SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Reference Document

SUPPORT DOCUMENT
WATER SUPPLY PLAN UPDATE

2011-14

2011-2014

WATER SUPPLY PLAN SUPPORT DOCUMENT

The South Florida Water Management District thanks everyone who contributed to the development and production of this 2011–2014 Water Supply Plan Support Document.

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Acronyms and Abbreviations

°F	degrees Fahrenheit
ASR	Aquifer Storage and Recovery
AWE	Alliance for Water Efficiency
bls	below land surface
BMP	best management practice
C&SF Project	Central and Southern Florida Flood Control Project
CERP	Comprehensive Everglades Restoration Plan
CFCA	Central Florida Coordination Area
cfs	cubic feet per second
CFWI	Central Florida Water Initative
CREW	Corkscrew Regional Ecosystem Watershed
CUPCon	statewide consumptive use permit consistency effort
CWCP	Comprehensive Water Conservation Program
DBP	disinfectant/disinfection by-product
District	South Florida Water Management District
DWMP	District Water Management Plan
DWSA	Districtwide Water Supply Assessment
EAA	Everglades Agricultural Area
ERTP	Everglades Restoration Transition Plan
ET	evapotranspiration
ETp	potential evapotranspiration
F.A.C.	Florida Administrative Code
FAS	Floridan aquifer system
FAWN	Florida Automated Weather Network
FDACS	Florida Department of Agriculture and Consumer Services
FDEP	Florida Department of Environmental Protection
FGCU	Florida Gulf Coast University

FPL	Florida Power & Light
F.S.	Florida Statutes
FY	Fiscal Year
gal	gallons
GPD	gallons per day
GPM	gallons per minute
IAS	intermediate aquifer system
ICU	intermediate confining unit
IOP	Interim Operating Plan
KB	Kissimmee Basin
KCOL	Kissimmee Chain of Lakes
KOE	Kissimmee-Everglades-Okeechobee
KWh	kilowatt hour
LEC	Lower East Coast
LEC Plan Update	Lower East Coast Water Supply Plan Update
LFA	Lower Floridan aquifer
LILA	Loxahatchee Impoundment Landscape Assessment
LKB	Lower Kissimmee Basin
LKB Plan	Lower Kissimmee Basin Water Supply Plan
2008 LORS	2008 Lake Okeechobee Regulation Schedule
LOSA	Lake Okeechobee Service Area
LPRO	lower pressure reverse osmosis
LWC	Lower West Coast
LWC Plan Update	Lower West Coast Water Supply Plan Update
MCL	maximum contaminant level
MDL	Maximum Developable Limit
MF	microfiltration
MFL	Minimum Flow and Level
MGD	million gallons per day
mg/L	milligrams per liter
MGM	million gallons per month
MGY	million gallons per year
MIL	Mobile Irrigation Laboratory

MSL	mean sea level
NEEPP	Northern Everglades and Estuaries Protection Program
NF	nanofiltration
NGVD	National Geodetic Vertical Datum of 1929
NWFWMD	Northwest Florida Water Management District
O&M	operations and maintenance
PCBs	polychlorinated biphenyls
pH	potential of hydrogen
psi	pounds per square inch
RO	reverse osmosis
SAS	surficial aquifer system
SFWMD	South Florida Water Management District
SJRWMD	St. Johns River Water Management District
SOR	Save Our Rivers
SRWMD	Suwannee River Water Management District
STA	Stormwater Treatment Area
SWFWMD	Southwest Florida Water Management District
TDS	total dissolved solids
TTHMs	total trihalomethanes
UEC	Upper East Coast
UEC Plan Update	Upper East Coast Water Supply Plan Update
UF	ultrafiltration
UFA	Upper Floridan aquifer
UKB	Upper Kissimmee Basin
ULV	ultralow volume
U.S.	United States
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USDA–NRCS	U.S. Department of Agriculture–Natural Resources Conservation Service
USDOI	U.S. Department of Interior
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey

UV	ultraviolet
Water CHAMP	Water Conservation Hotel and Motel Program
WaterSIP	Water Savings Incentive Program
WCA	Water Conservation Area

Planning south Florida's water supply needs for tomorrow.

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Introduction

This *2011–2014 Water Supply Plan Support Document* supplements the four regional water supply plan updates produced by the South Florida Water Management District (SFWMD or District). In this volume, readers will find extensive background information helpful in understanding the SFWMD, the areas it serves, and the many considerations required for developing comprehensive water supply plans with a 20-year planning horizon.

TOPICS

- Basis of Water Supply Planning
- Significant Changes and Outlook

This Support Document is organized as follows:

- Introduction – Chapter 1
- Natural Systems Descriptions – Chapter 2
- Natural Systems Protection and Restoration Efforts – Chapter 3
- Water Supply Regulatory Overview – Chapter 4
- Water Source Options and Water Conservation – Chapter 5
- Water Quality and Treatment – Chapter 6
- Planning Area Descriptions – Chapters 7–10

Lake Okeechobee

Figure 1 represents the District's jurisdiction and planning areas.

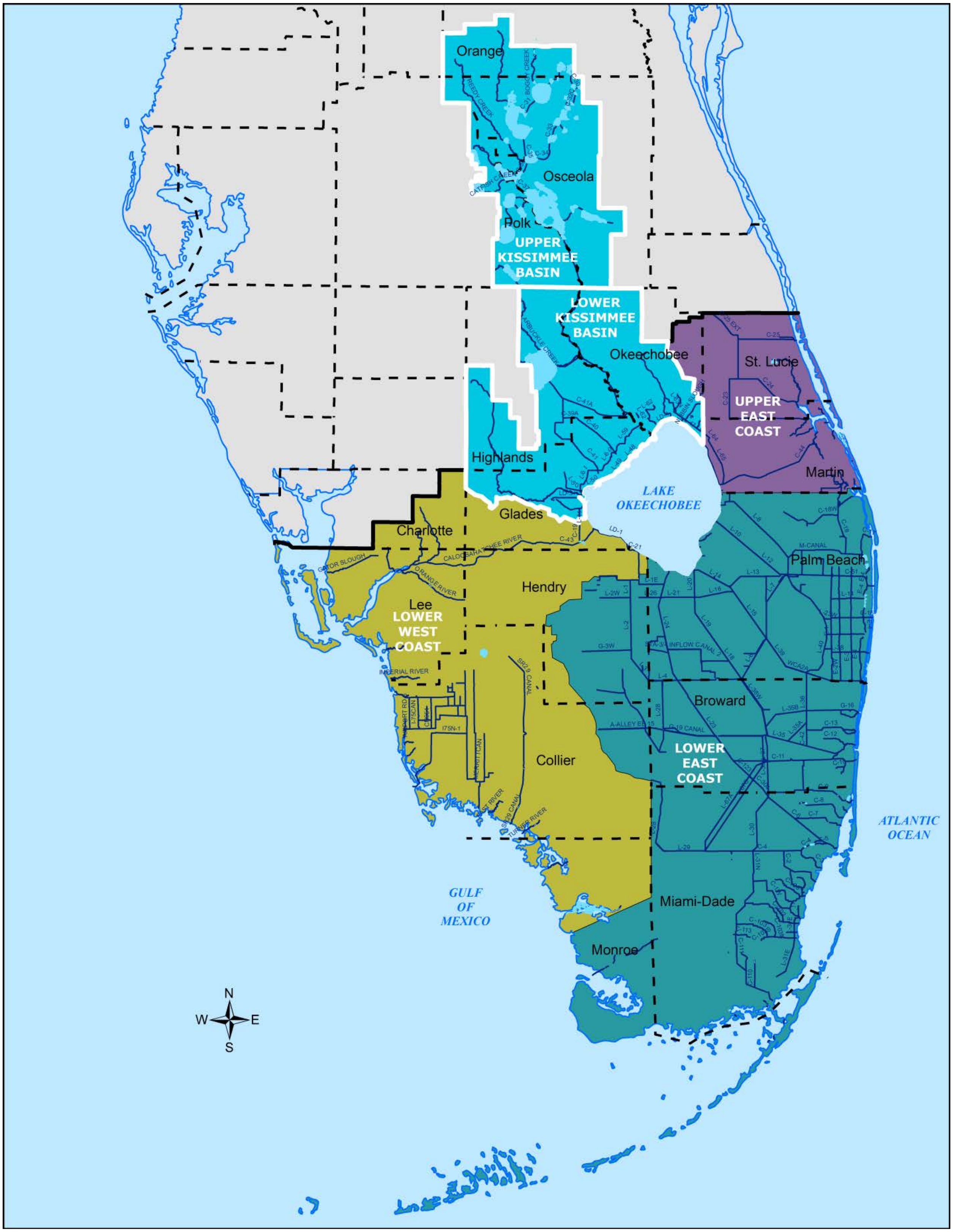

Figure 1. Planning areas of the South Florida Water Management District showing county level.

BASIS OF WATER SUPPLY PLANNING

This section provides a brief legal and historical overview of the water supply planning process. Responsible to state governance, the District's water supply plans coordinate with local government planning to identify sustainable future water supplies. The relationship between the District's water supply plans and local governments' comprehensive plans is explained, as well as the rationale and legislative background of water supply planning.

Legal Authority and Requirements

Nearly 40 years ago, *A Model Water Code* (Maloney, Ausness, and Morris 1972) advocated a statewide, coordinated planning framework as the best way to accomplish proper water resource allocation. Subsequently, the *Florida Water Resources Development Act of 1972* [Chapter 373, Florida Statutes (F.S.)] was enacted. One outcome of this legislation was the establishment of the state's five regional water management districts. **Figure 2** shows the current legal framework for water supply planning in Florida.

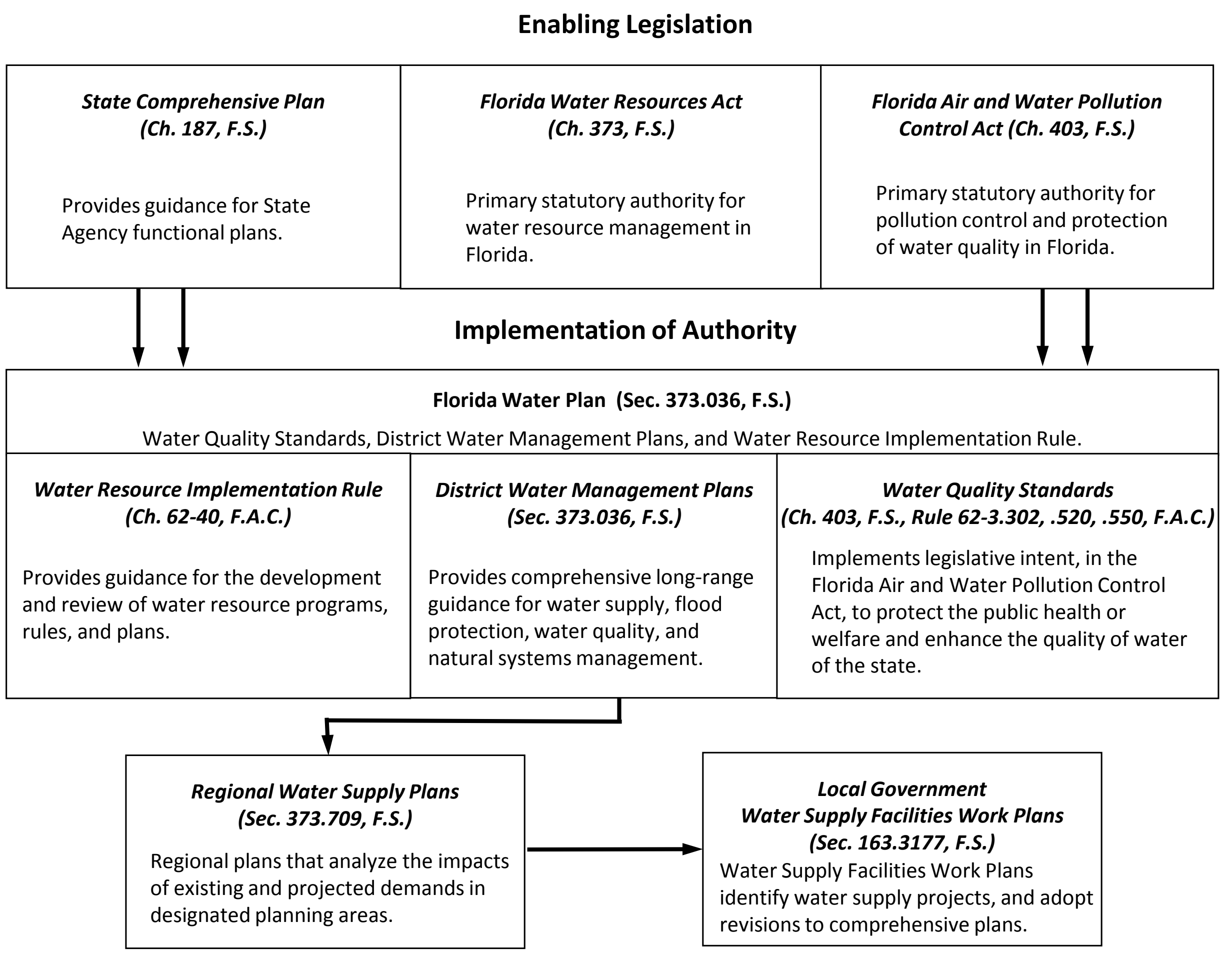

Figure 2. Legal framework for Florida water supply planning.

In 1997, the Florida legislature enacted laws specifying the role the state's water management districts perform in water resource and water supply planning and development. The legislative intent was to provide for human and environmental water demands for a 20-year planning horizon.

The *State Comprehensive Plan* establishes:

> 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.

Initially, the *State Water Use Plan* and the *State Water Policy* were the primary documents developed to meet the state's water supply planning objectives. With the passage of later legislative amendments, the *Florida Water Plan* replaced the *State Water Use Plan*. The *Florida Water Plan* now includes the *State Water Policy* (which was renamed the *Water Resource Implementation Rule*). 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. Relevant SFWMD documents resulting from this legislation include:

LAW / CODE

The statutes providing the basic authorities, directives, and policies for statewide water management, pollution control, and environmental protection, include:

- State Comprehensive Plan (Chapter 187, F.S.)
- Water Resources (Chapter 373, F.S.)
- Environmental Control (Chapter 403, F.S.)

- ***Water Supply Policy Document*** (SFWMD 1991).
- ***Water Supply Needs and Sources*** (SFWMD 1992).
- ***District Water Management Plan*** (DWMP) (SFWMD 1995). The District approved DWMPs in 1995 and 2000 (SFWMD 2000), as well as updates in 2001, 2002, and 2003 (SFWMD 2001, 2002, 2003). Beginning in 2004, the SFWMD chose to exercise its option to do an annual Water Resource Development Work Program report, published in the *South Florida Environmental Report – Volume II* (for example, SFWMD 2013b), in lieu of the DWMP. In addition, the SFWMD *Strategic Plan* now contains the long-range planning information formerly reported in the DWMP.
- ***Districtwide Water Supply Assessment*** (DWSA) (SFWMD 1998). In 1997, Chapter 373, F.S., was modified to require each water management district to prepare a DWSA. This was in part to identify areas that have potential for water demands to exceed available supplies over a 20-year planning horizon. The *SFWMD Districtwide Water Supply Assessment* confirmed the District's decision to prepare water supply plans that cumulatively cover the entire SFWMD.

Water Supply Planning

Chapter 373, F.S., contains legal mandates for water supply planning and development by the water management districts, in cooperation with the Florida Department of Environmental Protection (FDEP). The FDEP has general supervisory authority over the state's water management districts.

