is a rigorous process and few have been approved. However, the USEPA has indicated that a flexible assessment approach will be applied for systems that meet all drinking water standards, except fecal coliform.

Aquifer Storage and Recovery System

The volume of water that could be made available through ASR wells depends on several local factors, such as well yield, water availability, variability in water supply and variability in demand. Due to insufficient data, it is currently not feasible to estimate the water that could be available through ASR. Typical storage volumes for individual wells range from 10 million gallons to 500 million gallons, or 31 acre-feet to 1,535 acre-feet (Pyne 1995). Where appropriate, multiple ASR wells could be operated as a wellfield, with the capacity determined from the recharge and/or recovery periods. There are potentially many different applications of ASR; however, all applications store sufficient volumes (adequate volumes to meet the desired need) during times when water is available and then recover water from the same well(s) when needed. The storage time is usually seasonal, but can also be diurnal, long-term or for emergencies. The volume of water that could be made available by any specific user must be determined through the District's Consumptive Use Permitting (CUP) Program.

To better understand the variables associated with potential pathogen survival in surface water and groundwater used for ASR, the Fate of Microorganisms in Aquifers Study was conducted by the SFWMD and SWFWMD. The final report entitled, *Survival of Fecal Indicator Bacteria, Bacteriophage and Protozoa in Florida's Surface and Ground Waters – Potential Implications for Aquifer Storage and Recover* (John 2004), documents the findings of this study. The results of this report clarifies some of the potential impacts of surface water injection to aquifers, and should help water managers make informed decisions about the future direction of aquifer storage and recovery.

The District has several wells with an operations permit using treated drinking water or partially treated surface water. There were numerous ASR wells under operational testing or construction. In addition to these utility uses, the SFWMD, in cooperation with the U.S. Army Corps of Engineers (USACE), is pursuing regional ASR systems as part of the Comprehensive Everglades Restoration Plan (CERP). More than 300 ASR wells are proposed as part of the CERP, and most of these are planned around Lake Okeechobee.

Treated Water ASR

Treated water ASR involves using potable water as the injection water. Since potable water meets the drinking water standards, this type of ASR application is more easily permitted. There are many examples in Florida of utilities using treated water ASR, including several in the SFWMD. These include Collier County, Lee County and the City of Boynton Beach utilities.

Raw Water or Partially Treated ASR

Raw water or partially treated ASR involves using groundwater from freshwater aquifers or surface water. Some treatment may be needed prior to injection to meet the appropriate standards. Raw water or partially treated ASR is usually discussed in combination with surface water storage, such as a reservoir or canal system. The reservoir or canal system would capture excess surface water and provide sufficient volumes of water for the ASR injection cycle. In lieu of withdrawing surface water directly from a surface water body, potential projects may involve installation of vertical and/or horizontal wells, and use of the soil matrix between the water body and well intake for filtration, sometimes referred to as bank filtration. This type of ASR could be used as a source of water for potable needs, a supplemental source to reclaimed water or for environmental purposes.

Reclaimed Water ASR

Reclaimed water ASR involves using reclaimed water as the injection water. Several communities in Florida are interested in reclaimed water ASR and are investigating the feasibility of such a system. In 2002, two utilities in the SWFWMD initiated operational testing of ASR systems using reclaimed water. Some modifications to treatment systems or installations of additional treatment components may be needed to meet applicable standards.

Aquifer Storage and Recovery Estimated Costs

Estimated costs for an ASR system depend on the type of the ASR system. Estimated costs for a 2-MGD potable water ASR system and a 5-MGD surface water ASR system are provided in **Table 10**. For a 2-MGD drinking water ASR system, the total construction cost is estimated at $990,000 and an annual operation and maintenance cost of $83,300. This equates to a cost of about $0.44 per thousand gallons. For a 5-MGD surface water ASR system, the total construction cost is estimated at $6.54 million and an annual operation and maintenance cost of $364,781. This equates to a cost of about $1.05 per thousand gallons.

Table 10. Aquifer Storage and Recovery Estimates.

Plant Capacity (MGD)	Construction Cost	Non-Construction Costs	Land & Acq. Cost	Annual O & M Cost	Equivalent Annual Cost	Cost ($/1,000 gal)
Potable Water ASR						
2	$800,000	$160,000	$0	$80,000	$134,885	$0.54
Surface Water ASR						
5	$4,150,000	$830,000	$0	$360,000	$644,718	$1.02

Source: Email from Robert Verrastro, Lead Hydrogeologist, SFWMD, October 5, 2006.

The potable water cost information assumes the ASR well will be located at the water treatment plant site and have a 70 percent recovery rate. The surface water ASR cost information assumes the ASR facilities will be located at a remote site, with microfiltration treatment of the water being injected, and a 70 percent recovery rate.

Drainage Wells – Kissimmee Basin

Drainage wells are injection wells and are regulated under the same guidelines as ASR wells; however, the function and costs associated with these wells are different. Like ASR wells, a drainage well's function is to store surface water that is captured in the underground aquifer system. Unlike ASR wells, however, there is no extraction operation associated with these wells. The advantage of the storage function is to recharge the aquifer, benefiting multiple wells.

The metro-Orlando area is the only location in the District where drainage wells exist. An estimated 350 to 400 wells are known. The majority of these wells were installed about 40 years ago to assist in controlling lake levels. The wells generally receive storm water discharged to lakes, but there are wells that take water directly from street runoff. With these wells, the potential for aquifer system contamination is a concern. It is estimated that as much as 20 inches per year of recharge may be due to drainage wells in the Orlando area.

The costs associated with drainage wells are similar to those of normal production wells, except there are no energy costs. The permitting of these wells is similar to that of ASR wells and requires approval from the FDEP. Recently, however, the potential water quality problems associated with these wells have escalated. Thus, the number of drainage wells permitted has dropped dramatically. Consideration of this option would include a lengthy permitting effort to document risks associated with direct injection to the freshwater aquifer.

Regional and Local Retention

Regional and local retention is an opportunity to increase water storage in watersheds through the manipulation and modification of the drainage system serving that area, while still maintaining an appropriate level of flood protection. As described earlier in this document, much of the SFWMD's region was drained to support urban and agricultural development. This has resulted in lowered groundwater tables that may affect natural systems, as well as water availability in these areas. In some areas of the SFWMD, increased water retention in canal systems has increased groundwater levels, thereby reducing the frequency of irrigation.

This water supply option includes structural and operational changes that allow the capture of additional runoff water to be held in the secondary canal systems. A portion of the water captured in the secondary canal systems will come from excess water in the primary canal system, in addition to water captured within the secondary system itself. This option will also foster the use of this water by allowing appropriate reductions in water levels before water is obtained from regional sources to replenish water in the secondary canal systems. One benefit of this option is to stabilize the salt front by holding higher surface water and groundwater levels in coastal areas, thereby minimizing saltwater intrusion. Higher groundwater levels should also help to recharge wellfields and decrease the impact of water shortages. Modifying secondary canal operations will improve local water use and recharge, and will help to reduce the need to bring water in from regional sources. When considering higher water levels, the potential impacts on flood protection must also be addressed.

Reservoirs

Reservoirs involve the capture and storage of excess surface water during rainy periods and subsequent release during drier periods for environmental and human uses. The capture of excess surface water runoff and groundwater seepage from canals and rivers, 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 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, seepage losses, and the high evaporation rates of surface water bodies.

L-8 Reservoir Near C-51 Canal

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

Costs associated with two types of reservoirs are depicted in **Table 11**. The first is a minor facility with pumping inflow structures and levees designed to handle a maximum water depth of 4 feet. It also has internal levees and infrastructure to control internal flows and discharges. The second type, shown as follows, is a major facility with similar infrastructure as the minor facility. However, the water design depths for this facility range from 10 feet to 12 feet. Costs increase significantly for construction of higher levees, but these costs can be somewhat offset by reduced land requirements. Increased land cost could significantly increase cost.

Table 11. Surface Water Storage Costs.

Reservoir Type		COST			
		Construction $/Acre-feet	**Engineering $/Acre-feet**	**Construction Management $/Acre-feet**	**Land $/Acre**
Minor Reservoir/STA	Range	424–6,612	78–1,074	30–786	3,666–24,690
	Average	2,799	470	393	13,295
Major Reservoir	Range	421–4,223	29–565	63–745	2,702–32,533
	Average	1,671	140	292	14,188

Note: All costs were obtained from the latest "Master Implementation Sequencing (MISP) Plan Version 1.0" or the MISP developed as part of the P3E schedule of the CERP Project Implementation Reports.

Surface Water

Surface water can be considered a water supply source option. Surface water bodies that could be used for water supply include lakes, rivers and canals. Several potential sources of surface water have been identified in each planning area that could be considered to meet future demands. Most of these potential sources convey water from inland areas and discharge to estuarine systems along the coast, or discharge from the Kissimmee River into Lake Okeechobee. The volume of surface water that could be considered available from these sources for human uses would be the volume over what is needed for environmental purposes. Water would usually be available during the wet season from these sources, but limited during the dry season. Minimum flows and levels have been established for some water bodies, which have to be considered when determining water availability from surface water. Likewise, water reservations (see **Chapter 4**) must be considered when determining surface water availability.

Surface Water Estimated Costs

Estimates of costs for the installation of these facilities are provided in **Table 12**. For the purposes of the estimate, a pump rated at 60,000 gallons per minute (GPM) is assumed.

Table 12. Pump Installation and Operating Costs.

Pump Type	Engineering/ Design Cost	Construction Costs	Operation and Maintenance Cost
Electric	$50,000	3–4 million[a]	$60/hr
Diesel	$50,000	$1.5–3 million	$40/hr

a. Does not include cost of installing electrical power to site.

Stormwater Reuse

Stormwater reuse is defined as the collection of stormwater runoff from urban areas and should be distinguished from runoff collection from agricultural land, which is addressed under surface water storage. The stormwater use option is thought to be most applicable to landscape irrigation practices on a localized scale. A common application of stormwater use is the use of man-made lakes to supplement golf course irrigation demands and residential landscaping. The costs associated with these types of uses are considered to be nominally above those for the groundwater alternative they would replace.

Utility Interconnections

Interconnection of treated and/or raw water distribution systems is an option typically limited for the purposes of providing backup water service in the event of disruption of a water service. This operation, although currently employed by many utilities, is thought of as a means to address local or temporary service shortfalls. Regional implementation of a utility interconnection system could be employed as a supply management tool. The purpose of implementing this alternative would be to shift withdrawals from areas deemed to be at highest risk for adverse impacts to areas where the withdrawals are projected to have less impact. This would be completed through bulk purchase of raw or treated water from neighboring utilities in lieu of expanding an existing withdrawal and/or treatment plant.

A detailed study of distribution systems proposed for interconnection would need to be conducted to address system pressures, physical layout of the supply mains, impacts on fire flows and compatibility of the waters, among other items. Most existing water distribution systems are constructed with the smallest diameter pipes (low volume) at its extremities. As a result, utility interconnects for the purposes of bulk transfers of water could involve connecting more than two distribution systems. This would require extension of larger water mains within the service area to extremities and connecting to similar pipes in the adjoining service area.

Utility Interconnection Estimated Costs

The costs associated with public water system interconnects are difficult to estimate and could vary greatly depending on the size, distance and potential engineering challenges. Typically, an interconnect system includes transmission mains, valves, jack and bores, encasements, and tunneling. Transmission mains are primarily made from ductile iron pipe and prestressed concrete cylinder pipe, typically varying in size from 12 inches to 60 inches in diameter.

The cost of transmission mains is provided in **Table 13**. Costs vary with diameter and length of the transmission main. These costs do not include the cost of land and right-of-way requirements or the cost of jack and bores, valves, and other appurtenances. **Table 14** presents the combined costs of transmission mains, valves, and jack and bores. The combined costs assume valves would be installed approximately every mile along the pipeline, and jack and bores would occur approximately every 5 miles.

Table 13. Transmission Main Costs.

Pipe Size (in-dia)	Construction Costs ($/ft)	Nonconstruction Costs ($/ft)	Total ($/ft)
12	$39	$18	$57
16	$55	$25	$80
20	$71	$32	$102
24	$87	$39	$126
30	$110	$49	$159
36	$134	$60	$194
42	$158	$71	$228
48	$203	$91	$294
54	$241	$108	$349
60	$277	$125	$402

Source: St. Johns River Water Management District, 1997 Updated with Projected 2005 Construction Cost Index.

Table 14. Total Transmission Main Costs.

Pipe Size (in-dia)	Construction Costs ($/ft)	Nonconstruction Costs ($/ft)	Total ($/ft)
12	$42	$19	$60
16	$58	$26	$84
20	$77	$35	$111
24	$95	$43	$137
30	$121	$54	$175
36	$149	$67	$216
42	$175	$79	$254
48	$224	$101	$325
54	$266	$120	$385
60	$307	$138	$446

Source: St. Johns River Water Management District 1997 updated with Projected 2005 Construction Cost Index.

Water Conservation is Everyone's Responsibility.

4

Water Supply Regulation

Chapters 187, 373 and 403, Florida Statutes (F.S.), provide the legal authority and requirements for water supply planning. The primary regulatory tools related to water supply and uses of water are contained in Chapter 373, F.S. These tools include the Water Protection and Sustainability Program, consumptive use permitting, water reservations, minimum flows and levels, water shortage declarations, resource protection standards, water conservation measures, and the Conserve Florida Program for public water supply.

WATER PROTECTION AND SUSTAINABILITY PROGRAM

During the State of Florida's 2005 legislative session, lawmakers established a new "pay-as-you-grow" plan—a growth management strategy ensuring the roads, schools and water needed to support Florida's growing communities are in place, or planned for, ahead of time. Lawmakers revised state water law and created the Water Resource Protection and Sustainability Program, which requires a higher level of water supply planning coordination between water management districts and local governments. Section 403.890, F.S., details the intent, goals and purpose of the Water Resource Protection and Sustainability Program.

The new statutory provision strengthens the link between regional water supply plans and the potable water provisions of a local government's comprehensive plan. This portion of the law is designed to ensure that adequate potable water facilities are constructed and concurrently available with new development. All local governments within the South Florida Water Management District (SFWMD or District) are required to prepare 10-Year Water Supply Facilities Work Plans that identify water supply projects, and adopt revisions to comprehensive plans within 18 months following the approval of an updated regional water supply plan.

The alternative water supply portion of the Water Resource Protection and Sustainability Program is intended to reduce competition between users and natural systems for available water by encouraging the development of alternative water supplies. Section 373.1961(3), F.S., describes the funding of alternative water supply projects through the Water Protection and Sustainability Program

Trust Fund, which provides annual state revenues and matching District funds to support alternative water supply development. This combination of state and District funds is specifically for cost-sharing alternative water supply project construction costs.

Applicants for projects eligible to receive funding assistance pursuant to the Water Protection and Sustainability Program are required to pay 60 percent of the project's construction costs. In addition, the governing boards of the water management districts determine the projects to be selected for financial assistance, and may establish factors to determine project funding, while giving significant weight to the factors listed in Subsection 373.1961(3)(f), F.S. The program also adds permitting incentives for water providers selecting projects recommended by the water supply plans.

CONSUMPTIVE USE PERMITTING

The SFWMD's Consumptive Use Permitting (CUP) Program protects the supply and quality of groundwater and surface water resources by ensuring water use is reasonable, beneficial and consistent with the public interest, and does not interfere with existing legal uses. Consumptive use permits are issued by the water management districts pursuant to Part II of Chapter 373, F.S.

> Section 373.217(2), Florida Statutes (F.S.): It is the further intent of the Legislature that Part II of the Florida Water Resources Act of 1972, as amended, as set forth in s. 373.203-373.249, shall provide the exclusive authority for requiring permits for the consumptive use of water and for authorizing transportation thereof pursuant to s. 373.223(2).

The legislation has expressly repealed any other provision, limitation or restriction of the state, any political subdivision or municipality dealing with the regulation of the consumptive use of water, with the exception of the *Florida Electrical Power Plant Siting Act.* (Section 373.217, F.S., *et seq.*)

All water withdrawals within the SFWMD require a District water use permit except: 1) water used in a single-family dwelling or duplex, provided the water is obtained from one well for each single-family dwelling or duplex, 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.

To obtain a consumptive use permit, the permit applicant must provide reasonable assurances the use is "reasonable-beneficial," will not interfere with any presently existing legal use of water, and is consistent with the public interest, pursuant to Section 373.223, F.S.

> Section 373.019(13), F.S.: "Reasonable-beneficial use" means the 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.

The SFWMD implements this test pursuant to rules adopted in Chapter 40E-2 and Chapter 40E-20, Florida Administrative Code (F.A.C.). Permits are conditioned to assure uses are consistent with the overall objectives of Chapter 373, F.S., and are not harmful to the water resources of the area, under Section 373.219, F.S. Conditions for issuance of a consumptive use permit address several issues, including saltwater intrusion; wetland protection; pollution; impacts to off-site land uses; use of reclaimed water; interference with existing legal uses; and, minimum flows and levels. In addition, the rules require consideration of relevant portions of the State Water Resource Implementation Rule (Chapter 62-40, F.A.C.) adopted by the Florida Department of Environmental Protection (FDEP) as part of the reasonable-beneficial use test.

The *Basis of Review for Water Use Permit Applications* (SFWMD 2003a), which is incorporated by reference into Chapters 40E-2 and 40E-20, F.A.C., specifies the general procedures and information used by District staff for reviewing water use permit applications. All criteria in the *Basis of Review for Water Use Permit Applications* apply to processing individual permit applications, and specified criteria apply to processing general permit notices of intent.

> Rule 40E-5.011(1), Florida Administrative Code (F.A.C.): This Chapter implements Section 373.106, F.S., which authorizes the District to issue permits for projects involving artificial recharge or the intentional introduction of water into any underground formation, except activities under Chapter 377, F.S. Projects that inject waters into aquifers that contain a total dissolved solids concentration greater than 10,000 milligrams per liter (mg/L) or for the purpose of disposal are not regulated under this Chapter.

In 2003, the SFWMD significantly amended Chapters 40E-2, 40E-20 and 40E-5, F.A.C., and the *Basis of Review for Water Use Permit Applications*. These rule changes went into effect September 1, 2003. In addition, procedures for processing water use permit applications are set forth in Rules 40E-1.603 and 40E-1.606, F.A.C. Rule 40E-1.610, F.A.C., provides procedures for permit renewals and Rule 40E-1.6107, F.A.C., sets forth procedures for permit transfers.

Under Florida law, a consumptive use permit provides the permittee with the right to use water consistent with the conditions of the permit for the duration of the permit. Prior to permit expiration, the permittee must obtain a renewal of the permit in order to continue the water use. Water is consumed for many purposes, including golf course, landscape and agricultural irrigation use; public water supply; and, commercial and industrial uses. District rules classify permits into these separate use classifications.

Existing legal uses of water must meet the conditions for issuance of a permit during a 1-in-10 year drought condition, known as the level of certainty. Level of certainty is a concept providing a probability of certainty that given a specific drought event (up to a 1-in-10 year drought event), demands for reasonable-beneficial uses of water will be fully met. Certainty also means that the water resource from which the water is withdrawn will be evaluated to assure no harm will occur during this drought event. The result is not a guarantee that droughts will not occur, but rather that legal users of the natural environment understand that during normal climatic times, water will be available and the resource protected from harm. The level of certainty planning criteria have been incorporated into the consumptive water use process and the Florida Statutes. The level of certainty planning goal established by the Florida Legislature is the 1-in-10 year drought event provided in Subsection 373.0361(2)(a)1, F.S.

The SFWMD's irrigation permit basin expiration dates have been adjusted to stagger the permits within the four areas of the District to ensure the appropriate rules are in place to implement the applicable regional water supply plans and to ensure the permits can be processed for renewal in an integrated cumulative manner. Specific basin expiration dates are set forth in the *Basis of Review for Water Use Permit Applications*. If the basin boundaries overlap, the District will assign a basin that best reflects the resource issues. For those permits with split basins, the rule provides that a request may be made for the permit application to be reviewed concurrently with other water use applications in the same irrigation permit basin. Applications for permit renewals are to be made six months prior to the basin expiration dates.

Pursuant to Section 373.233, F.S., applications are considered to be competing when the proposed use of water by two or more applicants are in conflict, or will exceed the amount of water available for consumptive use due to water resource availability.

REGIONAL WATER AVAILABILITY RULE

Several state and federal laws regarding implementation of the CERP require the SFWMD to protect water necessary for the restoration of the Everglades. In 2003, along with the B-List rulemaking process, a permit duration rule was adopted, which identified the Central and Southern Flood Control Project (C&SF Project) and dependent groundwater sources as a "source of limited availability." This meant that only historically used demand would receive a 20-year duration at permit renewal, and increases over that amount would only be authorized for a five-year period. This short duration was specifically implemented to reassess whether the CERP was going forward as planned, or whether growth was occurring as planned.

In April 2006, the SFWMD Governing Board authorized District staff to initiate the development of a rule to limit increased reliance on the Everglades system and dependent groundwater sources, which had previously been identified as a source of limited availability. This rulemaking effort also addressed withdrawals requiring increased water from the Loxahatchee River Watershed water bodies. The District subsequently held five rounds of workshops and issued five rule drafts in response to comments from stakeholders, prior to finalizing the draft.

In February 2007, the SFWMD Governing Board authorized the adoption of the Regional Water Availability Rule. This rule limits allocations on permit renewal or modification to conditions or pumpage, depending on the specific use class, that existed prior to April 1, 2006, known as the "base condition water use." The rule only allows allocations over the "base condition water use" if additional impacts to the Everglades are avoided through alternative source development, or eliminated through the implementation of offsets (recharge barriers, recharge trenches), or terminated or reduced water uses that existed as of April 1, 2006. Wet-season water can also be allocated if the permit applicant demonstrates that such flows are not needed for restoration of the Everglades pursuant to the CERP, Acceler8 or the *Northern Palm Beach County Water Management Plan* (for the Loxahatchee River Watershed water bodies) (SFWMD 2002).

The net result of these changes is a need for some local governments to develop alternative sources for part or all of their future water supply. These sources must not directly or indirectly impact the Everglades or conflict with restoration projects. An alternative source could be brackish water from the Floridan Aquifer, which is treated with reverse osmosis (RO) to create potable water. Another alternative source could provide highly treated reclaimed water or storm water to recharge canals or aquifers in such a manner as to meet a 1-in-10 year level of certainty, thus offsetting potential impacts to the Everglades from new groundwater withdrawals.

Water Resource Protection Standards

Harm, serious harm and significant harm standards are defined in Rule 40E-8.021, F.A.C., and apply throughout the District's consumptive use permit rules. The definitions are as follows:

> Harm – means the temporary loss of water resource functions, as defined for consumptive use permitting in Chapter 40E-2, F.A.C., which results from a change in surface or ground water hydrology and takes a period of one to two years of average rainfall conditions to recover.

> Significant Harm – means the temporary loss of water resource functions, which result from a change in surface or ground water hydrology, that takes more than two years to recover, but which is considered less severe than serious harm. The specific water resource functions addressed by a MFL and the duration of the recovery period associated with significant harm are defined for each priority water body based on the MFL technical support document.
>
> Serious Harm – means the long-term loss of water resource functions, as addressed in Chapters 40E-21 and 40E-22, F.A.C., resulting from a change in surface or ground water hydrology.

The conceptual relationship among the harm, serious harm and significant harm standards is illustrated in **Figure 6**.

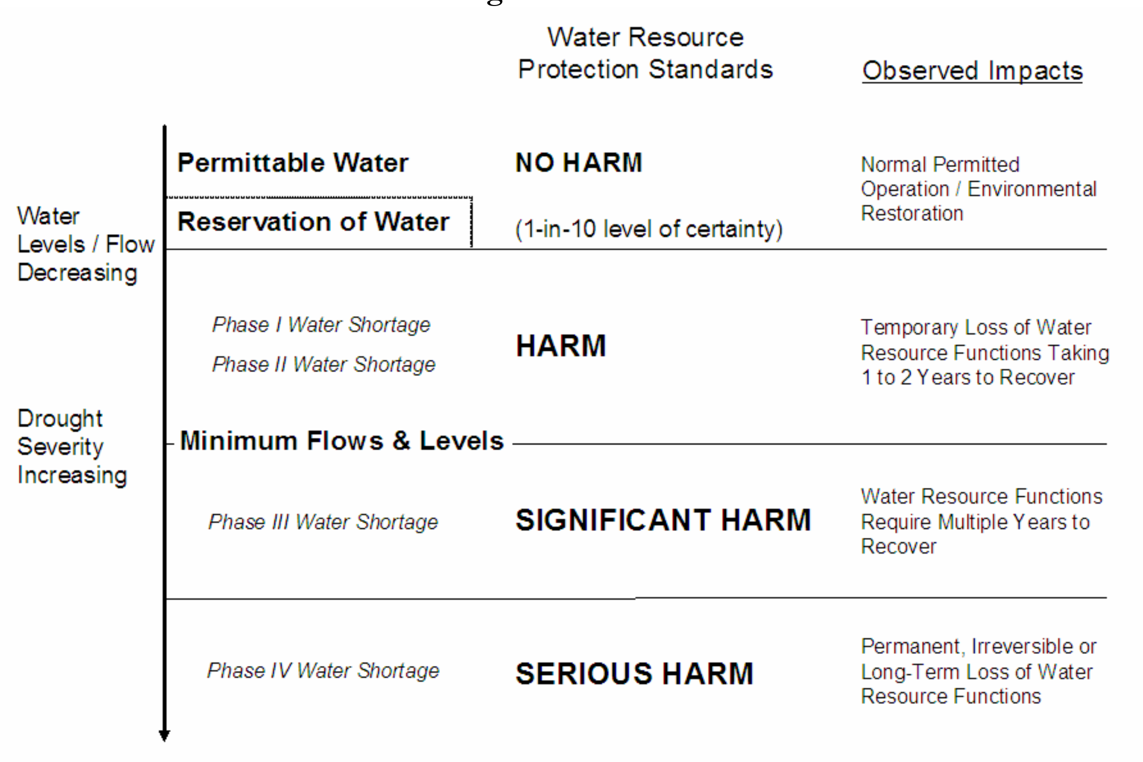


Figure 6. Conceptual Relationship Among the Harm, Serious Harm and Significant Harm Standards.

Wetland Protection Standards

Wetland protection standards and thresholds have been established in Section 3.3 of the *Basis of Review for Water Use Permit Applications* to protect wetlands and other surface waters from harm caused by consumptive use withdrawals of water. This rule was based on analysis of wetland monitoring data.

WATER RESERVATIONS

District staff recommends the Governing Board initiate rule development for initial reservations of water for the Everglades system within the District, pursuant to Section 373.223(4), F.S. Water reservations are rules that set aside quantities of water in specified locations and seasons of the year as may be required for the protection of fish and wildlife, or public health and safety. By adopting a reservation rule, the reserved water is not available for consumptive uses and is protected under the District's water shortage plan. Under Florida law, permitted uses and domestic water uses (which are exempt from requirements to obtain a permit) have the legal status of an "existing legal use." All presently existing legal uses of water shall be protected so long as such use is not contrary to the public interest.

Red-shouldered Hawk

There are two types of water reservations being developed by the SFWMD. The first is an *initial water reservation*. Development of initial reservations focuses on determining the volume, duration and timing of existing flows required to protect fish and wildlife resources. The first drafts of initial water reservation criteria for the Northwest Fork of the Loxahatchee River and the Caloosahatchee Estuary are expected by the end of 2007. The technical approach and methodology for establishing initial water reservations for the Everglades will be reassessed after completion of the Regional Water Availability Rule in 2007.

The second type of water reservation, known as a *project reservation*, will be used in the implementation of CERP-related projects. Project reservations determine the appropriate quantity, timing and distribution of water that is generated by individual CERP projects for the protection of fish and wildlife. Project reservations protect water anticipated to be available in the future through implementation of a project for the protection of fish and wildlife. The water is reserved in advance, ensuring that when a project is completed, those quantities remain available for the protection of fish and wildlife, or public health and safety. A methodology to identify water for the natural system made available for restoration is being drafted under the federal CERP process and is expected to be finalized in 2007.

MINIMUM FLOWS AND LEVELS

The SFWMD is responsible for the implementation of statutory provisions in Section 373.042, F.S., requiring establishment of Minimum Flows and Levels (MFLs) for watercourses and aquifers. Generally stated, the MFLs for a given watercourse or aquifer are the limit at which further withdrawals would be significantly harmful to the water resources of the area provided in Section 373.042, F.S. Significant harm is the temporary loss of water resource functions, which result from a change in surface water or groundwater hydrology, and takes more than two years to recover, as set forth in Rule 40E-8.021, F.A.C. Certain exclusions and considerations for establishing MFLs, including defining significant harm for a specific water body, are contained in Section 373.0421, F.S. Recovery and prevention strategies must be developed if there are existing or projected shortfalls in meeting the MFL, as provided in Section 373.0421, F.S.

Minimum flow and level standards for specific water bodies and aquifers within the SFWMD are contained in Chapter 40E-8, F.A.C., which also includes recovery and prevention strategies for each MFL. Currently, MFLs have been established for Lake Okeechobee; the Everglades (Water Conservation Areas, Everglades National Park, and Rotenberger and Holey Land wildlife management areas); the northern Biscayne Aquifer within the Lower East Coast (LEC) Planning Area; the confined aquifers in the Lower West Coast (LWC) Planning Area; the Caloosahatchee River; the Northwest Fork of the Loxahatchee River; the St. Lucie River; Lake Istokpoga; and, Florida Bay.

The SFWMD updates its Priority Water Body List annually, stating the water bodies and schedules for establishing MFLs, pursuant to Section 373.042, F.S.

In addition to the standards and recovery and prevention strategies, specific CUP criteria for MFLs are adopted in Chapter 40E-2, F.A.C., and water shortage criteria for specific MFL regions, if needed, are adopted in Chapters 40E-21 and 40E-22, F.A.C.

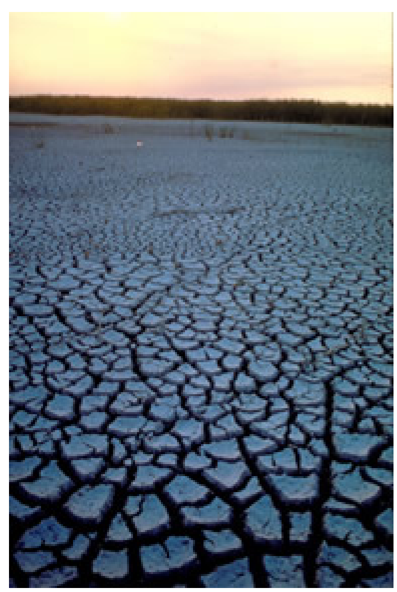
The CUP rules require, as a condition for permit issuance, that an applicant provide reasonable assurances the use of water will meet established minimum flows and levels and implementation provisions provided in Rule 40E-2.301(1)(i), F.A.C. The basic premise underlying these rules is the requirement that the use be consistent with the applicable recovery or prevention strategy. The MFL implementation rule for CUP in Section 3.9.1 of the *Basis of Review for Water Use Permit Applications* has separate criteria for requests for permit renewals and requests for new or modified permits. Two categories of impact criteria are also identified for direct withdrawals from the MFL water body and for indirect withdrawals from a MFL water body. Direct withdrawals are those that directly pump from a MFL water body, or cause more than a 0.1 foot of drawdown from the groundwater source under the MFL water body. Indirect withdrawals are those that indirectly influence water levels or flows within the MFL water body (Rule 40E-8.021, F.A.C.). This provides a link to the applicable regional water supply plan where the MFL water body is located and to the associated water resource development projects designed to help recover or prevent violation of the MFL.

MAXIMUM DEVELOPABLE LIMITS

The SFWMD adopted rules in 2003 for maximum developable limits (MDLs, Section 3.2.4 of the *Basis of Review for Water Use Permit Applications*) for the LWC Planning Area. The rule states that reasonable assurances shall be provided, and that the proposed use shall not cause harmful drawdowns to mine semi-confined freshwater aquifers in the LWC Planning Area. The potentiometric head within the Lower Tamiami, Sandstone and Mid-Hawthorn aquifers shall not be allowed to drop to less than 20 feet above the top of the uppermost geologic strata that comprises the aquifer at any point during a 1-in-10-year drought condition. These criteria must be met, except in areas closer than 50 feet from any existing pumping well. The MDL criteria represent a prevention strategy for keeping the Surficial and Intermediate aquifer systems confined aquifer levels above the MFL.

WATER SHORTAGE PLAN

Pursuant to Section 373.246, F.S., water shortage declarations are designed to prevent serious harm from occurring to water resources. Serious harm is defined by the SFWMD in Rule 40E-8.021, F.A.C., as long-term, irreversible or permanent impacts to the water resource. Declarations of water shortages by the Governing Board are used as a tool to assist in preventing serious harm to the water resources during droughts, while equitably distributing water resources for consumptive and nonconsumptive uses, as provided in Chapter 40E-21, F.A.C. Water shortage declarations are imposed in phases, increasing water use cutbacks as drought conditions become more severe.