Subsection 373.036(1), F.S., requires the FDEP to develop the *Florida Water Plan* 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 *Florida Water Plan* includes, but is not limited to, the following items:

- FDEP programs and activities related to water supply, water quality, flood protection and floodplain management, and natural systems
- FDEP water quality standards
- 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

Regional Water Supply Plans

The SFWMD updates each of its four regional water supply plans approximately every five years. Based on a minimum 20-year planning period, current regional water supply plans include, but are not limited to, the following:

- A water supply development component
- A water resource development component
- The Minimum Flows and Levels (MFLs) established for water resources within the planning area
- A recovery strategy or a prevention strategy for addressing attainment and maintenance of 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
- The technical data and information applicable to the planning area contained in the District's *Strategic Plan* and needed to support the regional water supply plans
- Water Reservations adopted by rule pursuant to Subsection 373.223(4), F.S.

- Analysis of areas or instances in which the variance provisions of Paragraph 378.212(1)(g), F.S., or Subsection 378.404(9), F.S., may be used to create water supply development or water resource development projects

Local Government Water Supply Planning

The water supply projects proposed in the water supply plans for Public Water Supply utilities are useful to local governments in the preparation of their Water Supply Facilities Work Plans, which contain the capital improvements element. Within 18 months following the approval of the water supply plans, local governments are required to adopt or amend their Water Supply Facilities Work Plans to reflect the regional water supply plans.

As of June 2012, 90 percent of all local governments within the SFWMD have developed and formally submitted their Water Supply Facilities Work Plans, many with the technical assistance of the SFWMD. The development of these plans has assisted the SFWMD in coordinating future water supply planning and permitting with local government land use planning.

Local Government Comprehensive Plans

Chapter 163, Part II, F.S., includes The *Community Planning Act* (163.3164, F.S.), which requires each municipality and county to adopt and maintain a comprehensive plan. In Florida, all proposed and approved development in the community must be consistent with the comprehensive plan.


Residential Development in Collier County

In terms of water supply planning, additional information about state requirements for local government comprehensive plans is available in each regional water supply plan update, including checklist guidance for water supply-related aspects of local government comprehensive plans, including some of the following:

- Identify water supply sources needed to meet existing and projected water use demands for the established planning period of the comprehensive plan
- Base future land use plan and plan amendments on the availability of water supplies and associated public facilities
- Identify alternative and traditional water supply projects, water conservation, and reuse needed to meet the water needs identified in the regional water supply plan for the local government's jurisdiction

Water Protection and Sustainability Program

Lawmakers revised state water law and created the Water Resource Protection and Sustainability Program in 2005, which requires a higher level of water supply planning coordination between water management districts and local governments. Section 373.707, F.S., details the intent and purpose of the Water Protection and Sustainability Program, and defines the responsibilities of the utilities and the water management districts.

Alternative Water Supply

The Florida legislature passed an amendment to Section 373.707, F.S., which concerns water management district funding of alternative water supply projects. The legislation added "water conservation projects that result in quantifiable water savings" to those projects eligible for funding, effective July 1, 2010.

Applicants for projects eligible to receive funding assistance are required to pay at least 60 percent of the project's construction costs. Funding for alternative water supply projects is limited to construction costs. The District's Governing Board approves the recommended projects for financial assistance based on current program guidelines. From Fiscal Year (FY) 2006 through FY 2011, the SFWMD approved more than $165 million in funding (including Water Protection and Sustainability Program funds) for 285 projects that created more than 420 million gallons per day of additional water supply capacity, reducing the reliance on freshwater sources while diversifying water supplies.

SIGNIFICANT CHANGES AND OUTLOOK SINCE THE LAST UPDATES

Since the previous water supply plan updates, the national economic downturn has slowed residential and commercial development, and in turn, overall population growth, leading to a reduced rate of increase in future urban water demands. Although population growth has been slower than previously projected, the growth is such that additional water supplies over the 20-year planning horizon will likely be required in many areas. This reinforces the need for local governments to develop alternative water sources to ensure adequate future water supplies. In central Florida, future projections indicate that groundwater availability is insufficient to meet the region's growing demand, which led to the formation of the Central Florida Coordination Area and ultimately to the Central Florida Water Initiative. Recent drought conditions and water shortages have emphasized the need for efficient water use. Water conservation continues to be an effective way to maximize existing water supplies, and to further its efforts, the District developed its Comprehensive Water Conservation Program.

Water Shortage

South Florida experienced severe drought conditions between 2006 and 2009. In response to these dry conditions, water levels in many groundwater monitor wells in south Florida were at the lowest 10th percentile in history. The SFWMD issued water shortage orders in various basins placing water users, including public water suppliers, under water restrictions to reduce demand and stretch remaining water supplies.

After this historic water shortage, the SFWMD evaluated the water savings that resulted from phased water restrictions. A marked decrease in both indoor and outdoor water use occurred in response to water shortage restrictions, even though the restrictions mainly addressed outdoor uses. Consumer behavior changed with each subsequent water shortage order to follow the modified restrictions. The effectiveness of water shortage rules increased when messaging and enforcement were consistent on both regional and local levels. These results suggest that a consistent culture of water conservation, efficiency, and water-conserving technology is key to maximizing water savings and effecting long-term sustainable change.

Lake Okeechobee during Drought

In March 2011, a Districtwide water shortage was declared, calling for reduced use and conservation of water for some water use classes and a number of water shortage orders went into effect. The orders limited landscape irrigation to two days per week and require mandatory reductions in agricultural and other large water uses. Landscape irrigation using reclaimed water is not restricted by water management districts during a water shortage, unless requested by the utility providing reclaimed water (Chapter 373.250, F.S.). Many agricultural and diversion and impoundment systems, as well as nurseries and golf courses throughout the region are required to reduce withdrawals.

More information about water shortage is available in the *Water Shortage Management* section of **Chapter 4** of this document and from the SFWMD website at: http://www.sfwmd.gov.

Central Florida Coordination Area and Central Florida Water Initiative

The Central Florida Coordination Area (CFCA) is the region in and around metro-Orlando where the jurisdictional boundaries of the South Florida, St. Johns River, and Southwest Florida water management districts meet. Since 2006, the three water management districts have jointly concluded that sustainable quantities of groundwater in central Florida are insufficient to meet all future demands and recognized the need to develop and implement alternative water supply projects as part of the CFCA Action Plan. In 2010, the CFCA Action Plan was modified to incorporate a broader, more collaborative approach in resolving water supply technical and policy issues, titled the Central Florida Water Initiative (CFWI). For a comprehensive review of water supply status and issues in the KB Planning Area, refer to the the Draft *Central Florida Water Initiative Regional Water Supply Plan* (SJRWMD, SWFWMD and SFWMD 2014) and the *Lower Kissimmee Basin Water Supply Plan* (LKB Plan) (SFWMD 2014). This Support Document generally describes the Kissimmee Basin Planning Area in its entirety (both Upper and Lower basins), and supports both planning documents mentioned above. In addition, information about the Central Florida Water Initiative is available from http://cfwiwater.com.

Water Conservation

Reducing future water demands before expanding water supplies and treatment facilities can be a cost-efficient way to manage resources. Therefore, employing sound water conservation measures prior to developing viable water source options is helpful to regional water supply planning efforts. The SFWMD is continuing water conservation efforts, especially by providing support to Public Water Supply utilities and other providers about the most cost-effective ways to reduce water use.

In September 2008, the District's Governing Board approved the SFWMD Comprehensive Water Conservation Program (CWCP). The CWCP is a series of recommendations and implementation strategies designed to bring about a permanent reduction in individual water use. The program is organized into 1) regulatory, 2) voluntary and incentive-based, and 3) educational and marketing water conservation initiatives. Under the umbrella of these initiatives, the SFWMD and other agencies provide numerous water conservation tools. Details on the CWCP can be found in **Chapter 5** of this Support Document.

Climate Change Impacts

To better understand climate change and provide a high-level foundation for future discussions about water management planning and operations, the SFWMD established an Interdepartmental Climate Change Group. The group's initial mission was to review scientific literature and prepare a climate change white paper to guide water management decisions. Released in November 2009, the paper is entitled *Climate Change and Water Management in South Florida* (SFWMD 2009a).

Some changes in climate and subsequent effects on hydrologic conditions are known. Long-term data show increasing temperatures and a corresponding sea level rise. For planning purposes, the District is estimating a sea level rise of 5–20 inches in south Florida by 2060.

Most coastal communities in southeastern Florida depend on shallow, freshwater wellfields for water supply. The Florida Oceans and Coastal Council believes the area from Miami to Palm Beach, located within the Lower East Coast (LEC) Planning Area, to be particularly vulnerable to saltwater intrusion into freshwater supplies. Monitoring and detailed analysis are needed to identify the impact of potential sea level rise on utility wellfields at risk of saltwater intrusion. Both Broward and Miami-Dade counties in the LEC Planning Area have initiated studies to help with this determination. Monitoring and studies are also needed for areas at risk within the Lower West Coast Planning Area.

Temperatures are anticipated to continue increasing at a rate of about 0.4°F per decade. This change will likely foster an increase in evapotranspiration (ET). Surface water storage from lakes, reservoirs, ponds, rivers, and canals will have higher evaporation losses than current ET levels. Water demands for most water use categories can be expected to rise as temperatures increase.

Projections for effects on average annual rainfall are varied. Some models predict a wetter south Florida and some predict a drier climate, increasing or decreasing by as much as 20 percent. A rainfall decrease will increase the demand for water, lower groundwater levels, and increase the risk of saltwater intrusion. An increase in rainfall could mean more water will be available for storage with higher groundwater and surface water levels. Changes in rainfall timing, intensity, and frequency will also affect water supply. Longer periods of dry weather could cause more frequent droughts and increased water demand. More intense, short periods of rainfall could increase total precipitation, but could result in much of the water being lost to tide.

Tropical storms and hurricanes also influence water supplies. The Interdepartmental Climate Change Group reports that hurricane and tropical storm frequency and intensity have increased since 1995, and that much of the change relates to natural cycles. One such cycle is the Atlantic Multidecadal Oscillation, a cyclic variation in the large-scale atmospheric flow and ocean currents in the North Atlantic Ocean. It is likely that hurricane and tropical storm frequency will continue to change in comparison to the historical record. A decrease in storm events could result in less rain, more frequent drought conditions, and increased water demand.

As stated in the *Climate Change and Water Management in South Florida* white paper (SFWMD 2009a), the District will continue to expand its understanding of climate change trends and develop tools to plan for these changes. The District will need to develop and implement climate change adaptation strategies to address future impacts to water supply planning.

2

Natural Systems

This chapter introduces south Florida's natural systems (**Table 1**), specifically its major ecosystems. Natural systems that are important to water supply planning are discussed in each regional water supply plan five-year update. The regional chapters of this Support Document also describe the surface and groundwater features of each planning area.

TOPICS

- South Florida Ecosystem
- Freshwater Systems

SOUTH FLORIDA ECOSYSTEM

The south Florida ecosystem (**Figure 3**) is defined as the area consisting of the lands and waters within the boundary of the SFWMD, including the built environment, the Everglades, the Florida Keys, and the contiguous near-shore coastal waters of south Florida (Title 33 of the Code of Federal Regulations, Part 385.3).

Alligators in the Everglades

This ecosystem stretches from the Kissimmee Basin through Florida Bay and encompasses Lake Okeechobee at the heart of the system; the Loxahatchee and St. Lucie river estuaries to the east; the Caloosahatchee River and Estuary to the west; the Water Conservation Areas and most of Everglades National Park to the south, including Biscayne Bay, Florida Bay, and the Florida Keys.

Northern and Southern Everglades

The south Florida ecosystem is divided by legislative mandate into the Northern and Southern Everglades. The Northern Everglades includes the Kissimmee Chain of Lakes and Kissimmee River, Lake Okeechobee, and the Caloosahatchee and St. Lucie river watersheds. The Southern Everglades encompasses the watersheds south of Lake Okeechobee through

Florida Bay, such as Big Cypress National Preserve and Everglades National Park, and coastal bays, lagoons, and estuaries south of Lake Okeechobee, and the Loxahatchee River.

The Kissimmee Basin, comprising the Kissimmee Chain of Lakes and the Kissimmee River and floodplain, forms the headwaters of Lake Okeechobee and the Everglades. Collectively, these areas are known as the historical Kissimmee-Okeechobee-Everglades (KOE) Watershed.

Table 1. Major surface water features.

Major Surface Water Features	Planning Area
Northern Everglades	
Kissimmee Chain of Lakes	Upper Kissimmee Basin
Kissimmee River	Upper and Lower Kissimmee Basins
Lake Istokpoga	Lower Kissimmee Basin
Fisheating Creek	Lower Kissimmee Basin and Lower West Coast
Lake Okeechobee	All Planning Areas[a]
St. Lucie River	Upper East Coast
Loxahatchee River	Lower East Coast
Lake Trafford	Lower West Coast
Caloosahatchee River	Lower West Coast
Southern Everglades	
Loxahatchee River	Lower East Coast
Everglades National Park	Lower East Coast
Water Conservation Areas	Lower East Coast
Big Cypress National Preserve	Lower West Coast
Fakahatchee Strand	Lower West Coast
Picayune Strand	Lower West Coast
Estuarine Systems	
Southern Indian River Lagoon and St. Lucie Estuary	Upper East Coast
Loxahatchee River and Estuary	Upper East Coast and Lower East Coast
Lake Worth Lagoon	Lower East Coast
Caloosahatchee River and Estuary and Charlotte Harbor	Lower West Coast
Estero Bay	Lower West Coast
Fakahatchee Estuary	Lower West Coast
Naples Bay	Lower West Coast
Biscayne Bay	Lower East Coast
Ten Thousand Islands and Rookery Bay	Lower West Coast
Florida Bay	Lower East Coast

a. Analysis performed in Lower East Coast Water Supply Plan Update.

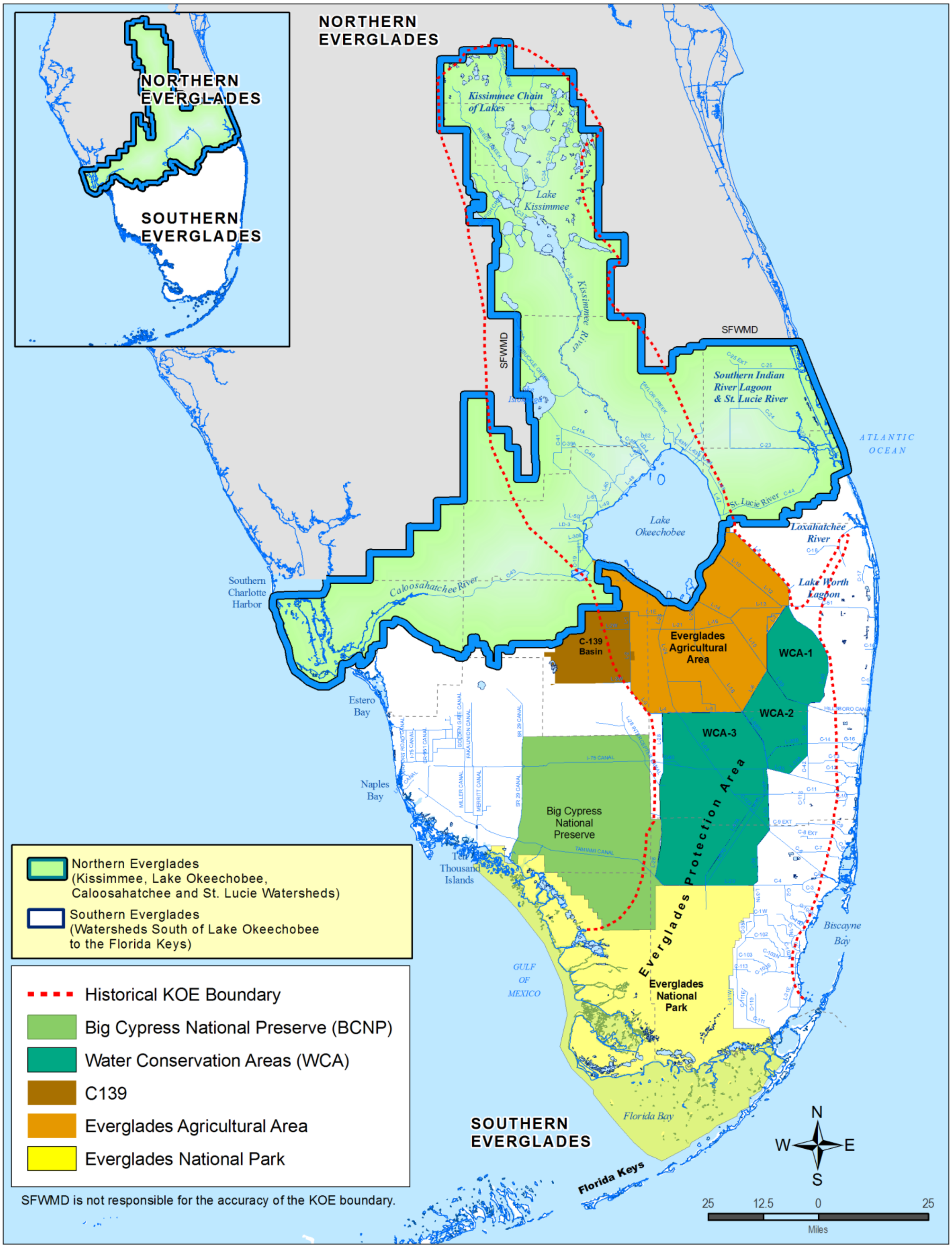

Figure 3. The south Florida ecosystem and historical Kissimmee-Everglades-Okeechobee (KOE) watershed boundary.