Drought

The Water Shortage Plan (Sections 373.175 and 373.246, F.S.) is linked to MFL implementation pursuant to Chapter 40E-8, F.A.C. Water shortage cutbacks are not intended to be implemented as a recovery plan for meeting a

MFL; rather, cutbacks are intended for drought management purposes, as provided in Rule 40E-8.441, F.A.C. For drought conditions greater than a 1-in-10 year event, it may be necessary to decrease water withdrawals to help prevent water levels from declining to and below a level where significant harm to the resource could potentially occur. Minimum flows and levels are considered a factor in triggering intermediate phases of water shortage cutbacks. Water shortage triggers are water levels at which phased restrictions will be declared under the SFWMD's Water Shortage Plan. Other considerations associated with the implementation of the water shortage plan are set forth in Rule 40E-8.441(4), F.A.C., and Chapter 40E-21, F.A.C.

WATER CONSERVATION PROGRAM

The SFWMD's overall conservation goal is to prevent and reduce wasteful, uneconomical, impractical or unreasonable uses of water resources. During the 2004 session, the Florida Legislature made substantial revisions to Florida's laws concerning water conservation. Specifically, the revisions address the creation of a statewide, Comprehensive Water Conservation Program and development of landscape irrigation and Xeriscape™ design standards. Chapters 367, 373, 403 and 570 of the Florida Statutes provide the specific legislative authority on the statewide, Comprehensive Water Conservation Program.

Section 373.227, F.S., creates a Comprehensive Water Conservation Program targeting public water supply utilities. The Legislature finds that conditions throughout Florida relating to the use of water for public supply vary, and that utilities must have flexibility to tailor water conservation measures to best suit individual circumstances. To accomplish water conservation objectives in this regard, the Legislature directs the state to emphasize "…goal-based, accountable, tailored and measurable water conservation programs for public water supply."

The SFWMD consumptive use permitting rules require planning and implementation of water conservation measures by public water supply utilities (and associated local governments), commercial/industrial users, landscape and golf course users, and agricultural users. All permit applicants for a potable public water supply permit must submit a water conservation plan, as discussed in **Chapter 3**.

Rulemaking efforts are under way at the SFWMD to consider goal-based conservation as a permit condition. Workshops are being held concerning revisions to Chapter 40E-2, F.A.C., and the *Basis of Review for Water Use Permit Applications* that would require individual water utilities to develop goal-based conservation programs. Goal-based conservation allows utilities to achieve a water management district agreed-upon conservation goal, such as reduction in per capita or overall reduction in pumpage, using any method from a suite of methods the utilities chooses, to satisfy CUP conservation requirements.

The Legislature also created Section 373.228, F.S., concerning development of landscape irrigation and Xeriscape™ design standards. The Legislature's intent is to improve landscape irrigation water use efficiency by ensuring irrigation systems meet or exceed minimum design criteria. These model guidelines are to be developed by numerous agencies and stakeholders and used by local governments when developing landscape irrigation and Xeriscape™ ordinances.

Chapter 40E-24, F.A.C., imposes mandatory, year-round landscape irrigation measures for Lee and Collier counties and the portion of Charlotte County in the SFWMD. These measures prohibit landscape irrigation during those periods of the day when irrigation efficiency significantly decreases, and limit landscape irrigation water use to a maximum number of three days per week unless specified otherwise.

Florida State Capitol Buildings

Chapter 373 of the Florida Statutes provides the primary regulatory tools for water supply and uses of water.

5

Water Quality and Treatment

Water quality standards must be met for different types of water 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 surface water and groundwater quality.

WATER QUALITY STANDARDS

Drinking Water Standards

There are two types of drinking water standards, primary and secondary. Both of these standards establish maximum contaminant levels (MCLs) for public drinking water systems. Primary drinking water standards include contaminants that can pose health hazards when present in excess of the MCL. Secondary drinking water standards, commonly referred to as aesthetic standards, are those parameters that may impart an objectionable appearance, odor or taste to water, but are not necessarily health hazards. Current MCLs for drinking water in Florida are available from the Florida Department of Environmental Protection (FDEP) Web site: http://www.floridadep.org.

Nonpotable Water Standards

Water for potable and nonpotable water uses have different water quality requirements and treatability constraints. Nonpotable water sources include surface water, groundwater 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 ornamental crops. Excessive iron must also be removed for use in microirrigation systems, which become clogged by iron precipitates.

Nonpotable water uses include golf course, landscape, agricultural and recreational irrigation. This water may also be acceptable for some industrial and commercial uses. For an irrigation water source to be considered for a specific use, there must be sufficient quantities of that water, at a quality 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, such as iron or calcium, which can damage the irrigation system infrastructure or equipment, must be absent or economically removable. Landscape, golf course or recreational irrigation water often has additional aesthetic requirements, such as color and odor. Water for industrial use is required to meet certain criteria, e.g., the suspended solids and salinity of the water cannot be so high as to build-up scales or sediments in the equipment.

In addition to water quality considerations associated with the intended use of nonpotable water, reclaimed water is subject to wastewater treatment standards ensuring the safety of its use. 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 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 source, should consider local factors, such as specific chemical properties, irrigated crops, climate and irrigation practices (Water Science and Technology Board 1996).

GROUNDWATER CONTAMINATION AND IMPACTS TO WATER SUPPLY

Groundwater Contamination Sources

The Surficial Aquifer System (SAS) is easily contaminated by activities occurring on the surface of the land. Once a contaminant enters the aquifer, it may be difficult to remove. In many cases, leaks, spills or discharges of contaminants spread over long periods, resulting in contamination of large areas of the aquifer. Therefore, the preferred method of addressing the issue of water supply contamination 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 regional planning areas.

Solid Waste Sites

Many of the older landfills and dumps were used for years with little or no control over what materials were disposed in them. Although most have not been active for some time, they may still be a potential threat to the groundwater resource. Groundwater monitoring began in the early 1980s for all the landfills.

Contaminants from landfills are 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 groundwater depend on several factors that dictate the extent and character of the resulting groundwater impacts, including:

- Landfill size and age.
- Types and quantities of wastes produced in the area.
- Local hydrogeology.
- Landfill design and landfilling techniques.

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

Hazardous Waste Sites

The FDEP Waste Management Division sponsors several programs that provide support for hazardous waste site cleanup. Not all the potential hazardous waste sites actually contain contamination. The potential hazardous waste sites include locations in the Early Detection Incentive Program, the Petroleum Liability and Restoration Program, the Abandoned Tank Restoration Program, the Petroleum Cleanup Participation Program, the Preapproved Advanced Cleanup Program and other programs. Locations and cleanup status can be obtained through the FDEP Waste Management Division. Current listings of hazardous waste sites are available from the FDEP Web site at: http://www.floridadep.org.

Superfund Program Sites

The *Comprehensive Environmental Response, Compensation and Liability Act of 1980*, commonly known as "Superfund," authorized the U.S. Environmental Protection Agency (USEPA) to identify and remediate uncontrolled or abandoned hazardous waste sites. The National Priorities List targets sites considered to have a high health and environmental risk. More information about the Superfund Program is available from the USEPA Web site at: http://www.epa.gov.

Petroleum Contaminant Sites

Sites are reported to the FDEP if contamination has been observed in the soil, surface water, groundwater or monitoring wells. For more information about the Petroleum Cleanup Program, please refer to the FDEP's Web site available from: http://www.floridadep.org.

Septic Tanks

Septic systems are a common method of on-site waste disposal. There are numerous septic tanks in the regional planning areas. Septic tanks may threaten groundwater resources used as drinking water sources, particularly older systems installed prior to regulatory separation requirements between the bottom of the tank's associated drain field and the top of the seasonal high water table.

Saltwater Intrusion

Saltwater intrusion along the coast of the planning areas has been advanced by canal excavation and aquifer development for public water supplies and agriculture. In some canals, 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 groundwater and surface water gradients are lowest.

Saltwater Intrusion Occurring in a Wetland

The South Florida Water Management District (SFWMD or District) maintains a saltwater intrusion database that collects information about 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 U.S. Geological Survey (USGS).

In addition to saltwater intrusion from coastal waters, overdevelopment of aquifers that overlie aquifers, which are more saline, increases the possibility of upconing and contamination from the poorer quality layers. This potential exists throughout the regional planning areas. Although upconing of saline water is not considered 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 System (FAS) wells in the regional planning areas. Numerous artesian wells were drilled into the FAS (central Okeechobee County and south) for agricultural water supply and oil exploration from the 1930s through the 1950s. Many of these wells were short-cased, meaning the casings extended to less than about 200 feet below land surface (bls), which exposed the shallower zones to invasion by the more saline Floridan water. Additionally, steel casings may have corroded, allowing interaquifer exchange through the casings. Often, if a well was abandoned, it was plugged improperly or simply left open, free flowing on the land surface and recharging the SAS 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, hundreds of known abandoned wells, including most of the known free-flowing wells, were plugged. Floridan wells are required by statute to be equipped with a valve capable of controlling the discharge from the well. These wells are the responsibility of the property owners where the well is located.

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 groundwater 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. 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 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 TREATMENT TECHNOLOGIES

Potable Water Treatment Facilities

Potable water in the SFWMD is supplied by three main types of treatment facilities: 1) regional public water supply, municipal or privately owned facilities; 2) small developer/homeowner association or utility owned public water supply treatment facilities; and, 3) self-supplied individual wells that serve individual residences. Many of the smaller facilities are constructed as interim facilities until regional potable water becomes available. Once regional water is available, the smaller water treatment facility is abandoned upon connection to the regional water system.

The FDEP regulates public water supply systems in the SFWMD. A public water supply system is defined as a system that provides water for human consumption, if the system has at least 15 service connections or regularly serves an average of at least 25 individuals daily, at least 60 days out of the year. In some counties, jurisdiction of smaller public water supply systems has been delegated to the local health department. The local health department regulates systems not regulated under the auspices of the FDEP [Chapter 62-550, Florida Administrative Code (F.A.C.)]. Several water treatment processes are currently employed by the regional water treatment facilities in the regional planning areas, including chlorination, lime softening and membrane processes. The FDEP regulates 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 processes and their associated costs.

Cost information is presented where rate information was available. Unless noted otherwise, cost information was obtained from the *Water Supply Needs and Sources Assessment: Alternative Water Supply Strategies Investigation, Water Supply and Wastewater Systems Component Cost Information* provided by the St. John's River Water Management District (SJRWMD 1997). The information was adjusted to 2005 dollars using a projected 2005 calibration cost index.

The *Draft Water Supply Cost Estimation Study*, which is expected to be completed in early 2007, will provide an updated evaluation of various water treatment technologies where applicable. When finalized, this cost study will be posted on the South Florida Water Management District's (SFWMD or District) Web site. However, given the rapidly rising costs of land and construction, these costs must not be viewed as a substitute for the detailed evaluation that should accompany utility-specific feasibility and design studies needed to assess and construct such facilities.

Over time, with the implementation and reporting of alternative water supply projects, and the information in the *Draft Water Supply Cost Estimation Study*, cost estimating relationships and curves for various water withdrawal facilities, technologies, by-product disposal methods, and surface storage and aquifer storage and recovery (ASR) systems can be updated and refined.

Disinfection

Disinfection, the process of inactivating disease-causing microorganisms, provides essential public health protection. All potable water requires disinfection as part of the treatment process prior to distribution. Disinfection methods include chlorination, ultraviolet (UV) radiation and ozonation.

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.

Chlorination

Chlorine is a common disinfectant used in the United States. The use of free chlorine as a disinfectant often results in the formation of unacceptable levels of Trihalomethanes (THMs) and other disinfectant by-products (DBP) when free chlorine combines with naturally occurring organic matter in the raw water source. Existing treatment processes are being modified to comply with changing water quality standards. Add-on treatment technologies that effectively remove these compounds or prevent their formation include ozone disinfection, granular activated carbon (GAC), enhanced coagulation, membrane systems, and switching from chlorine to chlorine dioxide (Hoffbuhr 1998).

The primary disinfectant used within the SFWMD is chlorine dioxide or chlorine used with ammonia to form chloramine. The rate of disinfection depends on the concentration and form of available chlorine residual, time of contact, 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.

Chlorination Costs

The costs associated with a chlorination system are presented in **Table 15**. The construction costs include equipment and installation, and the operation and maintenance costs include energy, labor, chemical and normal maintenance.

Table 15. Estimated Costs for Chlorination.

Plant Capacity (MGD)	Construction Cost	Non-Construction Cost[a]	Land & Acq. Cost	Annual O & M Cost	Equivalent Annual Cost	Cost ($/1,000 gal)
1	$74,423	$33,490	$0	$16,577	$26,763	$0.07
5	$114,719	$51,624	$0	$48,290	$63,991	$0.04
10	$192,033	$86,415	$0	$87,381	$113,664	$0.03
20	$346,500	$155,925	$0	$165,564	$212,988	$0.03

a. Nonconstruction costs include design, engineering and management.
Source: St. Johns River Water Management District 1997 updated with a Projected 2005 Construction Cost Index.

Ultraviolet Light

The ultraviolet (UV) light disinfection process does not use chemicals. Microorganisms, including bacteria, viruses and algae, are inactivated within seconds of radiation with UV light.

The UV disinfection process takes place as water flows through an irradiation chamber. Microorganisms in the water are inactivated when the UV light is absorbed. A photochemical effect is created and vital processes are stopped within the cells, thus making the microorganisms harmless. Ultraviolet light inactivates microbes by damaging their nucleic acid, thereby preventing the microbe from replicating. When a microbe cannot replicate, it is incapable of infecting a host.

Ultraviolet light is effective in inactivating *Cryptosporidium*, while at the same time decreasing chlorinated disinfection by-products. One major advantage of UV light disinfection is that it is capable of disinfecting water faster than chlorine, and without the need for retention tanks or potentially harmful chemicals (AWWA 2003).

Ozonation

Ozonation is a water disinfection method that uses the same kind ozone found in the atmosphere. By adding ozone to the water supply and then sending an electric charge through the water, water suppliers inactivate disease-causing microbes, including *Giardia* and *Cryptosporidium*. Contact times required for disinfection by ozone are short (seconds to several minutes) when compared to the longer disinfection time required by chlorine. Ozonation is also an effective way to alleviate most of a water supply's taste and odor issues (AWWA 2003).

Ozonation is widely used in Western Europe. In the United States, ozonation has had limited use by community water suppliers in California, Colorado, Michigan, Maine, New Jersey, Oklahoma, Pennsylvania, Texas, Wisconsin and Wyoming. Because of the massive amount of electricity needed for treatment, the cost of ozonation is approximately four times higher than that of traditional chlorine disinfection. Unlike chlorine, ozone dissipates quickly in water supplies. The disadvantage of this technology is that contaminants entering an ozonated water supply after treatment are unaffected. Ozonation does not produce the disinfection by-products associated with chlorine disinfection.

Aeration

Aeration is a water treatment process used to improve water quality. In this process, air and water are brought into intimate contact with each other to transfer volatile substances to or from the water. Aeration in water treatment is used primarily to:

- Reduce the concentration of taste- and odor-causing substances and, to a limited extent, to oxidize organic matter.
- Remove substances that may in some way interfere with, or add to, the cost of subsequent water treatment. A prime example is removal of carbon dioxide from water before lime softening.
- Add oxygen to water, primarily for oxidation of iron and manganese, so they may be removed by further treatment.
- Remove radon gas.
- Remove volatile organic chemicals (VOCs) considered hazardous to public health.

Aeration Processes

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 is not widely used 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 costs associated with an aeration system are presented in **Table 16**. The construction costs include the equipment and installation costs of the aeration unit. These costs do not include the cost of pumping and storage units.

Table 16. Estimated Costs for Aeration.

Plant Capacity (MGD)	Construction Cost	Non-Construction Cost	Land & Acq. Cost	Annual O & M Cost	Equivalent Annual Cost	Cost ($/1,000 gal)
1	$93,254	$41,964	$0	$4,561	$17,324	$0.05
5	$354,661	$159,597	$0	$7,205	$55,746	$0.03
10	$503,540	$226,593	$0	$12,837	$81,754	$0.02
20	$641,792	$288,807	$0	$22,528	$110,367	$0.02

Source: St. Johns River Water Management District 1997 updated with a Projected 2005 Construction Cost Index.

Coagulation, Flocculation and Sedimentation

Coagulation, flocculation, sedimentation and filtration are combined in a series to remove particles from water. Coagulation, flocculation and sedimentation are used to remove suspended material and color, and may be used as a pretreatment for other processes or technologies, such as reverse osmosis.

Coagulation is the process of combining small particles into larger aggregates. During coagulation, a chemical, such as alum (aluminum sulfate), is added to the raw water. When the water is stirred, the alum forms sticky globs or flocs that attach to small particles composed of bacteria, silt and other contaminants. The water is kept in a settling tank or basin where the flocs sink to the bottom. This prolonged phase of purification is called flocculation and sedimentation. Rapid filters are then used to retain most of the flocs and other particles that escape the chemical coagulation and sedimentation processes.

Costs

Cost estimates for coagulation, flocculation and sedimentation are presented in **Table 17**. The construction costs include treatment components, such as the rapid mix, flocculation basin, sedimentation basin and filters, and the costs associated with the other integral treatment plant components.

Table 17. Estimated Costs for Coagulation, Flocculation and Sedimentation.

Plant Capacity (MGD)	Construction Cost	Non-Construction Cost	Land & Acq. Cost	Annual O & M Cost	Equivalent Annual Cost	Cost ($/1,000 gal)
1	$2,410,380	$1,084,671	$250,000	$126,440	$471,025	$1.29
5	$7,129,080	$3,208,086	$375,000	$632,199	$1,629,955	$0.89
10	$11,394,810	$5,127,665	$562,500	$1,264,399	$2,857,002	$0.78
20	$19,000,800	$8,550,360	$1,062,500	$2,528,797	$5,191,773	$0.71

Source: St. Johns River Water Management District, 1997 Updated with a Projected 2005 Construction Cost Index.

Filtration

Filtration systems are used in water treatment to remove particulate matter from the water supply.

Filtration Processes

Filtration involves the passing of water through layers of sand, coal and other granular material to remove microorganisms, including viruses, bacteria and protozoans, such as *Cryptosporidium*. Filtration attempts to mimic the natural filtration of water as it moves through the ground. After the water is filtered, it is treated with chemical disinfectants, such as chlorine, to kill any organisms that might have made it through the filtration process. The most common filtration methods are rapid filtration, slow sand filtration, activated carbon filtration and membrane filtration.

Rapid filters are deep beds of sand, anthracite and sand, or granular activated carbon. The particle size of the medium is usually about 1 millimeter (mm). The filters are operated at flow velocities of about 15 feet to 50 feet per hour. Rapid sand filtration typically follows settling basins in conventional water treatment units.

Slow sand filtration is a biological treatment process. Typically, a slow sand filter has a depth of about 2 feet and is operated at flow rates of 0.3 feet to 1.0 feet per hour. The vital process in slow sand filtration is the formation of a biologically active layer, called the Schmutzdecke, in the top 20 mm of the sand bed. This layer provides an effective surface filtration of very small particles, including bacteria, parasites and viruses. Any particles that pass through the Schmutzdecke may be retained in the remaining depth of the sand bed by the same mechanisms that exist in rapid filtration.

Active carbon filters are used predominantly to remove organic compounds that impart taste and odor to the water. However, they may also affect counts of microbial organisms, including reduction of viruses and parasites.

In membrane filtration, water is passed through a thin film of semipermeable membrane, which retains contaminants according to their size. For microbial removal, the most commonly used membrane processes in drinking water treatment are microfiltration, ultrafiltration, nanofiltration and reverse osmosis.

Filtration Costs

The costs associated with conventional filtration systems, such as rapid sand and slow sand filters, are presented in **Table 18**.

Table 18. Estimated Costs for Filtration.

Plant Capacity (MGD)	Construction Cost	Non-Construction Cost	Land & Acq. Cost	Annual O & M Cost	Equivalent Annual Cost	Cost ($/1,000 gal)
1	$719,382	$323,722	$12,500	$3,493	$102,686	$0.28
5	$1,065,957	$479,681	$25,000	$11,577	$158,938	$0.09
10	$2,364,132	$1,063,859	$40,000	$21,738	$347,656	$0.10
20	$3,800,004	$1,710,002	$78,750	$40,073	$564,789	$0.08

Source: St. Johns River Water Management District 1997 updated with a Projected 2005 Construction Cost Index.

Lime Softening

Lime softening refers to the addition of lime (calcium hydroxide) 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. The lime softening process is effective at reducing hardness, but is relatively ineffective at controlling contaminants, such as chlorides, nitrates, Total Trihalomethanes (TTHM) precursors and others (Hamann *et al.* 1990). Therefore, disinfectants may be added at several places during the treatment process. To achieve better disinfection efficiency, the disinfectant is added after the lime softening process.

Lime softening is ineffective at 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 to avoid possible exceedance of the standard in the treated water.

The lime softening process does not effectively remove nitrates either. Lime softening facilities with raw water sources and nitrate concentrations exceeding the MCL will probably require additional treatment.

Safe Drinking Water Act (SDWA) regulations for TTHMs and DBPs are changing, resulting in the need for many existing lime softening facilities to modify their treatment processes to comply with the standards for these groups of compounds. With increasing parameters and more stringent MCLs, many utilities are using membrane water treatment processes.

Limestone Softening Costs

Cost estimates for lime softening are presented in **Table 19**. The construction costs include the lime softening treatment components, such as the head tank, aerator, clarifier, recarbonation vessel and filter, and the costs associated with the other integral treatment plant components.

Table 19. Estimated Costs for Lime Softening.

Plant Capacity (MGD)	Construction Cost	Non-Construction Cost	Land & Acq. Cost	Annual O & M Cost	Equivalent Annual Cost	Cost ($/1,000 gal)
1	$2,415,126	$1,086,807	$250,000	$156,793	$502,028	$1.38
5	$6,207,743	$2,793,484	$375,000	$783,966	$1,655,623	$0.91
10	$9,683,226	$4,357,452	$562,500	$1,567,933	$2,926,279	$0.80
20	$15,373,835	$6,918,226	$1,062,500	$3,135,865	$5,302,435	$0.73

Source: St. Johns River Water Management District 1997 updated with a Projected 2005 Construction Cost Index.

Membrane Processes

Membrane technology has continued to improve as more stringent water quality regulations are adopted by the USEPA. Membrane processes can remove dissolved salts, organic materials that react with chlorine DBP precursors, and 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.

Reverse Osmosis Process

Reverse osmosis (RO) is a pressure-driven process that relies on forcing water molecules (feedwater) through a semipermeable membrane to produce fresh water (product water). Heavy metals, dissolved salts and compounds, such as leads and nitrates, are unable to pass through the membrane and are left behind to be disposed of as concentrate or reject water. Reverse osmosis is capable of treating feedwaters containing up to 45,000 milligrams per liter (mg/L) of TDS. Most RO applications involve brackish feedwaters with TDS concentrations ranging from 1,000 to 10,000 mg/L. Transmembrane operating pressures vary considerably depending on the TDS concentration (**Table 20**). 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 determines the level of rejection of a membrane.

Table 20. Reverse Osmosis Operating Pressure Ranges.

System	Transmembrane Pressure Operating Range (psi)	Feedwater TDS Range (mg/L)	Recovery Rates (%)
High pressure	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.

Advantages of RO treatment systems include the 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 and maintenance costs, requirements for pretreatment and posttreatment systems, high corrosivity of the product water, and disposal of the reject. Reverse osmosis is also less efficient than the other filtration processes in terms of recovery rates, 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 and reuse. Whether a disposal alternative is allowable depends on the characteristics of the reject water and disposal site.

A 2001 feasibility study for co-locating seawater or brackish RO treatment facilities with electric power plants recommended a more detailed evaluation and cost analysis. As part of the 2005–2006 water supply planning process, it was concluded that seawater desalination is a potential alternative supply that merits future consideration. In December 2006, the District completed a feasibility study for co-locating seawater treatment facilities with once-through cooling power plants in south Florida (Metcalf & Eddy 2006). The study recommended three sites co-located with Florida Power & Light's (FPL) facilities in Fort Myers, Fort Lauderdale and Port Everglades.

Reverse Osmosis Costs

Advances in membrane technologies have substantially reduced the cost of RO treatment. At this time, water cost data for seawater desalination facilities range from \$2.49/1,000 gallons for the 25-million gallons per day (MGD) Tampa Bay Seawater Desalination Plant to \$8.77/1,000 gallons for water from the new 36-MGD facility in the country of Singapore.

Table 21 shows estimated costs for RO. The RO costs include those associated with the process and deep well disposal of the brine. The costs presented are for general reverse osmosis. Site-specific concentrate disposal and raw water variations can significantly affect the cost estimates. **Table 22** shows the estimated costs of a seawater desalination system with an operating range between 800 and 1,200 psi. The costs include the water intake system, desalination plant, storage units, pumping and transmission systems and brine disposal.

Table 21. Estimated Costs for Reverse Osmosis.

Plant Capacity (MGD)	Construction Cost	Non-Construction Cost	Land & Acq. Cost	Annual O & M Cost	Equivalent Annual Cost	Cost (\$/1,000 gal)
3	\$8,694,000	\$3,912,300	\$125,000	\$1,158,948	\$2,356,200	\$2.15
5	\$12,537,000	\$5,641,650	\$250,000	\$1,839,600	\$3,570,170	\$1.96
10	\$23,058,000	\$10,376,100	\$437,500	\$3,541,230	\$6,722,778	\$1.84
20	\$42,840,000	\$19,278,000	\$875,000	\$5,794,740	\$11,709,464	\$1.60

Source: St. Johns River Water Management District 1997 updated with a Projected 2005 Construction Cost Index.

Table 22. Estimated Costs for a Seawater Desalination System.

Plant Capacity (MGD)	Construction Cost	Non-Construction Cost	Land & Acq. Cost	Annual O & M Cost	Cost (\$/1,000 gal)
5	\$31,117,822	\$14,159,958	\$348,750	\$3,151,041	\$3.93
10	\$64,301,226	\$24,458,254	\$781,451	\$4,547,339	\$3.14
15	\$91,632,809	\$32,940,471	\$348,750	\$7,658,079	\$3.11
20	\$127,115,674	\$43,952,394	\$925,685	\$7,864,749	\$2.78
30	\$184,840,967	\$61,867,141	\$925,685	\$11,332,213	\$2.63

Source: St. Johns River Water Management District 1997 updated with a Projected 2005 Construction Cost Index.

Membrane Softening and Nanofiltration

Membrane softening or nanofiltration is an emerging technology in Florida. Membrane softening differs from standard RO systems in that the membrane has a higher molecular weight cutover, lower operating pressures and feedwater 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.

Nanofiltration is a diffusion-controlled membrane filtration process using nominal pore size and high operating pressure. These systems can remove virtually all cysts, bacteria, viruses, synthetic and organic compounds, and humic materials. Nanofiltration membranes are also called softening membranes because they remove hardness from the water.

Given the direction of increasing federal and state regulation of drinking water quality, membrane softening or nanofiltration seems to be a viable treatment option toward meeting future standards.

Ultrafiltration

Ultrafiltration is a pressure-driven process that removes nonionic matter, higher molecular weight substances and 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 involving the movement of ions through anion and cation-selective membranes from a less concentrated solution to a more concentrated solution driven by an 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. The ED and EDR processes are useful in desalting brackish water with TDS concentrations of up to 10,000 mg/L. However, ED/EDR is generally not considered an efficient and cost-effective organic removal process, and therefore is usually not considered for TTHM precursor removal applications (AWWA 1988).

Distillation

The distillation treatment process is based on evaporation. Salt water is boiled and the dissolved salts, which are nonvolatile, remain behind. The water vapor is cooled and condensed into fresh water. Three distinct treatment processes are in use: multistage flash distillation, multiple effect distillation and vapor compression.

In the multistage flash (MSF) process, saline feedwater is heated and the pressure is lowered, causing the water to boil rapidly, almost exploding or flashing into steam. This process constitutes one stage. Typically, a MSF plant can contain a series of up to 40 or more stages, set at increasingly lower pressures. The steam generated by flashing at each stage is converted to fresh water by being condensed on tubes of heat exchangers that run through each stage.

In multiple effect distillation, there are a number of evaporation stages in series. The vapor generated in one stage is condensed in the following stage, where it can be used as a thermal source for evaporation. The series of evaporation-condensation processes constitutes an effect. This continues for several effects, with eight or 16 effects being found in a typical large plant. The vapor resulting from the last stage is condensed into fresh water.

The vapor compression distillation process is generally used for small- and medium-scale plants. The heat for evaporating the water comes from the compression of vapor rather than the direct exchange of heat from steam produced in a boiler.

WASTEWATER TREATMENT TECHNOLOGIES

Wastewater Treatment Facilities

Wastewater treatment in the SFWMD is provided by: 1) regional, municipal or privately owned wastewater treatment facilities; 2) small developer/homeowner association or utility owned wastewater treatment facilities; and, 3) 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. Wastewater treatment is regulated by the FDEP for all facilities in the District. 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 gallons per day (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.).

All the FDEP regulated facilities within the District use the activated sludge treatment process. The methods of reclaimed water/effluent disposal include surface water discharge, reuse and deep well injection.

Wastewater treatment facilities are composed of several processes, which are integrated to treat wastewater to a desired quality. At a minimum, wastewater facilities in Florida provide secondary treatment. These facilities typically dispose of their effluent via deep injection wells or ocean outfalls. As these facilities find beneficial uses for this treated water, higher levels of treatment are required to meet the required water quality. For example, treatment facilities that use reclaimed water for public access irrigation must provide filtration and high-level disinfection (advanced secondary treatment). This section will discuss some of the treatment processes to produce higher quality reclaimed water.

Advanced Secondary Treatment

Advanced secondary treatment typically refers to the addition of filtration and high-level disinfection to a secondary treatment facility. Water from these facilities is usually drawn on for reuse via irrigation of public access areas.

Filtration

Filtration is a common component of advanced secondary wastewater treatment, which provides a higher quality effluent that can be used as reclaimed water. Filtration is required of all reclaimed water used for public access irrigation. The costs associated with a gravity dual-media filter are presented in **Table 23**. The construction costs include all equipment, material and installation, and the operation and maintenance costs include all energy, labor and other maintenance.

Table 23. Estimated Costs for Secondary Wastewater Filtration.

Plant Capacity (MGD)	Construction Cost	Non-Construction Cost	Land & Acq. Cost	Annual O & M Cost	Equivalent Annual Cost	Cost ($/1,000 gal)
1	$1,036,714	$466,521	$12,500	$7,139	$149,764	$0.41
5	$2,780,710	$1,251,320	$25,000	$25,301	$407,353	$0.22
10	$4,592,088	$2,066,439	$40,000	$47,021	$677,869	$0.19
20	$6,574,476	$2,958,514	$78,750	$86,571	$991,016	$0.14

Source: St. Johns River Water Management District 1997 updated with a Projected 2005 Construction Cost Index.

High-Level Disinfection

The purpose of disinfection is to kill pathogenic microorganisms in wastewater before it is discharged into the environment. To achieve high-level disinfection in an advanced secondary treatment process, monitoring and chemical feed equipment also need to be included.

The costs associated with the construction of an upgraded disinfection system are provided in **Table 24**. The construction costs include the equipment and installation, and the operation and maintenance costs include energy, labor, chemicals and normal maintenance.

Table 24. Estimated Costs for High-Level Disinfection.

Plant Capacity (MGD)	Construction Cost	Non-Construction Cost	Land & Acq. Cost	Annual O & M Cost	Equivalent Annual Cost	Cost ($/1,000 gal)
1	$169,548	$76,297	$0	$22,075	$45,280	$0.12
5	$309,828	$139,422	$0	$87,381	$129,786	$0.07
10	$438,253	$197,214	$0	$160,965	$220,947	$0.06
20	$651,598	$293,219	$0	$312,732	$401,913	$0.06

Source: St. Johns River Water Management District 1997 updated with a Projected 2005 Construction Cost Index.

Advanced Wastewater Treatment

Advanced wastewater treatment involves the upgrade of an existing wastewater treatment facility from advanced secondary treatment to advanced wastewater treatment to achieve dentritification and phosphorus removal. In the past, advanced wastewater treatment has been associated with facilities that use stream discharge for effluent disposal. However, advanced wastewater treatment is being employed to allow use of reclaimed water for wetland restoration, groundwater recharge systems and other advanced uses of reclaimed water. **Table 25** presents the costs associated with upgrading the treatment from advanced secondary to advanced wastewater treatment, including high-level disinfection. The costs include deep bed filters, the addition of methanol and alum to remove nitrogen and phosphorus from the wastewater, and high-level disinfection components.

Table 25. Estimated Costs for Advanced Wastewater Treatment.

Plant Capacity (MGD)	Construction Cost	Non-Construction Cost	Land & Acq. Cost	Annual O & M Cost	Equivalent Annual Cost	Cost ($/1,000 gal)
1	$1,429,548	$643,297	$0	$137,970	$333,626	$0.91
5	$6,609,828	$2,974,422	$0	$689,850	$1,594,507	$0.87
10	$13,038,253	$5,867,214	$0	$1,379,700	$3,164,187	$0.87
20	$25,851,598	$11,633,219	$0	$2,759,400	$6,297,592	$0.86

Source: St. Johns River Water Management District 1997 updated with a Projected 2005 Construction Cost Index.

6

Kissimmee Basin Planning Area

PLAN BOUNDARIES

In the South Florida Water Management District (SFWMD or District), the Kissimmee Basin (KB) Planning Area extends from southern Orange County, through the Kissimmee Chain of Lakes and the Kissimmee River, to the north shore of Lake Okeechobee. The area includes portions of Orange, Osceola, Polk, Highlands, Okeechobee and Glades counties, as shown in **Figure 1**. The portions of these counties within the KB Planning Area will be referred to as the Orange Area, Osceola Area, Polk Area, Highlands Area, Okeechobee Area and Glades Area in this document. The boundary of the KB Planning Area generally reflects the drainage basin of the Kissimmee River. The northern and eastern portions of the planning basin are adjacent to the St. Johns River Water Management District (SJRWMD), while the western boundary is adjacent to the Southwest Florida Water Management District (SWFWMD).

PHYSICAL FEATURES

Geography and Climate

The KB Planning Area encompasses 3,490 square miles and has an average elevation of 63 feet. In the Northern KB Planning Area, the Kissimmee Chain of Lakes is the dominant hydrologic feature, containing 176 square miles of lakes. The drainage area of the Upper Kissimmee Basin covers 1,368 square miles and the southern portions of the metro-Orlando area. The Lower Kissimmee Basin, below Lake Kissimmee, has less topographic relief and is drained by the Kissimmee River. The lower river system (Lower Kissimmee Basin) spans 2,109 square miles, of which 44 square miles are lakes [SFWMD geographic information system (GIS) data]. Included in this lower portion of the planning region is the Lake Istokpoga/Indian Prairie Basin.

Average seasonal temperatures range from 60° F during the winter to 83° F during the summer. Annual average rainfall in the KB Planning Area ranges between 46 and 50 inches. Rainfall is further discussed in the planning and appendices documents.

Physiography

The KB Planning Area has three major physiographic zones: 1) the Lake Wales Ridge, 2) the Osceola Plain and 3) the Okeechobee Plain. The Lake Wales Ridge traverses the western edge of the KB Planning Area and is bounded on the east by the Osceola and Okeechobee plains. In general, the physiographic features in the region were formed as the land mass gradually emerged from a retreating sea.

The Lake Wales Ridge is a relict beach ridge with elevations generally exceeding 100 feet, but may reach elevations over 200 feet National Geodetic Vertical Datum (NGVD) in portions of western Orange and Osceola counties and in eastern Polk County. The crest of the ridge forms the water divide between the SFWMD and the SWFWMD. Most of the surface waters to the east of the ridge drain toward the Kissimmee River and the SFWMD. Lakes located along the ridge are generally internally drained, leaking downward into the Intermediate and Floridan aquifer systems.

Kissimmee Basin

Most of the KB Planning Area lies within the Osceola Plain, which is named after Osceola County. The Osceola Plain is a broad flat area about 40 miles wide and 100 miles long. The highest elevation of the Osceola Plain is between 90 feet and 95 feet near the southern portion of Orlando. Elsewhere it is between 60 feet and 70 feet in elevation with small local relief. The Osceola Plain narrows toward the southeast where it meets the northeastern edge of the Okeechobee Plain.

The Osceola Plain has numerous lakes, including some of the largest lakes in Florida. Little research has been conducted on the geomorphology of the lakes. Most of the area's natural lakes probably originated as sinkholes when sea level was much lower than it is today. Sinkholes are common in areas underlain by limestone, which is soluble in water. The larger lakes may have formed over a long period through the coalescence of a large number of sinkholes.

These lakes drain into the Kissimmee River, which begins at the southern end of Lake Hatchineha and runs southward through Lake Kissimmee, and then south through the Osceola and Okeechobee plains, before flowing into Lake Okeechobee. Where the Kissimmee River flows across the Osceola Plain, it occupies a floodplain valley about a mile and a half wide. However, where the river flows in the Okeechobee Plain, the distinction between the valley and upland surface is obscure.

The Okeechobee Plain, named after Okeechobee County and the adjacent Lake Okeechobee, gradually slopes southward from an elevation of 30 feet to 40 feet near the top of its boundary, to about 20 feet at the north shore of Lake Okeechobee. The plain is about 30 miles wide and 30 miles long, with less local relief than the Osceola Plain.

WATER RESOURCES AND SYSTEM OVERVIEW

Regional Hydrologic Cycle

The main components of the hydrologic cycle for the KB Planning Area include precipitation, evapotranspiration, and the resulting flow of surface water and groundwater. The interaction between surface water and groundwater is expressed as either recharge to or discharge from the aquifer system.

Precipitation and Evapotranspiration

The average rainfall in the KB Planning Area ranges from 46 inches to 50 inches per year. There is a wet season from June through October, and a dry season from November through May. On average, 64 percent of the annual rainfall occurs in the wet season. The heaviest rainfall occurs in June or July, averaging 7.75 inches for the month. The lightest rainfall month is usually November or December, averaging 1.75 inches for the month. Much of this rainfall is returned to the atmosphere by plant transpiration or evaporation from soils and water surfaces. Hydrologic and meteorological 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). Precipitation minus ET is equal to the combined amounts of surface water runoff and average groundwater recharge. Evapotranspiration in south Florida returns approximately 45 inches of water per year to the atmosphere.

Surface Water Inflow and Outflow

Surface water flow includes inflow from areas adjacent to the planning basin and rainfall within the basin, storage and outflow to Lake Okeechobee via the Kissimmee River. There are several primary surface water features providing surface water drainage for the KB Planning Area. Reedy Creek, Shingle Creek and Boggy Creek, located in the northernmost section of the basin, are the primary drainage features for Orange and northern Osceola counties. The Alligator and Kissimmee chain of lakes act as the primary features in northern Osceola County. All of these features eventually connect to the Kissimmee River, which is the primary drainage feature of the basin.

In general, rainfall within the basin is directed to one of the hydrologic features mentioned previously. There are, however, three sources of natural inflow from areas adjacent to the planning basin. These are Josephine and Arbuckle creeks, which flow into Lake Istokpoga, and surface water from the Horse Creek Basin, which flows into Lake Hatchineha via Lake Marion Creek. All of these inflows originate in areas located within the SWFWMD. A detailed discussion of the surface water basins can be found within the *2000 Kissimmee Basin Water Supply Plan* (2000 KB Plan) **Appendix C** (SFWMD 2000c).

In some areas in the Orlando metropolitan area, surface water drainage is directed toward drainage wells, which discharge directly to the Floridan Aquifer System. These wells, constructed up until the 1970s, are generally limited to closed drainage basins in the Orlando area. An inventory of these wells was completed in 2003, and 500 known drainage wells are located in central Florida. The wells are believed to provide a significant portion of the aquifer recharge in the Orlando area. Estimates of annual recharge to the aquifer, which were performed by the U.S. Geological Survey (USGS), range between 20 million gallons per day (MGD) and 30 MGD. The majority of these wells are in the SJRWMD, and may represent a potential water source option for the Orange–Osceola area.

Surface Water Resources

Kissimmee Basin

The Kissimmee Basin has undergone over a century of development for drainage, flood control and navigation. In 1884, the Atlantic and Gulf Coast Canal and Okeechobee Land Company dredged canals to connect Lake Tohopekaliga to Lake Okeechobee via Cypress, Hatchineha and Kissimmee lakes. The company also dredged another canal to connect Lake Okeechobee to the Gulf of Mexico through the Caloosahatchee River.

Major hurricanes swept across the state in 1926, 1928, 1945 and 1947. The storm of 1947 caused extensive flooding on the farms south of Lake Okeechobee, in southeast coastal cities and suburbs, and in the Kissimmee Basin. The flooding of 1947 prompted the U.S. Congress to authorize the U.S. Army Corps of Engineers (USACE) to design and construct the Central and Southern Florida Flood Control Project (C&SF Project). Construction of the C&SF Project in the Kissimmee Basin began in 1962 and was completed in 1971. This resulted in channelizing the 103-mile Kissimmee River into a 56-mile canal. In addition, the Kissimmee Chain of Lakes was connected, and structures were added to regulate water levels.

For the purposes of discussion, the KB Planning Area has been divided at the outlet of Lake Kissimmee (S-65 Structure) into upper and lower basins. The Upper Kissimmee Basin includes 17 subbasins, while the Lower Kissimmee Basin includes nine subbasins.

Upper Kissimmee Basin

The Upper Kissimmee Basin is dotted with hundreds of lakes, ranging in size from less than an acre to over 55 square miles (Lake Kissimmee). The surface water drainage includes a series of interconnected lakes in its northern portion, called the Kissimmee Chain of Lakes. Trout Lake near Alligator Lake forms the drainage divide of the chain of lakes, and water can be released either to the north or to the south from this point. Water flows north through several canals and smaller lakes to Lake Mary Jane; the flow proceeds through Lakes Hart, East Tohopekaliga and Tohopekaliga; and, then finally to Cypress Lake. Southward flow travels a shorter route through Lake Gentry and then to Cypress Lake. From Cypress Lake, water flows southward to Lake Hatchineha and then to Lake Kissimmee. Most of these lakes are shallow, with mean depths varying from 6 feet to 13 feet.

Kissimmee Chain of Lakes

The major streams feeding into the Kissimmee Chain of Lakes are Shingle Creek, Reedy Creek and Boggy Creek. The headwaters for these creeks are located in urbanized portions of metro-Orlando. Flow moves southward through wetlands into their respective lakes. Water levels in the Kissimmee Chain of Lakes are managed according to a fixed regulation schedule for each lake subbasin. Typically, the regulation schedules vary from high stages in the late fall and winter to low stages at the beginning of the wet season. The minimum levels are set to provide for sufficient flood control storage and navigation depths.

The headwaters of Shingle Creek form in the City of Orlando. The creek runs southward for 24 miles through Shingle Creek Swamp and the City of Kissimmee before discharging into Lake Tohopekaliga. Natural flow in Shingle Creek has been substantially modified by the channelization of 13 miles in the 1920s and subsequent transection by utility transmission lines and access roads. Discharges from the City of Orlando's McLeod Road Wastewater Treatment Plant were an estimated 11 MGD until flows were diverted to conservation in

1989. The District has an aggressive land purchase program in the Shingle Creek Basin in an attempt to restore portions of the channelized creek. In the 1980s, the District targeted for acquisition 7,600 acres of swamp and adjacent uplands within the Shingle Creek Watershed as a Save Our Rivers Project. The District acquired and manages the 1,750-acre area known as the Shingle Creek Management Area. The *Shingle Creek Management Area Five-Year General Management Plan (2005–2010)*, which provides additional information, (SFWMD 2005), is available from: http://www.sfwmd.gov.

Reedy Creek in Osceola County represents the least disturbed of the three major creeks. Originating in Walt Disney World, Reedy Creek runs southeast for 29 miles before splitting into two branches near Cypress Lake. One branch enters Cypress Lake and the other enters Lake Hatchineha. During most of its course, the creek flows through Reedy Creek Swamp. The Reedy Creek also receives water from the Butler Chain of Lakes during periods of high lake levels. Boggy Creek has two main branches: east and west. The East Branch, which is 12 miles in length, is the main watercourse of Boggy Creek. The headwaters of this branch form in the City of Orlando northwest of Orlando International Airport. The East Branch runs through Boggy Creek Swamp before emptying into East Lake Tohopekaliga. The headwaters of the West Branch originate in another highly urbanized area of Orlando (Lake Jessamine). The West Branch flows to Boggy Creek Swamp.

Lower Kissimmee Basin

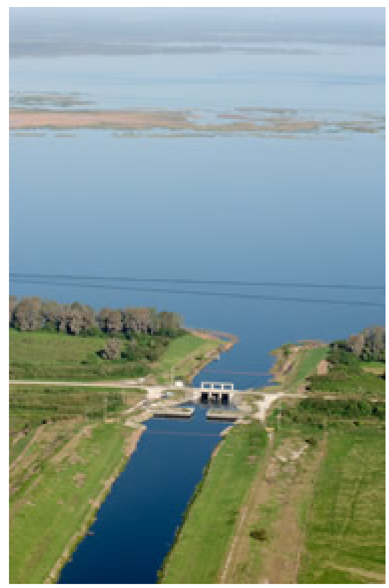
The Lower Kissimmee Basin includes the tributary watersheds of the Kissimmee River between the outlet of Lake Kissimmee (S-65 Structure) and Lake Okeechobee. The Kissimmee River and Lake Istokpoga are the major surface water features in the basin. Fisheating Creek and Taylor Creek/Nubbin Slough are prominent surface water features in the Southern KB Planning Area. Fisheating Creek marks the southernmost extent of the KB Planning Area and flows into Lake Okeechobee. Taylor Creek/Nubbin Slough is the site of one of the priority phosphorus removal projects identified as part of the Lake Okeechobee Surface Water Improvement and Management (SWIM) Plan and the Lake Okeechobee & Estuary Recovery (LOER) Plan. There are no known large uses of water from either creek.

The Kissimmee River was originally 103 miles in length until it was channelized in the 1960s into a 56-mile canal (C-38). The Kissimmee River is divided into five pools (pools A-E) by a series of combined locks and spillways. The water level in each of these pools is regulated according to a regulation schedule.

As a result of numerous studies on the channelization of the Kissimmee River and the associated impact on water quality, wetlands and the ecosystem, two restoration plans were developed that, when implemented together, will restore the ecological integrity of the Kissimmee Basin—the upper basin headwaters revitalization and the lower basin restoration of the Kissimmee River.

The ongoing Kissimmee River Restoration Project will backfill 22 miles of the C-38 Canal, directing flows through the historic river channel and restoring the ecological functions of the river/floodplain system. Backfilling began in the 1990s and will continue southward to the S-65D Structure. Information about the Kissimmee River Restoration effort can be found in **Chapter 2** of this document and on the SFWMD Web site available from: http://www.sfwmd.gov.

Lake Istokpoga, at 44 square miles, is the fifth-largest lake in Florida. The lake is connected to the Kissimmee River via the Istokpoga Canal and the C-41A Canal. The Istokpoga Canal consists of two reaches, one upstream and one downstream of the G-85 Structure. The Istokpoga Canal drains into the Kissimmee River approximately 1.5 miles upstream of the S-65C Structure, which is scheduled for removal as part of the Kissimmee River Restoration Project. The G-85 Structure controls the rate of flow in the Istokpoga Canal. The Istokpoga Canal is proposed for modification along with replacement of the G-85 Structure, which maintains the stage of Istokpoga Canal. The restoration project is expected to re-establish the historic hydrology of the river and floodplain in areas north of the S-65E Structure. As a result, water surface elevations in the lower reach of the Istokpoga Canal, downstream of the G-85 Structure, are expected to fluctuate seasonally.



Lake Istokpoga

The main outlet for Lake Istokpoga is S-68 Structure, which regulates discharges from the lake to the C-40, C-41 and C-41A canals. The C-41A Canal discharges into the Kissimmee River below the S-65E Structure, passing through two additional water control structures (S-83 and S-84). The C-41 and C-40 canals also assist in discharging water from Lake Istokpoga draining to Lake Okeechobee. The C-40, C-41 and C-41A canals and associated structures make it possible to regulate the stages of Lake Istokpoga for irrigation water supply. Tests performed by the USACE, the USGS and the SFWMD showed design deficiencies in the S-68, S-83 and S-84 structures. These structures are being enlarged to allow design discharges from the lake. The USACE, Jacksonville District, is responsible for design and construction of structure modifications.

Modifications to the S-68 Structure include adding a single bay spillway to be known as S-68A Structure, with construction expected to begin in Fiscal Year 2007. Construction is also planned for the G-85 replacement structure (S-67), with modifications to other structures to follow. This proposed project is expected to begin in Fiscal Year 2007.

Groundwater Resources

The hydrogeology of the Kissimmee Basin consists of three major hydrogeologic units: the Surficial Aquifer System (SAS), the intermediate confining unit and the Floridan Aquifer System (FAS), as shown in **Figure 7. Table 26** lists the groundwater systems, hydrogeologic units and relative aquifer yields of each county in the KB Planning Area.

The groundwater system in the Kissimmee Basin is readily accessible, with groundwater being the main source of water supply in central Florida, critical for aquatic habitats and human consumption. Virtually all of the water required to meet municipal, industrial and agricultural needs is pumped from the FAS.

The FAS consists of two distinct production zones, the Upper and Lower Floridan aquifers, separated by the less permeable middle semi-confining unit. As recently as 1995, about 81 percent of the total water withdrawn from the FAS was from the Upper Floridan Aquifer (UFA). However, with increasing water demands, the Lower Floridan Aquifer (LFA) is being used as a source of fresh water, particularly for municipal needs in Orange County.

Groundwater Flow

The components of groundwater flow in the KB Planning Area include groundwater inflow from the west; the difference between surface water inflow to and outflow from the KB Planning Area; and, groundwater discharge to the north, east and south.

Two aquifer systems underlie the KB Planning Area, the SAS and the FAS. The SAS is exposed at the land surface and is primarily recharged by rainfall. It interacts with surface water features, such as rivers, canals and lakes. The FAS is a deeper carbonate aquifer, which is overlain by a confining layer in most areas of the basin. This deeper aquifer is the primary supply source of groundwater for the basin. The FAS is recharged by groundwater inflow from outside the basin (west side) and recharge occurring in the Kissimmee Basin. Aquifer discharge generally occurs along the Kissimmee River and floodplain, and along the St. Johns River farther to the east. Portions of the FAS discharge eastward and southward into other planning areas of the District.

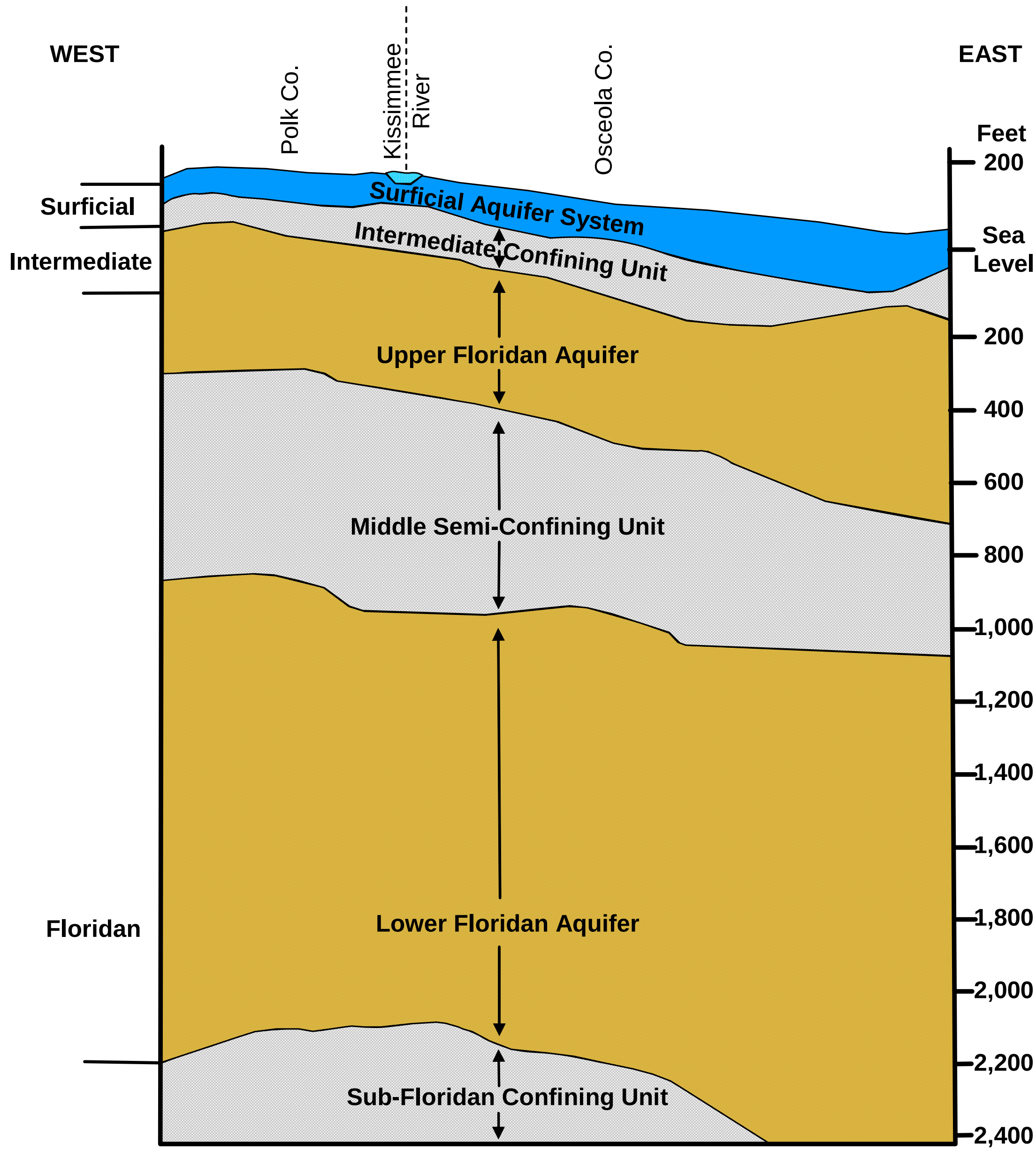


Figure 7. Generalized Geologic Cross-Section of the Kissimmee Basin Planning Area.

Table 26. Groundwater Systems in the Kissimmee Basin Planning Area.

Aquifer System		Hydrogeologic Unit	Aquifer Yield 1-Low 2-Moderate 3-High					
			Orange	Osceola	Polk	Highlands	Okeechobee	Glades
Surficial Aquifer System		Undifferentiated Clastic Deposits	2	2	2	2	2	2
Intermediate Aquifer System		Hawthorn Group Confining Beds	1	1	1	1	1	–
		Hawthorn Group and Tamiami	–	–	–	2	–	2
Floridan Aquifer System	Upper Floridan Aquifer	Ocala Group and Avon Park Limestone	3	3	3	3	3	2
	Middle Semi-Confining Unit	Lower Avon Park and Upper Lake City	1	1	1	1	1	1
	Lower Floridan Aquifer	Lake City Limestone and Upper Oldsmar	3	3	2	2	1	1

Surficial Aquifer System

The Surficial Aquifer System (SAS) is unconfined and consists of fine-to-medium grained quartz sand with varying amounts of silt, clay and crushed shell, of the Holocene and Pleistocene age. This uppermost aquifer is also called the Water Table Aquifer. It extends from land surface at the Upper Kissimmee Basin to a depth of about 270 feet in parts of Polk County within the boundaries of the SFWMD. The SAS produces small quantities of good-to-fair quality water. It is generally soft, low in mineral content, slightly corrosive, and often high in color and iron.

Due to the low yield, wells completed in the SAS are limited to residential self-supply, lawn irrigation and small-scale agricultural irrigation. The SAS is the major source for domestic self-supplied use in Okeechobee County. This shallow groundwater contains relatively high chloride and dissolved solids concentrations toward the western part of this county and near the Caloosahatchee River in Glades County.

Intermediate Aquifer System

The Intermediate Aquifer System (IAS) acts as a confining unit for the underlying FAS in the KB Planning Area. A few locally occurring producing zones exist, but do not produce large amounts of water. The IAS includes all sediments of late-to-middle Miocene age (Hawthorn Group) and low permeability beds of early Pliocene age (Miller 1986). The top of this unit is usually recognized by the first occurrence of a distinct and persistent greenish color. The unit consists of interbedded sands, calcareous silts and clays, shell, and phosphatic limestone and dolomite. These clays, silts and fine sands of the Hawthorn Formation retard vertical movement of water between the Water Table Aquifer and the underlying FAS. The thickness of this intermediate confining unit ranges from less than 50 feet in the Upper Kissimmee Basin to over 600 feet in parts of Okeechobee and Highlands counties.

Floridan Aquifer System

The Floridan Aquifer System (FAS) is the primary source for potable water in the Northern KB Planning Area and capable of producing large amounts of water. The aquifer is composed of a sequence of highly permeable carbonate rocks (limestone and dolomite) of Oligocene, Eocene and Late Paleocene age. The FAS is a confined or semi-confined aquifer within the basin boundaries. It contains two major producing zones, the Upper and Lower Floridan (UFA and LFA) aquifers. The middle semi-confining unit separates these units. The FAS has an average thickness of approximately 2,300 feet within the basin, but few wells have penetrated the entire FAS. The altitude of the top of the UFA ranges from 100 feet above sea level in portions of northern Polk County to more than 1,600 feet below sea level in the southwestern portion of the basin. The UFA is thicker in Glades and Okeechobee counties, averaging approximately 1,000 feet. However, chloride, total dissolved solids (TDS) and sulfate concentrations increase with depth and distance to the south.

The UFA in the Upper Kissimmee Basin is recharged primarily by downward leakance from the SAS, and where present, through the intermediate confining unit. Higher rates of recharge occur in areas with abundant sinkholes where the intermediate confining unit is thin or breached by collapse into underlying dissolution cavities. The UFA can also be recharged by the LFA depending on the conditions of the middle semi-confining unit that separates the two members of the FAS.

The LFA is present throughout east-central Florida (O'Reilly *et al.* 2002). The altitude of the top of the LFA ranges from 600 feet below sea level to more than 1,600 feet below sea level in the lower portion of the Kissimmee Basin. The LFA consists of the lower part of the Avon Park Formation of middle Eocene age and the upper part of the Cedar Keys Formation of late Paleocene age. The LFA is composed of alternating beds of limestone and dolomite, and characterized by abundant fractures and solution cavities.

Surface Water / Groundwater Relationships

The relationship between a surface water feature and the underlying groundwater system is one of the most difficult hydrologic relationships to understand. This relationship is based on the hydraulic characteristics of each aquifer and the thickness and type of soils separating the two features. When a river, canal or wetland has a higher water level than the water table, these surface water bodies provide seepage into the local shallow groundwater system. Conversely, when the water level of the surface water bodies is lower than the water table, groundwater discharge may occur. The rate at which this transfer occurs depends on the difference in these two levels and the permeability and thickness of the materials separating the two aquifers.

The FAS experiences both natural and artificial recharge. Natural recharge of the FAS within the KB Planning Area is greatest along the Lake Wales, Mount Dora and Bombing Range ridges. These areas represent locations where the differences in surface and FAS levels are greatest, and the thickness of the Intermediate Aquifer System (IAS) is thinnest or breached by karst activity. Recharge areas are often evident as potentiometric highs on the surface of the FAS; however, this is not always the case. The potentiometric high located in Polk County is not a high recharge, but instead an artifact of several surrounding discharge areas. Along the eastern part of the Green Swamp, high recharge occurs in the sand-filled cavities that extend into the top of the UFA along U.S. Highway 27 at the edge, and not in the middle of Green Swamp.

An estimated 500 drainage wells in central Florida discharge into the FAS. Approximately 50 percent of the water these drainage wells receive is from direct stormwater runoff; another 30 percent is from lake overflow; and, the remaining percentage is from excess overflow from wetlands and unused wells that in the past were used to dispose of industrial effluent, sewage and air-conditioner return water.

WATER NEEDS OF INLAND RESOURCES

Wetland Water Needs and Concerns

Maintaining appropriate wetland hydrology (water levels and hydroperiod) is the single most critical factor in maintaining a viable wetland ecosystem. Rainfall, along with associated groundwater and surface water inflows, is the primary source of water for the majority of wetlands in the KB Planning Area. 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.

Rivers and Floodplains

The Kissimmee River and its floodplains contain forested, wetland shrub and marsh wetlands, and at one time meandered through the Osceola Plain. In addition to serving as a temporary water storage system, the floodplain along the Kissimmee River served as a filtration system, regulating the velocity and timing of the flood discharge by slowing the waters that spilled over the banks of the river. Pollutants and nutrients (nitrogen and phosphorus) were taken up by the floodplain vegetation before water flowed into Lake Okeechobee or seeped into the aquifer.

The floodplain supported diverse vegetation, which in turn sustained huge populations of fish and wildlife. During the 1960s, however, the natural curves and extensive floodplain of the Kissimmee River were replaced with a straighter, more drainage-efficient waterway for navigation and flood control purposes. Unfortunately, this resulted in the loss of thousands of acres of wetlands and riverine habitat. Migratory waterfowl decreased by 92 percent and the bald eagle population by 74 percent. The food chain base became depleted as small fish, shrimp and invertebrates disappeared along with their wetland habitat. Fisheries dwindled and game fish catch declined by half.

Eastern Meadowlark

Restoration of parts of the river is taking place, bringing back wetland habitat. The premise of the federally authorized Kissimmee River Restoration Project is restoration in its truest sense—to re-establish natural water levels and flow, and to restore the ecological integrity of the watershed. The restoration project will restore over 40 square miles of the existing channelized system, including 43 continuous miles of meandering river channel and about 27,000 acres of wetlands. The project is expected to benefit over 320 fish and wildlife species.

Lakes

The KB Planning Area has hundreds of lakes. A lake can be classified according to its trophic level. Oligotrophic lakes have low levels of nutrients, good water clarity, and low levels of plant and animal life. Mesotrophic lakes have moderate levels of nutrients, moderate water clarity, and a moderate amount of plants and animals. High levels of nutrients, reduced water clarity, and an abundance of aquatic plant and animal life characterize eutrophic lakes. Hypereutrophic lakes often have a pea soup appearance from the amount of algae in the water column, the presence of algal mats and an overabundance of nutrients. As rotting plant material uses oxygen, aquatic animal life may die off from a lack of dissolved oxygen in the water. Eventually, the mucky bottom of the lake fills up with sediments and converts into a marsh. Eutrophication is a natural process; however, human activities can accelerate this process (cultural eutrophication).

A decrease in nutrients to the lake systems should slow eutrophication. In the 1970s, the water quality in the Upper Kissimmee Basin (especially Lake Tohopekaliga) was significantly degraded by nutrients originating from sewage treatment plants in Orlando, and from untreated nonpoint urban and agricultural sources. When the nutrient sources were identified and consequently reduced or eliminated, the water quality in the lakes improved.

Springs

Although there are no natural springs located within the KB Planning Area, several environmentally critical springs are located just outside the SFWMD's boundary, in the Wekiva Basin in northern Orange County. These springs contribute to the base flow of the Wekiva River and several of its tributaries. The St. Johns River Water Management District (SJRWMD) has established minimum flow values for eight Wekiva Basin springs. Estimated spring flow requirements are based, in part, upon environmental demands of the Wekiva River and its tributaries.

7

Upper East Coast Planning Area

PLAN BOUNDARIES

The Upper East Coast (UEC) Planning Area encompasses the northern reaches of the South Florida Water Management District (SFWMD or District) on the east coast. The area includes Martin and St. Lucie counties, and a small portion of Okeechobee County, as shown in **Figure 1**. The portion of Okeechobee County within the planning area will be referred to as the Okeechobee Area in this document. The boundary of the UEC Planning Area generally reflects the drainage basins of the C-23, C-24, C-25 and C-44 (St. Lucie Canal) canals. The northern boundary corresponds to the St. Lucie–Indian River County line, which is also the SFWMD/St. Johns River Water Management District (SJRWMD) jurisdictional boundary. The southern boundary is the Martin–Palm Beach County line.

PHYSICAL FEATURES

Geography and Climate

The UEC Planning Area covers approximately 1,430 square miles and has an average elevation of 20 feet. Average seasonal temperatures range from 64°F during the winter to about 81°F during the summer (University of Florida 1993). Annual average rainfall in the planning area is about 51 inches. There is a wet season from May through October, and a dry season from November through April.

Physiography

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

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

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

WATER RESOURCES AND SYSTEM OVERVIEW

Regional Hydrologic Cycle

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

Precipitation and Evapotranspiration

The average annual rainfall in the planning area is about 55 inches per year, but varies considerably from year to year. About 72 percent of the annual rainfall occurs during the May through October wet season. The maximum monthly average rainfall is 7.52 inches in September (St. Lucie County) and the minimum monthly average rainfall is 1.93 inches in December (Martin County). Monthly rainfall displays a higher measure of relative variability during the dry period. Rainfall also varies areally (from location to location), with rainfall amounts generally decreasing from east to west, especially during the wet season. Management of surface water systems is one of the main factors affecting movement of water through the regional hydrologic cycle.

Surface Water Inflow and Outflow

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

The District is moving forward, through Acceler8, with the design and construction of the C-44 Reservoir/Stormwater Treatment Area Project of the Comprehensive Everglades Restoration Plan (CERP) Indian River Lagoon South Restoration Project. This 12,000-acre project consists of a 3,400-acre, 15-foot-deep reservoir for 50,600 acre-feet of storage and a 6,300-acre aboveground stormwater treatment area to capture and treat excess stormwater runoff before it enters the St. Lucie Canal and, ultimately, the St. Lucie Estuary and Indian River Lagoon. Construction of the Acceler8 components is expected to be completed by the end of 2009. Ninety-nine percent of the land has been acquired for this project. Construction of the C-23/24 components of the Indian River Lagoon South Restoration Project could start as early as 2008 and be completed within six years.

Groundwater Flow

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

Surface Water Resources

Prior to development, most of the UEC Planning Area was characterized by nearly level, poorly drained lands subject to frequent flooding. The natural surface drainage systems included large expanses of sloughs and marshes, such as

St. Johns Marsh, Allapattah Slough (also referred to as Allapattah Flats), Cane Slough and the Savannas. Drainage systems with higher conveyance included the North and South Forks of the St. Lucie River, Ten Mile Creek, Five Mile Creek, the Loxahatchee River and Bessey Creek. Most of these surface water systems, especially those with poor drainage, have been altered to make the land suitable for development and to provide flood protection.