In 1948, Congress authorized the construction effort, known as the Central and Southern Florida Flood Control Project (C&SF Project), to provide flood protection and water management throughout south Florida. During the 1950s and 1960s, canals, water control structures, and pumps were constructed to modify the native Kissimmee-Okeechobee-Everglades Watershed. The natural, meandering Kissimmee River and its floodplain were channelized in the 1960s for flood control improvements. The 103-mile river was replaced by a 56-mile canal.

Over the past 60 years, widespread development and increased urbanization fundamentally altered the spatial extent, hydrology, water quality, and ecology of ecosystems throughout south Florida. Today, Florida's shoreline and nearby coastal ridges are densely populated. Natural hammock and dune communities along the coast survive as unique subtropical ecosystems. In addition, at present, the remaining Everglades are less than half the natural system's original extent.

Although regional development and related water management efforts altered the local movement and balance of water, the interdependence of subregions and overall north–south movement of water still exist. Within the Lake Okeechobee Watershed, water flows from the Upper Kissimmee Basin through the Kissimmee Chain of Lakes into the Lower Kissimmee Basin, where the Kissimmee River flows into Lake Okeechobee.


Baby Gopher Tortoise

Lake Okeechobee is commonly referred to as the liquid heart of the system. The lake is linked by canals to the St. Lucie and Caloosahatchee river estuaries. Discharges through these canals influence the quantity, quality, and timing of fresh water entering the estuaries.

From Lake Okeechobee, some water moves southward through the Everglades Agricultural Area (EAA), then through the Everglades Stormwater Treatment Areas (STAs), and into tributary basins or Water Conservation Areas (WCAs). The Everglades Protection Area, which includes the WCAs and most of Everglades National Park, contains remnant Everglades marshes that provide vital surface water to sustain the natural elements of the southern part of the regional ecosystem.

Changes in hydrology, soil subsidence, exotic plant invasion, and water quality constituents have altered the historic ridge-and-slough landscape, such as sawgrass plains, aquatic sloughs (slow moving, shallow rivers), and tree islands in the WCAs and Everglades National Park. Extending downstream from the Everglades are the mangrove estuaries and coastal basins of Florida Bay and Biscayne Bay. As these bays are the receiving waters of the Everglades, changes upstream have created changes downstream, such as altered salinity.

Initiatives to protect and restore natural systems and increase available water supplies are under way. Water-related directives from legislation or programs at federal and state levels, as well as the SFWMD, include planning, land acquisition and management, regulatory, and restoration efforts. **Chapter 3** discusses water protection and restoration Districtwide.

FRESHWATER SYSTEMS

Characteristics of ecosystems in central and south Florida include their unique mix of flora and fauna, as well as geographic location and hydrologic conditions. This section describes some of the representative ecosystems found within the boundaries of the SFWMD that are particularly dependent on freshwater flows. The planning area chapters in this Support Document also provide information about the physical features and water resources within each respective region. The list of ecosystems in **Table 2** is not all-inclusive.

Table 2. Representative ecosystems.

Ecosystems	Planning Area
Kissimmee River and Floodplain	Upper and Lower Kissimmee Basins
Lake Okeechobee	All Planning Areas
Indian River Lagoon / St. Lucie River and Estuary	Upper East Coast
Caloosahatchee River and Estuary	Lower West Coast
The Savannas	Upper East Coast
Loxahatchee	Upper East Coast and Lower East Coast
The Everglades	Lower East Coast
Okaloacoochee Slough	Lower West Coast
Corkscrew Regional Ecosystem Watershed	Lower West Coast
Fakahatchee Strand	Lower West Coast

Kissimmee River and Floodplain

The Kissimmee River and its floodplain are delineated by the 100-year floodplain boundary established by the U.S. Army Corps of Engineers (USACE) between the S-65 and S-65E structures. The area includes the historic Kissimmee River and its tributary watersheds between Lake Kissimmee, Lake Okeechobee, and the C-38 flood control canal (see **Figure 10** and **Figure 11** in **Chapter 7** of this document).


Kissimmee River

A considerable extent of the original Kissimmee River and its floodplain was drained when the C-38 Canal was constructed. As a result, wetlands and populations of waterfowl, wading birds, fish, and other animals began to decline drastically. The ongoing Kissimmee River Restoration Project is restoring ecological integrity to a portion of the ecosystem while retaining existing levels of flood protection to surrounding communities. With the completion of each restoration phase, vegetation and densities of aquatic invertebrates, fish, wading birds, and waterfowl have shown improvement.

Birds are integral to the Kissimmee River/floodplain ecosystem. Some of the wading bird species in this region include a variety of egrets (cattle egret, great egret, and snowy egret), herons (tricolored heron, great blue heron, little blue heron, black-crowned night heron), and ibis (glossy ibis and white ibis).

Waterfowl species, such as the blue-winged teal, green-winged teal, mottled duck, hooded merganser, and wood duck, are increasing in restored areas as well. Other species observed following the completion of restoration phases include the American wigeon, northern pintail, northern shoveler, ring-necked duck, and black-bellied whistling duck.

Lake Okeechobee

The largest lake in the southeastern United States, Lake Okeechobee is a central component of the hydrology and environment of south Florida (**Figures 1** and **2**). Lake Okeechobee is a shallow, eutrophic lake that supports a crucial recreational and commercial fishery and provides important habitat for migratory waterfowl, wading birds, and several threatened and endangered plant and animal species. The lake is a component of the C&SF Project and serves multiple functions. The lake is regulated in accordance with a federally adopted regulation schedule known as the 2008 Lake Okeechobee Regulation Schedule (2008 LORS). In general, the Congressionally authorized Project purposes for Lake Okeechobee include: flood control; navigation; recreation; water supply for agricultural irrigation, municipalities, industry, the Seminole Tribe, Everglades National Park, regional groundwater control, and salinity control; and fish and wildlife preservation and enhancement.

NAVIGATE

See **Chapter 3** for additional information about the Kissimmee River Restoration Project. Read more about the Kissimmee River and Floodplain in the upcoming *Lower Kissimmee Basin Water Supply Plan* (SFWMD in process).

Lake Okeechobee receives water from a 5,400-square-mile watershed that includes the Kissimmee Chain of Lakes, the Kissimmee River, Lake Istokpoga, Fisheating Creek, and other drainage basins. Lake waters can be delivered south to the Everglades Protection Area, east to the St. Lucie River (C-44 Canal), and west to the Caloosahatchee River (C-43 Canal).

Indian River Lagoon / St. Lucie Estuary

Indian River Lagoon is characterized by a great diversity of species compared to other North American estuaries. Approximately 2,200 species have been identified in the lagoon system, with 35 of these species listed as threatened or endangered.

> **NAVIGATE**
>
> More information about the Indian River Lagoon is provided in the *2011 Upper East Coast Water Supply Plan Update* (SFWMD 2011b).

Sheltered by sandy beaches and beds of seagrass, the lagoon has evolved into a nursery for young sea creatures—oysters, clams, shrimp, crabs, and hundreds of species of fish that thrive in the warm shallow waters. Species diversity is generally high in the southern end of the lagoon system and near inlets. Species diversity is lower near cities, where stormwater discharges, nutrient input, sedimentation, and turbidity are high, and where large areas of mangroves and seagrass have been lost.

The St. Lucie River is located in Martin and St. Lucie counties. The river is 35 miles long and has two major forks, the North Fork and the South Fork. Both forks combine in the St. Lucie Estuary (see **Figure 14** in **Chapter 8** of this document).

The Five and Ten Mile creeks form the headwaters and tributaries to the North Fork of the St. Lucie River, which is a freshwater system upstream and a brackish system near the St. Lucie Estuary. The North Fork is approximately 10 miles long and encompasses 5,000 acres.

The Port Mayaca lock and dam east of Lake Okeechobee releases water from Lake Okeechobee into the C-44 Canal (St. Lucie Canal), which discharges into the South Fork of the St. Lucie River. This connection from Lake Okeechobee to the South Fork was constructed for flood relief and navigational purposes.

Caloosahatchee River and Estuary

The Caloosahatchee River stretches from the western edge of Lake Okeechobee to San Carlos Bay on the Gulf of Mexico (see **Figure 18** in **Chapter 9** of this document).

From Lake Okeechobee, the Caloosahatchee River runs west to the Franklin Lock and Dam (Structure S-79), which separates the fresh water of the river from the brackish water of the Caloosahatchee Estuary. The river provides water supply, drainage, and conveyance of regulatory releases of water from Lake Okeechobee to tide.

Modifications to the Caloosahatchee River allowed development in the watershed, resulting in a network of secondary and tertiary canals in the Caloosahatchee River Watershed. This network provides conveyance for both drainage and irrigation to accommodate agricultural and urban needs.

The Savannas

The Savannas is a remnant freshwater coastal wetland system located west of the Atlantic Coastal Ridge in Martin and St. Lucie counties. Today, Savannas Preserve State Park contains the largest and most ecologically intact stretch of this Florida east coast ecosystem. Encompassing 5,000 acres and stretching 10 miles from Fort Pierce to Jensen Beach, the preserve consists of marsh, pine forest, sandy ridge, and two natural deep lakes, Eden Lake and Henderson Pond.

Savannas Preserve State Park

In the Savannas, flora and fauna on the upland ridge have adapted to the dry, desert-like habitat called scrub. Many of the species in this environment, such as the threatened Florida scrub jay, cannot survive in any other habitat than scrub. The indigo snake, also considered threatened, uses abandoned gopher tortoise holes as homes, as do numerous other scrub inhabitants. The wooly cactus is a rare plant found only in the Savannas. Like some desert habitats, the scrub sand dune is one of the most fragile components of the Savannas ecosystem.

The Loxahatchee Watershed

The Loxahatchee River and Estuary and its upstream watershed are located along the southeastern coast of Florida within the Lower East Coast (LEC) and Upper East Coast (UEC) planning areas. This watershed connects to the Atlantic Ocean via the Jupiter Inlet. The Loxahatchee Watershed contains a number of natural areas that are essentially intact and in public ownership. These areas include:

- 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

Jonathan Dickinson State Park, an 11,500-acre park in southeastern Martin County, contains 13 natural communities, including sand pine scrub, pine flatwoods, mangroves, and river swamps. The Northwest Fork of the Loxahatchee River, a part of which is Florida's first federally designated Wild and Scenic River, runs through the park.

NAVIGATE

See **Chapter 10: Lower East Coast Planning Area** for more information about the Loxahatchee Watershed.

Loxahatchee Slough, covering more than 14,000 acres, is one of the largest, relatively undisturbed wetlands remaining in Palm Beach County. It contains a mixture of habitats, including pine flatwoods, cypress forest, and wet prairie.

The Everglades

Once a vast, free-flowing river of grass extending from the Kissimmee Chain of Lakes to Florida Bay, the Everglades subtropical wetlands supported a rich diversity of plants, fish, and wildlife. For over a century, drainage of wetlands and changes in the natural variability of water flows have altered the Everglades. The Comprehensive Everglades Restoration Plan (see **Chapter 3**) is a framework and guide to restore, protect, and preserve much of the water resources of central and southern Florida.

NAVIGATE

More information about the Everglades is provided in **Chapter 10** of this document.

As a result of the C&SF Project, the Everglades were divided into three hydrologic units known as the Water Conservation Areas (WCAs – WCA-1, WCA-2A/WCA-2B, and WCA-3A/WCA-3B). The WCAs are shallow, diked marshes operated and maintained in accordance with federal regulation schedules. These project components serve multiple purposes, including flood control, water conservation, prevention of saltwater intrusion, recreation, fish and wildlife habitat, and environmental water supply for Everglades National Park.

Everglades National Park contains temperate and tropical plant communities, including sawgrass prairies, mangrove and cypress swamps, pinelands, and hardwood hammocks, as well as marine and estuarine environments. The park is home to rare and endangered species, including the American crocodile, Florida panther, and West Indian manatee, as well as large wading bird colonies of different species, such as the roseate spoonbill, wood stork, great blue heron, and a variety of egrets.

Okaloacoochee Slough

The Okaloacoochee Slough encompasses more than 13,000 acres in the Okaloacoochee Wildlife Management Area in Hendry County and consists of natural marsh and forest communities. The Big Cypress National Preserve and the Fakahatchee Strand are dependent on fresh water supplied by the slough. The Okaloacoochee area also provides important habitat for the endangered Florida panther, Florida black bear, bald eagle, roseate spoonbill, sandhill crane, wood stork, and the crested caracara.

Fakahatchee Strand


Fakahatchee Strand Estuary

Fakahatchee Strand Preserve State Park in Collier County hosts an array of habitats and forest types, from swamps and prairies to tropical hardwood hammocks and pine rock lands. Beneath a protective canopy of bald cypress and native royal palm trees flows a slough that is warmer than the ambient temperature in the winter and cooler in the summer. The buffering effect of the slough and deeper lakes enables the strand to support a variety of rare and endangered tropical plant species, including 44 native orchids and 14 native bromeliads.

The stand is also a haven for wildlife, including resident and migratory birds, Florida panthers, white-tailed deer, Florida black bears, eastern indigo snakes, Everglades minks, and diamondback terrapins.

NAVIGATE

Refer to **Chapter 9: Lower West Coast Planning Area** for more discussion about the Fakahatchee Strand.

Corkscrew Regional Ecosystem Watershed

The Corkscrew Regional Ecosystem Watershed (CREW) encompasses 60,000 acres in Collier and Lee counties. This area contains 16,000 acres of preserved land, including the Corkscrew Swamp.

The CREW shelters endangered Florida panthers, wood storks, and several species of rare orchids. Protecting the CREW is also crucial in preserving southwest Florida's water supply.

NAVIGATE

Chapter 9: Lower West Coast Planning Area also includes Corkscrew Regional Ecosystem Watershed information.

Protection of the Okaloacoochee Slough, Fakahatchee Strand, and the CREW will preserve connections between these areas, providing a corridor for both wildlife and water flows, including the natural flow-way to the headwaters of the Estero Bay Basin.

3

Natural Systems Protection and Restoration Efforts

TOPICS

- Natural Systems Protection
- Ecosystem Restoration

Protection and restoration of natural systems are accomplished through the integration of planning, regulatory, land acquisition, and restoration programs. When discussing natural systems or ecosystem programs and projects, protection and restoration activities are often connected. Generally, natural systems protection efforts involve resource protection criteria or standards to protect the water resources necessary for the sustained health of a natural system, whereas restoration efforts focus on recovering the original characteristics of an ecosystem. This chapter defines natural systems protection efforts and identifies restoration efforts, many of which involve a combination of protection and restoration activities.