C-23 Canal

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

Torrential rains and extensive flooding in south Florida in 1947 prompted the U.S. Congress to authorize the design and construction of the Central and Southern Florida Flood Control Project (C&SF Project). The C&SF Project included construction of levees, canals, spillways, pump stations and dams. Within the UEC Planning Area, the project incorporated the existing canals and provided increased outlet capacity for Lake Okeechobee by making improvements to the St. Lucie Canal.

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

There are 12 basins without C&SF Project works in the planning area. The level of flood protection in these basins varies widely, depending on the conveyance of the natural drainage system and extent of land development. Water control districts have been established in some basins to provide drainage, flood control and water supply.

Surface Water Planning Areas

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

St. Lucie Agricultural Area

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

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

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

Flow in each of the C&SF Project canals is regulated by each canal's respective control structures. For flood control and drainage, water elevations in the canal are set far enough below ground surface to provide slope in the secondary drainage systems. Water supply requires the water surface in the primary canal to be maintained sufficiently high to prevent overdrainage. When flow in the canals is adequate, control structures are operated to maintain a headwater stage within a seasonally dependent range (**Table 27**).

Table 27. Optimal Headwater Stage for Project Canals.

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

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

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

Prior to the large-scale expansion of citrus in the 1960s, storage in the drainage network in St. Lucie County was adequate to meet irrigation demands. However, the drainage and development of the large marsh areas in western St. Lucie County have depleted much of the surface water storage. The lowering of water tables has also reduced the amount of water in groundwater storage. The reduction of surface and groundwater storage coupled with increased acreages of citrus has resulted in inadequate supplies of surface water to meet demands during droughts. Surface water availability in the C-23, C-24 and C-25 basins is restricted when water levels reach 14.0 feet National Geodetic Vertical Datum (NGVD). Artesian well water from the FAS is used as an irrigation supplement when surface water supplies become limited. Due to the high mineral content of the Floridan Aquifer, this water is generally blended with surface water before it is used as irrigation water.

Eastern St. Lucie Area

The Eastern St. Lucie Area includes most of the North Fork St. Lucie River Basin. The North Fork of the St. Lucie Basin is a 169-square-mile (108,165 acres) watershed located in the northern part of the planning area. The North Fork St. Lucie River is fed by Five Mile Creek and Ten Mile Creek at the north end and flows south until it merges with the C-23 Canal at the headwaters of the St. Lucie Estuary.

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

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

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

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

The Header Canal runs parallel to the western boundary of the NSLRWCD, and is located 3 miles east of the north-south reach of the C-24 Canal. It collects runoff from secondary canals extending westward, and is connected to Ten Mile Creek to the east, the C-25 Canal to the north and the C-24 Canal to the south. Ten Mile Creek and Five Mile Creek are natural streams, having been improved to transport water from the secondary drainage system to the North Fork of the St. Lucie River.

Water control structures in both the FPFWCD and NSLRWCD are regulated on a day-to-day basis to maintain optimum canal water levels for agricultural production.

St. Lucie River Area

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

The Canal Area contains the only basin (C-44 Basin) in the UEC Planning Area hydrologically connected to Lake Okeechobee.

Canal Area

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

Lockages are performed on an on-demand basis at the S-80 Structure, except when water shortages are declared, or maintenance and repairs to the structure occur. Although there is no formal water shortage plan for the S-80 Structure, the USACE will curtail lockages at the request of the District. Maintenance and repairs that interrupt lockages are done on an as-needed basis, usually occurring every three to five years. Each lockage at the S-80 Structure releases over 1.3 million gallons of water. The average number of lockages at the S-80 Structure varies monthly.

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

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

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

Basins 4, 5 and 6

Bessey and Danforth creeks drain Basins 4 and 6, respectively. Bessey Creek discharges to the mouth of the C-23 Canal, which in turn empties into the St. Lucie River. Danforth Creek discharges to the South Fork of the St. Lucie River Estuary. Basin 5 is generally landlocked, with a poor hydraulic connection to Bessey Creek. Inadequate conveyance in the drainage systems in these basins has frequently resulted in areas of inundation in flood-prone areas.

Tidal Area

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

Groundwater Resources

The hydrogeology of south Florida is diverse. Within an individual aquifer, hydraulic properties and water quality may vary both vertically and horizontally. Because of this diversity, groundwater supply potential varies greatly from one place to another. This section identifies the aquifers in the UEC Planning Area and each aquifer's water producing capability.

Three major hydrogeologic units underlie the UEC Planning Area: 1) the Surficial Aquifer System (SAS); 2) the intermediate confining unit (low permeable sediments of the Hawthorn Group); and, 3) the Floridan Aquifer System (FAS), as presented in **Figure 8**. The SAS extends from land surface to the top of the intermediate confining unit, and the intermediate confining unit extends to the top of the FAS. **Table 28** lists the groundwater systems, hydrogeologic units and relative aquifer yields to each county in the UEC Planning Area.

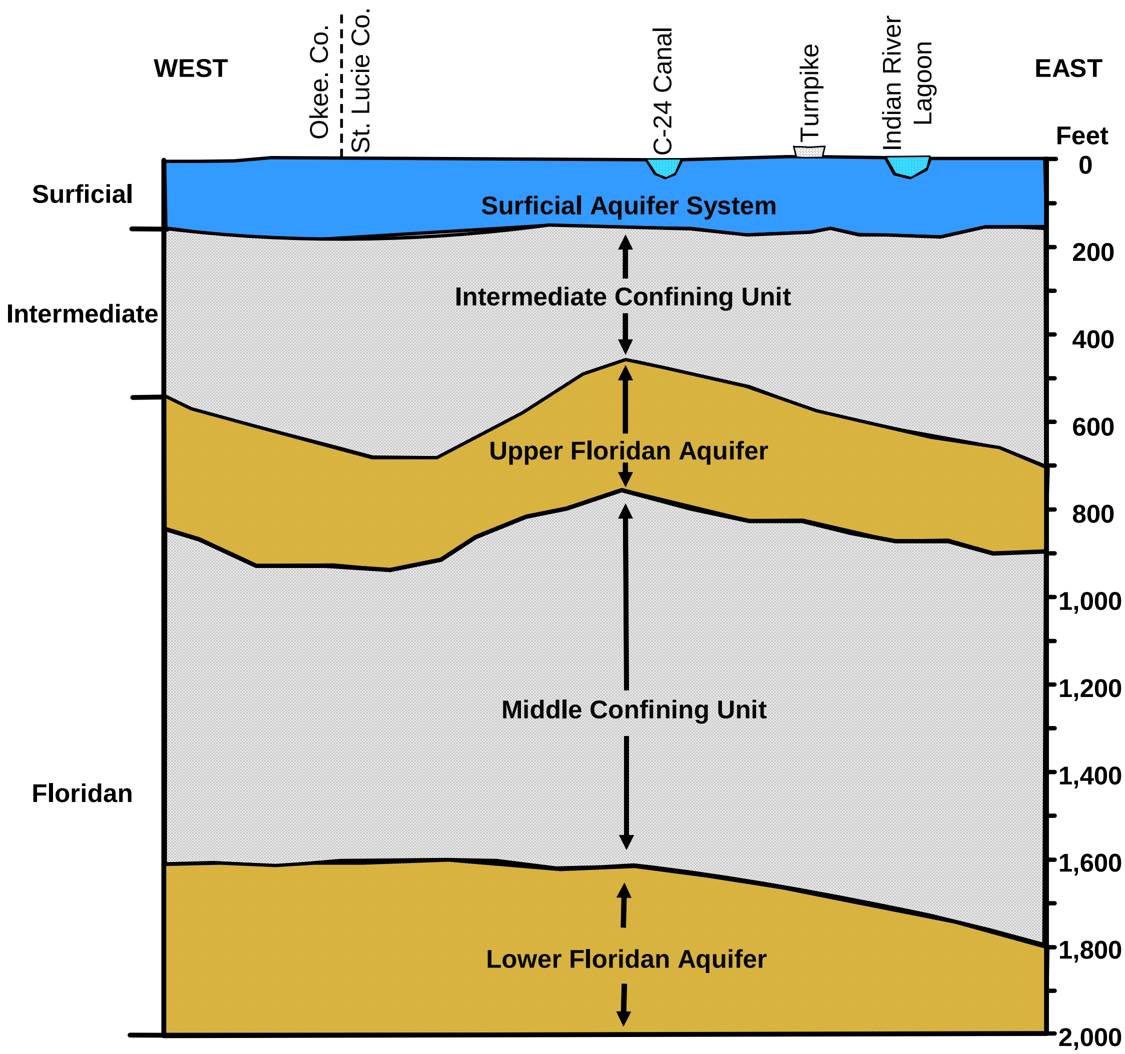


Figure 8. Generalized Geologic Cross-Section of the Upper East Coast Planning Area.

Table 28. Groundwater Systems in the Upper East Coast Planning Area.

Aquifer System	Hydrogeologic Unit	Aquifer Yield 1-Low 2-Moderate 3-High		
		Martin	St. Lucie	Okeechobee
Surficial Aquifer System	Surficial Aquifer	2	1–2	1
Intermediate Confining Unit	Hawthorn Group	1	1	1
Floridan Aquifer System	Upper Floridan Aquifer	3	3	2–3
	Middle Confining Unit	1	1	1
	Lower Floridan Aquifer	3	3	3

Surficial Aquifer System

The SAS is the principal source of water for urban uses, including potable water, within the UEC Planning Area. It includes all saturated rock and sediment from the water table to the top of the underlying intermediate confining unit. The SAS ranges in thickness from 50 feet to 250 feet in the UEC (Brown and Reece 1979). Its lithology consists of quartz sand, silts, clay, shell beds, coquina, calcareous sandstone and shelly limestone. The geologic units that make up the aquifers range from the youngest to the oldest: the Pamlico sand (Pleistocene), the Anastasia Formation (Pleistocene), the Fort Thompson Formation (Pliocene), and possibly part of the Tamiami Formation (Pliocene).

The SAS is generally unconfined to semi-confined (Adams 1992). The permeability of the aquifer typically increases to the south and east in the UEC Planning Area (Butler and Padgett 1995). Productivity and water quality in the aquifer also tend to improve from north to south and west to east. Throughout most of the UEC Planning Area, water in the SAS meets national drinking water standards with respect to chloride, total dissolved solids (TDS) and sulfate concentrations (Lukasiewicz and Switanek 1995).

Intermediate Confining Unit

Within the UEC Planning Area, the intermediate confining unit comprises relatively impermeable phosphatic clays, silts and limestones of the Hawthorn Group. The top of the confining unit lies approximately -80 feet NGVD in the northwest corner of St. Lucie County. It dips gently to the southeast, reaching a maximum depth of more than -200 feet NGVD in southeastern Martin County. Thickness also varies, ranging from less than 300 feet in northern St. Lucie County, to more than 600 feet at the extreme southern end of the planning area. The intermediate confining unit does not yield significant quantities of water to wells. The intermediate confining unit, which has low permeability, separates the overlying SAS from the underlying FAS.

Floridan Aquifer System

The FAS, which underlies all of Florida, ranges in thickness from 2,700 feet to 3,400 feet within the UEC Planning Area. The top of the FAS lies around -300 feet NGVD in the northwest corner of the planning area, then dips to the southeast to more than -900 feet NGVD in southeastern Martin County. The elevation of the top of the FAS corresponds to the top of the basal Hawthorn/Suwannee unit. The FAS includes parts of the middle Eocene (Avon Park and Lake City Limestone), Upper Eocene (Ocala Limestone), Oligocene (Suwannee Limestone) and Miocene (Tampa Limestone, and permeable parts of the Hawthorn Formation that are in hydrologic contact with the rest of the aquifer) ages (Parker *et al*. 1955).

Within the FAS, there are multiple permeable intervals, or producing zones, sandwiched between low permeability confining materials. The permeable intervals are associated with solution cavities and formational unconformities, the latter of which can be correlated over large areas. The FAS is divided into two aquifers based on the vertical occurrence of two highly permeable zones: the Upper and Lower Floridan aquifers. They are separated by a low permeability interval named the middle semi-confining unit. The term Lower Floridan, as it appears here, refers to the upper portion of the Lower Floridan Aquifer (LFA). The following terminology and geologic description of the FAS were adopted from Lukasiewicz (1992).

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

Upper Floridan Aquifer

The Upper Floridan Aquifer (UFA) is the principal source of supply to users of the FAS in the UEC Planning Area. It is approximately 500 feet thick, and characterized by two distinct and continuous producing zones. These two zones occur along the unconformities, serving as the lithologic contacts between the

Suwannee Formation and the Ocala Group, and the Ocala Group and the Avon Park Formation. There are also numerous high permeability zones created by solutioning and dolomitization (the replacement of calcium carbonate with magnesium carbonate). These zones are not stratigraphically controlled and occur irregularly throughout the planning area.

The UFA is an important source of irrigation water for agriculture in St. Lucie County and to a lesser extent in Martin County. Floridan wells, which flow without pumping, produce large volumes of brackish water. Total dissolved solids (TDS) concentrations in UFA water average about 900 milligrams per liter (mg/L) and increase toward the southeast to 3,000 mg/L in southeastern Martin County. Because of the salinity, ranchers and grove operators tend to discharge Floridan water into irrigation ditches, where it mixes with fresher surface water and groundwater from the SAS. This dilutes the brackish Floridan water to a level acceptable for agricultural irrigation, and allows growers to supplement surface water supplies when availability is limited.

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

Middle Semi-Confining Unit

The middle semi-confining unit, corresponding stratigraphically to the Avon Park Formation, is composed of chalky calcilutite interbedded with limestones and dolomites. Because few wells in the planning area fully penetrate this unit, data on its variability are limited. Data from a few test wells in the planning area place its thickness from 800 feet to 900 feet.

Lower Floridan Aquifer

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

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

The two producing zones may also be distinguished by a significant difference in water quality. Water samples collected from a test well in central St. Lucie County showed TDS concentrations between 1,100 and 1,200 parts per million (ppm) in the upper producing zone, and greater than 2,000 ppm in the lower zone.

Although very transmissive zones have been documented within the LFA, they are generally not used as supply sources within the UEC Planning Area due to the high salinity and mineral content of the water and higher drilling costs required to complete a well in this zone. An exception to this is in the Town of Jupiter wellfield, which has several wells completed in the LFA. This portion of the Lower Floridan has been determined to have high potential for aquifer storage and recovery (ASR) due to its capacity for receiving and storing large quantities of injected water.

An area of extremely high transmissivity, known as the boulder zone, occurs at the base of the LFA. In south Florida, the boulder zone has been used for disposal of treated wastewater effluent and reject water/concentrate from reverse osmosis water treatment facilities. A thick confining layer of dense limestones and dolomites prevents flow between the boulder zone and the transmissive zones at the top of the LFA. The base of the Lower Floridan generally coincides with the top of the evaporate beds in the Cedar Keys Formation (Miller 1986).

Surface Water / Groundwater Relationships

In the preceding sections, surface water and groundwater resources have been addressed as separate entities. In many ways, however, they are interdependent. The construction and operation of surface water management systems affect the quantity and distribution of recharge to the SAS. Although surface water management systems are a major source of water supply, in terms of interaction with groundwater, the systems within the planning area function primarily as aquifer drains. An estimated 19 percent of groundwater flow in Martin County is discharged into surface water bodies, while only 1 percent of aquifer recharge is derived from surface water sources. Surface water management systems also affect 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, and supply a downstream consumptive use lost to evapotranspiration (ET) or discharged to tide.

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

WATER NEEDS OF COASTAL RESOURCES

St. Lucie Estuary

The St. Lucie Estuary is one of the largest brackish water bodies on the east coast of Florida and a primary tributary to the southern Indian River Lagoon. The St. Lucie Estuary comprises the North Fork, the South Fork and the middle estuary. The middle estuary extends east for approximately 5 miles until it meets the Indian River Lagoon (IRL), just before opening to the Atlantic Ocean at the St. Lucie Inlet. The St. Lucie Estuary has been highly altered at both its landward and seaward ends.


St. Lucie River

The C&SF Project has created some long-range problems. Freshwater discharges from the C-23, C-24, C-25 and C-44 canals to the St. Lucie Estuary and IRL pose problems in maintaining a healthy estuarine system. High volume, prolonged freshwater releases from Lake Okeechobee via the C-44 Canal also have a dramatic effect on water quality and the health of the estuarine system. As fresh water is released, sediment from eroding canal banks and pollutants from stormwater runoff have negative effects on water quality in the St. Lucie River. Another problem associated with water releases from Lake Okeechobee is the drastic change in salinity levels within the St. Lucie Estuary.

Maintaining appropriate freshwater inflows is essential for a healthy estuarine system. 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 due to flood control activities can significantly reduce salinities and introduce stormwater contaminants.

The CERP and modifications to the Lake Okeechobee regulation schedule will address freshwater discharges from Lake Okeechobee to the St. Lucie River via the C-44 Canal.

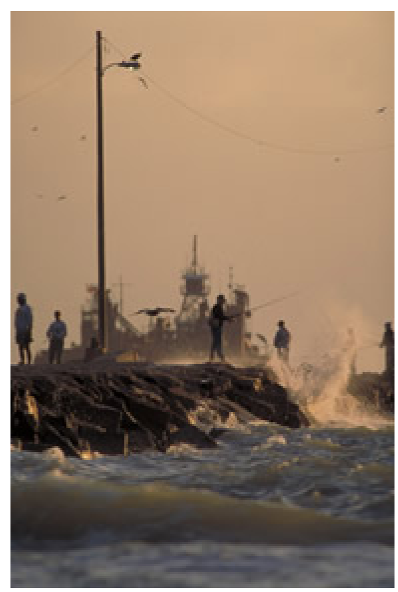
Indian River Lagoon

As the St. Lucie River's fresh water flows toward the St. Lucie Estuary, it becomes part of the Indian River Lagoon, the most biodiverse estuarine system in all of North America.

The Indian River Lagoon is a series of three distinct, but interconnected, estuarine systems, which extend 156 miles from Ponce DeLeon Inlet in Volusia County southward to Jupiter Inlet in Palm Beach County on Florida's east coast. The northern portion of the lagoon is within the St. Johns River Water Management District (SJRWMD). The lagoon's southern section is located within the SFWMD in St. Lucie, Martin and northern Palm Beach counties.

More than 4,000 species of plants and animals have been observed in the lagoon, which supports multimillion-dollar fishing, clamming, tourism, agricultural and recreational industries.

Increasing industrial, agricultural, residential and commercial development has influenced the health of the IRL. The combined effects of wastewater and stormwater runoff, drainage, navigation, loss of marshland and development has influenced the lagoon's water, sediment and habitat quality. The lagoon system has lost emergent wetlands through destruction and impoundment, isolating marsh and mangrove communities from the lagoon. The effects of these man-made changes have altered the timing (excess wet season flows, insufficient dry season flows), distribution, quality and volume of fresh water entering the lagoon. The estuarine environment is sensitive to freshwater releases, and these alterations have influenced the entire ecosystem. Extreme salinity fluctuations and ever-increasing inflows have contributed to changes in the structure of the communities within the estuary.


Fort Pierce Inlet

The SFWMD C-25 Canal and the FPFWCD Canal (Number 1) discharge through Taylor Creek into the IRL at Fort Pierce. On outgoing tides, these discharges exit the lagoon at the Fort Pierce Inlet; however, on incoming tides discharge water moves northward into the IRL. Salinity in this area of the IRL is reduced considerably as discharges continue, and the lowered salinities linger for days after the discharges have ceased.

The high biological diversity of the IRL is largely dependent on the interchange of species and individuals with the ocean. The Fort Pierce Inlet links these ecosystems together. The high diversity of fish in the IRL depends on maintenance of relatively high salinities in the Fort Pierce Inlet and its vicinity. These higher salinities are typical when the stormwater canals are not discharging. The occurrence of lowered salinity influences the biodiversity of the Indian River.

The CERP Indian River Lagoon – South Feasibility Study investigated options to alter the effects of the flow of surface waters through the existing regional flood control system to the St. Lucie River and Estuary and the IRL. This study focused on making improvements to restore the environmental health of the receiving water bodies, as well as the watershed, while maintaining the existing functionality of the flood control system.

The Final Indian River Lagoon – South Feasibility Study (IRLFS), completed in 2003, recommended a plan in Martin, St. Lucie and Okeechobee counties to improve water quality within the St. Lucie Estuary and the Indian River Lagoon by reducing the damaging effects of watershed runoff; reducing high peak freshwater discharges to control salinity levels; and, reducing nutrient loads, pesticides and other pollutants. The project will also provide water supply for agriculture to offset reliance on the Floridan Aquifer.

The final CERP Project Implementation Report (PIR) and Environmental Impact Statement (EIR) were completed in March 2004, and the final report was submitted to Congress in the fall of 2005 for authorization by a future *Water Resources Development Act*. This legislation will move the CERP Indian River Lagoon South Restoration Project one-step closer to implementation. Appropriation of federal funds is needed and land for this project must be purchased. The Indian River Lagoon South Restoration Project includes approximately 130,000 acre-feet of storage in reservoirs for runoff from the C-23, C-24, C-25 and C-44 canals; provides storage on approximately 90,000 acres of natural storage areas; and, removes 7.9 million cubic yards of muck from the St. Lucie River and Estuary.

Through Acceler8, the SFWMD is moving forward with the design and construction of the C-44 Reservoir and stormwater treatment areas of the plan. The project, located in southern Martin County directly north of the C-44 Canal, consists of a 3,400-acre, 15-foot-deep aboveground reservoir and a 6,300-acre stormwater treatment area to capture and treat stormwater runoff before it enters the St. Lucie Canal and, ultimately, the St. Lucie Estuary and Indian River Lagoon. The SFWMD initiated test cell construction in 2006 and expects to begin major construction activities in 2007. Construction of the Acceler8 components is expected to be completed by the end of 2009.

The Ten Mile Creek Water Preserve Area, located just south of the Ten Mile Creek in St. Lucie County, also addresses regional storage and freshwater flows from the watershed. This Critical Restoration Project was completed in 2006, with the exception of storm damage repairs and improvements. These projects are expected to be completed in 2008.

Information about other CERP components of the Indian River Lagoon South Restoration Project are available from the CERP Web site: http://www.evergladesplan.org/pm/program_docs/proj_status_reports.cfm.

Loxahatchee River

The diverse natural ecosystems and hydrology found within the Loxahatchee River Watershed are unique, beginning with the Atlantic Ocean, which feeds its marine waters inshore through the Jupiter Inlet. Just inshore, the river broadens into the aquatic preserves of the IRL. Continuing westerly and upstream, the water systems include vast wetlands and the Loxahatchee Slough. The Loxahatchee River, Florida's first federally designated "National Wild and Scenic River," winds its way through Jonathan Dickinson State Park.


Loxahatchee River

In contrast to concerns of freshwater encroachment in estuarine systems, the Loxahatchee River has been significantly affected by the creation of the Jupiter Inlet. Prior to development, the Loxahatchee River Watershed was nearly level, poorly drained land subject to frequent flooding. With the construction of the C-18 Canal and installation of drainage projects for urban and agricultural development, water tables have been lowered and the amount of fresh water available to the Loxahatchee River has been reduced.

These changes have significantly altered natural flow patterns allowing salt water to move farther up the river, resulting in the displacement of freshwater wetland species by estuarine species. The effects on regional hydrology, river flow, estuary hydrodynamics and river vegetation communities are documented. Over a century of water control and structural modifications to the Loxahatchee system have led to changes in the quality, quantity, timing and distribution of flows delivered to the river and estuary, resulting in hydrologic and ecological changes to the system. Salinity impacts observed within the river occurred in association with construction and dredging of the Jupiter Inlet in 1947 and subsequent upstream navigational improvements over time. Drainage and land development activities have changed the timing and distribution of flows from the watershed to the river, producing large discharges during wet periods and extended periods of little or no discharge during extreme dry periods.

A minimum flow and level (MFL) was established for the Northwest Fork of the Loxahatchee River in 2002, and restoration efforts are under way. Implementation of projects in the *Northern Palm Beach County Comprehensive Water Management Plan* (SFWMD 2002c) and recommendations in the *2000 Lower East Coast Regional Water Supply Plan* (2000 LEC Plan) are beginning to address freshwater flows to the Loxahatchee River (SFWMD 2000d). In 2006, the SFWMD approved the *Restoration Plan for the Northwest Fork of the Loxahatchee River* (SFWMD 2006).

The C-51 and Southern L-8 Reservoir and L-8 Basin Modification components of the CERP North Palm Beach County – Part 1 in the Lower East Coast (LEC) Planning Area are currently being evaluated during the planning phase to determine the most efficient and effective method to increase environmental water supply deliveries to the Grassy Waters Preserve, Loxahatchee Slough and Northwest Fork of the Loxahatchee River. The SFWMD has acquired at a cost of $218 million up to 47,000 acre-feet of storage for the L-8 Reservoir, which is scheduled to be completed in 2008–2009. Phase 1 of the M-Canal Widening effort has been completed by the City of West Palm Beach in partnership with the SFWMD. Phase 2 of the M-Canal Widening effort is scheduled to be completed by 2008. Construction of the G-160 Loxahatchee Slough Structure and G-161 Northlake Boulevard Structure was completed. This was a major step to reconnect the historical watershed of the L-8 Reservoir and the Grassy Waters Preserve to the Loxahatchee Slough and Northwest Fork of the Loxahatchee River, which were separated for many years by Northlake Boulevard. Hydraulic reconnection of the watershed will be achieved when other interconnection facilities (M-Canal widening, Control Pump 2, East Perimeter Canal) have been improved and the G-161 operations protocol and agreements have been completed between the District, the City of West Palm Beach and others.

Salinity Envelope Concept

The SFWMD has used data from several sources to identify a favorable range of inflow and related salinity, which would be conducive to growth and survival of juvenile marine fish and shellfish, oysters, and submerged aquatic vegetation in the St. Lucie Estuary. These sources include research on fish and shellfish, monthly salinity data collected over many decades and results from studies of similar estuaries throughout the world (SFWMD and SJRWMD 2002). This favorable range of flows, from 350 cubic feet per second (cfs) to 2,000 cfs, is referred to as the "Salinity Envelope." The "Salinity Envelope" was established for the St. Lucie Estuary to provide preferred salinities for oysters and submerged aquatic vegetation in areas within the estuary where "healthy" populations of these communities could exist. These populations can persist as long as the favorable ranges of flows and salinity are not violated beyond the frequency attributed to natural variation of flows from the watershed (Haunert and Konyha 2001).

Coastal Resources Water Needs Goal

A long-term goal of the SFWMD is to develop coupled watershed-estuarine models that can be used to: 1) estimate historical runoff patterns that occurred prior to human intervention, and 2) evaluate the effects of watershed alterations on receiving waters. Such alterations include changes in canal discharge or point of discharge; operation of storage facilities; impacts of filter marshes and best management practices (BMPs) on water quality; and, operation of coastal structures. These management tools can be used to explore creative ways to meet MFLs and pollution load reduction goals (PLRGs); to test operational criteria for CERP infrastructure; to define environmentally sensitive operating procedures for existing water management schedules; and, to establish restoration goals.

8

Lower West Coast Planning Area

PLAN BOUNDARIES

The Lower West Coast (LWC) Planning Area includes all of Lee County, most of Collier and Hendry counties, and portions of Charlotte, Glades and mainland Monroe counties (**Figure 1**). The portions of counties partially 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 South Florida Water Management District (SFWMD or District)/ Southwest Florida Water Management District (SWFWMD) jurisdictional boundary in Charlotte County, while the eastern boundary delineates the divide between the Big Cypress Swamp and the Everglades system. The area east of this divide is in the Lower East Coast (LEC) Planning Area.

PHYSICAL FEATURES

Geography and Climate

The LWC Planning Area covers approximately 5,129 square miles. Average seasonal temperatures range from 64.3°F in January to 82.6°F in August. There is a wet season from May through October, and a dry season from November through April.

Physiography

The SFWMD includes two major basins, the Okeechobee Basin and the Big Cypress Basin. 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 solution-riddled 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 and water control structures in western Collier County. This system is monitored, controlled and managed by the Big Cypress Basin. The physiography of south Florida is discussed in further detail in *Environments of South Florida: Present and Past II* (Gleason 1984).

WATER RESOURCES AND SYSTEM OVERVIEW

Regional Hydrologic Cycle

The main components of the hydrologic cycle are precipitation (and the resulting infiltration); evapotranspiration (and the resulting withdrawal); surface water inflow and outflow; and, groundwater flow.

Precipitation and Evapotranspiration

The average annual precipitation in the LWC Planning Area is approximately 52 inches. Nearly two-thirds of the rainfall occurs during the six-month wet season from May through October.

Surface Water Inflow and Outflow

Most surface water in the LWC Planning Area derives from rainfall. The exception to this is the Caloosahatchee River (C-43 Canal), which also receives water from Lake Okeechobee. Historic flowways in the region were 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. 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 little water is in storage, drought conditions may occur during periods of deficient rainfall. Conversely, when storage is at capacity, flooding may occur due to excessive rainfall, especially during the wet season. Management of surface water systems is one of the main factors affecting movement of water through the regional hydrologic cycle.

Groundwater Flow

Three major aquifer systems underlie the LWC Planning Area: 1) the Surficial Aquifer System (SAS), 2) the Intermediate Aquifer System (IAS), and 3) the Floridan Aquifer System (FAS). Rainfall is the main source of recharge to the SAS. The IAS is partially recharged from the SAS. The FAS receives its recharge from outside the LWC Planning Area.

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.

The Caloosahatchee River, the most important source of surface water in the region, extends across seven of the 10 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 Structure) toward Lake Okeechobee and the cities of LaBelle and Moore Haven. West of the S-79 Structure, 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 into Estero Bay, the Caloosahatchee River or the Gulf of Mexico.

Drainage Basins

The LWC Planning Area is divided into 10 major drainage basins according to their respective hydrologic characteristics. 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.

The *2000 Lower West Coast Water Supply Plan* (2000 LWC Plan) recommended that the District identify opportunities to evaluate the feasibility of using the Caloosahatchee River as a seasonal source of supply (SFWMD 2000e). The

Caloosahatchee Water Management Plan (2000 CWMP Plan), completed in April 2000 (SFWMD 2000a), addresses availability of water from the river. In addition, the Southwest Florida Feasibility Study (SWFFS) is analyzing the feasibility of restoration projects to develop a comprehensive water resources plan. The SWFFS area covers about 4,300 square miles, including the Caloosahatchee Estuary and all of Lee County, most of Collier and Hendry counties, and portions of Charlotte, Glades and Monroe counties. The feasibility study will provide a framework to address the health of aquatic ecosystems, water flows, water supply, wildlife, biological diversity and natural habitat for the entire southwest Florida area.

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 basin drains through the Gator Slough Canal into the Cape Coral Canal System.

The 400-mile canal system flows through Cape Coral, the state's third-largest city in land mass, with an area of 115 square miles. The system drains a large area, affecting the hydrology of the Matlacha Pass and Caloosahatchee estuaries. Approximately 295 miles of the canal system are considered fresh water, and about 105 miles are brackish water.

The City of Cape Coral, which uses 100 percent of alternative water supplies, built a reverse osmosis (RO) plant in 1976 to treat its water. Twenty-three deep wells supply the plant, the majority of which are in the Lower Hawthorne Aquifer at a depth of 650 feet to 700 feet. Prior to building the RO plant, the city used lime softening. This technology was abandoned in 1985, primarily due to saltwater intrusion. The original 3-million gallons per day (MGD) RO plant was expanded to 15 MGD, which allows the city to keep pace with the growth occurring in Cape Coral.

The City of Cape Coral's reuse water system consists of the Everest Parkway Water Reclamation Facility, the Southwest Water Reclamation Facility and five canal pumping stations placed in various locations along the city's vast freshwater canal system. This system provides irrigation water for domestic households and commercial buildings. The canal water is used to supplement the reuse system water when the demand for irrigation water is more than the supply capacity of both water reclamation facilities.

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 suitable as a major source of surface water withdrawal. The *Lee County Interim Surface Water Management Plan* (Johnson Engineering *et al.* 1995) recommended 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 sheet flow 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. The East County Water Control District is modifying internal weirs to retain more water on-site for groundwater recharge. A minimum flow and level (MFL) for the Caloosahatchee River and Estuary was established in 2000, and an update initiated in 2003. (SFWMD 2003d)

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 sheet flow into Telegraph Creek in Lee County. Since this is a large watershed (approximately 92 square miles) with sheet flow discharge, there is a potential for this basin to be a good recharge area (Johnson Engineering *et al.* 1995).

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

Caloosahatchee River / C-43 Canal

The West and East Caloosahatchee, C-21 and S-236 basins, respectively, extend along the freshwater portion of the Caloosahatchee River (C-43 Canal), from the S-79 Structure (Franklin Lock and Dam) to the S-77 Structure 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. There are three structures (S-77, S-78 and S-79) providing navigation and water control in the C-43 Canal. These structures serve to control the water stages in the C-43 Canal from Lake Okeechobee (S-77 Structure) to Franklin Lock (S-79 Structure). Water levels upstream of the S-78 Structure 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.

The Comprehensive Everglades Restoration Plan (CERP) C-43 Basin Storage Reservoir Project includes the Acceler8 C-43 West Reservoir Project, which will address surface water storage needs within the basin by constructing a reservoir with 170,000 acre-feet of storage. With construction of the full-scale reservoir scheduled to begin in 2007, the C-43 West Reservoir will capture C-43 Basin runoff and releases from Lake Okeechobee. The project is also designed to supply water by attenuating peak flows during the wet season and essential flows during the dry season; provide environmental water deliveries to the Caloosahatchee Estuary; and, reduce salinity and nutrient impacts of runoff to the estuary.

Estero Bay Basin

In the Estero Bay Basin in southern Lee County, there is a twofold water management problem. Overdrainage is a problem in areas due to development. Conversely, lack of conveyance in other areas results 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 waterworks projects have been completed, or are under way, 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. It was 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 (Johnson Engineering *et al.* 1995).

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 eastern 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 feet to 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 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. 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. An assessment of the 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 3 miles into southern Hendry County and south into Monroe County. Sheet flow 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. There are no major rivers or major sources of surface water for year-round water supply use in this basin.

Groundwater Resources

Three major aquifer systems underlie southwestern Florida—the Surficial, Intermediate and Floridan—as shown in the west to east cross-section in **Figure 9.** These aquifer systems are composed of multiple, discrete aquifers separated by low permeability confining units.

Within an individual aquifer, hydraulic properties (i.e., ability to yield water to wells) and water quality may vary both vertically and horizontally. Because of this heterogeneity, groundwater supply potential varies greatly from one place to another. **Table 29** lists the aquifer systems, hydrogeologic units and aquifer yields in the LWC Planning Area. This section identifies the aquifers in the LWC Planning Area and describes their characteristics.

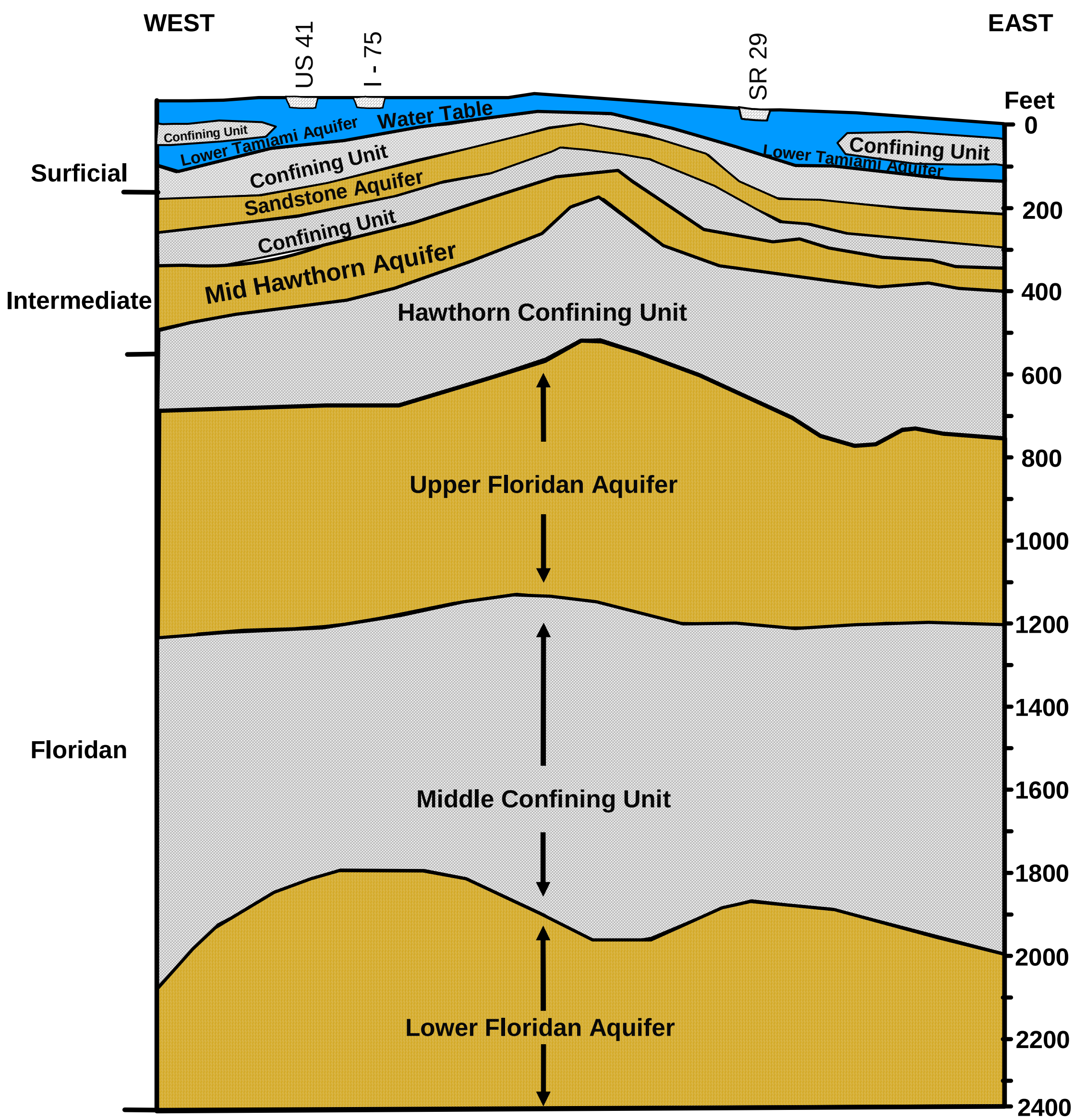


Figure 9. Generalized Geologic Cross-Section of the Lower West Coast Planning Area.

Table 29. Groundwater Systems in Lower West Coast Planning Area.

Aquifer System	Hydrogeologic Unit	Aquifer Yield 1-Low 2-Moderate 3-High				
		Charlotte	Glades	Lee	Hendry	Collier
Surficial Aquifer System	Water Table Aquifer Lower Tamiami Aquifer	1	2	2	2	3
Intermediate Aquifer System	Sandstone Aquifer Mid-Hawthorn Aquifer	2	2	2	2	2
Floridan Aquifer System	Upper Floridan Aquifer	3	3	3	3	3
	Middle Confining Unit	1	1	1	1	1
	Lower Floridan Aquifer	3	3	2	2	2

Surficial Aquifer System

The Surficial Aquifer System (SAS) consists of, in descending order, the Water Table Aquifer, confining beds and the Lower Tamiami Aquifer of Holocene to Pliocene age. The thickness of the system ranges from about 200 feet in southwestern Collier County to less than 25 feet in northern Lee County (Reese 2000). The SAS is recharged primarily by precipitation, seepage from canals and other surface water bodies, and upward leakance from the Intermediate Aquifer System (IAS).

Water Table Aquifer

The Water Table Aquifer is composed of sediments from the land surface to the top of the Tamiami confining beds. Within Lee County, several major public water supply wellfields, all located in areas where the confining beds are absent, pump water from the Water Table Aquifer. 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. 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 where high concentrations of chlorides and dissolved solids are found. Some isolated areas also exist with high iron concentrations.

Lower Tamiami Aquifer

The Lower Tamiami Aquifer is a major water producer in most of the LWC Planning Area and supplies water to several wellfields, agricultural interests and domestic self-suppliers in the region. Because of the large demands on the aquifer, saltwater intrusion is a continuing concern along much of the coast. In addition, the SFWMD adopted rules in 2003 for maximum developable limits (MDLs) for the LWC Planning Area (SFWMD 2003a).

Intermediate Aquifer System

The Potentiometric Mapping Project for the Intermediate Aquifer System (IAS) was completed in 2003. This project defined and delineated the Water Table, Lower Tamiami, Sandstone and Mid-Hawthorn aquifers, and provided great interpretations of the LWC Planning Area's regional hydrogeology. The IAS consists of those units overlying and confining the Floridan Aquifer System (FAS) and underlying the SAS. It consists of three relatively impermeable confining units between the Sandstone and Mid-Hawthorn aquifers and lies within the Hawthorn Group (Oligocene to Pliocene age). Recharge to the IAS occurs through upward leakance from the FAS and through downward leakance from the SAS (Bush and Johnston 1988).

The Sandstone Aquifer has variable thickness. On average, it is approximately 100 feet near Immokalee and portions of central Lee County. The productivity of the Sandstone Aquifer is highly variable. It provides all of the water used by several wellfields in the region. In western Hendry County, where the Lower Tamiami Aquifer is absent, the Sandstone Aquifer is an important source of water for agricultural irrigation. However, it is not capable of supporting large-scale agricultural operations in most areas. Only marginally acceptable for potable uses in Hendry and Collier counties due to salinity, water from the Sandstone Aquifer is suitable primarily for irrigation purposes, with the exception of the LaBelle area, where flowing Floridan wells have contaminated the water.

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 is 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 Floridan Aquifer System (FAS), which underlies all of Florida, is found between 600 feet and 1,000 feet below land surface (bls) in the region (SE Florida Geologic Ad Hoc Committee 1986). The top of the FAS coincides with the top of a vertically continuous permeable carbonate sequence. The FAS contains several thin, highly permeable, water bearing zones, which define the Upper, Middle and Lower Floridan aquifers. The Upper Floridan Aquifer (UFA) includes the lower part of the Hawthorn Group, Suwanee Limestone, Ocala Limestone and upper part of the Avon Park Formation. Production zones in the lower part of the Hawthorn Group and upper part of the Avon Park Formation are not always present. The UFA consists of several thin water bearing zones interlayered with thick zones of much lower permeability. It contains brackish (not saline) water and has potential as a water supply source through reverse osmosis or aquifer storage and recovery (ASR). Although it is the principal source of water in central Florida, the FAS yields only nonpotable water throughout most of the LWC Planning Area due to salinity and requires desalination or blending to meet potable standards. Salinity and hardness of water in the FAS increases from north to south and vertically with depth.

The Lower Floridan Aquifer (LFA) is a highly permeable, fractured and/or highly solutioned, crystalline brown dolomite sandwiched between low permeability carbonate confining units. The base of the LFA ranges between 3,700 feet and 4,100 feet bls (Miller 1986). The middle portion of the LFA contains a highly transmissive cavity and/or fracture-riddled dolomite known as the boulder zone, typically about 3,000 feet bls. The boulder zone lies well beneath the saltwater interface; therefore, water in it is typically more saline than the ocean. It is highly cavernous and/or fractured, has extremely high transmissivity and is found in a section of rock approximately 400 feet thick (Reese 2000). In some areas of south Florida, the boulder zone is used as a place to dispose (through pumping downhole) treated wastewater effluent and/or residual brines resulting from the desalination process.

Water Quality

Water in the UFA is brackish and salinity increases with depth. Desalination technological improvements have made treatment of water from the FAS (and the Lower Hawthorn Aquifer) more feasible and cost-effective in that chloride concentrations are not prohibitively high. Currently, several utilities obtain source desalination water from the Lower Hawthorn or Upper Floridan aquifers. Elsewhere, the UFA supplies only a few agricultural irrigation wells.

Efficiencies in desalination treatment technology will likely lead to the increased use of the FAS to satisfy the growing population and demand in the LWC Planning Area. Aquifer storage and recovery is another attractive emerging technology that will likely further the increased use of the Floridan Aquifer to help meet growing water demands. In concept, ASR is simply the underground storage (through injection) of excess wet season rainfall and runoff. The hydrologic characteristics of the Floridan Aquifer are ideally suited for storing and recovering large volumes of stored water. The Florida Department of Environmental Protection (FDEP) regulates all injection wells in Florida.

C-43 West Reservoir Construction

Aquifer storage and recovery wells are proposed to maximize the benefits of the C-43 (Caloosahatchee River) Basin Storage Reservoir. The CERP Caloosahatchee River (C-43) Basin ASR Pilot Project is designed to address technical and regulatory uncertainties associated with regional implementation of ASR projects. This project will provide information regarding the characteristics of the aquifer system within the Caloosahatchee River Basin, as well as determine the specific characteristics and acceptability of the Upper Floridan Aquifer System in that area as a storage zone. For this project, ASR technology continues to be tested and evaluated.

Surface Water / Groundwater Relationships

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 undrained, ambient groundwater levels generally exceed surface water elevations within the LWC Planning Area. The Caloosahatchee River and the Gulf of Mexico act as regional groundwater discharge points. Groundwater 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. Surface water management systems also affect 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 be lost to evapotranspiration or discharged to tide.

WATER NEEDS OF COASTAL RESOURCES

Maintaining 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. The mean daily flows range from 0 cfs to more than 13,652 cfs (Chamberlain *et al*. 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 due to flood control activities can significantly reduce salinities and introduce stormwater 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.

A minimum flow and level for the Caloosahatchee River and Estuary was established in 2000 and an update was initiated in 2003 (SFWMD, 2003d). The MFL document included a recovery and prevention strategy, which was incorporated into the rule [Rule 40E-8.421, Florida Administrative Code (F.A.C.)].

Fishing Pier – Pine Island Sound

Estuarine biota is well adapted to natural seasonal changes in salinity. The temporary storage and concurrent decrease in velocity of floodwaters within upstream wetlands aids in controlling the timing, duration and quantity of freshwater flows into the estuary. Upstream wetlands and their associated groundwater 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 downstream 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. Maintaining these base flows is crucial to the propagation of many fish species that are the basis of extensive commercial and recreational fishing industries.

The estuarine environment is sensitive to freshwater releases. The disruption of volume, distribution, circulation and 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. Other aspects of water quality, such as turbidity, dissolved oxygen content, nutrient loads and toxins, affect functions of these areas.

In addition to providing a significant portion of the overall water storage requirements for the C-43 Basin, the CERP and Acceler8 C-43 projects are also designed to provide environmental water supply deliveries to the Caloosahatchee Estuary, and to reduce salinity and nutrient impacts of runoff to the estuary.

9

Lower East Coast Planning Area

PLAN BOUNDARIES

The Lower East Coast (LEC) Planning Area in the South Florida Water Management District (SFWMD or District) covers approximately 6,100 square miles and includes essentially all of Miami-Dade, Broward and Palm Beach counties, most of Monroe County, and eastern portions of Hendry and Collier counties (**Figure 1**). The entire Lake Okeechobee Service Area, which includes portions of four additional counties—Martin, Okeechobee, Glades and Lee—was incorporated into the analyses because of its reliance on Lake Okeechobee for water supply. The LEC Planning Area encompasses a sprawling, fast-growing urban complex, primarily along the coast. This planning area has extensive, economically significant agricultural lands and world-renowned environmental resources, including the Everglades ecosystem and Lake Okeechobee, the largest freshwater lake in the southern United States. Highly productive coastal estuaries, such as Biscayne Bay and Florida Bay, occur along the shores.

PHYSICAL FEATURES

Climate

The subtropical climate of south Florida, with distinct wet and dry seasons, high rates of evapotranspiration, and climatic extremes of floods, droughts and hurricanes, represents a major physical driving force that sustains the Everglades. Seasonal rainfall patterns in south Florida resemble the wet and dry season patterns of the humid tropics more than the winter and summer patterns of temperate latitudes. Wet season rainfall follows a bimodal pattern with peaks during May–June and September–October. The amount of rainfall varies regionally within the District.

Tropical storms and hurricanes also provide major contributions to wet season rainfall with a high level of interannual variability and low level of predictability.

During the dry season, rainfall is governed by large-scale winter weather fronts passing through the region, usually on a weekly basis. High evapotranspiration rates in south Florida roughly equal annual precipitation. Recorded annual rainfall in south Florida has varied from 37 inches to 106 inches, and interannual extremes in rainfall result in frequent years of flood and drought. Multiyear high and low rainfall periods often alternate on a time scale approximately of decades.

South Florida's climate, in combination with low topographic relief, delayed the development of south Florida until the 20th century. The storm of 1947 caused extensive flooding in south Florida and prompted the U.S. Congress to authorize the U.S. Army Corps of Engineers (USACE) to design and construct the Central and Southern Florida Flood Control Project (C&SF Project). Water supply and flood control issues in the urban and agricultural segments continue to drive the water management planning of the Comprehensive Everglades Restoration Plan (CERP) and the *2005–2006 Lower East Coast Water Supply Plan Update* (2005–2006 LEC Plan Update).

Physiography

The surface features of central and southern Florida are largely of marine or coastal origin with subsequent erosion and modification by non-marine waters. The features include flat, gently sloping plains, shallow water-filled depressions, elevated sand ridges and a limestone archipelago. The elevations of the ridges and plains are related to former higher stands of sea level. Some ridges have been formed above the level of these higher seas as beach ridges, while the plains developed as submarine shallow sea bottoms.


The Everglades

The topography of the SFWMD has low elevation and wide areas of very low relief. Nearly the entire District is less than 200 feet above sea level and nearly half its area is less than 25 feet above sea level. Elevations within the District generally decline from north to south.

The bottom of Lake Okeechobee is approximately at sea level. Water levels in the lake generally range from 11 feet to 18 feet National Geodetic Vertical Datum (NGVD). The land immediately surrounding Lake Okeechobee is at an elevation of about 20 feet to 25 feet NGVD. The coastal regions and most of the peninsula south of the latitude of Lake Okeechobee lie below 25 feet NGVD in elevation. From Lake Okeechobee southward, an axial basin, occupied by the lake and the Everglades, occurs near the longitudinal center of the peninsula with slightly higher ground to the east and west. A small area near Immokalee and parts of the Atlantic Coastal Ridge are higher than 25 feet NGVD. Except for the coastal and beach ridges, this southern region is very flat in appearance and slopes vary gradually from approximately 25 feet NGVD near Lake Okeechobee to sea level at the coasts.

Land elevations in the Water Conservation Areas (WCAs) generally range from about 16 feet NGVD at the northern end of WCA-1 to 9 feet to 10 feet NGVD at the southern end of WCA-3. Within Everglades National Park, the land surface generally slopes from 8 feet to 9 feet NGVD at the northern end to below sea level as the freshwater wetlands of the Everglades merge with the saltwater wetlands of Florida Bay.

WATER RESOURCES AND SYSTEM OVERVIEW

Regional Hydrologic Cycle

The main components of the hydrologic cycle are precipitation (and the resulting infiltration); evapotranspiration (and the resulting withdrawal); surface water inflow and outflow; and groundwater flow.

Precipitation and Evapotranspiration

The average annual precipitation in the LEC Planning Area is approximately 53 inches. Nearly 75 percent 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 meteorological 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. Evapotranspiration in south Florida returns approximately 45 inches of water per year to the atmosphere.

Surface Water Resources

The LEC Planning Area is divided into three hydrologically related geographical areas consisting of: 1) Lake Okeechobee and the Lake Okeechobee Service Area, which includes the Everglades Agricultural Area; 2) the Everglades Protection Area, which includes the Holey Land and Rotenberger wildlife management areas, the five Water Conservation Areas and Everglades National Park; and, 3) the Lower East Coast canals and the Lower East Coast service areas (**Figure 10**). **Figure 10** also shows the St. Lucie Canal (C-44) and the Caloosahatchee River basins (C-43) as areas located outside the LEC Planning

Area with significant relationships to the LEC planning process. These two basins were included within the LEC planning process because of their dependence on Lake Okeechobee for water supply and concerns about environmental impacts associated with regulatory releases from Lake Okeechobee.

Lake Okeechobee Service Area

The major features of Lake Okeechobee and the Lake Okeechobee Service Area (LOSA) are shown in (**Figure 10**). Lake Okeechobee, Florida's largest lake (730 square miles), has a water storage capacity of over 1 trillion gallons of water and represents the heart of the C&SF Project. The lake is managed jointly by the SFWMD and the USACE as a multipurpose reservoir. Its multiple functions include flood control, urban and agricultural water supply, navigation, recreation, and fish and wildlife enhancement. Major inflows to the lake include the Kissimmee River, Fisheating Creek and Taylor Creek/Nubbin Slough. The lake supports an extensive littoral zone (154 square miles) that provides important feeding and nesting habitat for fish, wading birds, migratory waterfowl, as well as the endangered Everglades snail kite. The lake is nationally renowned for its fishing (black bass and crappie) and supports a viable commercial and sportfishing industry. Migratory birds and waterfowl also use the littoral zone and open water areas of the lake as a resting area along the Atlantic flyway. Recreational and commercial fisheries are valued in multimillion dollars per year. The lake's littoral zone also supports significant wading bird populations and is an important waterfowl hunting area.

Water levels in Lake Okeechobee are regulated by a complex system of pumps and locks. The Lake Okeechobee regulation schedule supports multiple uses and provides seasonal lake level fluctuations that vary from high stages in the late fall, winter and early spring to low stages at the beginning of the wet season. More details concerning the management of Lake Okeechobee can be found under the Water Needs section of this chapter. Information about the operation systems of Lake Okeechobee can be found in **Chapter 10**.

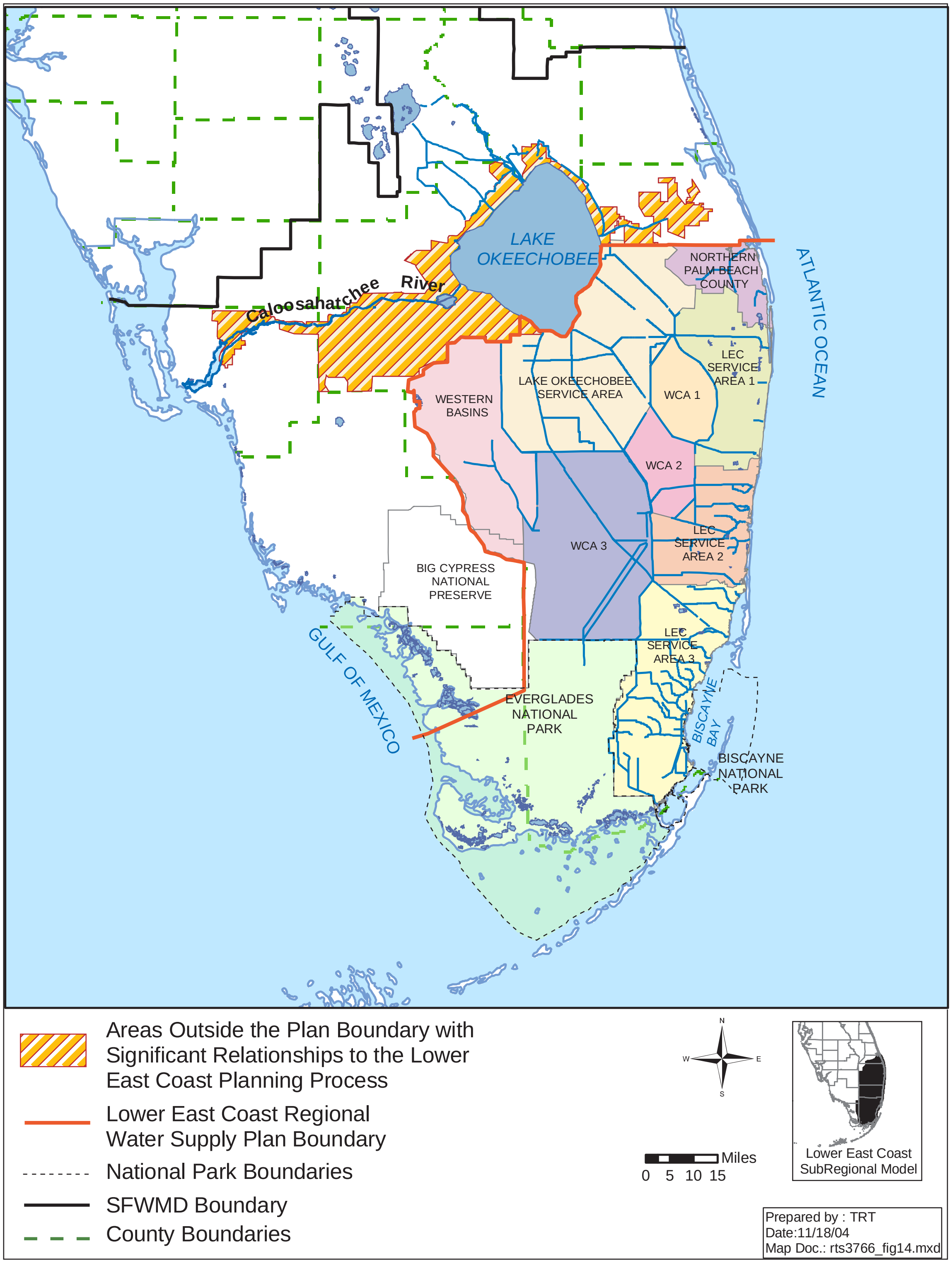


Figure 10. Major Features of the Lower East Coast Planning Area.

Everglades Agricultural Area

Sugarcane Processing Plant – EAA

The Everglades Agricultural Area (EAA) is located within the Lake Okeechobee Service Area (**Figure 10**), south of Lake Okeechobee within eastern Hendry and western Palm Beach counties. The EAA is composed of rich organic peat or muck soils, making it highly productive agricultural land. Nitrogen-rich organic (peat) soils and a warm subtropical climate permit the year-round farming of sugarcane, winter vegetables and rice. As part of the District's Acceler8 initiative, about 47,000 acres of EAA agricultural land are being converted into reservoir cells or expanded stormwater treatment areas (STAs). The largest portion of the lands for STAs had already been taken out of agricultural production by the end of 2005.

Agriculture within the EAA requires extensive drainage of rich organic soil. The primary drainage and irrigation system within the EAA consists of an extensive network of canals, levees, pumps and water control structures constructed by the USACE as part of the C&SF Project, and operated and maintained by the District. Drainage of the EAA is achieved through six primary canals (Hillsboro, North New River, Miami, West Palm Beach, Cross and Bolles canals). Seven major pump stations have a total design capacity to remove excess water from each subbasin at a maximum rate of ¾ of an inch of runoff per day. Nine smaller drainage districts, known as the Chapter 298 Special Drainage Districts, also maintain secondary drainage systems and operate pump facilities within the EAA to provide local control of water movement within and between subbasins. In addition, individual farms operate numerous private pumps, some of which are portable, that move water to and from the main canals.

Everglades Protection Area

The Everglades Protection Area lies south of the EAA, west of the Atlantic Coastal Ridge, and east of the Big Cypress Preserve. It comprises a number of different management areas that have different operational needs and priorities, including the five Water Conservation Areas (WCAs), the Holey Land and Rotenberger wildlife management areas (WMAs), and Everglades National Park, which includes Florida Bay (**Figure 10**).

The Everglades, an internationally recognized ecosystem covering approximately 2 million acres in south Florida, represents the largest subtropical wetland in the United States. Prior to drainage and development, this area consisted largely of vast sawgrass plains, dotted with tree islands and interspersed with wet prairies and aquatic sloughs covering most of southeastern Florida (Davis 1943). Everglades National Park and the WCAs are the surviving remnants of the historical Everglades, which extended over an area approximately 40 miles wide by 100 miles long, from the south shore of Lake Okeechobee to the mangrove estuaries of Florida Bay. This remaining area provides significant ecological, water storage, flood control and recreational benefits to the region, as well as important habitat for wildlife of national significance. The pre-drainage Everglades had three essential characteristics: 1) it was largely a rain-driven ecosystem; 2) it contained large spatial scale and extent; and, 3) its hydrologic regime featured dynamic storage and sheet flow.

Water Conservation Areas

Construction of canals, levees and water control structures as part of the C&SF Project has compartmentalized the historical Everglades into five separate reservoirs (**Figure 10**) known today as the Water Conservation Areas (WCAs). The five WCAs contain the last remnants of the tall sawgrass, wet prairie, deepwater slough and tree island landscapes that remain intact outside of Everglades National Park. The WCAs are completely contained by levees, except for about 7 miles on the west side of WCA-3A, which has a tieback levee. Additional levees on the east side of the Everglades protect adjacent urban, agricultural and industrial areas. This whole region is managed with a system of canals, pump stations and control structures.

The WCAs provide a detention reservoir for excess water from the EAA and parts of the LEC Planning Area, and for flood discharges from Lake Okeechobee. The WCA levees prevent the Everglades floodwaters from inundating east coast urban areas and hold backwater that can later be supplied to east coast areas and Everglades National Park. In addition, these levees help maintain higher water levels that provide recharge to the Surficial Aquifer System (SAS), lessen saltwater intrusion in coastal basins, reduce seepage, and benefit fish and wildlife in the Everglades.

Tree Islands – Water Conservation Area 1

The WCA regulation schedules essentially represent seasonal and monthly limits of storage. This seasonal range permits the storage of runoff during the wet season for use during the dry season. In addition, it maintains and preserves native plant communities, which are essential to fish, wildlife and the prevention of wind tides. Additional descriptions of WCAs 1, 2 and 3 and their respective regulation schedules are provided under the Water Needs section of this chapter.

Modifications to the regulation schedules for WCAs and the rainfall delivery formula for Everglades National Park were recommended in the *1998 Interim Plan for Lower East Coast Water Supply* (SFWMD 1998b) and the Restudy to implement rain-driven operations. These new operational rules are intended to improve timing and range of water depths in the WCAs and Everglades National Park to restore more natural hydropatterns, as well as meet minimum flows and levels (MFLs) for these areas.

Everglades National Park

South of the WCAs lies Everglades National Park, encompassing 2,353 square miles of wetlands, uplands and submerged lands located within the southern portion of the LEC Planning Area (**Figure 10**). The park contains both temperate and tropical plant communities, including sawgrass prairies, mangrove and cypress swamps, pinelands, hardwood hammocks, as well as marine and estuarine environments. The topography of this area is extremely low and flat, with most of the area lying below 4 feet NGVD. The southern portion of the park contains saline wetlands, including mangrove and buttonwood forests, salt marshes and coastal prairies, which are subject to the influence of salinity from tidal action. The park has been recognized for its natural and cultural resources, as well as for its recreational values, and has been designated an International Biosphere Reserve, a World Heritage Site and a Wetland of International Importance. Everglades National Park is known for its abundant bird life, particularly large wading bird colonies that include the roseate spoonbill, wood stork, great blue heron and a variety of egrets. Its abundant wildlife includes rare and endangered species, such as the American crocodile, Florida panther and West Indian manatee. Sheet flow from the park flows southward and enters Florida Bay principally through 20 creek systems fed by Taylor Slough and the C-111 Canal. Surface water from Shark River Slough flows to the southwest into Whitewater Bay.

East Coast Canals and Service Areas

Coastal Canals

Flood control and outlet works extend from St. Lucie County southward through Martin, Palm Beach and Broward counties to Miami-Dade County, a distance along the coast of about 170 miles. The South Miami-Dade Conveyance System was added to the existing flood control system to provide a way to deliver water to areas of south Miami-Dade County. The main design functions of these project canals and structures are to: 1) protect adjacent lands against floods; 2) store water in the WCAs; 3) control water elevations; and, 4) provide water for conservation and human uses. These works protect against major flood damages. However, due to urbanization, the existing surface water management system has to handle greater peak flows than in the past. Project works consist of 40 operating canals, 50 operating structures and one levee. The operating structures consist of 35 spillways, 14 culverts and one pump station. Many of these canals are used to remove water from interior areas to tidewater. Damages to agriculture, citrus and pasturelands are reduced due to the effective drainage capabilities of the canals. The project works maintain optimum stages for flood control, water supply, groundwater recharge and prevention of saltwater intrusion.

Areas become flooded during heavy rainfall events due to antecedent conditions that cause saturation and high runoff from both developed and undeveloped areas. To reduce the threat of flooding, automatic controls have been installed on some control structures. Saltwater intrusion has declined considerably at coastal structures since the installation of salinity dams downstream and salinity sensors near the structures.

The coastal canals and control structures are designed to permit rapid removal of floodwaters from immediately adjacent drainage areas. The degree of flood protection provided by outlet capacity depends on whether the protected area is urban or agricultural. Maximum rates of removal vary from 40 percent to 100 percent of the Standard Project Flood (SPF).

The network of canals and control structures also provide capacity for water supply and salinity control in the area. Releasing water from the WCAs and conveying this water through coastal canals to the vicinity of the wellfields significantly recharge the wellfields, which are the primary source of municipal water supplies. Water stored in the WCAs can also be used to maintain groundwater levels, provide a freshwater head for salinity control in the coastal area and irrigate agricultural areas.

North Palm Beach Service Area

L-8 Reservoir Near C-51 Canal

The North Palm Beach Service Area (NPBSA) includes all of the coastal and inland portions of northern Palm Beach County west of the EAA and north of the West Palm Beach Canal Basin (**Figure 10**). The southern L-8 Basin and the M-Canal/Water Catchment Area basins are included within the NPBSA. This service area contains extensive urban, agricultural and natural areas. The major natural areas within the NPBSA include the DuPuis Reserve, the J.W. Corbett Wildlife Management Area, the West Palm Beach Water Catchment Area, the Loxahatchee Slough, the Loxahatchee River and the Pal Mar Wetlands. The urban areas have experienced rapid growth for several decades and a continuation of this growth is expected to continue through 2025. Agricultural land uses occur mostly in the L-8 and C-18 basins.

Lower East Coast Service Area 1

The Lower East Coast Service Area 1 (LECSA-1) includes the portion of Palm Beach County east of WCA-1 and a small portion of Broward County (**Figure 10**). The service area includes the West Palm Beach Canal (C-51) and Hillsboro basins. This service area, which is heavily urbanized, has experienced rapid growth for several decades. A large amount of agriculture, principally winter vegetables, citrus and nurseries, are located in the western portions of the service area.

Lower East Coast Service Area 2

The Lower East Coast Service Area 2 (LECSA-2) includes the portion of Broward County east of the WCAs and south of the Hillsboro Canal Basin and the C-9 Canal Basin in northern Miami (**Figure 10**). Also heavily urbanized, the LECSA-2 has experienced rapid growth for several decades. While the rate of growth is slowing, the increasing population results in significant increases in demand for potable water.