NATURAL SYSTEMS PROTECTION

The SFWMD's mission is to manage and protect south Florida's water resources by balancing and improving flood control, water supply, water quality, and natural systems. To assist in achieving the agency's mission, the Water Supply Program's goal is to ensure sustainable water supplies to protect natural systems and to meet all existing and future reasonable-beneficial uses. The District implements water resource development projects and updates water supply plans every five years to meet the water needs of central and south Florida for the next 20-year planning horizon.

Water use permits play a key role in the water supply planning process, and permit applicants must provide reasonable assurances that the proposed activity will be consistent with the overall objectives of the District and will not cause harmful impacts to the water resource. In addition, various scientific, policy, and legal tools, as well as water supply regulatory programs, are used to protect water supplies for the needs of natural systems. **Chapter 4** reviews the types of tools used to protect natural systems.

ECOSYSTEM RESTORATION

Chapter 2 presented an overview of the Greater Everglades ecosystem, which comprises the Northern and Southern Everglades. As discussed in that chapter, changes in the region's hydrology and habitats over the past century have caused degradation of this vital subtropical wetland system. Because of development and drainage in the Greater Everglades, the right quantity and quality of water is not always available in dry periods for both the environment and the human population. Conversely, in wet times, the lack of natural storage capacity often causes damaging flooding of the Everglades and coastal estuaries.

The Comprehensive Everglades Restoration Plan (CERP) is one of the largest environmental restoration programs in history. Congress authorized the CERP in 2000, and the plan serves as a framework for modifications and operational changes to the C&SF Project to restore, preserve, and protect the land and water within the boundary of the SFWMD while providing for other water related needs of the region. The U.S. Army Corps of Engineers (USACE) is the lead federal agency and the SFWMD is the lead state agency for this multidecadal effort.

Great Egrets

In addition, the SFWMD serves as the lead state agency with the USACE for foundational projects the CERP is intended to build upon, which were assumed to be complete during the planning processes for the CERP. The full suite of benefits from the implementation of all of the CERP projects depends on the successful completion of the these foundational projects. Key among these foundational projects is the Modified Water Deliveries to Everglades National Park Project (Mod Waters), which is critical for restoration of more natural flows to Everglades National Park. Other foundational projects include the federally authorized Kissimmee River Restoration Project, Modifications to the C-111 Project, the Critical Restoration Projects, and the State of Florida's Everglades Construction Project.

Restoration scientists, planners, and engineers hope to recover many of the original characteristics of the Everglades. These characteristics would allow the Everglades to function as one cohesive ecosystem (USACE 2010). Such characteristics would include interconnected wetlands, low concentrations of nutrients in freshwater wetlands, sheetflow, healthy and productive estuaries, hardy native plant communities, and an abundance of native wetland flora and fauna (USDOI and USACE 2005).

Two examples of restoration projects are the Kissimmee River Restoration Project [see Chapter 9 of the *2013 South Florida Environmental Report, Volume I* (SFWMD 2013b)] and the CERP Picayune Strand Restoration Project [see the *2012 Lower West Coast Water Supply Plan Update* (SFWMD 2012) for more information].

Ecosystem Restoration Initiatives and Projects

This section provides a high-level overview of some of the major initiatives and projects under way at the SFWMD. The District and its partners (e.g., USACE, FDEP) maintain updated information about each undertaking on the Internet. The links to dedicated project website pages and related documentation are included in this chapter for easy referencing.

CERP and Critical Restoration Projects

As mentioned earlier, the CERP is composed of a series of projects designed to capture, store, and redistribute fresh water and to restore the Everglades ecosystem by improving the quality, quantity, timing, and distribution of water flows. Together, the various components of the CERP will benefit the ecological functioning 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.

The SFWMD is responsible for acquiring the real estate needed for the construction and operation of the CERP projects. Land Acquisition Program activities are available from http://www.evergladesplan.org/pm/progr_land_aquisition.aspx.

Separate from the CERP, Critical Projects, were authorized in the *Water Resources Development Act of 1996*, as restoration projects designed to achieve early benefits to the south Florida ecosystem. A list of these Critical Projects is available from http://www.saj.usace.army.mil/Divisions/Planning/Branches/Environmental/Projects_Critical.htm

Everglades Restoration Projects

The SFWMD takes a systemwide approach to protecting and restoring the Southern and Northern Everglades. These interdependent ecosystems originate in central Florida near metropolitan Orlando and stretch southward to the coastal estuaries and bays of south Florida and involve other federal and state partners, such as the USACE, the Florida Department of Environmental Protection (FDEP), and the Florida Department of Agriculture and Consumer Services (FDACS). Everglades restoration projects are designed to address multiple concerns, such as ecosystem health, environmental protection, and water resources for fish and wildlife and consumptive use. Ongoing restoration projects are improving regional water quality, hydrology, and ecology. The latest information about Everglades Restoration Projects is available from http://www.sfwmd.gov/sferdb. Additional project information is available from http://www.evergladesplan.org.

Kissimmee River Restoration Project

The Kissimmee River Restoration Project is a large-scale, multiphased ecosystem restoration effort. The project reestablishes the river-floodplain system's ecological integrity by recreating the river's physical form and reestablishing pre-channelization hydrologic characteristics; provides the water storage and regulation schedule modifications needed to approximate the system's historical water levels and flow; and increases the quantity and quality of shoreline habitat in Lakes Kissimmee, Hatchineha, Tiger, and Cypress for the benefit of fish and wildlife. In addition, the project ensures the maintenance of existing flood protection.


Kissimmee River Restoration

Three of four canal backfilling phases of the Kissimmee River Restoration Project are complete. Backfilling of the C-38 Canal began in 1999 with Reach I construction (completed in 2001); work continued north in two additional construction phases, which were completed in 2007 and 2009, respectively. The remaining Reach II/III construction is scheduled to begin in 2012, with overall completion in late 2014. Other construction associated with the Kissimmee River Restoration Project includes levee removal, water control structure additions/ improvements, flood protection, and various infrastructure improvements within the project area including the headwater lakes.

Construction project status is available from http://www.saj.usace.army.mil/Divisions/ProgramProjectMgt/Branches/EcoSys/Everglades/KRR/index.htm.

Northern Everglades and Estuaries Protection Program

Underscoring the state's commitment to ecosystem restoration, the Florida legislature in 2007 expanded the Lake Okeechobee Protection Act to include the protection and restoration of the interconnected Kissimmee, Lake Okeechobee, Caloosahatchee, and St. Lucie watersheds. This interagency initiative, known as the Northern Everglades and Estuaries Protection Program (NEEPP), is focusing on the water storage and water treatment needed to help improve and restore the Northern Everglades and coastal estuaries. As part of this initiative, the SFWMD and the State of Florida will expand water storage areas, construct treatment marshes, and expedite environmental management initiatives to enhance the ecological health of the lake and downstream coastal estuaries. The NEEPP requires the SFWMD, in collaboration with the FDEP and the FDACS as coordinating agencies, and in cooperation with local governments, to develop and implement protection plans for three northern watersheds: the Lake Okeechobee

Watershed, St. Lucie River Watershed, and Caloosahatchee River Watershed. While Northern Everglades projects have been conceptually identified in these plans, specific projects and activities are included in annual work plans and updates in the *South Florida Environmental Report – Volume I*, available from http://www.sfwmd.gov/sfer.

Information about the NEEPP and the *2011 Lake Okeechobee Protection Plan Update* (SFWMD 2011a) is available from http://www.sfwmd.gov/northerneverglades.

Everglades Forever Act Projects

Projects related to land acquisition and the design, permitting, and construction of Everglades Stormwater Treatment Areas (STAs) were authorized by the *1994 Everglades Forever Act* (Section 373.4592, F.S.). Annual updates for the Everglades STAs are provided in the *South Florida Environmental Report – Volume I* and *Volume III,* available from http://www.sfwmd.gov/sfer.

SUMMARY

Projects and programs to protect and restore natural resources are essential to ensure an adequate supply of water for natural systems. Natural systems protection efforts also involve resource protection criteria or standards to protect the water resources necessary for the sustained health of a natural system. Various scientific, policy, and legal tools are used to protect water supplies for the needs of natural systems, as well as water supply regulatory programs, which protect, enhance, mitigate, and monitor wetlands and water resources. These tools are discussed in detail in **Chapter 4**.

Lotus

4

Water Supply Regulatory Overview

The previous two chapters of this Support Document introduced the natural systems within the South Florida Water Management District (SFWMD or District) (**Chapter 2**), and several efforts related to natural systems protection and ecosystem restoration (**Chapter 3**). This chapter provides a brief overview and description of some key regulations and statutes that concern the protection of water resources and affect water supply planning.

TOPICS

- Water Use Permitting
- Water Resource Protection Standards
- Lake Okeechobee Regulation Schedule
- Water Shortage Management
- Water Conservation in Water Use Permitting

Water resource protection standards use regulatory mechanisms, such as Minimum Flows and Levels (MFLs), Water Reservations, and Restricted Allocation Areas, which are explained in this regulatory overview.

Section 373.709, Florida Statutes (F.S.), prescribes the legal authority and requirements for water supply planning with additional guidance provided in Chapters 187 and 403, F.S. The primary regulatory tools related to water supply and uses of water are contained in Chapter 373, F.S., and Chapters 40E-2 and 62-40, Florida Administrative Code (F.A.C.).

The *Applicant's Handbook for Water Use Permit Applications* (Applicant's Handbook, SFWMD 2014) contains additional SFWMD's water use permitting criteria. The Florida Department of Environmental Protection (FDEP) recently led a statewide effort called CUPCon to improve consistency in the consumptive/water use permitting programs implemented by the water management districts. CUPCon resulted in changes to SFWMD water use permitting rules and criteria that became effective in 2014.

WATER USE PERMITTING

INFO

Examples of specific regulations and water conservation initiatives can be found in each regional water supply plan update.

Consumptive use of water is broadly defined as any use of water that reduces the supply from which it is withdrawn or diverted. The SFWMD's water use permitting program protects the supply and quality of groundwater and surface water resources by requiring that permit applicants demonstrate their proposed use is reasonable, beneficial, consistent with the public interest, and will not interfere with existing legal uses.

District rules classify water use permits for uses that include, but are not limited to, the following:

- Agricultural irrigation
- Golf course irrigation
- Landscape irrigation
- Public Water Supply
- Dewatering
- Diversion and impoundment
- Commercial and industrial uses

Water use permits are issued by the State of Florida's water management districts pursuant to Part II of Chapter 373, F.S. The specific conditions of issueance for water use permits are described in Section 373.223, F.S., and Chapter 40E-2, F.A.C.

Types of Water Use Permits

Presently, the SFWMD issues three types of water use permits:

- **General Permit by Rule** For single family/duplex landscaping, small dewatering projects, and closed-loop systems
- **Noticed General Permit** For uses with a cumulative average daily use of less than 100,000 gallons per day (GPD) on an annual basis that meet facility and geographic restrictions based on source
- **Individual** For uses with a cumulative average daily use greater than 100,000 GPD on an annual basis or otherwise do not meet Noticed General Permit thresholds

Individual permits for more than 15 million gallons per month require approval from the District's Executive Director or designee. All other permits are approved by District staff.

Water Conservation Planning and Implementation

Existing SFWMD water use permitting rules require planning and implementation of water conservation measures by Public Water Supply utilities (and associated local governments), industrial/commercial/institutional users, landscape and golf course irrigation users, and agricultural users. Further information about the Public Water Supply conservation efforts are discussed in the *Water Conservation in Water Use Permitting* section of this chapter.

Permit Duration and Renewal

Generally, permits are issued for a period of up to 20 years, unless particular circumstances warrant a shorter or longer permit duration.

If an application for renewal is submitted before the permit expiration date, the permit remains in effect until the pending application is processed. Permits are conditioned to require compliance monitoring and reporting, which may include calibrated pumpage, wetland monitoring, saline water monitoring, 10-year compliance reports, or other project-specific restrictions.

Permitting Criteria

To obtain a water 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.

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 FDEP as part of the reasonable beneficial use test. The SFWMD implements this test pursuant to rules adopted in Chapter 40E-2, F.A.C. and the Applicant's Handbook. Permits are conditioned to ensure uses are consistent with the overall objectives of the District and are not harmful to the water resources of the area (Section 373.219, F.S).

Conditions for issuance of a water use permit address multiple issues, including but not limited to:

- Saltwater intrusion
- Wetland and other surface waters
- Pollution
- Impacts to off-site land uses
- Use of reclaimed water
- Interference with existing legal uses
- Minimum Flows and Levels
- Water Reservations

- Restricted Allocation Areas

Level of Certainty

The level of certainty planning goal established by the Florida legislature is a 1-in-10 year drought event. See Paragraph 373.709(2)(a), F.S. The District implemented the level of certainty planning goal in its water use permitting program, and as such, permit applicants must demonstrate the conditions for issuance of a permit are satisfied during a 1-in-10 year drought condition. Demands are calculated, assuming the 1-in-10 year drought condition, and impacts resulting from a proposed withdrawal are analyzed during this same drought event.

Impact Evaluation Criteria

Impact evaluation criteria are applied to various resource functions and existing legal user interference criteria to establish the hydrologic change that can occur without causing harm. For the purposes of water use allocation, the harm standard [Chapter 40E-2, F.A.C.] addresses each of the following:

- Saltwater intrusion
- Wetland and other surface water body drawdown
- Aquifer mining
- Pollution movement
- Off-site land uses
- Existing legal users

Detailed criteria concerning proposed water uses and evaluation of potential impacts are contained in Section 3.0 of the Applicant's Handbook (SFWMD 2014).

WATER RESOURCE PROTECTION STANDARDS

The purpose of the *Florida Water Resources Act* is to ensure the sustainability of state water resources (Section 373.016, F.S.). Chapter 373, F.S., provides water management districts with several tools consisting of varying levels of resource protection standards to carry out this responsibility.

Florida's *Water Resource Implementation Rule*, Chapter 62-40, F.A.C., outlines specific factors to consider in protecting natural systems, including protection of natural seasonal changes in water flows or levels, water levels in aquifer systems, and environmental values associated with aquatic and wetland ecology.

WATER RESOURCE PROTECTION STANDARDS

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

Harm The temporary loss of water resource functions, as defined for water use permitting in Chapter 40E-2, F.A.C., 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.

Significant Harm 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.

Serious Harm 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 groundwater hydrology.

Protecting Water for Natural Systems

In addition to wetland and other surface water body protection criteria, the SFWMD uses three additional rules to protect natural system water (wetlands, rivers, lakes, estuaries, and aquifers) from consumptive use:

1. Minimum Flows and Levels
2. Water Reservations
3. Restricted Allocation Areas

The District is required to annually develop and submit to the FDEP a list and schedule for MFLs. Included in this "Priority Water Bodies List and Schedule," is information about Water Reservation and Restricted Allocation Area rules under development. This list and schedule is provided in the SFWMD's annual *South Florida Environmental Report – Volume II*, available from http://www.sfwmd.gov/sfer.

Minimum Flows and Levels

The SFWMD is responsible, within its boundaries, for implementing the provisions in Section 373.042, F.S., requiring the establishment of MFLs for surface waters. The minimum flow for a given watercourse specifies the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area. Similarly, the minimum water level identifies 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. To date, MFL criteria have been adopted for 13 surface water bodies and aquifers within the SFWMD. These water bodies include:

- Lake Okeechobee
- The Everglades (including the Water Conservation Areas, the Holey Land and Rotenberger Wildlife Management Areas, and Everglades National Park)
- Biscayne aquifer
- The Lower West Coast (LWC) aquifer system encompassing three semi-confined units (Tamiami, Sandstone, and Mid-Hawthorn)
- Caloosahatchee River
- North Fork of the St. Lucie River
- Northwest Fork of the Loxahatchee River and Estuary
- Lake Istokpoga
- Florida Bay

Protection of non-consumptive uses may also be considered and provided for when establishing MFLs (Section 373.042, F.S.). A baseline condition for the protected resource functions must be identified through consideration of changes and structural alterations in the hydrologic system [Paragraph 373.042(1)(a), F.S.]. Certain exclusions for establishing MFLs are contained in Paragraph 373.0421(1)(b), F.S.; however, the Everglades Protection Area is not subject to these exclusions.

PROTECTION

Minimum Flow and Level Criteria
Minimum Flow and Level (MFL) technical criteria are important management tools used by the District to protect major water bodies from significant harm due to reductions in water levels or flows. These criteria provide a basis for defining the point at which additional withdrawals will result in significant harm to water resources.

MFL Recovery and Prevention Strategies

If it is determined that water flows or levels for a water body are presently below the relevant MFL, or will fall below an established MFL within the next 20 years, the District must develop and implement a recovery or prevention strategy [Subsection 373.0421(2), F.S.]. The strategy is developed in concert with the water supply planning process.

The general goal of the recovery strategy is to achieve the established MFL as soon as practicable. A prevention strategy aims to keep the existing flow or level from falling below the established minimum criteria. The recovery or prevention strategy includes the provision of sufficient water supplies for reasonable beneficial uses, and may include the development of additional water supplies, construction of new or improved storage facilities, and implementation of conservation or other efficiency measures. New or additional withdrawals may be limited until the water body is no longer experiencing significant harm.

Water Use Permitting Criteria for MFLs

As discussed in the *Water Use Permitting* section of this chapter, as a condition of permit issuance, water use permitting rules require an applicant to provide reasonable assurances that a proposed use of water is in accordance with the established MFLs and implementation rules, (See Rule 40E-2.301(1)(i), F.A.C.). Applicants for water use are reviewed based on the recovery or prevention strategy approved at the time of permit application review.

Osprey Pair – Estero Bay

Rule 40E-8.021, F.A.C., identifies two categories of impact criteria: direct withdrawals and indirect withdrawals from the MFL water body. Direct withdrawals are those from surface water facilities physically located within the boundaries of a MFL surface water body or groundwater withdrawals that cause a water table drawdown greater than 0.1 feet at any location beneath the MFL surface water body or aquifer, up through a 1-in-10 year drought. Indirect withdrawals are from a water source for a consumptive use that receives surface water or ground water from a MFL water body or is tributary to a MFL water body. The Applicant's Handbook (SFWMD 2014) describes evaluation criteria for permit renewals and new or modified permits for water bodies subject to a MFL Recovery Strategy (Section 3.9.1) or a MFL Prevention Strategy (Section 3.9.2), and whether the application requests a direct or an indirect withdrawal from a MFL water body. The detailed review criteria are contained in Section 3.9 of the Applicant's Handbook.

Water Reservations

> **PROTECTION**
>
> **Water Reservations**
> Section 373.470, F.S. and Section 601(h)(4) of the Water *Resources Development Act of 2000* requires the District to reserve or allocate water provided by CERP projects for the natural system identified for each CERP project.

A Water Reservation is a legal mechanism to set aside water for the protection of fish and wildlife or public health. When a volume of water is reserved, it is not available for allocation for water use permittees [Subsection 373.223(4), F.S.].

Water Reservations may be developed based on an evaluation of existing water availability for the natural system, as well as for water anticipated to become available for the natural system upon completion of water resource development projects.

The quantification of the water to be reserved can include a seasonal component and a location component. In quantifying water to be reserved, existing legal uses of water are protected as long as they are not contrary to the public interest. Issues associated with determining whether an existing legal use of water is or is not contrary to the public interest are determined by the District's Governing Board.

In addition, reasonable assurances are provided for existing legal users, as cited in Paragraph 373.1501(d)(5), F.S.

> Consistent with this chapter, the purposes for the restudy provided in the Water Resources Development Act of 1996, and other applicable federal law, provide reasonable assurances that the quantity of water available to existing legal users shall not be diminished by implementation of project components so as to adversely impact existing legal users, that existing levels of service for flood protection will not be diminished outside the geographic area of the project component, and that water management practices will continue to adapt to meet the needs of the restored natural environment.

SFWMD Water Reservation rule activities to date include the following:

- In February 2009, the District's first water reservation rule was adopted for the Comprehensive Everglades Restoration Plan (CERP) Picayune Strand Restoration Project in the LWC Planning Area.
- In February 2010, a water reservation rule was adopted for the North Fork of the St. Lucie River in support of the CERP Indian River Lagoon – South Project in the Upper East Coast (UEC) Planning Area.
- In July 2013, a water reservation rule was adopted for Nearshore Central Biscayne Bay.
- In May 2014, a water reservation rule was adopted for the CERP Caloosahatchee River (C-43) West Basin Storage Reservoir.

- In June 2014, the District Governing Board reinitiated rule development to reserve water for the Kissimmee River Basin and adoption is expected by December 2015.

Federally Funded Restoration Project Water

Section 373.470, F.S, and Section 601(h)(4) of the *Water Resources Development Act of 2000* require the SFWMD to reserve or allocate water made available for the natural system from each CERP project from consumptive use. The Comprehensive Everglades Restoration Plan projects may also make water available for consumptive use as identified in the plan formulation for each project.

Restricted Allocation Areas

Restricted Allocation Areas encompass large geographic areas with multiple ecosystems. Restricted Allocation Area criteria are regulatory mechanisms that protect specific water bodies for a variety of reasons, such as protecting water resources from harmful impacts due to consumptive uses of water; assuring MFL recovery strategy implementation components and availability of water for future restoration projects; protecting public health and safety; and preventing interference among and to existing legal uses. Restricted Allocation Area criteria are set forth in Section 3.2.1 of the Applicant's Handbook (SFWMD 2014).

The following geographic areas are designated Restricted Allocation Areas:

- Lake Istokpoga/Indian Prairie Canal System (1980s)
- C-23, C-24, and C-25 Canal System (1980s)
- L-1, L-2, and L-3 Canal System (1980s)
- Pumps on Floridan wells in Martin and St. Lucie counties (1980s)
- Northern Palm Beach County / Loxahatchee River Watershed Water Bodies and Lower East Coast Everglades Water Bodies (2007)
- Lake Okeechobee Service Area (including the lake) (2008)

The purpose of the individual Restricted Allocation Areas is more specifically described in the respective regional water supply plan update and Section 3.2.1 of the Applicant's Handbook (SFWMD 2014). A description of the Lake Okeechobee Service Area is provided in **Chapter 10** of this document.

NAVIGATE

Detailed information about MFLs, Water Reservations, and Restricted Allocation Area rules are available from the District's website at http://www.sfwmd.gov/watersupply.

Status updates are provided annually in the *South Florida Environmental Report – Volume II*, available from http://www.sfwmd.gov/sfer.

Related rule development and peer-review activities can be accessed from http://www.sfwmd.gov/webboards.

Details concerning MFLs can be found in Section 3.9 of the *Applicant's Handbook for Water Use Permit Applications* (Applicant's Handbook, SFWMD 2014).

Additional information about Restricted Allocation Area criteria is described in Section 3.2.1 of the Applicant's Handbook.

LAKE OKEECHOBEE REGULATION SCHEDULE

The USACE establishes Lake Okeechobee water levels with the goal of balancing the lake's multiple purposes. In 2008, the USACE implemented a new Lake Okeechobee Regulation Schedule (2008 LORS) to optimize operations within existing structural constraints and to meet the diverse requirements of the lake, its receiving waters, and its users. The 2008 LORS is intended to be a temporary schedule that focuses on public health and general welfare considerations associated with the integrity of the Herbert Hoover Dike and impacts of high water levels on lake ecology. The current 2008 LORS is designed to operate lake levels at lower elevations than previous schedules.


Lake Okeechobee Water Control Structures

The new regulation schedule has three main bands: 1) High Lake Management Band, 2) Operational Band, and 3) Water Shortage Management Band. The Operational Band is divided into High, Intermediate, Low, Base Flow, and Beneficial Use sub-bands. In the High Lake Management Band, the objective is to lower the lake rapidly with maximum discharges through the primary lake outlets (i.e., S-308 and S-77). Baseflow releases in the Low and Base Flow sub-bands (generally less than 650 cubic feet per second) are designed to keep the lake lower and reduce the need for maximum discharges that are damaging to the estuaries. When the lake is in the Beneficial Use sub-band, the USACE defers to the SFWMD's recommendations for lake operations.

The 2008 LORS interim schedule is anticipated to be in effect until either the risk of Herbert Hoover Dike failure is reduced with the required improvements or until CERP Band 1 projects are implemented, whichever comes first. Implementation of an alternative schedule will eventually be required to address prolonged low lake levels and the associated impacts on the lake's ecology and regional water supply.

2008 LORS Releases and Adaptive Protocols for Lake Okeechobee Operations

Updated in 2010, the Adaptive Protocols for Lake Okeechobee Operations (SFWMD, USACE, and FDEP 2010) describe how water managers can meet the intent of the 2008 LORS and the accompanying Water Control Plan provisions. The Adaptive Protocols provide SFWMD guidance when making recommendations to the USACE about Lake Okeechobee water releases during Low, Base Flow, and Beneficial Use sub-bands. A key feature of the Adaptive Protocols for Lake Okeechobee Operations is looking for opportunities to improve water supply, flood protection, ecosystem needs, and environmental protection. The process includes input from the public, other agencies, the District's Governing Board, and technical input from experts at the USACE, SFWMD, and Florida Department of Environmental Protection (FDEP). Technical information regarding the need for water releases from the lake is based on a set of quantitative performance measures of ecosystem health and water supply conditions. The adaptive protocols will be periodically assessed and adjusted as necessary to deal with potential future issues not accounted for and to reflect new knowledge. Details information about the Adaptive Protocols for Lake Okeechobee are available from the SFWMD website at: http://www.sfwmd.gov/portal/page/portal/xrepository/sfwmd_repository_pdf/ap_lo_final_20100916.pdf.

WATER SHORTAGE MANAGEMENT

The south Florida hydrologic system is driven by rainfall. Lack of sufficient rainfall and increased evapotranspiration can lead to water shortage events.

The consequences of a water shortage event within the District include increased potential of saltwater intrusion and contamination of coastal Public Water Supply wellfields; environmental impacts including MFL violations; and significant

> **INFO**
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> Water shortage 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.

economic loss to agriculture, nurseries, and other water-dependent businesses.

The lack of water in Lake Okeechobee also threatens the District's ability to deliver water from the Water Conservation Areas (WCAs) to the LEC Planning Area. Lower water levels in canals and surface waters could hamper the ability to fight fires in rural areas and present the potential for organic soil (muck) fires in the Everglades.

Water Shortage Plan

The District's *Water Shortage Plan*, contained in Chapter 40E-21, F.A.C., provides guidance and direction for the management of water resources during drought conditions. The purposes of the *Water Shortage Plan* and rules are to protect the water resources of the District from harm; to assure equitable distribution of available water resources among all water users during times of shortage, consistent with the goals of minimizing adverse economic, social and health related impacts; to provide advance knowledge of the means by which water apportionments and reductions will be made during times of shortage, and to promote greater security for water use permittees (Rule 40E-21.011, F.A.C.). The District's overall water shortage management program also includes a regional water shortage plan (Chapter 40E-22, F.A.C.), as well as numerous additional considerations, such as agreements with the Seminole Tribe of Florida, operation of the C&SF Project, minimum MFLs, water use permit conditions, monitoring of resource conditions by users and the District, and compliance. The provisions of Chapters 40E-21 and 40E-22, F.A.C., are geared toward considerations such as:

- Protecting water resources from serious harm
- Assuring equitable distribution of available water resources among all water users during times of shortage
- Providing knowledge of potential conditions that can trigger the various phases of water shortage restrictions

Water Shortage Restriction Phases

The water shortage restriction phases (Phase I–Phase IV) range from moderate to critical according to severity (**Table 3**), and define the type of water use restrictions and cutbacks that will be considered by the District's Governing Board in a declared water shortage. In addition, the *Water Shortage Plan* identifies specific water-saving measures to implement with each phase by user type.

The Water Shortage Plan calls for Governing Board evaluation of water conditions including existing and projected supplies and demands prior to declaring a water shortage. (Rule 40E-21.221, F.A.C.) Some District water bodies also have water shortage triggers set forth in rules; these are water levels at which phased restrictions will be declared under the SFWMD's *Water Shortage Plan*. (See e.g., Chapter 40E-22, F.A.C) The water shortage program also considers minimum flows and levels. (See e.g., Rules 40E-8.441 and 40E-21.441, F.A.C.)

Table 3. SFWMD phased water use restrictions.

Water Shortage Phase	Percent Reduction Goal in Overall Demand
Warning	When the Governing Board calls for voluntary reductions in demand before declaring a water shortage
Phase I, **Moderate**	**Less than** 15% reduction in overall demand
Phase II, **Severe**	**Less than** 30% reduction in overall demand
Phase III, **Extreme**	**Less than** 45% reduction in overall demand
Phase IV, **Critical**	**Less than** 60% reduction in overall demand

Note: Restrictions may be imposed when water levels fall below trigger lines.

Decision Process for Water Shortage Action

The District coordinates its water shortage activities with federal, state, and local governments, water utilities, water users, and other entities. Specific and timely water shortage action is determined based on some of the following conditions:

- Water levels in the Water Conservation Areas
- Lake Okeechobee water levels
- Water levels in system canals
- Aquifer water levels
- Climate forecast
- Environmental conditions, as described in Chapter 40E-21, F.A.C., Water Declaration Factors
- Time of year
- Demand by various use classes
- Computer model simulations of future conditions
- Geographic extent of basin(s) most affected by a water shortage

Different water management actions may be required, depending on the location, nature, and magnitude of drought conditions.

Declaration of Water Shortage Restrictions

As previously described, water shortage declarations are imposed by the District's Governing Board in phases; water use cutbacks are increased as drought conditions become more severe. The *Water Shortage Plan* and rules are used to manage water use when there is existing or projected insufficient groundwater or surface water available to meet user needs or when conditions require temporary reduction in use according to Sections 373.246 and 373.175, F.S., and Chapter 40E-21, F.A.C.

Upon declaration of a water shortage, water users within the boundaries of the District are prohibited to use water in a manner inconsistent with the specified restrictions. It is the responsibility of each water user to stay informed about the phase of water shortage and the applicable restrictions for that specific phase. Violations of the restrictions by users are subject to enforcement action.

Water Conditions Analysis

Water conditions are analyzed throughout water shortage periods. Refer to the following *Response Mechanisms* section of this chapter for an overview of the types of analyses conducted by the District.

Water Shortage Events since 2005–2006

Starting in 2006 and extending through part of 2009, a water shortage affected much of south Florida. As a result, water shortage restrictions were imposed in the Lake Okeechobee Service Area (LOSA), and the UEC and the LEC planning areas. As conditions worsened, the first in a series of Water Shortage orders and restrictions were enacted for residential and commercial water uses throughout the District. By April 2009, the Lower East Coast had been under landscape irrigation restrictions for 25 months, and the LWC and UEC planning areas had been under landscape irrigation restrictions for 24 months.

Subsequent water shortage orders were written to focus restrictions on activities that demonstrated measurable water savings. For example, initial SFWMD orders in 2007 contained detailed rules about most types of outdoor water use, including irrigation, pressure washing, car washing, utility line flushing, and recreation. In 2007, the District held meetings with interested water users to better understand the water restriction experiences of utilities, parks and recreation facilities, and nursery growers in an effort to reduce the number of variance requests, increase compliance with the water restrictions, and focus on efforts to reduce use.


Drought Effects in Water Conservation Area 2

During the 2006–2009 water shortage, more than 105 billion gallons of water were saved Districtwide from March 2007 through April 2009 (SFWMD 2009b). The lower demand may be attributed, in part, to both a mandatory reduction in outdoor irrigation and voluntary indoor water consumption reductions. Although agricultural water use restrictions were eventually relaxed when drought restrictions were lifted in 2009, the urban lawn irrigation restrictions became a permanent water conservation strategy with the implementation of the Year-round Landscape Irrigation Rule (described later in the *Water Conservation for Water Use Permitting* section this chapter).

In spring 2011, Water Shortage orders were again required, imposing modified Phase I and Phase II restrictions.