Lower East Coast Service Area 3

Lower East Coast Service Area 3 (LECSA-3) includes the portion of Miami-Dade County east of WCA-3B and Everglades National Park, as well as the Florida Keys (**Figure 10**). The Florida Keys are included in LECSA-3 because their primary source of drinking water is the Florida Keys Aqueduct Authority Wellfield located near Florida City.

Urban / Agricultural Land Use

Water demand in the LECSA-3 is generated primarily by a mixture of urban and agricultural land uses. The citrus, winter vegetables and tropical fruit farming in southern Miami-Dade County represents the second-largest agricultural area in south Florida. Early efforts to drain the area caused significant saltwater intrusion and the abandonment of coastal wellfields in favor of large, regional wellfields located west of the Atlantic Coastal Ridge. Construction of coastal canal water control structures has helped to stabilize or slow the advance of the saline interface, although isolated areas still show evidence of continued inland migration of salt water.

During dry periods, rainfall and seepage are insufficient to maintain the Biscayne Aquifer at levels that meet demands and prevent saltwater intrusion. In these times, the area is highly dependent on additional deliveries from regional storage via the C-4 and C-6 canals for the recharge of major public water supply wellfields.

Besides local rainfall, the LECSA-3 receives large quantities of regional water due to groundwater seepage from WCA-3B and Everglades National Park. Due to this seepage, efforts to restore water levels in areas west of the levee system to historic levels affect the drainage needs of land uses east of the levee system, while helping to recharge major public water supply wellfields.

The CERP Everglades National Park Seepage Management Project includes three CERP components: 1) L-31N Improvements for Seepage Management, 2) S-356 Structure, and 3) Bird Drive Recharge Area. The L-31N Levee Seepage Improvements include relocating and enhancing the L-31N, groundwater wells and sheet flow delivery system adjacent to Everglades National Park. This project reduces levee seepage flow across L-31N adjacent to Everglades National Park via a levee cutoff wall. Groundwater flows during the wet season will be captured by groundwater wells adjacent to L-31N and pumped back to Everglades National Park, where sheet flow will be re-established. This project will also include the relocation of the Modified Water Deliveries S-356 Structure to provide more effective water deliveries to Everglades National Park. The purpose of the Bird Drive Recharge Area component, which consists of pumps, water control structures, canals and an aboveground recharge area, is to recharge groundwater and reduced seepage from the Everglades National Park buffer area by increasing water table elevations east of Krome Avenue.

In addition, one of the components of the Acceler8 Water Preserve Areas Project, is the WCA-3A/3B Seepage Management Project. This project includes the WCA-3A/3B Seepage Management Area, a 14-mile tract of wetlands invaded by exotic vegetation, and two adjacent aboveground impoundments, the C-11 and C-9 impoundments. These project components will enhance the buffer between residential development and protected Everglades wetlands, capturing and diverting stormwater runoff and reducing underground seepage.

Groundwater Resources

The principal groundwater resources for the LEC Planning Area are the Surficial Aquifer System (SAS), including the Biscayne Aquifer, and the Floridan Aquifer System (FAS). Both are critical to the local ecology and economy. **Figure 11** shows a generalized geologic cross-section of the hydrogeology of south Florida, depicting the aquifers. **Table 30** presents the groundwater systems, hydrogeologic units and relative aquifer yields of each county in the LEC Planning Area.

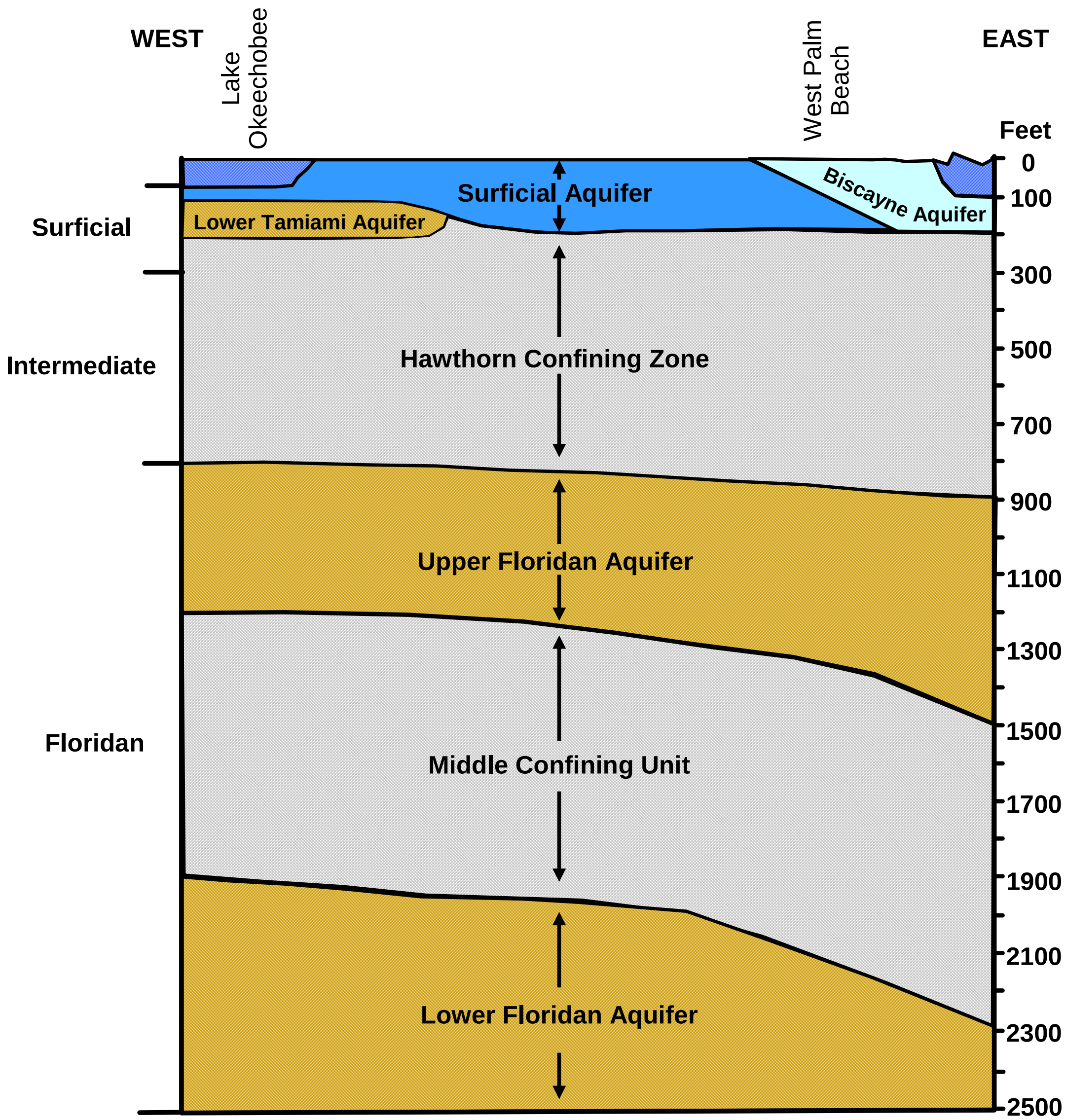


Figure 11. Generalized Geologic Cross-Section of the Lower East Coast Planning Area.

Table 30. Groundwater Systems in the Lower East Coast Planning Area.

Aquifer System	Hydrogeologic Unit	Aquifer Yield 1-Low 2-Moderate 3-High		
		Miami-Dade	Broward	Palm Beach
Surficial Aquifer System	Surficial Aquifer	3	3	2
Intermediate Confining Unit	Hawthorn Group	1	1	1
Floridan Aquifer System	Upper Floridan Aquifer	3	3	3
	Middle Confining Unit	1	1	1
	Lower Floridan Aquifer	3	3	3
	Lower Floridan Aquifer Confining Unit	1	1	1
	Boulder Zone	3	3	3

Surficial Aquifer System

The Surficial Aquifer System (SAS), which extends throughout southeast Florida, provides most of the fresh water for public and agricultural water supply within the LEC Planning Area. The SAS is an unconfined aquifer system, meaning that the groundwater is at atmospheric pressure and that water levels correspond to the water table. It is composed of solutioned limestone, sandstone, sand shell and clayey sand, and includes sediments from the water table down to the intermediate confining unit (Hawthorn Group). The SAS sediments have a wide range of permeability, and have been locally divided into aquifers separated by less permeable units. The best known of these is the Biscayne Aquifer. One of the most productive aquifers in the world, the Biscayne Aquifer extends from coastal Palm Beach County south, including almost all of Broward and Miami-Dade counties, and portions of southeastern Monroe County. Another less widely used aquifer in the SAS is the Gray Limestone Aquifer. The Gray Limestone Aquifer lies below and west of the Biscayne Aquifer, extending into Hendry and Collier counties.

The SAS provides major sources of water for the following uses:

- Meeting drinking water requirements for 5.6 million people living in urban areas in the LEC Planning Area.
- Maintaining water levels in local wells, canals and lakes.
- Irrigating agricultural crops.
- Replenishing regional wetlands and providing base flow to estuaries, such as Biscayne Bay and Florida Bay.

Biscayne Aquifer

The Biscayne Aquifer (**Figures 12** and **13**) is composed of interbedded, unconsolidated sands and shell units with varying thickness of consolidated, highly solutioned limestones and sandstones. In general, the Biscayne Aquifer contains less sand and more solutioned limestone than most of the SAS. The Biscayne Aquifer is one of the most permeable aquifers in the world and has transmissivities in excess of 7 million gallons per day (MGD) per foot of drawdown.

The major geologic deposits comprising the Biscayne Aquifer include Miami Limestone, the Fort Thompson Formation, the Anastasia Formation and the Key Largo Formation. The base of the Biscayne Aquifer is generally the contact between the Fort Thompson Formation and the underlying Tamiami Formation of Plio-Miocene Age. However, in places where the upper unit of the Tamiami Formation contains highly permeable limestones and sandstones, the zones are also considered part of the Biscayne Aquifer if the thickness exceeds 10 feet.

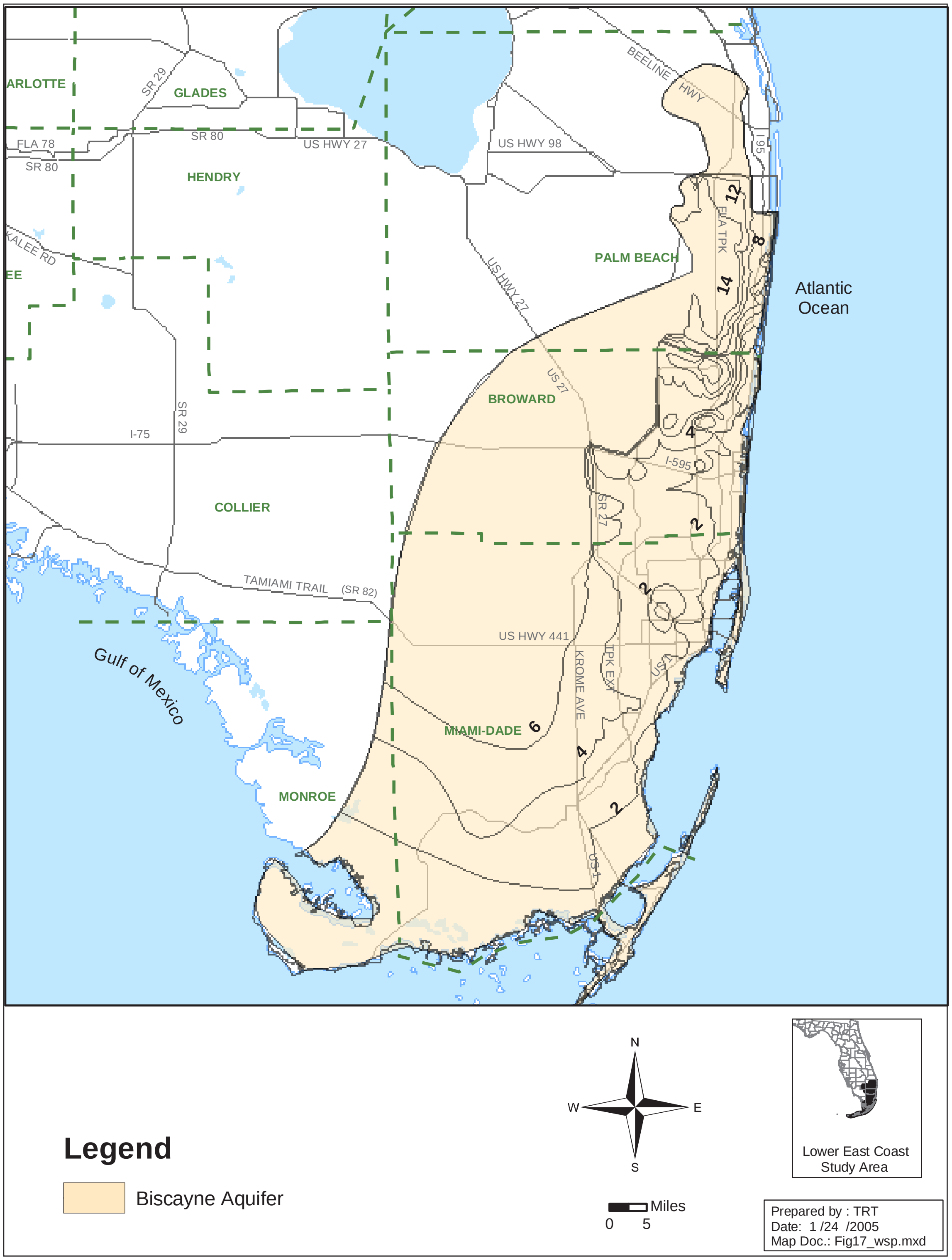


Figure 12. Location of the Biscayne Aquifer in Eastern Miami-Dade, Broward and Palm Beach Counties with Elevation of the Top of the Aquifer. Contour Lines are Feet NGVD.

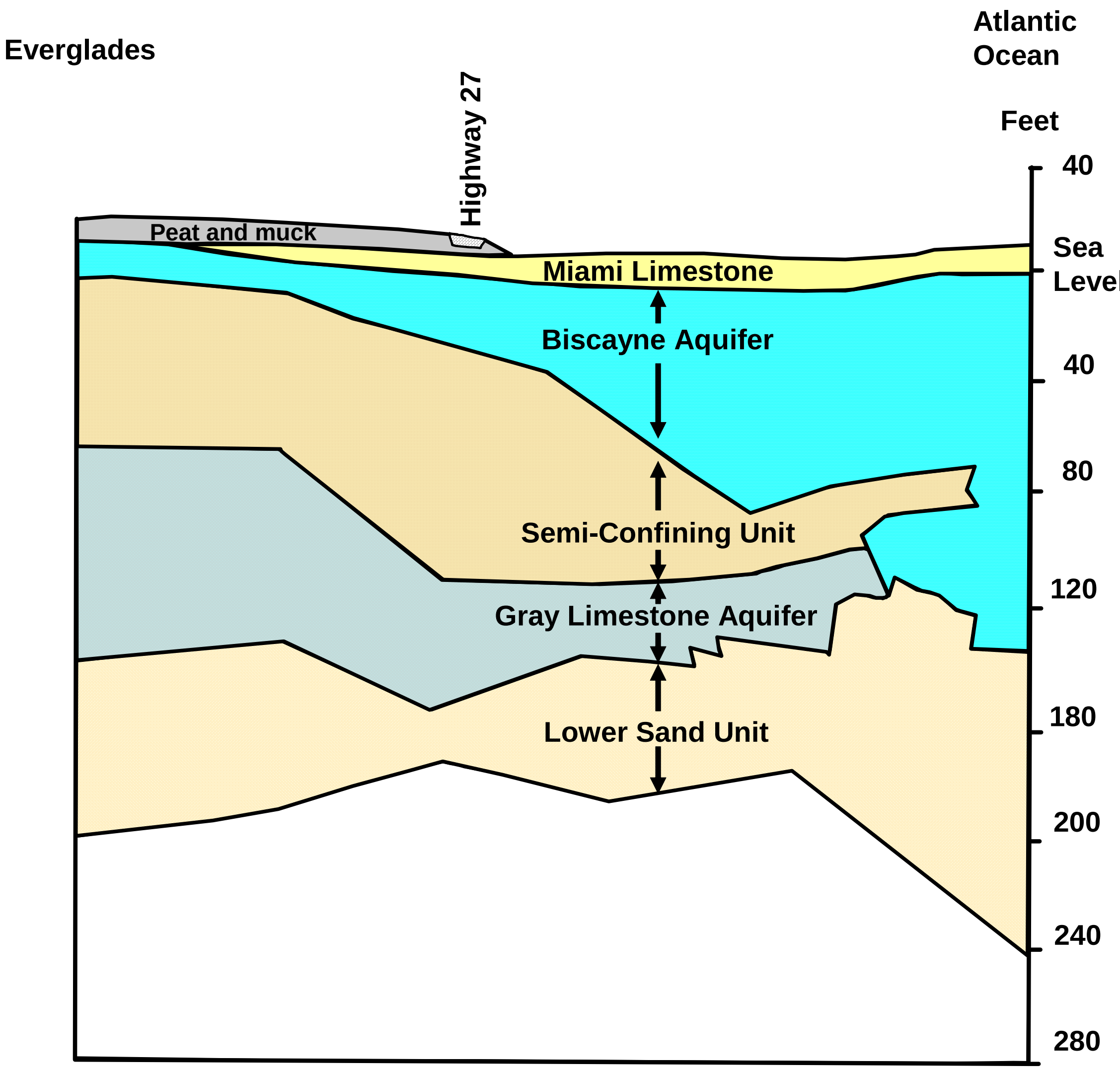


Figure 13. Generalized Geologic Cross-Section of the Biscayne Aquifer.

Due to the regional importance of the Biscayne Aquifer, it has been designated as a sole source aquifer by the U.S. Environmental Protection Agency (USEPA) under the *Safe Drinking Water Act* (SDWA) and is therefore afforded stringent protection. This designation was made because it is a principal source of drinking water and is highly susceptible to contamination due to its high permeability and proximity to land surface in many locations. Major sources of contamination are saltwater intrusion and infiltration of contaminants from canal water. Sources of contamination include surface water runoff (pesticides and fertilizers); leachate from landfills, septic tanks and sewage plant treatment ponds; and, injection wells used to dispose of stormwater runoff or industrial waste. Trichloroethylene and vinyl chloride are examples of groundwater contaminants of concern. Numerous hazardous waste sites (e.g., *Superfund and Resource Conservation and Recovery Act* sites) have been identified in the area underlain by the Biscayne Aquifer. Action to remove existing contamination is under way at many of these sites. Waste management practices are generally monitored to prevent further contamination.

Gray Limestone Aquifer

The Gray Limestone Aquifer is composed of gray, shelly limestone with abundant shell fragments and sand. The hydraulic conductivity of the Gray Limestone Aquifer generally increases from east to west, and ranges from approximately 200 feet to 12,000 feet per day. Transmissivity values range from greater than 50,000 feet squared per day west of Miami-Dade and Broward counties to greater than 300,000 feet squared per day in eastern Collier County (Reese and Cunningham 2000). For most of its extent, the Gray Limestone Aquifer is confined by sand, clayey sand, mudstone and clays of low hydraulic conductivity (Reese and Cunningham 2000).

Floridan Aquifer System

The Floridan Aquifer System (FAS) is a confined aquifer system made up of a thick sequence of limestones, with dolomitic limestone and dolomite commonly found in the lower portions of the aquifer. The FAS is separated from the SAS, and confined by the sediments of the Hawthorn Group, which are referred to as the intermediate confining unit. Less permeable carbonate units, referred to as the middle confining unit, separate the FAS into two major aquifers called the Upper and Lower Floridan aquifers.

The Upper Floridan Aquifer (UFA) comprises fossiliferous limestones from the Suwannee, Ocala and Avon Park formations. The potentiometric surface of the UFA ranges from 40 feet to 60 feet above land surface in the LEC Planning Area, with groundwater flow occurring primarily within several thin, high-permeability zones. The middle confining unit is relatively less permeable than both the UFA and the Lower Floridan Aquifer (LFA). It separates the brackish water of the UFA from the more saline water of the LFA. The LFA comprises dolostones of the Oldsmar and Upper Cedar Keys formations. Groundwater in the LFA is close to seawater in composition, and upwells into the middle confining unit through fractures (Meyer 1989).

The FAS is one of the most productive aquifers in the world and a multiuse aquifer system. Where it contains fresh water, it is the principal source of water supply, especially north of Lake Okeechobee. Throughout the LEC Planning Area, water from the FAS is generally nonpotable due to salinity and requires desalination or blending to meet potable standards.

More than 600 feet of low permeability sediments confine this aquifer and create artesian conditions in the LEC Planning Area. Although the potentiometric surface of the aquifer is above land surface, the low permeability units of the intermediate confining unit prevent significant upward migration of saline waters into the shallower aquifers. The depth of the Floridan Aquifer is approximately 900 feet in coastal Miami-Dade County. In the LEC Planning Area, the UFA is being considered for storage of potable water within an aquifer storage and recovery (ASR) system. At the base of the LFA, there are cavernous zones with extremely high transmissivities collectively known as the boulder zone. Because of their depth and high salinity, these deeper zones of the LFA are used primarily for injection of treated wastewater.

Saltwater Intrusion

The inland movement of salt water is a major resource concern in the coastal areas of the LEC Planning Area and can significantly affect water availability in areas adjacent to saline water bodies. When water is withdrawn from the Surficial Aquifer at a rate that exceeds its recharge capacity, the amount of freshwater head available to impede the migration of salt water is reduced, and saltwater intrusion becomes likely. The groundwater hydrology of the LEC Planning Area has been permanently altered by urban and agricultural development and construction of the C&SF Project. Construction of a series of canals has drained both the upper portion of the Biscayne Aquifer and the freshwater mound behind the coastal ridge. This has resulted in a significant decline in groundwater flow toward the ocean and, consequently, has allowed the inland migration of the saline interface during dry periods. Large coastal wellfields have also been responsible for localized saltwater intrusion problems. Construction of coastal canal water control structures has helped to stabilize or slow the advance of the saline interface, although isolated areas still show evidence of continued inland migration of salt water.

The District's consumptive use permitting (CUP) criteria include denial of permits that would cause harm to the water resources because of saline water intrusion. Section 3.4, Saline Water Intrusion, of the *Basis of Review for Water Use Permit Applications* (SFWMD 2003a) describes harmful saline water intrusion occurring when:

> Withdrawals result in the further movement of a saline water interface to a greater distance inland toward a freshwater source, except as a consequence of seasonal fluctuations; climatic conditions, such as drought; or operation of the Central and Southern Flood Control Project, secondary canal systems, or stormwater systems.

Withdrawals could permanently move the saline interface inland, reducing the quality and quantity of water available at existing wellfields and impeding future withdrawals at favorable locations (near population centers and treatment plants).

Historically, the District's CUP Program has required water users to maintain a minimum of 1.0 foot of freshwater head between wellfields and saline water as a guideline for the prevention of saltwater intrusion. This guideline, in combination with a saltwater intrusion-monitoring program, has been largely successful in preventing salt water from occurring based on consideration of individual permits and utility operations.

WATER NEEDS

In the preceding sections, surface water and groundwater resources were addressed as separate entities; however, they are highly interconnected. Local water supply utilities and individual users obtain water from two primary sources: 1) withdrawal from a surface water body, such as a canal, lake, river or wetland, or 2) withdrawal from a groundwater well. Virtually all of the public water supply in the LEC Planning Area is from groundwater, except for lakeside communities in Palm Beach County and the City of West Palm Beach, which uses surface water obtained through a system of lakes and wetlands. Throughout much of the LEC Planning Area, a regional system of canals provides a means to move water from one location to another. Water is transported generally from north to south, from Lake Okeechobee through water control structures to the Everglades Agricultural Area (EAA) canals and into the WCAs. Water flows from the WCAs via structures and canals to Everglades National Park and the coastal basins. Water in coastal canals provides recharge to the SAS, enhancing groundwater supplies and helping replenish water in lakes, rivers and wetlands.

Lake Okeechobee

Lake Okeechobee serves as a direct source of drinking water for lakeside cities and towns, and as a backup water supply for urban areas located along the Lower East Coast of Florida. Two reservations of the Seminole Tribe of Florida also rely on Lake Okeechobee as a supplemental irrigation supply source for their surface water federal entitlement rights, with specific volumes of water identified for this purpose for the Big Cypress Seminole Indian Reservation and an operational plan addressing this same subject for the Brighton Seminole Indian Reservation during drought-water shortage declarations.

The lake also provides irrigation water for the 700-square-mile EAA located south of the lake, and represents a critical supplemental water supply for the Everglades during dry periods. Given these often-competing demands on the lake, management of the water resource is a major challenge. The primary tool for managing lake water levels is the regulation schedule. This schedule defines the ranges of water levels, in which specific discharges are made to control excessive accumulation of water within the lake's levee system. The schedule varies seasonally to best meet the objectives of the C&SF Project. A number of lake regulation schedules have been adopted since the construction of the C&SF Project (Trimble and Marban 1988). For more information about Lake Okeechobee operations, see **Chapter 10**.

Water Conservation Areas

As a result of the Central and Southern Florida Flood Control Project (C&SF Project), the remaining Everglades were divided into three hydrologic units, known as the Water Conservation Areas (WCAs) (**Figure 10**). The WCAs are shallow, diked marshes maintained for flood control, environmental restoration and water supply to the LEC Planning Area. The WCAs are located south of Lake Okeechobee and the EAA and comprise an area of about 1,350 square miles. The WCAs provide water storage and detention for excess water discharged from urban and agricultural areas, as well as for regulatory releases from Lake Okeechobee. The WCAs provide water supply for agricultural lands and Everglades National Park; provide recharge for the Biscayne Aquifer (the sole source of drinking water to LEC urban areas); and, help to retard saltwater intrusion of coastal wellfields. The WCAs contain the region's last remnants of the original sawgrass marsh, wet prairies and hardwood swamps located outside of Everglades National Park. The WCAs are managed as surface water reservoirs using a set of water regulation schedules.

Water Management Considerations

One primary function of the C&SF Project is to provide a highly efficient flood control system, which is designed to keep urban and agricultural areas dry in the wet season. Flood protection is provided by discharging excess water to tide or into the WCAs and Everglades National Park. Rapid wet season flood releases to tide—coupled with the reduced capacity to retain water in Lake Okeechobee, the northern historical sawgrass plains, and the eastern peripheral wetlands and sloughs—have severely reduced the overall ability to store water in the regional system.

The sawgrass plains, for example, once stored and slowly released much of the water that overflowed from Lake Okeechobee. Today, large areas of these sawgrass plains have been converted into agricultural land within the EAA. Water from the lake and excess runoff water are quickly passed to the WCAs and the coast during the wet season to prevent crop damage. Water levels in coastal canals are maintained at relatively low levels during the wet season to provide additional capacity for storage and conveyance of floodwaters, resulting in low groundwater levels.

Another impact of the loss of water storage is that, during the dry season, high levels of demands may exceed the capacity to obtain water from nearby wetlands. When this occurs, water is released from Lake Okeechobee to meet crop and urban demands. Lack of storage, not lack of water, is the problem. During dry periods, minimum levels for canals in the LEC Planning Area are principally maintained to protect the Biscayne Aquifer from saltwater intrusion. The head created in the canals raises groundwater levels, recharging the aquifer and the urban wellfields, but also increases the likelihood that localized flooding will occur during an extreme storm event. During the wet season, wellfields are recharged by local rainfall and by seepage from the Everglades and the canals. During the dry season, recharge is more dependent on the regional system. Unfortunately, during both the wet and dry seasons, excess storm water is passed through the canals and out to tide when it should be stored. Without sufficient storage, it is difficult to have water available during dry periods and avoid flooding during wet periods.

The Eastern Hillsboro Regional Aquifer Storage and Recovery (ASR) Project, recommended in the *2000 Lower East Coast Regional Water Supply Plan* (2000 LEC Plan), will develop a functional ASR system to store excess water from the Hillsboro Basin for later beneficial use (SFWMD 2000d). Construction of the Eastern Hillsboro Regional ASR Pilot Project was completed in 2003 and cycle testing began in 2004. While cycle testing continued, Palm Beach County applied to the Florida Department of Environmental Protection (FDEP) for an operating permit.

The CERP Lake Okeechobee ASR Project will provide additional regional storage, while reducing evaporation losses and the amount of land removed from use normally associated with aboveground reservoirs. This project will manage a portion of regulatory releases from the lake, primarily to improve the Everglades hydropatterns and meet supplemental water supply demands of the LEC Planning Area.

The Acceler8 Everglades Agricultural Area Reservoir, a component of the larger CERP Everglades Agricultural Area Storage Reservoir (EAASR) Project, is designed to provide significant additional water storage in the southern region of the EAA. The Phase 1 project, with Bolles and Cross canals improvements, is an aboveground reservoir for water storage, with a capacity of 190,000 acre-feet at a maximum depth of 12 feet. Excavation groundbreaking occurred in August 2006.

Because the LEC Planning Area is affected by activities in the Caloosahatchee and St. Lucie river basins for water supply, two additional Acceler8 projects are important to this region: the C-43 (Caloosahatchee River) West Reservoir and the C-44 (St. Lucie Canal) Reservoir/Stormwater Treatment Area. The C-43 (Caloosahatchee River) West Reservoir Project, located in Hendry County in the Lower West Coast (LWC) Planning Area, is designed to capture water from the Caloosahatchee River (C-43) during high-flow times for use in dry season to provide flows to the estuary downstream. The C-44 (St. Lucie Canal) Reservoir/STA, located in southern Martin County in the Upper East Coast (UEC) Planning Area, is designed to capture and treat local stormwater runoff from the C-44 Basin, thereby decreasing flows and improving water quality into the St. Lucie Estuary.

While sufficient water is present to meet local needs during wet seasons and normal rainfall years, during extremely dry years, urban wellfields depend heavily on seepage and releases from the WCAs and Lake Okeechobee. During drought years, urban and agricultural areas have additional needs and more water is used for landscape maintenance, primarily lawn irrigation.

The amount of water needed to recharge urban wellfields is less than the volume needed to prevent saltwater intrusion. However, the cost of replacing damaged wells is very high. The amount of water needed to prevent saltwater intrusion in turn is much less than the wet season coastal discharges. If coastal flows were captured and stored, more than enough water would be available to maintain dry season salinity barriers without removing water from the natural system.

Within the LEC Planning Area, ecological benefits may accrue from maintaining higher groundwater levels. For example, low groundwater levels have had significant effects on Biscayne Bay, including increased salinity, increased turbidity and lower water quality. In south Miami-Dade County, lowered groundwater levels have caused wetland desiccation and shifts in vegetation from freshwater marshes that existed next to the bay in the early 1900s to salt marsh and mangrove communities that exist today.

Management During Wet Periods

During wet years, seepage from the Everglades is generally more than adequate to maintain water levels in the coastal aquifers and no releases for this purpose are required. However, releases through coastal canals may be required to maintain regulation schedules in natural storage areas, such as Lake Okeechobee and the WCAs, and to provide flood protection.

In order to promote development of coastal basins for urban and agricultural use in the past century, water levels along the coastal ridge have been lowered by construction of drainage facilities. Over time, drainage has continued farther westward to allow replacement of most of the wetlands in the Transverse Glades areas in Miami-Dade and Broward counties with homes, farms and nurseries. Large areas have been mined for the underlying rock, which is used for roads and fill.

Due to the high transmissivity of the surficial Biscayne Aquifer, lowering of water levels to protect one area may result in reduction of water levels over large areas. Attempts to provide drainage and flood protection to coastal areas have lowered water tables and shortened hydroperiods of wetlands farther west into the Everglades. Large amounts of fresh water that would have remained in these wetlands or moved slowly southward to Everglades National Park have been lost as surface water flow through coastal canals to Biscayne Bay.

Analyses conducted for the Restudy and the development of the 2000 LEC Plan have attempted to compensate for the effects of drainage by establishing long-term restoration goals and management targets that reflect how the natural systems functioned before the area was drained. The Natural System Model (NSM) is used to represent pre-drainage conditions by simulating hydrologic conditions that existed before canals were constructed and before water levels and topography were altered by drainage. The water levels predicted by the NSM, in conjunction with historical data and expert opinion, were used during the Restudy as a basis to establish restoration goals for both low water and high water conditions. Consumptive use permits in turn consider these restoration water levels as the no harm standard that should be maintained under all conditions less severe than a 1-in-10 year drought. In addition, the Restudy report includes the provision that "flood level protection monitoring will ensure that the existing level of protection is not compromised as a result of implementation of the recommended plan." (USACE and SFWMD 1999)

The objective of the CERP is the restoration, preservation and protection of the south Florida ecosystem, while providing for other water-related needs of the region, including water supply and flood protection. The *2000 Water Resources Development Act* (WRDA) outlines the CERP assurance of project benefits, including maintenance of flood protection, providing that the implementation of the CERP shall not reduce levels of service for flood protection that are in existence on the date of enactment of the WRDA of 2000, and are in accordance with applicable law.

Maintaining levels of flood protection remains an important purpose of the C&SF Project and an objective of the CERP. The USACE carefully evaluates any potential flood control impacts before any CERP components are built. Project Implementation Reports (PIRs) for individual components, or groups of components, include a detailed review of flood protection for the area affected by the components. Opportunities for enhancing flood protection in conjunction with other design objectives are explored.

Management During Droughts

During dry years, additional water may be released from the regional system through the coastal canals to help recharge the SAS in the coastal basins. Triggered either by a decline in water levels in the canals below maintenance levels or a movement of the saltwater front in the coastal aquifers, these water supply releases are made on an as-needed basis. **Figures 14** and **15** show how regional water conveyance facilities are managed during wet and dry periods. **Chapter 10** provides additional information about the Lake Okeechobee Water Shortage Management Plan.

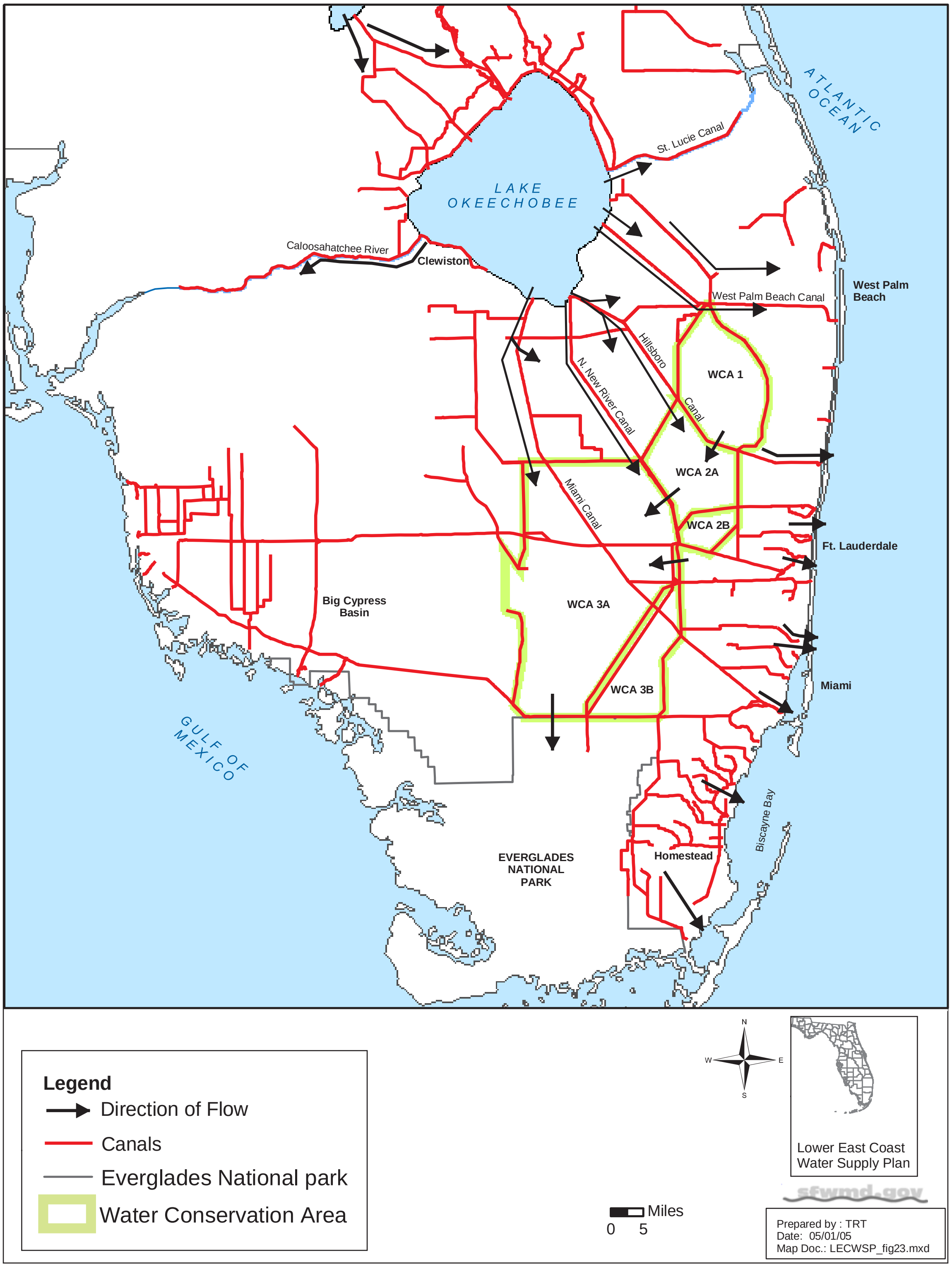


Figure 14. Water Conveyance in the Regional Systems During Wet Period. Arrows Indicate Direction of Pumpage or Flow.

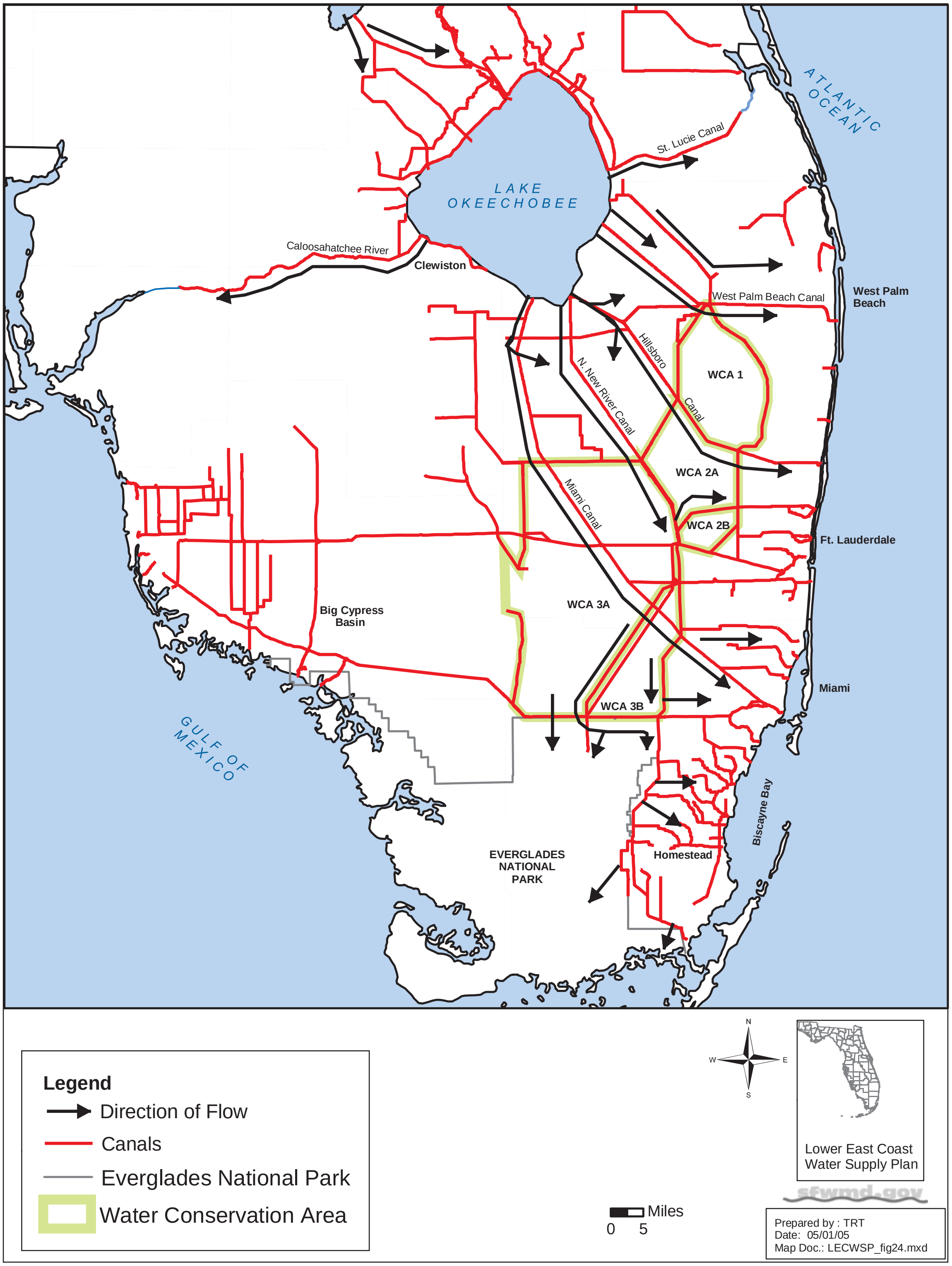


Figure 15. Water Conveyance in the Regional Systems During Dry Period. Arrows Indicate Direction of Pumpage or Flow.

Urban Development

As populations and the demand for available water supplies increase in South Florida, there is an increased need to balance the protection of the natural systems with efficient use of current and future water resources.

10

Regional System Operations

Covering 730 square miles, Lake Okeechobee is the heart of the Central and Southern Florida Flood Control Project (C&SF Project) and a key water storage feature in the Kissimmee – Okeechobee – Everglades system. Lake Okeechobee is Florida's largest freshwater lake and the second-largest lake in the United States. Lake Okeechobee originally served as a freshwater reservoir, with water flowing from the Kissimmee Basin into the lake. The land around Lake Okeechobee was so flat and the waters of the lake so plentiful that whenever the lake reached its fill, it overflowed its low natural banks and streamed into the Everglades. In 1948, the U.S. Army Corps of Engineers (USACE) was authorized to build levees around the lake to provide better flood protection. In 1960, Congress named the levees the Herbert Hoover Dike.

The lake has multiple functions, including flood protection, urban and agricultural water supply, navigation, and fisheries and wildlife habitat. As such, operation of the lake affects a wide range of environmental and economic issues. Lake operations must carefully consider the entire, sometimes conflicting, needs of the regional water management system. Together, the USACE and the South Florida Water Management District (SFWMD or District) manage the lake levels according to a regulation schedule. In addition, other mandated plans and programs are in place as part of the regional system operations.

LAKE OKEECHOBEE REGULATION SCHEDULE

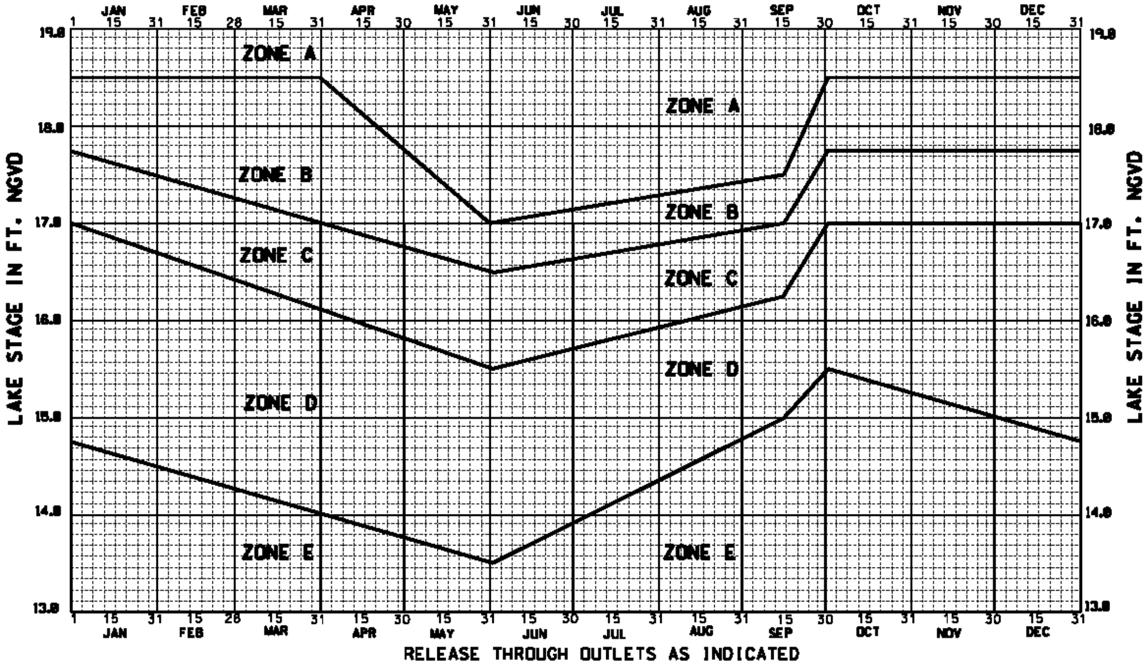
A complex system of pumps and locks regulates Lake Okeechobee's water levels, and the primary tool for managing the lake's levels is the Water Supply and Environmental (WSE) Regulation Schedule, in effect since its approval in July 2000. **Figure 16** shows the WSE schedule and its various management zones. Detailed analysis demonstrated that the WSE schedule performance is equal to or better than the previous regulation schedule, "Run 25," for flood protection, water supply and environmental objectives, including benefits to the lake's ecosystem and downstream estuaries (USACE 1999).

Designed to provide environmental benefits to the lake and downstream systems, while protecting the region's water supply, this schedule uses climate forecasting and tributary hydrologic conditions to determine the volumes of water to release from the lake. The WSE schedule is used in conjunction with the WSE Operational Guidelines Decision Tree for operation of the lake. The Decision Tree is used to help water managers make decisions about whether or not lake regulatory releases should be made to downstream water bodies, such as the Water Conservation Areas (WCAs) or to tidewater via the St. Lucie Canal (C-44) or Caloosahatchee River (C-43).

The extent of water released to the estuaries in the Decision Tree ranges from "up to maximum discharge" in the case where the lake is in Zone A of the regulation schedule, to "no discharge to tide" when the lake is in Zone D and tributary conditions are dry. A key feature of the WSE schedule is the lower operational zone, Zone D, which allows the flexibility to deliver water to the Everglades WCAs during lower lake stages. The WSE schedule also allows dry season discharges to the estuaries to be gradually increased as needed to control water levels, and allows more water to be kept in the regional system for water supply and hydroperiod restoration (USACE 1999).

The WSE schedule also allows for adjustments to be made in the timing and magnitude of Lake Okeechobee regulatory discharges based on conditions in Lake Okeechobee's tributary basins, and can incorporate extended meteorological and climate outlooks. When regulatory releases are required to be made to each downstream water body, the schedule provides information about possible ranges of discharge volumes, not exact amounts.

The USACE is expediting modifications to the Lake Okeechobee WSE Regulation Schedule to reduce the risk of impacts to the natural aquatic resources, while balancing competing demands on the regional system.



Releases Through Lake Okeechobee Outlets

Zone	**Agricultural Canals to WCAs (1, 2)**	**Caloosahatchee River at S-7 (1, 2, 4)**	**St Lucie Canal at S-80 (1, 2, 4)**
A	Pump Maximum Practicable	Up to Maximum Capacity	Up to Maximum Capacity
B (3)	Maximum Practicable Releases	Releases per decision tree (these can range from maximum pulse release up to maximum capacity)	Releases per decision tree (these can range from maximum pulse release up to maximum capacity)
C (3)	Maximum Practicable Releases	Releases per decision tree (these can range from no discharge up to 6500 cfs)	Releases per decision tree (these can range from no discharge up to 3500 cfs)
D (3, 5)	As needed to minimize adverse impacts to littoral zone; no adverse impacts to the Everglades	Releases per decision tree (these can range from no discharge up to 4500 cfs)	Releases per decision tree (these can range from no discharge up to 2500 cfs)
E	No Regulatory Discharge	No Regulatory Discharge	No Regulatory Discharge

(1) Subject to first removal of runoff from downstream basins.
(2) Guidelines for wet, dry and normal conditions are based on: 1) selected climatic indices and tropical forecasts; and 2) projected inflow conditions. Releases are subject to the guidelines in the WSE Operational Decision Tree, Parts 1 and 2.
(3) Releases through various outlets may be modified to minimize damages or obtain additional benefits. Consultation with Everglades and estuarine biologists is encouraged to minimize effects to downstream ecosystems.
(4) Pulse releases are made to minimize adverse effects to downstream ecosystems.
(5) Only when the WCAs are below their respective schedules.

Figure 16. WSE Schedule for Operation of Lake Okeechobee.

The large-scale discharges sometimes required in the WSE schedule can be damaging to the downstream estuarine systems. Best Management Zones were developed to provide a buffer or safety factor for making early or pulsed releases of lake water to downstream estuaries. These release patterns are called pulse releases because they mimic the pulse release associated with a rainfall event that would normally occur in an upstream watershed of the estuary. This release concept allows the estuary to absorb the freshwater release without drastic or long-term salinity fluctuations. **Table 31** shows specific discharge criteria for the Caloosahatchee River and St. Lucie River estuaries.

Table 31. Pulse Release Schedules for the St. Lucie and Caloosahatchee River Estuaries and Their Effect on Lake Okeechobee Water Levels.

Day of Pulse	Daily Discharge Rate (cubic feet per second)					
	St. Lucie S-80 Level I	**St. Lucie S-80 Level II**	**St. Lucie S-80 Level III**	**Caloosa. S-77 Level I**	**Caloosa. S-77 Level II**	**Caloosa. S-77 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
Average Flow	730	950	1,170	1,600	2,300	3,000
Acre-Feet per Pulse and Correlating Lake Level Fluctuations						
Volume (Ac-Ft)	14,480	18,843	23,207	31,736	45,621	59,505
[a]Equivalent Depth (feet)	0.03	0.04	0.05	0.07	0.10	0.13

a. Volume-depth conversion based on average lake surface area of 467,000 acres.

Lake Okeechobee Adaptive Protocols

In January 2003, the SFWMD Governing Board accepted the *Adaptive Protocols for Lake Okeechobee Operations* (SFWMD *et al.* 2003), which spells out in detail how lake managers can meet the intent of the WSE schedule. The Adaptive Protocols provide guidance for short-term operational decisions concerning volumes of water that can be released from the lake for flood control purposes, and procedures to be followed for addressing Lake Okeechobee and downstream water resource opportunities. Decisions regarding water releases from the lake are grounded in a set of performance measures (indicators of ecosystem health and water supply conditions) that scientists use on a weekly basis to evaluate the status of the regional system.

The decisions made under the Adaptive Protocols balance the missions of the SFWMD for water supply, flood protection and environmental protection, and comply with the regional water supply performance projected in the *2000 Lower East Coast Regional Water Supply Plan* (2000 LEC Plan), within the constraints of the approved WSE schedule (SFWMD 2000d). The SFWMD and the USACE continue to look at ways to improve the WSE schedule within the constraints of its Environmental Impact Statement (EIS) in order to improve performance of the lake's various purposes.

Lake Okeechobee Water Shortage Management

In addition to the communities surrounding the lake, competing users of Lake Okeechobee water include the Lake Okeechobee Service Area, as well as the Lower East Coast (LEC) and Lower West Coast (LWC) planning areas (**Chapters 8** and **9**). During periods of water shortage, the SFWMD equitably implements water use restrictions to prevent serious harm to the water resources and distributes available water supplies to consumptive and nonconsumptive users. These types of restrictions may be used for the purpose of managing water supplies in Lake Okeechobee. The Water Shortage Plan [Chapter 40E-21, Florida Administrative Code, (F.A.C.)] provides specific guidelines for implementing these water restrictions. As part of this overall plan, the *Lake Okeechobee Supply-Side Management Plan* (SFWMD 2002b) provides protocols for implementing water use restrictions and managing water resources during declared water shortages.

According to Supply-Side Management Plan, 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 in Lake Okeechobee is calculated on a weekly basis, along with a provision that allows users to borrow from 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. Supply-Side Management is implemented if it is projected the lake could fall below 11 feet National Geodetic Vertical Datum (NGVD) at the end of the dry season.

In addition to efforts to revise the existing Lake Okeechobee regulation schedule, the District's current Supply-Side Management Plan is being revised through an ongoing rulemaking effort. Now known as the *Lake Okeechobee Water*

Shortage Management Plan, this effort includes provisions in Chapters 40E-21 and 40E-22, F.A.C., and identifies how water supplies are allocated to users within the Lake Okeechobee Service Area during declared water shortages. The plan allows for supply allotments and cutbacks to be identified on a weekly basis based on the water level within the lake, demands, time of year and rainfall forecasts.

During drought conditions in 2000 and 2001, Lake Okeechobee receded to levels below 9 feet NGVD. During this time, issues with the current process for identifying short-term (weekly) user allotments within the LOSA were identified. The ongoing rulemaking includes a new process for allocating the water based on pre-identified cutback goals, similar to water shortage phases in Chapter 40E-21, F.A.C. The *Lake Okeechobee Water Shortage Management Plan* incorporates temporary forward pumps—designed to deliver water out of the lake when gravity-driven flows can no longer occur (below approximately 10.2 feet NGVD). It also considers the USACE's proposed revision to the Lake Okeechobee regulation schedule. This rulemaking effort is ongoing and expected to be completed in 2007.

Water Shortage Frequencies

The frequency of water shortages is defined based on statistical analysis of data from a particular monitoring station, basin or region. The numbers represent the estimated time period between occurrences of events that have similar magnitude. Drought events can be defined for different time periods (monthly, dry season, wet season, annual and biannual) based on a number of different criteria, including lack of sufficient rainfall, lack of adequate water levels in the aquifer or lack of water available in the regional system.

For example, assume that the average rainfall is 54 inches per year in a particular basin and rainfall of 47 inches occurs that year. Based on statistical analysis of historical data from rainfall monitoring stations within this basin, this degree of deficiency was determined to occur once every 10 years. Annual rainfall of 47 inches corresponds to a 1-in-10 year drought condition for that basin based on rainfall. Different water management actions may be required, depending on the location, nature and magnitude of the drought.

Drainage Districts

Chapter 298, Florida Statutes (F.S.), governs local water control districts. The 298 Special Drainage Districts are empowered to develop and implement a plan for draining and reclaiming the lands, and control all water movement within their jurisdiction. The 298 districts have the authority to construct and maintain canals; divert flow of water; construct and connect works to canals or natural watercourses; and, construct pumping stations. The 298 districts 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 are issued. The individual 298 districts must still meet all conditions for issuance of a permit. The permit indicates how water will be allocated, and should list the type and quantity of water use for each user.

Water Conservation Areas

Loxahatchee National Wildlife Refuge – WCA-1

As a result of the C&SF Project, the remaining Everglades were divided into three hydrologic units known as the Water Conservation Areas (WCAs). The WCAs are shallow, diked marshes maintained for flood control, environmental restoration and water supply to the Lower East Coast of Florida. The WCAs are located south of Lake Okeechobee and the Everglades Agricultural Area (EAA) and comprise an area of about 1,350 square miles. The WCAs provide water storage and detention for excess water discharged from urban and agricultural areas, as well as for regulatory releases from Lake Okeechobee. The WCAs provide water supply for agricultural lands in the LEC Planning Area and Everglades National Park; provide recharge for the Biscayne Aquifer (the sole source of drinking water to LEC urban areas); and, help to retard saltwater intrusion of coastal wellfields. The WCAs contain the region's last remnants of the original sawgrass marsh, wet prairies and hardwood swamps located outside of Everglades National Park. The WCAs are managed as surface water reservoirs using a set of water regulation schedules (**Figures 17**, **18** and **19**).

Water Conservation Area 1 (WCA-1) covers an area of 243 square miles and is located in south-central Palm Beach County (**Figure 17**). Most of the basin lies within the Arthur R. Marshall National Wildlife Refuge. The area is enclosed by 58 miles of canals and levees, and provides storage for excess rainfall, runoff from agricultural lands to the north and west, and regulatory releases from Lake Okeechobee. When marsh stages exceed the regulation schedule, water is discharged to the south into Water Conservation Area 2A (WCA-2A). This area contains a complex mosaic of wet prairies, numerous tree islands, aquatic sloughs and cypress forests that represent the last remaining examples of native (relatively undisturbed) Everglades habitat. The refuge is managed by the U.S. Fish and Wildlife Service (USFWS) under a lease agreement with the SFWMD.

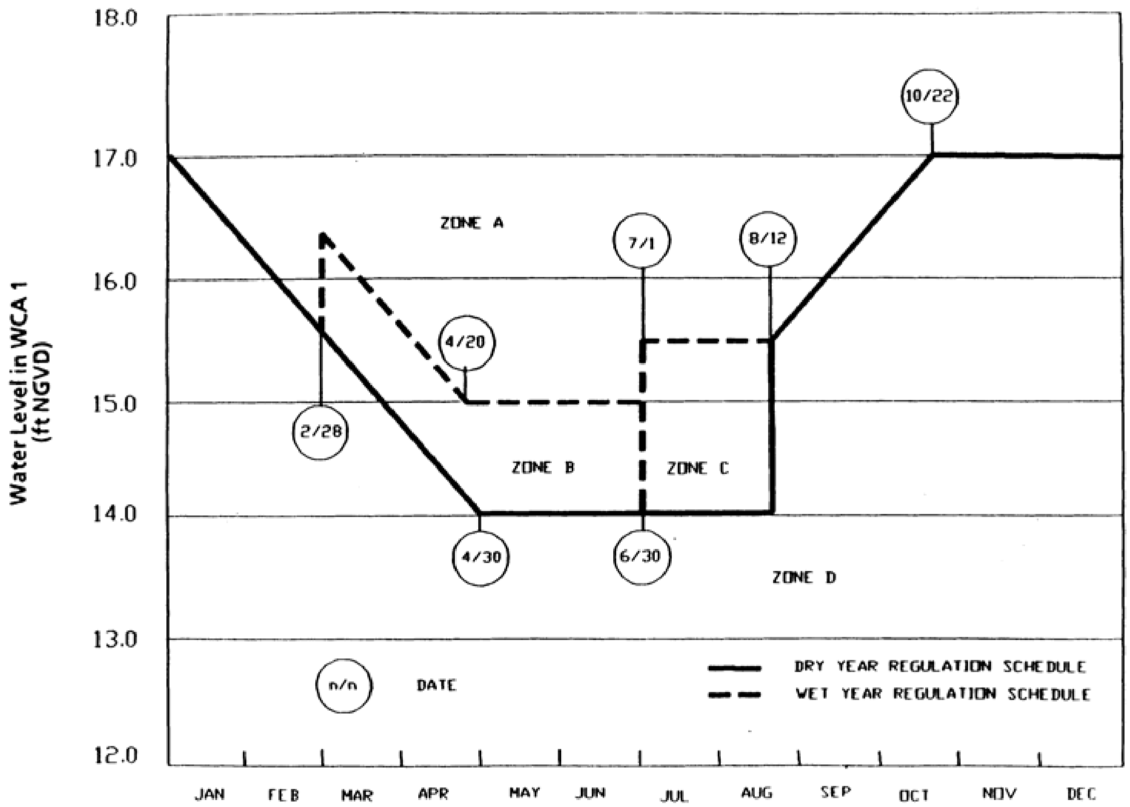


Figure 17. Regulation Schedule for Water Conservation Area 1.

Water Conservation Areas 2A and 2B (**Figure 18**) together comprise about 210 square miles located within southwestern Palm Beach and northwestern Broward counties. Water Conservation Area 2A provides a 173-square-mile reservoir for storing excess water from WCA-1, as well as agricultural areas located to the west. This area provides wellfield recharge and water supply for urban areas located within Broward County, and has been the subject of extensive research by the District and other agencies focusing on the problem of vegetation changes (cattails replacing native sawgrass communities) caused by increased nutrient and high water levels.

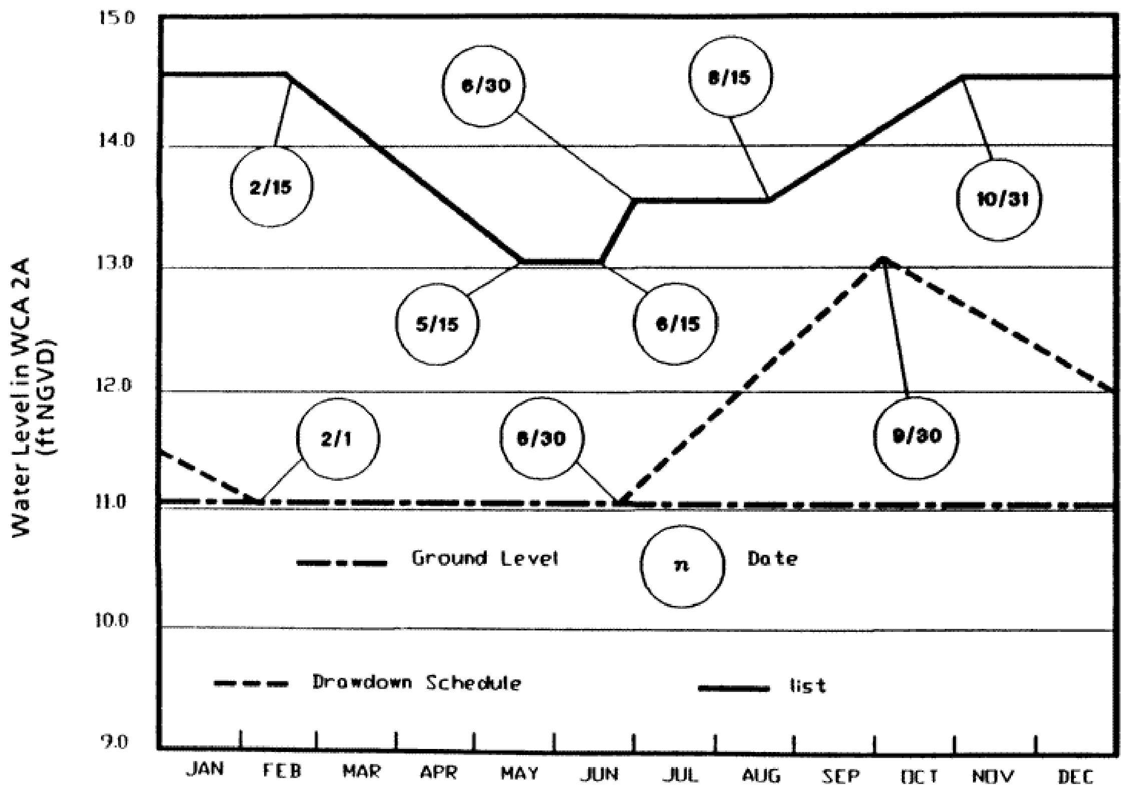


Figure 18. Regulation Schedule for Water Conservation Area 2A.

Together, Water Conservation Areas 3A and 3B (**Figure 19**) represent the largest of the three water conservation areas (915 square miles). The Miami Canal traverses WCA-3A from northwest to southeast, and receives the majority of its water from direct rainfall, EAA runoff and regulatory releases from Lake Okeechobee. This area also serves as a reservoir to hold excess runoff from WCA-2A, excess rainfall from the Big Cypress Swamp located to the west, as well as flood control discharges from Pump Station S-9 located within western Broward County. Water stored within WCA-3A/3B is used to meet the principal water supply needs of adjacent areas, including water supply and salinity control requirements for Miami-Dade and Monroe counties, irrigation requirements for LEC agricultural interests, and as a source of water supply from Everglades National Park. Many areas of WCA-3 still contain vast tracts of habitat consisting of tree islands, sawgrass marshes, wet prairies and aquatic sloughs. However, many areas have been impacted by canal construction and impoundment of the original marsh. These structural changes have caused overdrainage of wetlands located within northern WCA-3A and prolonged hydroperiods and deepwater conditions to the south.

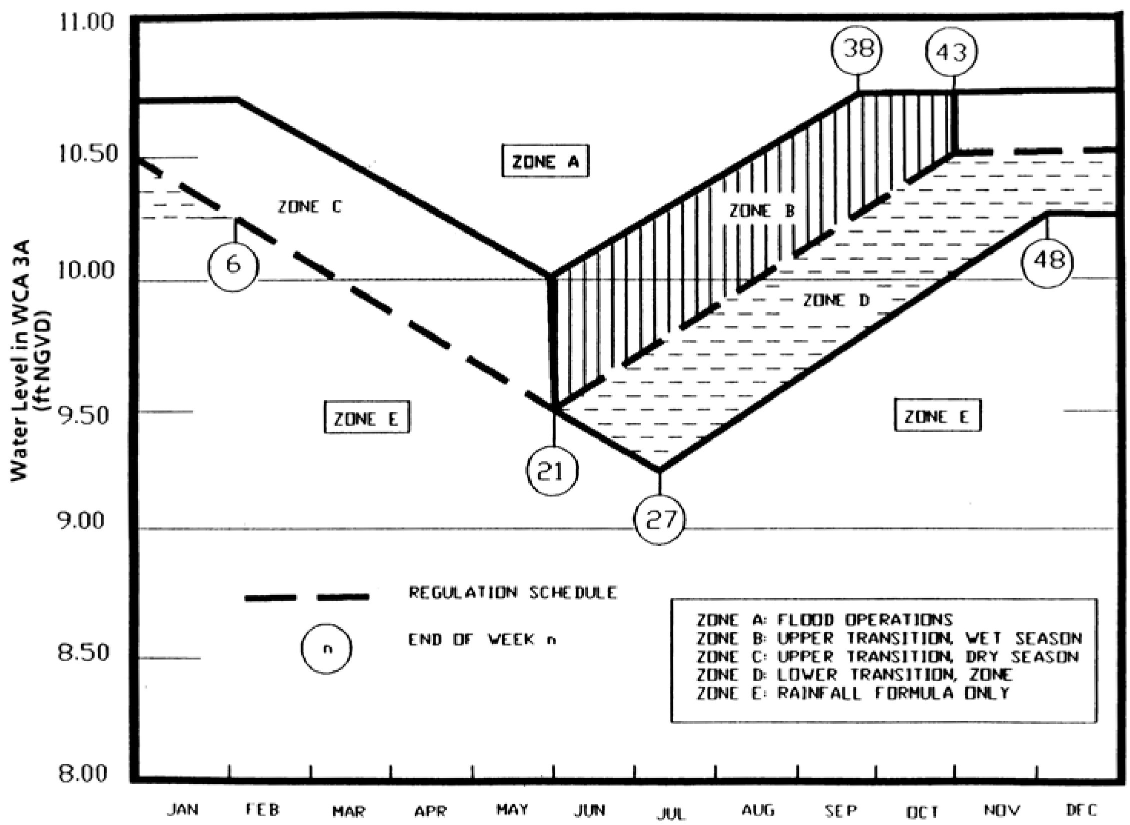


Figure 19. Regulation Schedule for Water Conservation Area 3A.