Response Mechanisms

Throughout the water shortage, response mechanisms were in place to mitigate most of the adverse effects of the drought:

- The SFWMD issued water shortage orders in all basins, placing specific water users under water restrictions in an effort to reduce demand and stretch existing water supplies.
- A weekly analysis of groundwater and surface water conditions expanded monitoring during the water shortage.
- Water level and chloride concentration data from SFWMD and utility monitor wells were collected, graphed, and analyzed to evaluate saltwater intrusion potential.
- Water-level data were also gathered from the 298 Special Drainage Districts with diversion and impoundment permits to allow water managers to track conditions and determine areas with the greatest water-level decline.
- Status reporting of MFLs was provided for all affected surface water bodies and the Biscayne aquifer.
- Stormwater treatment area (STA) cells were monitored to ensure water levels were sufficient to support emergent vegetation.
- Target and drought management stages were developed to indicate optimum and declining STA performance, respectively.

To address reduced water availability due to inland movement of the saltwater interface or depleted surface water sources, the SFWMD divided utilities into three categories:

1. **Coastal Utilities at Risk** Utilities with wellfields near the saltwater interface that do not have an inland wellfield, have not developed adequate alternative sources of water, and have limited ability to meet user needs through interconnects with other utilities.

2. **Coastal Utilities of Concern** Utilities having wellfields near the saltwater interface, the ability to shift pumpages to an inland wellfield, or an alternative source that is not impacted by the drought.

3. **Surface Water Utilities of Concern** Cities relying on surface water from rivers, lakes, and impoundments for water supply (and so are highly sensitive to rainfall).

In addition, communication and data reporting requirements were increased during the water shortage for water utilities most vulnerable to drought impact. Utility reporting of current utility contingency plans revealed that many utilities did not have formally written drought contingency plans.

WATER CONSERVATION IN WATER USE PERMITTING

Water conservation practices are required in water use permits in order for the proposed use to be considered reasonable-beneficial. The District's water use permitting rules in Section 2.3.2 of the Applicant's Handbook (SFWMD 2014) include specific water conservation requirements for Public Water Supply, Industrial/Commercial/Power Plant, and Landscape/ Recreation uses. The *Water Use Permitting* section of this chapter provides information about the permitting process. **Chapter 5** of this Support Document provides more information about statewide and Districtwide conservation programs and objectives.

NAVIGATE

Chapter 5 provides an overview of the District's entire Comprehensive Water Conservation Program, including the Regulatory Initiative Programs and Implementation element.

Public Water Supply Utilities

All Public Water Supply utilities applying for a water use permit are required to develop and implement a standard water conservation plan [Section 2.3.2.F.1.a of the Applicant's Handbook (SFWMD 2014)] or a goal-based water conservation plan [Section 2.3.2.F.1.b of the Applicant's Handbook (SFWMD 2014)]. To be accepted, proposed water conservation plans must maintain or increase overall utility-specific water conservation effectiveness.

For standard water conservation plans, the applicant is required to implement the following five elements as necessary to achieve efficient use to the extent economically, environmentally, and technically feasible:

1. Implementation of a water conservation public education program
2. An outdoor water use conservation program
3. Selection of a rate structure designed to promote efficient use
4. Implementation of a water loss reduction program, if required
5. An indoor water conservation program

NAVIGATE

Water conservation measures that make additional water available from existing sources are discussed in **Chapter 5** of this document.

The District reviews the conservation plan submitted by the applicant as part of the public water supply permit application. The plan will be subject to the schedule and reporting requirements specified in the permit. If implementation of the plan fails to demonstrate progress toward increasing water use efficiency, the permittee shall request a permit modification, if necessary, to revise the plan to address the deficiency [Section 2.3.2.F of the Applicant's Handbook (SFWMD 2014)].

A goal-based water conservation plan can be used in lieu of the standard water conservation plan. This type of plan allows the permittee to select plan elements that are different from those in the standard plan, but which are appropriate to their service area. If any standard plan elements are not included, the permittee must provide reasonable assurances that the alternative elements will achieve effective conservation at least as well as the standard plan.

Implementation of a Water Conservation Public Education Program

Utilities selecting a standard water conservation plan are required to implement a water conservation public education program to inform consumers about water conservation benefits, such as lower water bills. Some examples of program elements include:

- Public service announcements
- Speakers, posters, literature, videos, or other information provided to schools and community organizations
- Public exhibits
- Articles or reports provided to local news media
- A water audit customer assistance program to address indoor and outdoor water use
- Information provided to customers regarding year-round landscape irrigation conservation measures
- Construction, maintenance, and publication of water efficient landscape demonstration projects

See **Chapter 5** of this Support Document for more information about water conservation educational and outreach programs.

Implementation of an Outdoor Water Conservation Program

Outdoor irrigation can account for as much as 50 percent of residential water use. Watering wisely outside the home reduces water use and promotes healthier lawns and landscapes. Public Water Supply utilities can adopt conditions of service or work with local governments to develop ordinances to help reduce outdoor water use. An outdoor water conservation program has a number of elements to consider, including:

- Year-round Landscape Irrigation Rule
- Florida-friendly landscapes
- Rain sensor device or smart or advanced irrigation system
- Landscape irrigation audit program
- Outdoor irrigation education element

Year-Round Landscape Irrigation Rule for Water Conservation

The variable rainfall the District experiences each year is a driving force behind the Governing Board's adoption of the Year-round Landscape Irrigation Conservation Measures (Year-round Irrigation Rule), Chapter 40E-24, F.A.C., that place permanent limits on landscape irrigation throughout the SFWMD's 16-county region. Highlights of the rule include:

- Up to two-day-per-week watering in Charlotte, Highlands, Okeechobee, Orange, Osceola, and Polk counties.
- Option for up to three-day-per-week watering in Broward, Collier, Glades, Hendry, Lee, Martin, Miami-Dade, Monroe, Palm Beach, and St. Lucie counties.
- No irrigation allowed on any day between 10 a.m. and 4 p.m.
- Irrigation using reclaimed water, rain harvesting systems, and various low volume methods, such as microirrigation, container watering, and hand watering with a hose and automatic shut-off nozzle, can be conducted at any time.
- Additional watering is allowed following the installation of new lawns and landscaping for up to 90 days, with specific limits.

More information about the Year-round Irrigation Rule is available from http://www.sfwmd.gov/conserve.

Florida-Friendly Landscapes

Florida-friendly landscaping requirements are found in Section 373.185, F.S. A Florida-friendly landscape conserves water, protects the environment, is adaptable to local conditions, and is drought-tolerant. Actions required by Section 373.185, F.S. include:

- Water management districts to provide model Florida-friendly landscape ordinances to local governments
- Use of Florida-friendly landscaping for public properties, highway construction, and maintenance projects
- Local governments to consider adopting Florida-friendly landscape ordinances that would be beneficial as a water conservation measure

The use of Florida-friendly landscaping principles, Florida Water Star (described in **Chapter 5**), or other generally accepted water conservation programs, guidelines, or criteria that address landscape water conservation can greatly reduce water use.

Rain Sensor Device Ordinance

An operational rain sensor device, automatic switch, or smart irrigation system will reduce unneeded landscape irrigation. The FDEP created a model ordinance to ensure the proper installation, maintenance, and operation of systems that use automatic shut-off devices (http://www.dep.state.fl.us/water/waterpolicy/docs/sb494-model-irrigordinance.pdf). Smart or advanced irrigation systems that use soil moisture sensors can save substantially more water than conventional time-controlled irrigation systems. When smart irrigation systems that meet statutory requirements are used, individuals and entities are eligible for a variance from year-round, days-of-week water restrictions. **Chapter 5** of this Support Document contains more information about smart irrigation systems.

Smart Irrigation Sensor

Landscape Irrigation Audit Program

The Public Water Supply utility should consider developing or funding a landscape irrigation audit program for businesses and residences that includes information to assist customers in implementing the recommendations of the audit. A description of the program, including implementation details and contents of the audits, should be provided as part of the water conservation plan.

Outdoor Irrigation Education Element

The Public Water Supply utility should consider including specific educational information aimed at increasing the efficiency of outdoor irrigation use in their conservation plan.

Adoption of a Water Conservation-based Rate Structure

As part of a standard water conservation plan, Section 2.3.2.F of the Applicant's Handbook (SFWMD 2014) requires Public Water Supply utilities to consider the selection of a rate structure to provide additional economic incentives to promote the efficient use of water. The rate structure may include, but is not limited to, increasing block rates, seasonal rates, quantity-based surcharges, and/or time of day pricing as a means of reducing demands. **Chapter 5** of this Support Document contains more information about water conservation based rate structures.

Implementation of a Water Loss Reduction Program

Utilities may not have more than 10 percent unaccounted-for water losses. Utilities exceeding that threshold in unaccounted-for losses are required to implement a leak detection program [Section 2.3.2.F.2.c of the Applicant's Handbook (SFWMD 2014)]. The leak detection program must include water auditing procedures, in-field leak detection efforts, and leak repairs. The water loss reduction program description should include the number of labor hours for leak detection, the type of leak detection equipment being used, and an account of the water saved through leak detection and repair [Section 4.1.2 of the Applicant's Handbook (SFWMD 2014)].

Implementation of an Indoor Water Conservation Program

Education and simple plumbing retrofits have been proven to reduce indoor water use. The program should consider plumbing retrofit rebates, faucet aerator and showerhead giveaways, and an educational element focusing on indoor conservation. Implementing these elements may be achieved through collaborating with other entities, including the District.

Industrial / Commercial / Power Plants Water Users

All individual industrial, commercial, and power plant water use permit applicants within the jurisdiction of the SFWMD are required to submit a water conservation plan at the time of permit application. Water conservation plans for individual permit applicants must include:

- An audit of water use
- Implementation of cost-effective water conservation measures if found to be cost-effective during an audit, such as a leak detection/repair program, recovery/recycling, and processes to reduce water consumption
- An employee awareness and consumer education program concerning water conservation
- Procedures and time frames for implementation of tasks

A well-planned and scheduled audit program is a prerequisite for improving and sustaining water use efficiency in an industrial or commercial facility. A water use audit or assessment is a systematic review of all water consumption from point of entry to discharge. A comprehensive assessment includes an examination of historic water use, the calculation of a facility's true cost of water, the measurement and/or calculation of all on-site water consumption, the detection of leaks, and the identification of on-site water sources and potential opportunities for reducing unnecessary water use.

Recreational / Landscape Water Users

New projects or modifications to existing landscaping require landscape and golf course water permit applicants to develop a water conservation plan that incorporates rain sensor devices and Florida-friendly landscaping principles. Applicants are also required to install rain sensor devices, automatic switches, or other automated mechanisms that have the ability to override operation of the irrigation system when adequate rainfall has occurred.

Agricultural Water Users

Standard irrigation system types include microirrigation, overhead sprinkler, and flood/seepage irrigation. For certain crops, such as citrus and container nursery, water use permit holders are required to use microirrigation or other systems of equivalent efficiency. Most citrus groves use the more efficient microjet or drip irrigation. This rule applies to new installations or modification of existing irrigation systems. Flood/ seepage type systems are typically used for tomato, corn, rice, and sugarcane production.

Agricultural Irrigation Systems

Low-volume Irrigation

The most important benefit of low-volume irrigation is its potential to reduce or eliminate water waste. With low-volume irrigation, the water application can be matched to the specific needs of each plant. In addition, water application rates can be matched to the soil's infiltration rate more closely, and water can be applied directly to the plant root zones to virtually eliminate evaporation. As water is directed exactly where needed, very little water is wasted on the areas between widely spaced plants. Low-volume irrigation systems can be either drip irrigation or microirrigation. Drip systems typically use polyethylene pipe to deliver water to a small drip emitter. Emitters come in a variety of sizes, shapes, and specifications. Most are rated in gallons/hour, making it relatively easy to determine how much water is being applied at each irrigation event. Drip emitters can be spaced evenly along the delivery pipe or clustered at specific locations. Drip emitters with pressure compensation and backflow prevention provide optimum control over the volume of irrigation water supplied.

Flood/Seepage Irrigation

Flood/seepage irrigation is a method of artificially raising the water table to allow the soil to be moistened from below the root zone of plants. Flood irrigation is commonly used in the region to irrigate vegetables, sugarcane, and citrus crops. Farms that use seepage irrigation techniques often maintain it through pumping stations, canals, gates, and weirs to lower or raise the water level. Typical irrigation efficiency for these systems is about 50 percent, meaning that half of the water delivered is actually used by the plants. Classified by method of water application, two types of seepage irrigation systems are used in the region – surface ditch systems and subsurface ditch systems. Surface ditch systems use field ditches, which are called water furrows or lateral ditches.

Design of seepage systems requires calculating lateral spacing needed to maintain the required water table heights. Closer spacing produces greater uniformities, while wider spacing is less expensive.

Pelican among Mangroves

5

Water Source Options and Water Conservation

This chapter presents water source options and water conservation measures suitable for all the planning areas within the SFWMD. Water source options address supply management, whereas water conservation relates to demand management. The District seeks to make the best possible use of regional water resources by implementing a combination of water source options and water conservation policies and programs.

> **TOPICS**
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> - Water Source Options – Supply Management
> - Water Conservation – Demand Management

WATER SOURCE OPTIONS – SUPPLY MANAGEMENT

This section discusses a number of water supply sources, along with some related costs, including:

> **LAW / CODE**
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> "Alternative water supplies" means 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, municipal, industrial, commercial, or agricultural uses; the downstream augmentation of water bodies with reclaimed water, storm water, 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.).

1. **Groundwater Sources** Water beneath the surface of the ground, primarily withdrawn from three south Florida aquifer systems: the surficial aquifer system (SAS), intermediate aquifer system (IAS), and Floridan aquifer system (FAS).
2. **Surface Water** Lakes, rivers, and canals are surface water bodies used to supplement water supply.
3. **Seawater** Sources of desalinated water in south Florida are the Atlantic Ocean and Gulf of Mexico.

4. **Reclaimed Water** Water reused after receiving at least secondary treatment and basic disinfection, flowing out of a domestic wastewater treatment facility.
5. **Storage Solutions** Three major types of potential storage options in the SFWMD are Aquifer Storage and Recovery (ASR), regional and local retention, and reservoirs.
6. **Utility Interconnects** Public Water Supply interconnection of treated or raw water distribution systems as a means to address local or temporary service shortfalls.

Water Source Option Cost Information

Cost information pertaining to water withdrawal, storage, and utility interconnection is introduced in this chapter. Each of these components is part of a larger multifaceted water delivery and treatment framework. The quality of the water dictates the treatment technologies and processes necessary to meet water quality standards.

Water treatment technologies, components, and processes related to the second and third phases of the water delivery and treatment process are presented in **Chapter 6** of this document.

Although the criteria for meeting drinking water standards do not vary, other variables, such as water source availability, water quality, and water source location, affect cost considerations. Therefore, the scope of this Support Document does not include a comprehensive discussion of process technologies and components. Readers must be careful to use the information as a starting point for gaining an understanding of some of the fundamental considerations and costs of incorporating new water supplies and treatment capabilities within specific localities. This chapter and **Chapter 6** support comprehension of this material, and references to specific sections for related discussions are provided throughout both chapters. Examples of utility project costs may be available in each planning area's water supply plan update. Finally, unless otherwise noted, the cost information presented in this chapter and **Chapter 6** cites the Camp, Dresser & McKee, Inc. report, *Water Supply Cost Estimation Study* (Cost Study) (CDM 2007a).

Cost Study

The Cost Study and addendum (CDM 2007a, 2007b) provide engineering cost data and cost estimation relationships and curves to evaluate various water treatment technologies for the District's four water supply planning areas. Options included are groundwater; surface water; seawater; reclaimed water; and storage, such as ASR and reservoirs. Costs are planning-level estimates.


Water Treatment Plant in Collier County

The Cost Study includes case studies for some technologies constructed close to the time of the study, such as surface water and seawater treatment facilities. The case studies address actual facility sizes and their costs.