The CERP Everglades National Park Seepage Management Project will reduce levee seepage flow across L-31N adjacent to Everglades National Park, relocate the Modified Water Deliveries S-356 Structure to provide more effective water deliveries to Everglades National Park, and recharge groundwater and reduce seepage from the Everglades National Park buffer area.

In addition, the Acceler8 Water Preserve Areas–WCA-3A/3B Seepage Management Project will enhance the buffer between residential development and protected Everglades wetlands, capturing and diverting stormwater runoff and reducing underground seepage.

Glossary

1-in-10 Year Drought A drought of such intensity, that it is expected to have a return frequency of once in 10 years. A drought, in which below normal rainfall, has a 90 percent probability of being exceeded over a 12-month period. A drought event that results in an increase in water demand to a magnitude that would have a 10 percent probability of being exceeded during any given year.

1-in-10 Year Level of Certainty A water supply planning goal to assure at least a 90 percent probability, during any given year that all the needs of reasonable-beneficial water uses will be met, while also sustaining water resources and related natural systems during a 1-in-10 year drought event.

Acceler8 Part of the Comprehensive Everglades Restoration Plan (CERP) program, Acceler8 accelerates eight restoration projects through SFWMD's issuance of "Certificates of Participation" bond revenue for construction finance. Acceler8 projects include: C-44 (St. Lucie Canal) Reservoir/Stormwater Treatment Area (STA); C-43 (Caloosahatchee River) West Reservoir; Everglades Agricultural Area (EAA) Reservoir - Phase 1, with Bolles and Cross canals improvements; Everglades Agricultural Area (EAA) Stormwater Treatment Areas (STAs) Expansion; Water Preserve Areas (includes Fran Reich Preserve, C-9, C-11, Acme Basin B, WCA-3A/3B); Picayune Strand (Southern Golden Gate Estates) Restoration; Biscayne Bay Coastal Wetlands - Phase 1; and, C-111 Spreader Canal. The Lake Okeechobee Fast Track (LOFT) projects are also being constructed as a part ofAcceler8.

Algal Bloom Rapid growth of algae on the surface of lakes, streams or ponds; stimulated by nutrient enrichment.

Alternative Water Supply Salt water; brackish surface and groundwater; surface water captured predominately during wet-weather flows; sources made available through the addition of new storage capacity for surface or groundwater, water that has been reclaimed after one or more public supply, municipal, industrial, commercial or agricultural uses; the downstream augmentation of water bodies with reclaimed water; stormwater; and any other water supply source that is designated as nontraditional for a water supply planning region in the applicable regional water supply plan (Section 373.019, F.S.).

Anthropogenic Resulting from human influence.

Aquatic Preserve Water bodies that are set aside by the state to be maintained in essentially natural or existing condition, for protection of fish and wildlife and public recreation so that their aesthetic biological and scientific values may endure for the enjoyment of future generations.

Aquifer A geologic formation, group of formations or part of a formation that contains sufficient saturated, permeable material to yield significant quantities of water to wells and springs.

Aquifer Storage and Recovery (ASR) The underground storage of storm water, surface water, fresh groundwater or reclaimed water, which is appropriately treated to potable standards and injected into an aquifer through wells during wet periods. The aquifer (typically the Floridan Aquifer System in south Florida) acts as an underground reservoir for the injected water, reducing water loss to evaporation. The water is stored with the intent to later recover the water for use in the future during dry periods.

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

Area of Influence For groundwater systems the area of influence is defined by the cone of depression, and for surface water systems the area of influence is defined as the extent to which the withdrawal results in a measurable change in surface water levels or flows.

Artesian A commonly used expression, generally synonymous with Confined and referring to subsurface (ground) bodies of water which, due to underground drainage from higher elevations and confining layers of soil material above and below the water body (referred to as an Artesian Aquifer), result in underground water at pressures greater than atmospheric.

Backpumping The practice of actively pumping water leaving an area back into a surface water body.

Basin (Groundwater) 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.

Basis of Review From the District's publication, *Basis of Review for Water Use Permit Applications within the South Florida Water Management District*. Read in conjunction with Chapters 40E-2 and 40E-20, the Basis of Review further specifies the general procedures and information used by District staff for review of water use permit applications with the primary goal of meeting District water resource objectives.

Benthic Pertaining to the bottom or sediment habitats of a body of water.

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

Biochemical Oxygen Demand (BOD) The amount of dissolved oxygen required to meet the metabolic needs of aerobic microorganisms in water rich in organic matter, such as sewage. Also known as Biological Oxygen Demand.

Biscayne Aquifer A portion of the Surficial Aquifer System, which provides most of the fresh water for public water supply and agriculture within Miami-Dade, Broward and southeastern Palm Beach County. It is highly susceptible to contamination due to its high permeability and proximity to land surface in many locations.

Boulder Zone A highly transmissive, cavernous zone of limestone within the Lower Floridan Aquifer.

Brackish Water, Saline Water or **Seawater** Water containing significant amounts or concentrations of dissolved salts or total dissolved solids (TDS). The concentration is the amount (by weight) of salt in water, expressed in "parts per million" (ppm) or milligrams per liter (mg/L). The terms fresh, brackish, saline and brine are used to describe the quality of the water. (~1 mg/L TDS = 0.5 mg/L of Chlorides.)

Capacity Capacity represents the ability to treat, move or reuse water. Typically, capacity is expressed in million gallons per day (MGD).

Central and Southern Florida Project Comprehensive Review Study (C&SF 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).

Central and Southern Florida Flood Control Project (C&SF Project) A complete system of canals, storage areas and water control structures spanning the area from Lake Okeechobee to both the east and west coasts and from Orlando south to the Everglades. It was designed and constructed during the 1950s by the U.S. Army Corps of Engineers (USACE) to provide flood control and improve navigation and recreation.

Clastic Rock or sediment composed of individual grains or fragments from physical breakdown of a larger mass, which have been transported from its place of origin.

Comprehensive Everglades Restoration Plan (CERP) The framework and guide for the restoration, protection and preservation of the south Florida ecosystem. The CERP also provides for water-related needs of the region, such as water supply and flood protection.

Cone of Depression The conical of the water table or potentiometric surface showing the variation of drawdown with distance due to pumping from a well, wellfield or surface water body within its area of influence.

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

Confined Aquifer Water bearing stratum of permeable rock, sand or gravel overlaid by a thick, impermeable stratum. An aquifer that contains groundwater, which is confined under pressure and bounded between significantly less permeable materials, such that water will rise in a fully penetrating well above the top of the aquifer. In cases where the hydraulic head is greater than the elevation of the overlying land surface, a fully penetrating well will naturally flow at the land surface without means of pumping or lifting.

Confining Unit A body of significantly less permeable material than the aquifer, or aquifers, that it stratigraphically separates. The hydraulic conductivity may range from nearly zero to some value significantly lower than that of the adjoining aquifers.

Conservation (See *Water Conservation*.)

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 Any use of water that reduces the supply from which it is withdrawn or diverted.

Consumptive Use Permitting (CUP) The issuance of permits by the SFWMD, under authority of Chapter 40E-2, F.A.C., allowing withdrawal of water for consumptive use.

Contact Time A measure of the microorganism inactivation due to time and concentration of the disinfectant.

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

DBHYDRO The SFWMD's corporate environmental database, storing hydrologic, meteorologic, hydrogeologic and water quality data.

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

Demand Management 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 that treats saline water to remove or reduce chlorides and dissolved solids, resulting in the production of fresh water.

Detention The delay of stormwater runoff prior to discharge into receiving waters.

Discharge The rate of water movement past a reference point, measured as volume per unit time (usually expressed as cubic feet or cubic meters per second).

Disinfection The process of inactivating microorganisms that cause disease. All potable water requires disinfection as part of the treatment process prior to distribution. Disinfection methods include chlorination, ultraviolet (UV) radiation and ozonation.

Disposal Effluent disposal involves the wasteful practice of releasing treated effluent back to the environment using ocean outfalls, surface water discharges and deep injection wells.

Dissolved Oxygen The concentration of oxygen dissolved in water, sometimes expressed as percent saturation, where saturation is the maximum amount of oxygen that theoretically can be dissolved in water at a given altitude and temperature.

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

Districtwide Water Supply Assessment (DWSA) Document providing water demand assessments, projections and descriptions of the surface water and groundwater resources within each of the SFWMD's four planning areas.

Domestic Self-Supply (DSS) Water Demand The water used by households whose primary sources of water are private wells or water treatment facilities with pumpages of less than 0.1 million gallons per day.

Downstream Augmentation Use of reclaimed water downstream of the point of treatment and discharge for indirect potable and nonpotable projects, such as wellfield recharge, wetland rehydration, applicable irrigation, and maintaining minimum flows and levels.

Drainage District A locally constituted drainage, water management or water control district created by a special act of the Legislature and authorized under Chapter 298 F.S., to constrict, complete, operate, maintain, repair and replace any and all works needed to implement an adopted water control plan.

Drawdown The vertical distance between the static water level and the surface of the cone of depression.

Drought A long period of abnormally low rainfall, especially one that adversely affects growing or living conditions.

Ecosystem Biological communities together with their environment, functioning as a unit.

Effluent Water that is not reused after flowing out of any plant or other works used for the purpose of treating, stabilizing or holding wastes. Effluent is "disposed" of.

Electrodialysis Dialysis that is conducted with the aid of an electromotive force applied to electrodes adjacent to both sides of the membrane.

Elevation The height in feet above mean sea level according to North American Vertical Datum (NAVD) or the National Geodetic Vertical Datum (NGVD). May also be expressed in feet above mean sea level (MSL) as reference datum.

Environmental Resource Permit (ERP) A permit issued by the SFWMD under authority of Chapter 40E-4 F.A.C. to ensure that land development projects do not cause adverse environmental, water quality or water quantity impacts.

Epiphytes Plants that derive their moisture and nutrients from the air and rain, usually growing on other plants.

Estuary The part of the wide lower course of a river where its current is met by ocean tides or an arm of the sea at the lower end of a river where fresh and salt water meet**.**

Eutrophic An aquatic environment enriched with nutrients, usually associated with high plant productivity and low oxygen levels.

Eutrophication The gradual increase in nutrients in a body of water. Natural eutrophication is a gradual process, but human activities may greatly accelerate the process.

Evapotranspiration (ET) The total loss of water to the atmosphere by evaporation from land and water surfaces and by transpiration from plants.

Everglades Agricultural Area (EAA) An area of histosols (muck) extending south from Lake Okeechobee to the northern levee of WCA-3A, from its eastern boundary at the L-8 Canal to the western boundary along the L-1, L-2 and L-3 levees. The EAA incorporates almost 3,000 square kilometers (1,158 square miles) of highly productive agricultural land.

Everglades Construction Project (ECP) Twelve interrelated construction projects located between Lake Okeechobee and the Everglades. The cornerstone of the ECP is six large constructed wetlands known as Stormwater Treatment Areas (STAs). They use naturally occurring biological processes to reduce phosphorus that enters the Everglades. The ECP also contains four hydropattern restoration projects designed to improve the volume, timing and distribution of water entering the Everglades.

Everglades Protection Area This area is comprised of the Water Conservation Areas and Everglades National Park.

Existing Legal Use of Water A water use that is authorized under a District water use permit or is existing and exempt from permit requirements.

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

Fauna All animal life associated with a given habitat.

Fiscal Year (FY) The South Florida Water Management District's fiscal year begins on October 1 and ends on September 30 the following year.

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

Flora All plant life associated with a given habitat.

Florida Administrative Code (F.A.C.) The Florida Administrative Code is the official compilation of the administrative rules and regulations of state agencies.

Florida Department of Agricultural and Consumer Services (FDACS) FDACS communicates the needs of the agricultural industry to the Florida Legislature, the FDEP and the water management districts, and ensures participation of agriculture in the development and implementation of water policy decisions. The FDACS also oversees Florida's Soil and Water Conservation districts, which coordinate closely with the federal Natural Resources Conservation Service (NRCS).

Florida Department of Environmental Protection (FDEP) The SFWMD operates under the general supervisory authority of the FDEP, which includes budgetary oversight.

Florida Statutes (F.S.) The Florida Statutes are a permanent collection of state laws organized by subject area into a code made up of titles, chapters, parts and sections. The Florida Statutes are updated annually by laws that create, amend or repeal statutory material.

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

Floridan Aquifer System (FAS) A highly used aquifer system composed of the Upper Floridan and Lower Floridan aquifers. It is the principal source of water supply north of Lake Okeechobee, and the Upper Floridan Aquifer is used for drinking water supply in parts of Martin and St. Lucie counties. From Jupiter to south Miami, water from the Floridan Aquifer System is mineralized (total dissolved solids are greater than 1,000 mg/L) along coastal areas and in southern Florida.

Flow The actual amount of water flowing by a particular point over some specified time. In the context of water supply, flow represents the amount of water being treated, moved or reused. Flow is frequently expressed in millions of gallons per day (MGD).

Food Web The totality of interacting food chains in an ecological community.

Fresh Water Water with less than 1,000 mg/L of TDS, but drinking water, by EPA standards, must have less than 500 mg/L of TDS. (~1 mg/L TDS = 0.5 mg/L of Chlorides.)

Geographic Information Systems (GIS) The abstract representation of natural (or cultural) features of a landscape into a digital database, geographic information system.

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

Groundwater Water beneath the surface of the ground, whether or not flowing through known and definite channels. Specifically, that part of the subsurface water in the saturated zone, where the water is under pressure greater than the atmosphere.

Harm As defined in Rule 40E-8.021, F.A.C., the temporary loss of water resource functions that results from a change in surface or groundwater hydrology and takes a period of one to two years of average rainfall conditions to recover.

Hydrology The scientific study of the properties, distribution and effects of water on the earth's surface, in the soil and underlying rocks and in the atmosphere.

Hydropattern Water depth, duration, timing and distribution of fresh water in a specified area. A consistent hydropattern is critical for maintaining various ecological communities in wetlands.

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.

Impoundment Any lake, reservoir or other containment of surface water occupying a depression or bed in the earth's surface and having a discernible shoreline.

Indian River Lagoon Extending for 156 miles from north of Cape Canaveral to Stuart along the east coast of Florida, this lagoon is America's most diverse estuary, home to more than 4,000 plant and animal species.

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

Inorganic Involving neither organic life nor the products of organic life; relating to or composed of chemical compounds not containing hydrocarbon groups.

Institute of Food and Agricultural Sciences (IFAS) Agricultural branch of the University of Florida that performs research, education and extension.

Intermediate Aquifer System (IAS) This aquifer system consists of five zones of alternating confining and producing units. The producing zones include the Sandstone and Mid-Hawthorn aquifers.

Intrusion (See *Saline Water of Saltwater Intrusion.*)

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

Invasive Exotic Species Species of plants or animals that are not naturally found in a region (nonindigenous). They can sometimes aggressively invade habitats and cause multiple ecological changes, including the displacement of native species.

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 Water Use A water use classification, which incorporates all uses of water for supplemental irrigation purposes including golf, nursery, agriculture, recreation and landscape.

Karst A topography formed over limestone, dolomite or gypsum and characterized by sinkholes, caves and underground drainage.

Lagoon A body of water separated from the ocean by barrier islands, with limited exchange with the ocean through inlets.

Lake Okeechobee Located in central Florida, the lake, at 730 square miles, is the largest freshwater lake in Florida and the second-largest freshwater lake wholly within the United States.

Lake Okeechobee Water Shortage Management Plan This effort includes provisions in Chapters 40E-21 and 40E-22, Florida Administrative Code (F.A.C.), and identifies how water supplies are allocated to users within the Lake Okeechobee Service Area during declared water shortages. The plan allows for supply allotments and cutbacks to be identified on a weekly basis based on the water level within the lake, demands, time of year and rainfall forecasts.

Landscape Irrigation The outside watering of shrubbery, trees, lawns, grass, ground covers, vines, gardens and other such flora, not intended for resale, which are planted and are situated in such diverse locations as residential and recreation areas, cemeteries, public, commercial and industrial establishments, and public medians and rights of way.

Leakance The vertical movement of water from one aquifer to another across a confining zone or zones due to differences in hydraulic head. Movement may be upward or downward depending on hydraulic head potential in source aquifer and receiving aquifer. This variable is typically expressed in units of gallons per day per cubic foot.

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 A water supply planning goal to assure at least a 90 percent probability, during any given year that all the needs of reasonable-beneficial water uses will be met, while also sustaining water resources and related natural systems during a 1-in-10 year drought event.

Littoral Of, relating to, situated or growing on or near a shore.

Load Concentration times flow.

Macrophytes Visible (non-microscopic) plants found in aquatic environments. Examples in south Florida wetlands include sawgrass, cattail, sedges and lilies.

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

Mesohaline Term to characterize waters with salinity of 5 to 18 parts per thousand, due to ocean-derived salts.

Microfiltration A membrane separation process in which particles greater than about 20 nanometers in diameter are screened out of a liquid in which they are suspended.

Microorganism A microscopic organism, including bacteria, protozoans, yeast, viruses and algae.

MIKE SHE An integrated surface water/groundwater model, which includes a module for estimating supplemental irrigation requirements based upon land use, soil type, crop type, rainfall and evapotranspiration.

Minimum Flow and Level (MFL) The point at which further withdrawals would cause significant harm to the water resources.

Mobile Irrigation Laboratory (MIL) 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.

Muck Dark, organic soil derived from well-decomposed plant biomass.

National Geodetic Vertical Datum (NGVD) A geodetic datum derived from a network of information collected in the United States and Canada. It was formerly called the "Sea Level Datum of 1929" or "mean sea level." Although the datum was derived from the average sea level over a period of many years at 26 tide stations along the Atlantic, Gulf of Mexico, and Pacific Coasts, it does not necessarily represent local mean sea level at any particular place.

Native Nuisance Species Native plant species that spread rapidly under disturbed conditions and displace more desirable plant communities.

Natural Resources Conservation Service (NRCS) An agency of the U.S. Department of Agriculture (USDA) that provides technical assistance for soil and water conservation, natural resource surveys and community resource protection. Formerly the U.S. Soil Conservation Service (SCS).

Net Water Demand The water demands of the end user, after accounting for treatment and process losses and inefficiencies (e.g. irrigation inefficiency). When discussing public water supply, the term "finished water demand" is commonly used.

Nonpoint Source Source originating over broad areas, such as areas of fertilizer and pesticide application or leaking sewer systems, rather than from discrete points.

Nutrients Organic or inorganic compounds essential for the survival of an organism. In aquatic environments, nitrogen and phosphorus are important nutrients that affect the growth rate of plants.

Oligotrophic An aquatic environment depleted of nutrients, resulting in low plant productivity.

Organics Involving organic or products of organic life; relating to or composed of chemical compounds containing hydrocarbon groups.

Other Surface Waters Surface waters other than wetlands, as described and delineated pursuant to Rule 62-340.600, F.A.C., as ratified by Section 373.4211, F.S.

Outflow The act or process of flowing out of.

Outstanding Florida Waters (OFW) A special category of water bodies within the state that have been defined by FDEP, based on Section 403.061(27), F.S., to be worthy of special protection because of their natural attributes.

Pelagic Zone Open water zone.

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

Periphyton The biological community of microscopic plants and animals attached to surfaces in aquatic environments. Algae are the primary component in these assemblages, which naturally reduce phosphorus levels in water and serve a key function in Stormwater Treatment Areas.

Permeability Defines the ability of a substrate to transmit fluid.

Phosphorus (P) An element that is essential for life. In freshwater aquatic environments, phosphorus is often in short supply; increased levels can promote the growth of algae and other plants.

Phytoplankton The floating, usually minute, plant life of a body of water.

Plume A body of contaminated groundwater originating from a specific source and influenced by such factors as the local groundwater flow pattern, density of contaminant and character of the aquifer.

Point Source Any discernible, confined and discrete conveyance from which pollutants are or may be discharged, including, but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation or vessel or other floating craft. This term does not include agricultural stormwater discharges and return flows from irrigated agriculture.

Pollutant Load Reduction Goal (PLRG) Targeted reduction in pollutant loading to a water body needed to achieve watershed management goals.

Potable Water Water that is safe for human consumption.

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

Potentiometric Surface A surface that represents the hydraulic head in an aquifer and is defined by the level to which water will rise above a datum plane in wells that penetrate the aquifer.

Public Water Supply (PWS) Water that is withdrawn, treated, transmitted and distributed as potable or reclaimed water.

Reasonable-Beneficial Use Use of water in such quantity as is needed for economic and efficient utilization for a purpose, 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 (Rule 62-610.200, F.A.C.).

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

Regional Water Supply Plan Detailed water supply plan developed by the District under Section 373.0361, F.S., providing an evaluation of available water supply and projected demands, at the regional scale. The planning process projects future demand for 20 years and recommends projects to meet identified needs.

Reservations of Water (See *Water Reservations*.)

Reservoir A man-made or natural water body used for water storage.

Restudy Shortened name for Central and Southern Florida Project Comprehensive Review Study (C&SF Restudy).

Retrofit The replacement of existing equipment with equipment of higher efficiency.

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

Reuse The deliberate application of reclaimed water for a beneficial purpose. Criteria used to classify projects as "reuse" or "effluent disposal" are contained in Rule 62-610.810, F.A.C. The term "reuse" is synonymous with "water reuse."

Reverse Osmosis (RO) A membrane process for desalting water using applied pressure to drive the feedwater (source water) through a semipermeable membrane.

Saline Water Any water that contains more than 1,000 mg/L of TDS. This may be brackish water (1,000 to 15,000 mg/L of TDS), seawater (15,000 to 40,000 mg/L of TDS), or brine (more than 40,000 mg/L of TDS). It is common in the literature to define coastal water that is very brackish simply as saline water. (~1 mg/L TDS = 0.5 mg/L of Chlorides.)

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

Saline Water or Saltwater Intrusion The invasion of a body of fresh water by a body of salt water, due to its greater density. It can occur either in surface water or groundwater bodies. The term is applied to the flooding of freshwater marshes by seawater, the upward migration of seawater into rivers and navigation channels, and the movement of seawater into freshwater aquifers along coastal regions.

Saline Water, Seawater or **Brackish Water** contains significant amounts or concentrations of dissolved salts or total dissolved solids (TDS). The concentration is the amount (by weight) of salts in water, expressed in "parts per million" (ppm) or milligrams per liter (mg/L). The terms fresh, brackish, saline, and brine are used to describe the quality of the water.

Saline Water or Saltwater Intrusion The invasion of a body of fresh water by a body of salt water, due to its greater density. It can occur either in surface water or groundwater bodies. The term is applied to the flooding of freshwater marshes by seawater, the upward migration of seawater into rivers and navigation channels, and the movement of seawater into freshwater aquifers along coastal regions.

Salinity Of or relating to chemical salts (usually measured in "parts per thousand" (ppm) or milligrams per lit (mg/L).

Save Our Rivers (SOR) In 1981, the Florida Legislature created the Save Our Rivers Program for the water management districts to acquire environmentally sensitive land. The legislation produced Section 373.59, F.S., known as the Water Management Lands Trust Fund.

Seawater, Saline Water or **Brackish Water** contains significant amounts or concentrations of dissolved salts or total dissolved solids (TDS). The concentration is the amount (by weight) of salts in water, expressed in "parts per million" (ppm) or milligrams per liter (mg/L). The terms fresh, brackish, saline, and brine are used to describe the quality of the water. (~1 mg/L TDS = 0.5 mg/L of Chlorides.)

Sedimentation The action or process of forming or depositing sediment.

Seepage Irrigation System A means to artificially supply water for plant growth, which relies primarily on gravity to move the water over and through the soil, and does not rely on emitters, sprinklers or any other type of device to deliver water to the vicinity of expected plant use.

Self-Supplied The water used to satisfy a water need, not supplied by a public water supply utility.

Semi-Confined Aquifer A completely saturated aquifer that is bounded above by a semi-pervious layer, which has a low, though measurable permeability, and below by a layer that is either impervious or semi-pervious.

Serious Harm As defined in Rule 40E-8.021, F.A.C., the long-term loss of water resource functions resulting from a change in surface or groundwater hydrology.

Service Area The geographical region in which a water supplier has the ability and the legal right to distribute water for use.

Significant Harm As defined in Rule 40E-8.021, F.A.C., the temporary loss of water resource functions, which result from a change in surface or groundwater hydrology, that takes more than two years to recover, but which is considered less severe than serious harm. The specific water resource functions addressed by a MFL and the duration of the recovery period associated with significant harm are defined for each priority water body based on the MFL technical support document.

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.

South Florida Water Management Model (SFWMM) An integrated surface water-groundwater model that simulates the hydrology and associated water management schemes in the majority of south Florida using climatic data from January 1, 1965, through December 31, 1995. The model simulates the major components of the hydrologic cycle and the current and numerous proposed water management control structures and associated operating rules. It also simulates current and proposed water shortage policies for the different subregions in the system.

Stage The height of a water surface above an established reference point (datum or elevation).

Standard Project Flood (SPF) A mathematically derived set of hydrologic conditions for a region that defines the water levels that can be expected to occur in a basin during an extreme rainfall event, taking into account all pertinent conditions of location, meteorology, hydrology and topography.

Storm Water Water that does not infiltrate, but accumulates on land as a result of storm runoff, snowmelt runoff, irrigation runoff or drainage from such areas as roads and roofs.

Stormwater Treatment Area (STA) A system of constructed water quality treatment wetlands that use natural biological processes to reduce levels of nutrients and pollutants from surface water runoff.

Submerged Aquatic Vegetation (SAV) Wetland plants that exist completely below the water surface.

Subsidence The loss of soil-bulk caused by the oxidation, decomposition and shrinkage of organic material.

Superfund Site Identified by the U.S. Environmental Protection Agency (USEPA) as an uncontrolled or abandoned hazardous waste site having high health and environmental risk and eligible for federal funding to ensure proper remediation and cleanup.

Supply-Side Management The conservation of water in Lake Okeechobee to ensure that water demands are met, while reducing the risk of serious or significant harm to natural systems.

Surface Water Water above the soil or substrate surface, whether contained in bounds created naturally or artificially or diffused. Water from natural springs is classified as surface water when it exits from the spring onto the earth's surface.

Surface Water Improvement and Management (SWIM) Plan A plan prepared pursuant to Chapter 373, F.S.

Surficial Aquifer System (SAS) Often the principal source of water for urban uses within certain areas of south Florida. This aquifer is unconfined, consisting of varying amounts of limestone and sediments that extend from the land surface to the top of an intermediate confining unit.

Swamp A frequently or continuously inundated forested wetland.

Total Maximum Daily Load (TMDL) The maximum allowed level of pollutant loading for a water body, while still protecting its uses and maintaining compliance with water quality standards, as defined in the *Clean Water Act*.

Total Trihalomethane (TTHM) A sum of chloroform, bromodichloromethane, dibromochloromethane and bromoform.

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.

Treatment Facility Any plant or other works used for the purpose of treating, stabilizing or holding wastewater.

Trophic Level One of the hierarchical strata of a food web characterized by organisms, which are the same number of steps removed from the primary producers

Turbidity The measure of suspended material in a liquid.

Ultralow Volume Plumbing Fixtures Water-conserving plumbing fixtures that meet the standards at a test pressure of 80 pounds per square inch (psi) listed below.

Toilets - 1.6 gal/flush
Showerheads - 2.5 gal/min.
Faucets - 2.0 gal/min.

Unconfined Aquifer A permeable geologic unit or units only partly filled with water and overlying a relatively impervious layer. Its upper boundary is formed by a free water table or phreatic surface under atmospheric pressure. Also referred to as Water Table Aquifer.

Upconing Process by which saline water underlying fresh water in an aquifer rises upward into the freshwater zone as a result of pumping water from the freshwater zone.

Uplands An area with a hydrologic regime that is not sufficiently wet to support vegetation typically adapted to life in saturated soil conditions; nonwetland; upland soils are non-hydric soils.

User/Customer Demand (see *Net Water Demand.*)

Use of Reclaimed Water (see *Reuse.*)

Utility Any legal entity responsible for supplying potable water for a defined service area.

Wastewater The combination of liquid and water-carried pollutants from residences, commercial buildings, industrial plants and institutions together with any groundwater, surface runoff or leachate that may be present.

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

Water Conservation Reducing the demand for water through activities that alter water use practices, e.g., improving efficiency in water use, and reducing losses of water, waste of water and water use.

Water Conservation Areas (WCAs) Part of the original Everglades ecosystem that is now diked and hydrologically controlled for flood control and water supply purposes. These are located in the western portions of Miami-Dade, Broward and Palm Beach counties, and preserve a total of 1,337 square miles, or about 50 percent of the original Everglades.

Water Control District (see *Drainage District.*)

Water Preserve Areas (WPA) Multipurpose water-holding areas located along the western border of southeast Florida's urbanized corridor.

Water Reservations State law on water reservations, in Section 373.223(4), F.S., defines water reservations as follows: "The governing board or the department, by regulation, may reserve from use by permit applicants, water in such locations and quantities, and for such seasons of the year, as in its judgment may be required for the protection of fish and wildlife or the public health and safety. Such reservations shall be subject to periodic review and revision in the light of changed conditions. However, all presently existing legal uses of water shall be protected so long as such use is not contrary to the public interest."

Water Resource Development The formulation and implementation of regional water resource management strategies, including the collection and evaluation of surface water and groundwater data; structural and nonstructural programs to protect and manage water resources; 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 groundwater recharge augmentation; and related technical assistance to local governments and to government-owned and privately owned water utilities (Section 373.019(22), F.S.).

Water Reuse (see *Reuse.*)

Watershed A region or area bounded peripherally by a water parting and draining ultimately to a particular watercourse or body of water.

Watershed Management Goals Goals that encompass any one or all of the major water management district responsibilities: flood protection, water supply, water quality and environmental system protection and enhancement. The goals provide the general direction for developing cohesive strategies to manage water resources within a drainage basin, subbasin or segment of a drainage basin or subbasin.

Water Shortage Declaration 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 (Rule 40E-21.231, F.A.C.). 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 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 (Section 373.019(24), F.S.).

Water Supply Plan (see *Regional Water Supply Plan.*)

Water Table The surface of a body of unconfined groundwater at which the pressure is equal to that of the atmosphere; defined by the level where water within an unconfined aquifer stands in a well.

Water Use Any use of water that reduces the supply from which it is withdrawn or diverted.

Water Well Any excavation that is drilled, cored, bored, washed, driven, dug, jetted or otherwise constructed when the intended use of such excavation is for the location, acquisition, development or artificial recharge of groundwater. This term does not include any well for the purpose of obtaining or prospecting for oil, natural gas, minerals or products of mining or quarrying; for inserting media to dispose of oil brines, or to repressure oil-bearing or natural gas-bearing formation; for storing petroleum, natural gas or other products; or, for temporary dewatering of subsurface formations for mining, quarrying or construction purposes. (373.303(7), F.S.)

Weir A barrier placed in a stream to control the flow and cause it to fall over a crest. Weirs with known hydraulic characteristics are used to measure flow in open channels.

Wetland An area that is inundated or saturated by surface water or groundwater with vegetation adapted for life under those soil conditions (e.g., swamps, bogs and marshes).

Wetlands Those areas that are inundated or saturated by surface water or groundwater 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. Soils present in wetlands generally are classified as hydric or alluvial, or possess characteristics that are associated with reducing soil conditions. The prevalent vegetation in wetlands generally consists of facultative or obligate hydrophytic macrophytes that are typically adapted to areas having soil conditions described above. These species, due to morphological, physiological or reproductive adaptation, have the ability to grow, reproduce or persist in aquatic environments or anaerobic soil conditions. Florida wetlands generally include swamps, marshes, bayheads, bogs, cypress domes and strands, sloughs, wet prairies, riverine swamps and marshes, hydric seepage slopes, tidal marshes, mangrove swamps and other similar areas. Florida wetlands do not include longleaf or slash pine flatwoods with an understory dominated by saw palmetto. The landward extent of wetlands shall be delineated pursuant to Rules 62-340.100 through 62-340.550, F.A.C., as ratified by Section 373.4211, F.S. (Basis of Review)

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

Wild and Scenic River A river as designated under the authority of the of Public Law 90-542, the *Wild and Scenic Rivers Act* as amended, as a means to preserve selected free-flowing rivers in their natural condition and protect the water quality of such rivers. The Loxahatchee River was federally designated as the first Wild and Scenic River in Florida on May 17, 1985.

Withdrawal Demand (See *Raw Water Demand.*)

Xeric Of or pertaining to a habitat having a low or inadequate supply of moisture, or of or pertaining to an organism living in such an environment.

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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