Where treatment technologies are addressed, the costs associated with facilities of 5 million gallons per day (MGD), 10 MGD, 15 MGD, and 20 MGD have been evaluated. For some treatment processes and technologies, the costs for 1 MGD and 3 MGD of the treatment capacity are also provided.

However, it should be noted that due to economies of scale, the capital cost per gallon per day of treatment capacity increases sharply as the facility capacity decreases from 5 MGD to 1 MGD, and the capital and operations and maintenance (O&M) costs become much larger components of the total project cost. For example, the cost of concentrate disposal for a 1 MGD lower pressure reverse osmosis (LPRO) treatment facility is essentially the same as for concentrate disposal for a 20 MGD LPRO facility. This is largely due to the fixed capital cost of a deep injection well for concentrate disposal in this capacity range. The labor component of the total O&M cost becomes much more significant for a smaller capacity facility due to typical process automation.

The Cost Study provides opinions of probable cost considered to be order-of-magnitude estimates as defined by the American Association of Cost Engineers. These costs are regarded as accurate within +50 percent or -30 percent, and presented as August 2006 dollars. After the release of the Cost Study, construction costs of water infrastructure rose significantly; then a reversal in pricing trends occurred. It was determined that the August 2006 dollar estimates were still valid for use in this planning update cycle to portray market conditions at the time this Support Document was written.

In addition, the Cost Study cites energy costs of $0.10/kilowatt hour (KWh) based on review of planning-level power costs for water utilities in both Palm Beach and Collier counties. For planning purposes, when considering plants that operate facilities, wells, and other pumps, the rate of $0.10/KWh appeared reasonable.

The costs of various water source options across the District were presented in terms of capital, O&M, and total production costs on a unit-cost basis, expressed in dollars per 1,000 gallons. The following cost definitions apply to the terms used in the study:

- **Construction Costs** The total estimated amount expected to be paid to a qualified contractor to build the required facilities, including costs for all materials, equipment, and installation.
- **Nonconstruction Capital Costs** Services such as engineering, design, permitting, and administration; and construction project contingencies associated with the constructed facilities.
- **Land and Acquisition Costs** Unless otherwise noted, the land and land acquisition costs are not included in the calculation of the total capital cost.
- **Total Capital Costs** The total capital costs for each of the water supply and wastewater system components are the sum of the construction and nonconstruction costs.

- **Operations and Maintenance Costs (O&M)** The costs of operating and maintaining the water supply system components each year, including costs for energy, chemicals, component replacement, and labor.
- **Equivalent Annual Capital Costs** To compare the costs for various technologies, capital investments are converted to equivalent annual capital costs. The parameters used in this amortization of initial capital investment are a term of 20 years and a discount rate of 7 percent. The 20-year term approximates the overall cost-weighted useful life of the capital investment in facilities and equipment.
- **Total Annual Production Costs** This cost category includes O&M costs and an annual renewal and replacement fund deposit that is not included as part of the O&M costs. The annual renewal and replacement fund deposit is equal to 10 percent of the equivalent annual capital cost, and is for replacement of major equipment during the course of the 20-year service life of the facilities.
- **Annual Production (Unit) Cost** A ratio of total annual production costs and a facility's annual finished water production rate expressed in dollars per 1,000 gallons.

Groundwater

Significant amounts of fresh water and brackish water demands within the SFWMD are met by groundwater sources, particularly 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. In each of the District's planning regions, groundwater is withdrawn from three primary water producing aquifer systems: SAS, IAS, and FAS. While the FAS exists throughout the SFWMD, all of these aquifers typically vary in their extent, usability, and quality from region to region. In addition, within an individual aquifer, hydraulic properties and water quality may vary both vertically and horizontally. The District's permitted rules, including Minimum Flows and Levels and Water Reservations (see **Chapter 4** of this document) must be considered when determining groundwater availability.

Surficial Aquifer System

The SAS is typically found at depths from land surface to 200 feet below land surface (bls). This includes the Upper East Coast (UEC) and Kissimmee Basin (KB) planning areas, the Biscayne aquifer in the Lower East Coast (LEC) Planning Area, and the Water table and Lower Tamiami aquifers in the Lower West Coast (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. Here, the IAS includes two producing zones, the Sandstone and Mid-Hawthorn aquifers. Depending on location, these aquifers can be found from 50 feet bls to almost 400 feet bls.

Floridan Aquifer System

The FAS is the deepest of the aquifers used for water supply in the SFWMD. Within the FAS, multiple permeable intervals, or producing zones, are layered between low-permeability confining materials. In some portions of the District, the FAS is artesian (flows at land surface without a pump because the water is at a higher pressure than atmospheric). The water-producing formations of the FAS in the Orlando area can be found between 80 feet bls and 1,500 feet bls. The water-producing formations of the FAS currently used for water supply south of central Okeechobee County can be found from 600 feet bls to over 1,800 feet bls, depending on the location.

DISTRICT

Brackish groundwater is typically defined as water with a total dissolved salt concentration between 1,000 milligrams per liter (mg/L) and 10,000 mg/L. The terms fresh, brackish, saline, and brine are used to describe the quality of water. Although brackish supplies in the low range of these salinities may be used for some agricultural purposes, they do not meet public drinking water standards. Advanced treatment technologies, such as reverse osmosis (RO), electrodialysis, or electrodialysis reversal, must be employed before this type of supply is suitable for human consumption.

The water quality in the FAS decreases significantly from central Florida to south Florida, increasing in hardness and salinity. Salinity also increases with depth, making the deeper producing zones less desirable for development than shallower parts of the system.

In the Upper KB Planning Area, the FAS is the primary source of fresh water for all uses. However, water from the FAS requires desalination treatment in the Lower KB Planning Area, south of central Okeechobee County, as well as in the Upper East Coast, Lower East Coast, and Lower West Coast planning areas.

Usage and Production Capacity

As of April 2012, there are 35 Reverse Osmosis (RO) facilities located in the SFWMD with an operating capacity of approximately 245 MGD. In addition, there are seven new facilities under construction that will produce 34.5 MGD and an existing plant that will add another 2 MGD, providing a total of 36.5 MGD of additional capacity. Of the 35 facilities, 33 acquire and treat brackish water from the FAS. Two are desalination facilities (Marathon and Stock Island) are located in the Florida Keys and use seawater rather than brackish water as their source.

In addition, a number of golf courses in south Florida use RO to treat FAS water to meet irrigation needs. In the UEC Planning Area, many citrus growers also use the FAS as a backup water supply when fresh surface water availability becomes limited.

Groundwater Estimated Costs

Floridan groundwater costs depend on the salinity of source water. Groundwater supply systems are composed of wellfields and their related features, such as pipelines and pumps. Groundwater well production is limited by the rate of water movement in the aquifers, rate of recharge, aquifer storage capacity, environmental impacts, and proximity to sources of contamination and saltwater intrusion. A combination of these factors determines the number, size, and distribution of wells that can be developed at a specific site.

The cost of a well is a function of diameter and depth. Well drilling construction costs include drilling, casing to SFWMD standards, minimal logging, aquifer testing, and the final wellhead. Equipment costs include pumps, valves, fittings, metering, a well house structure, electrical controls, installation, and taxes. The O&M costs consist of normal maintenance of the well, including equipment, energy, and labor. Cost estimates to construct a groundwater well represent only one component in the water withdrawal process. Additional process technologies and components, with some related costs for treating and delivering brackish groundwater, are included in **Chapter 6** of this document.

Surface Water

Surface water is also a water source option. Lakes, rivers, canals, and the Water Conservation Areas are surface water bodies that may be used to supplement water supply. Several potential sources of surface water have been identified in each of the SFWMD's planning areas to meet future water demands. Most of these potential sources convey water from inland areas and discharge via the Kissimmee River or other tributaries to Lake Okeechobee.

In Florida, water supply from surface water sources is usually available during the wet season and limited during the dry season. Surface water bodies can also provide aquifer recharge for groundwater. The District permitting rules, including Minimum Flows and Levels and Water Reservations (see **Chapter 4** of this document) must be considered when determining surface water availability.

Usage and Production Capacity

Surface water use and production vary from planning area to planning area within the SFWMD. The Agricultural Self-Supply category is the primary water user of surface water, including runoff. On-farm detention ponds, connections to conveyance canals, and other collection methods allow field runoff to be recovered and reused. Best management practices can augment the quality and use rates of this water, and should be executed with water recovery programs. Cost-share and other programs encouraging such surface water use are discussed in Chapters 4 and 6 of each regional water supply plan update.

Estimated Costs

In most planning areas, agricultural operations are the largest user of surface water, through canal withdrawals or on-farm storage ponds (see the *Storage* section of this chapter). **Table 4** provides estimates of costs to install water-pumping facilities designed to divert surface water.

Table 4. Pump installation and operating costs.[a]

Pump Type	Engineering/ Design Cost	Construction Costs	O&M Cost
Electric	$50,000	$3–4 million[b]	$60/hr
Diesel	$50,000	$1.5–3 million	$40/hr

Source: Water Supply Cost Estimate Study (CDM 2007a).

Notes:

a. For estimating purposes, a pump rated at 60,000 gallons per minute (GPM) is assumed.

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

NAVIGATE

The cost estimates provided for installing and operating a pump to process surface water represent only one water source withdrawal component. Additional process technologies and components, with some related costs for treating and delivering water, are also included in these sections:

See also the following section in this chapter:

- Reservoirs Estimated Costs

See also the following sections in **Chapter 6** of this document:

- Microfiltration and Ultrafiltration Water Treatment Technology
- Brackish Surface Water Reverse Osmosis Water Treatment Technology

Seawater

In south Florida, desalinated seawater is a potential alternative water supply. Use of seawater as a water source option involves drawing water from the Atlantic Ocean or Gulf of Mexico as raw water source and treatment through a desalination process. Seawater contains about 3.5 percent or 35,000 parts per million of dissolved salts, most of which is sodium chloride, with lesser amounts of sulfates, magnesium, potassium, and calcium. Therefore, removal of salts is required before potable or irrigation uses are feasible. To accomplish salt removal, a desalination treatment technology, such as distillation, reverse osmosis (RO), or electrodialysis reversal, is required.

Usage and Production Capacity

Reverse Osmosis Membrane

In December 2006, the SFWMD completed a feasibility study for co-locating seawater treatment facilities with once-through cooling power plants in south Florida (Metcalf & Eddy 2006). The study's three highest ranked sites are co-located with Florida Power & Light (FPL) facilities in Fort Myers, Fort Lauderdale, and Port Everglades. Some discussions about building a co-located seawater desalination facility have occurred between these entities.

In the LEC Planning Area, the Florida Keys Aqueduct Authority (FKAA) operates two seawater desalination facilities, located on Stock Island and Marathon, which produce fresh water from seawater, and are a backup source of 3 MGD of potable water for the Lower and Middle Keys.

Estimated Costs

The cost of seawater desalination is higher than the cost of brackish groundwater desalination due to seawater's higher salt content, which requires specialized intake facilities and concentrate disposal. However, technological advancements and incremental improvements in productivity and efficiency of RO membranes, pumps, energy recovery devices, and overall system configuration have reduced the cost of production of desalinated seawater. **Table 5** shows a brackish surface or seawater desalination facility co-located with a power plant listing cost-saving features, including savings from economy of scale. The higher salt content factor reduces the efficiency of the treatment facility (fewer gallons of potable water are produced from water pumped) and results in an increased amount of concentrate/reject water disposal compared to brackish groundwater desalination.

When considering costs for using seawater, the proximity to a major potable water transmission system or network must be considered. In most areas of the SFWMD, coastal areas are highly urbanized.

Benefits of Co-location

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 potential 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 facility 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 coolant 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 finished water product.

Table 5 provides planning-level costs from the Technical and Economic Feasibility of Co-Located Desalination Facilities Study (Metcalf & Eddy 2006) for 10 MGD and 20 MGD facility capacities. The table shows the economy of scale with lower cost per 1,000 gallons for the larger capacity.

Table 5. Estimated project costs for developing a co-located brackish surface water or seawater treatment facility.

Candidate Site	Facility Capacity (MGD)	Water Quality (TDS) (ppm)	Total Construction Costs (millions)	Capital $ Per Gallon of Capacity	Total Annual O&M Costs (millions)	Equiv. Annual Costs ($/1000 gallons)
Fort Lauderdale	20	15,000	$148.0	$7.40	$10.40	$3.88
Fort Myers	10	15,000	$91.1	$9.11	$6.40	$4.66

Source: Technical and Economic Feasibility of Co-Located Desalination Facilities (Metcalf & Eddy 2006).
Notes: TDS=total dissolved solids, ppm=parts per million.

Capital costs for building and maintaining a seawater treatment facility were developed by sizing individual components for each candidate site. Unit prices were estimated from equipment manufacturer pricing and recent historical data from other projects. When appropriate, equipment, electrical, and instrumentation costs were added. After the construction costs were estimated and totaled, the following cost assumptions were made:

- A 25 percent contingency cost adjustment was added for items that were unanticipated expenses and uncertainties.
- The final construction cost estimate based on 2006 dollars also includes a 17 percent cost adjustment for the contractor's overhead expenses, mobilization, demobilization, bonding, and insurance.
- The final project estimate includes a 10 percent cost adjustment for engineering.

St. Lucie West Water Treatment Facility

- The capital costs are based on a finished water production quantity that is unique to each of the candidate sites.

The costs presented in this section should be considered budget-level costs with an accuracy of +30 percent to -15 percent, and reflect capital amortized at 7 percent for 20 years.

Advances in membrane technologies have substantially reduced the cost of RO treatment, generating interest in the implementation of RO in Florida, Texas, and California. Costs can vary significantly between states due to regulatory requirements, as well as to site-specific conditions. The regulatory landscape differs vastly in the communities and states served by desalination facilities. These differences can have a profound impact on project delivery timelines, legal costs, and in some cases alter the design of the seawater RO facility (WateReuse 2012). In addition, as with any infrastructure projects, it is also important to recognize that the various components supporting the overall desalination treatment facility can vary significantly and are based on site location.

For example, the 25 MGD Tampa Bay co-located seawater facility became fully operational in 2007 and is operating at a cost of $3.38 per 1,000 gallons (Tampa Bay Water 2008). In Carlsbad, California a 50 MGD co-located seawater desalination facility is under construction and expected to be operation in 2016. Water from the plant is expected to cost between $1,849 and $2,064 per acre-foot ($5.67–$6.33 per 1,000 gallons), depending on how much is purchased (San Diego County Water Authority 2012).

Reclaimed Water

City of West Palm Beach Wetland-based Water Reclamation

Reclaimed water is wastewater that has received at least secondary treatment and is reused after flowing out of a wastewater treatment facility (Chapter 62-610, F.A.C.). Reuse is the deliberate application of reclaimed water for a beneficial purpose, in compliance with the Florida Department of Environmental Protection (FDEP) and water management districts' rules. Potential uses of reclaimed water include landscape (e.g., medians, parks, residential lots, and golf courses) and agricultural irrigation; groundwater recharge through rapid infiltration basins and percolation ponds; industrial uses; environmental enhancement; and fire protection. High-quality reclaimed water may also be used for groundwater recharge using injection wells, although this practice is not currently in use in the SFWMD.

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 the use of reclaimed water as an integral part of water management programs, rules, and plans.

Reclaimed Water Conservation

As customer demand for reclaimed water increases, supply shortages present an issue for utilities. Many water utilities have sought approval for supplemental reclaimed water supplies from the FDEP and Florida's water management districts to meet customer demands, as well as additional water supply during dry seasons and droughts.

Reclaimed-water conservation methods are under investigation Districtwide. In areas of the SFWMD where fresh water is limited and reclaimed water supplies are committed, reclaimed water conservation is recognized as a valuable tool for extending reclaimed water supplies. A leading solution is to replace existing flat-fee reclaimed water rates with a water-conserving, volume-based rate structure, similar to what many Public Water Supply utilities have in place for potable water.


Reclaimed Water Pipes

In addition to usage-based rate structures, there are several means of promoting water conservation in reclaimed water systems. Most options follow methods employed by potable water systems. A report by the Reuse Coordinating Committee (2003) provides a list of options for improving efficient use of water in reclaimed systems. Supported methods include, but are not limited to, development of storage and supplemental sources, educational programs, water audits of irrigation systems, ordinances on irrigation system efficiencies, and encouragement of aquifer recharge.

Water Reuse and Production Capacity

The *2010 Reuse Inventory* (FDEP 2011) indicates 113 wastewater facilities located with the SFWMD reused about 236 MGD of reclaimed water for a beneficial purpose. Disposal of the remaining 611 MGD of treated wastewater was by deep well injection and discharge to the ocean.

In 2006, Palm Beach County adopted a mandatory reuse ordinance requiring all new development within one mile of its Southern Water Reclamation Facility to use reclaimed water for irrigation. 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.

More information about existing wastewater treatment facilities, including water reuse data, is provided in Appendix D of each regional water supply plan update.

Reclaimed Water Estimated Costs

The costs associated with implementation of a reuse program vary depending on the size of the reclamation 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 also include the following:

- Secondary treatment with high level disinfection
- Reclaimed water transmission system
- Storage facilities
- Backup disposal

NAVIGATE

See also the *Wastewater Treatment Technologies* section of **Chapter 6** of this document.

When reclaimed water is provided to existing facilities, the end users may need to modify their irrigation systems to receive the reclaimed water.

Cost savings include reducing the use of alternative water disposal systems; negating or reducing the need for an alternate water supply development; and reducing fertilization costs for the end user using the system for irrigation.

Storage

Storage is required to keep water in the SFWMD water supply system instead of discharging it to tide. The three major types of potential storage options are ASR, regional and local retention, and reservoirs.

Aquifer Storage and Recovery

Aquifer Storage and Recovery is the underground storage of water. Water is stored with the intent to recover the water for use during times of need. Uses for the recovered water range from environmental to urban. The storage zone, typically within the brackish waters of the FAS in south Florida, acts as an underground reservoir for the injected water. While ASR recovery is typically less than 100 percent, losses are usually less than evapotranspiration of surface water. The stored water can be potable drinking water, fresh groundwater, storm water, surface water, or reclaimed water treated to the prescribed standards and recharged underground through wells. Current federal regulations require recharged

Hillsboro Canal ASR Pilot Project

water meet primary drinking water standards when the receiving aquifer is classified as an underground source of drinking water [U.S. Environmental Protection Agency; Title 40, Code of Federal Regulations, Section 144.3] unless an aquifer exemption is obtained. An underground source of drinking water is defined as an aquifer with a total dissolved solids (TDS) concentration of less than 10,000 mg/L.

Treatment costs for meeting the federal regulations are the main driver for the costs of ASR systems, particularly regarding disinfection technology. Disinfection is required to inactivate biologic pathogens that might enter the aquifer through an ASR well. Arsenic also remains a potential challenge for existing and future ASR systems because the injection of waters into an aquifer can release naturally occurring arsenic contained within the surrounding rock.

Although there are technologies to treat recovered water before it is used for Public Water Supply, technologies are being researched to prevent arsenic from being leached within the aquifer (SFWMD and USACE 2008) and to investigate microorganism survival and contamination (John, Rose, and Kamarainen 2004).

Usage and Production Capacity

The volume of water potentially available through ASR wells depends on many variables, such as well location, well yield, water availability, water quality, aquifer characteristics, and changes in demand. For this reason, it is difficult to provide a storage volume estimate for a specific ASR well project without examining these local factors. However, based on the ASR wells that have been tested and operated, a typical storage volume for an individual well ranges from 10 million gallons to 500 million gallons, or 31 acre-feet to 1,535 acre-feet (Pyne 2005). Potentially, where appropriate, multiple ASR wells could be operated as a wellfield, with the capacity determined from the recharge or recovery periods.

The storage time is usually seasonal for ASR systems associated with Public Water Supply, but can also be diurnal, long-term (multi-annual), or for emergencies. The potential volume of water made available to any specific user must be determined through the District's water use permitting program.

Within the SFWMD, there are several ASR wells owned by utilities with operations permits for using treated drinking water or partially treated surface water. As of May 2010, there were numerous 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), primarily around Lake Okeechobee. A summary of progress is presented in the SFWMD and USACE (2008). Some examples of ASR are:

- **Treated Water ASR** Uses potable water as the injection water. Because potable water meets drinking water standards, this type of ASR application is easier to permit. Utilities in Collier County, Lee County, and the City of Boynton Beach are using treated-water ASR.

- **Raw Water or Partially Treated ASR** Uses groundwater from freshwater aquifers or surface water. Some treatment may be needed before injecting the water into the aquifer to meet regulatory standards. Raw water or partially treated ASR is usually included in combination with surface water storage, such as a reservoir or canal system. The reservoir or canal system captures excess surface water quickly and in large volumes, and then provides the captured water to the ASR wells for a slower injection into the subsurface. In lieu of withdrawing water directly from a surface water body, potential projects may involve installation of vertical 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. The CERP ASR pilot projects employ this type of ASR.
- **Reclaimed Water ASR** Several communities in Florida are investigating the feasibility of a reclaimed water ASR system. Two utilities in the Southwest Florida Water Management District (SWFWMD) are conducting 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.

Estimated Costs

Estimated costs for an ASR system depend on many factors, including hydrogeologic conditions, well depth, flow rates, water treatment process, required number of monitor wells, and other required features. **Table 6** provides estimated costs for a 2 MGD potable water ASR system and a 5 MGD surface water ASR system. For a 2 MGD drinking water ASR system, the total capital cost is estimated at $2 million, with annual O&M costs of $200,000. For a 5 MGD surface water ASR system, the total capital cost is estimated at $5 million, with annual O&M costs of $500,000.

Table 6. Aquifer Storage and Recovery cost estimates.

System Capacity (MGD)	Costs by Category					
	Capital	Non-Construction	Land Acquisition	Annual O&M	Equivalent Annual	$ per 1,000 gal
2	$2,000,000	$160,000	$0	$200,000	$134,885	$0.54
5	$5,000,000	$830,000	$0	$500,000	$644,718	$1.02

Source: Water Supply Cost Estimate Study (CDM 2007a).

The potable water cost information assumes that the hypothetical ASR well will be located at the water treatment facility site and have a 70 percent recovery rate. Because the example ASR well will be recharging highly treated potable water into the aquifer, the costs associated with monitoring are generally lower. The surface water ASR cost information assumes the ASR facilities will be located at a remote site with microfiltration treatment of the injected water and a 70 percent recovery rate. The monitoring program for the surface water ASR system scenario would be more extensive, and therefore, costs are higher.

Related costs do not include expenses to provide a source of raw water, water treatment costs before injection, and costs for transmission between the water facility and the ASR wellfield.

Regional and Local Retention

Regional and local retention provide a way to increase water storage through the manipulation and modification of a watershed's drainage system, while maintaining an appropriate level of flood protection. Much of the land within the SFWMD was drained to support urban and agricultural development, resulting in lower groundwater tables that consequently affected natural systems and water availability in these areas. Conversely, in some areas of the SFWMD, increased water retention in canal systems has increased groundwater levels.

The regional and local retention water supply option includes structural and operational changes that allow the capture of additional runoff water to be held in secondary canal systems. One benefit of this option in coastal areas is to stabilize the salt front by holding higher surface water and groundwater levels, thereby minimizing saltwater intrusion. Higher groundwater levels should also help to recharge wellfields and decrease the impact of water shortages. Modifying secondary canal operations would be expected to improve local water use and recharge, and help to reduce the need to bring water in from regional sources. However, consideration of higher water levels must also address the potential impacts on flood protection. All modification of operations needs to be consistent with associated MFL strategies.

Usage and Production Capacity

In the SFWMD, regional and local retention projects benefit water supply by raising water levels through either system modifications or operational changes. Many water management structures have dry and wet season operational schedules that maximize retention without comprising flood protection. Many water control entities periodically review their systems to identify potential improvements to increase retention, such as the city of Cape Coral and the Big Cypress Basin.

The City of Cape Coral is using regional retention to increase water availability in the city's canal system to supplement its reuse irrigation system. Updates and modifications to the city's freshwater canals will enable the storage of an additional one billion gallons of fresh water in the canals during dry periods and in Aquifer Storage and Recovery wells during wet periods. These freshwater storage improvements will 1) provide additional irrigation water supply, 2) reduce freshwater discharges and loss to tidal waters, 3) provide water quality treatment through increased retention time of urban stormwater runoff, 4) increase freshwater wildlife habitat, and 5) reduce demands on regional groundwater sources (Citizens of Cape Coral 2010).

The Big Cypress Basin is implementing the Big Cypress Basin Watershed Management Plan (BCBWMP). The BCBWMP considers a range of alternative water management strategies to augment water supply and restore historic flow-ways by interbasin transfer through modifications to its primary canal network. The implementation of the BCBWMP projects (nine weirs retrofitted since 2000) and the backpumping operation of four existing pump stations have created an estimated 850 acre-feet of additional surface water storage in canals since 2000. This does not include increases in water availability due to the resulting increase in groundwater recharge. The CERP Picayune Strand Restoration Project implementation report (PIR) model indicates that the project will make 9,500 acre feet of additional groundwater available for the natural system during an average year due to recharge as result of plugging four canals and reduced freshwater discharges to the estuaries.

Estimated Costs

Regional and local retention costs vary greatly as they are site and type specific.

Dispersed Water Management Program

The Dispersed Water Management Program is an effort designed to encourage property owners to retain water on their land rather than drain it, accept regional excess runoff for storage, or both. Managing water on public, private, and tribal lands is a way to reduce the amount of water delivered into Lake Okeechobee and discharged to coastal estuaries for flood protection purposes. This program complements water storage options available through public facilities such as reservoirs, restoration projects, and stormwater treatment areas. The program consists of three approaches: 1) Easements/U.S. Department of Agriculture (USDA) Wetland Reserve and Reserved Rights Programs, 2) Payment for Environmental Services (Florida Ranchlands Environmental Services Pilot Project), and 3) Cost-Share/Water Storage.

Reservoirs

Reservoirs capture and store excess surface water during rainy periods and release water during drier periods for environmental and human uses. This water source option provides an opportunity to increase the supply of fresh water during dry periods.

The primary drawback to reservoir storage is large land parcel requirements and associated expenses. Expenses include land acquisition; construction, and O&M of large capacity pumping facilities; flood protection for existing urban and agricultural users; and water treatment costs. In addition, the availability of suitable locations, seepage losses, and the high evaporation rates of surface water bodies (reservoirs) can be problematic.

Usage and Production Capacity

In the SFWMD, reservoirs can provide multiple beneficial uses. For example, a reservoir could capture both Lake Okeechobee regulatory releases to reduce harmful estuary discharges and improve later environmental releases to the Everglades. This can be accomplished through the storage of water during the wet season and release during the dry season. Reservoir diversion and storage can improve flood control and provide regional and local water supply benefits. An example of a surface water reservoir used for Public

Water Supply is the Tampa Bay Water's Surface Water Treatment Plant Reservoir. When available, surface water from Tampa Bypass Canal and the Hillsborough and Alafia rivers is diverted and stored in the 15.5 billion gallon regional reservoir to supply the water treatment facility during dry times.

Estimated Costs

Costs associated with surface water storage vary depending on the site-specific conditions of each reservoir. A site located near an existing waterway increases the flexibility of design and management and reduces costs associated with water transmission infrastructure. Lower site elevations allow maximum storage, while reducing costs associated with water transmission and construction excavation. Deeper reservoirs result in higher levee elevations, which can significantly increase construction costs, but can have significant savings in land acquisition costs.

Table 7 depicts costs associated with two types of reservoirs. 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 is a major facility with greater depth, but an infrastructure similar to the minor facility. Costs increase significantly for construction of higher levees, but can be somewhat offset by reduced land requirements.

Table 7. Surface water storage costs.

Reservoir Type	Storage	Costs			
		Construction $/Acre-foot	Engineering/ Design $/Acre-foot	O&M $/Acre-foot	Land $/Acre
Minor Reservoir	Range	7,667–13,020	1,146-1,230	194–241	3,666–24,690
	Average	10,344	1,188	218	13,295
Major Reservoir	Range	1,867–6,295	75–513	12-111	2,702–32,533
	Average	3,440	297	52	14,188

Sources:
Costs (except for land) were obtained from the Cost Study (CDM 2007a).
Land costs were obtained from USACE and SFWMD (2005).

Related costs not included in the surface water storage option are costs for inflow and outflow transmission infrastructure, and costs for water treatment facilities, if any (depending on the end user).

Utility Interconnections

Utility interconnections involve bulk purchase of raw or treated water from neighboring utilities in lieu of expanding an existing withdrawal or treatment facility. Implementation of a utility interconnection system can be employed as a supply management tool. This water source option could shift withdrawals from areas deemed to be at highest risk for adverse environmental impacts to areas where the withdrawals are projected to have less impact, or allow a utility to purchase water rather than bearing the cost of construction and operation of a new or larger treatment facility.

A detailed study of distribution systems proposed for interconnection is necessary to address such issues as system pressures, physical layout of the supply mains, impacts on fire flows, and water compatibility. For example, most existing water distribution systems are constructed with the smallest diameter pipes (low volume) at the extremities. As a result, utility interconnects for the purposes of bulk transfers of water could involve connecting more than two distribution systems. Connecting distribution systems at the extremities of the system would require extension of larger water mains within the service area to extremities and connecting to similar pipes in the adjoining service area. In addition, differences in pressure and water quality will need to be addressed.

Usage and Production Capacity

Along with the development of traditional and alternative water supplies and water conservation and reuse programs, utility interconnects with bulk sales agreements proved beneficial during the 2000–2001 and 2006–2009 drought conditions, and helps serve existing and new development. These interconnections help utilities have flexibility to meet demands in their service areas by moving available water resources to where they are most needed. Bulk agreements provide the legal framework for this water sharing.

An example of utility interconnects is the Palm Beach County Water Utilities Department, which operates an interconnected distribution and production system with five water treatment facilities, five SAS wellfields, and a future FAS wellfield. In addition, Palm Beach County has several interconnects with adjoining utilities for bulk sale and emergency use.

Estimated Costs

The costs associated with Public Water Supply interconnects are difficult to estimate and could vary greatly depending on the size, distance, and potential engineering challenges. Typically, an interconnect system could include booster pump stations, transmission mains, valves, jack and bores, encasements, and tunneling. Costs are site-specific.

WATER CONSERVATION – DEMAND MANAGEMENT

Water conservation involves long-term reduction of daily water use. Reducing water demand can reduce the need for expansion of the water supply infrastructure. Permanent water use reductions require implementation of measures or technologies, such as low (or ultralow) volume fixtures indoors or smart irrigation systems outdoors, which reduce water use while satisfying consumer needs. In contrast, temporary water saving measures, such as cutbacks mandated during water shortage conditions, address short-term problems associated with water supply system capacity.

Reducing current and future water demands before expanding water supplies is a prudent and cost-efficient way to manage resources. Employing sound water conservation measures prior to developing viable water source options is vital to regional water supply planning efforts. Working within the existing legislative framework, the SFWMD is increasing water conservation efforts, especially by providing support to Public Water Supply utilities and other providers in finding the most cost-effective ways to reduce water use.

Creation of Statewide Comprehensive Water Conservation Program

Following the 2000–2001 drought, the 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* (FDEP 2002) identified methods to improve efficiency in all categories of water use. In addition to policy and regulatory measures, the initiative identified water conservation recommendations for Agricultural and Recreation/Landscape irrigation; water pricing; Commercial, Industrial, and Institutional users; indoor water use; and reclaimed water.

Multiple agencies and stakeholders signed the *Joint Statement of Commitment for the Development and Implementation of a Statewide Comprehensive Water Conservation Program for Public Water Supply* (FDEP 2004) to implement the recommendations of the *Florida Water Conservation Initiative*.

From these efforts, a statewide Comprehensive Water Conservation Program, known as Conserve Florida, was established to provide information and tools to improve water conservation through the development of utility-specific, goal-based water conservation programs. Through this effort, a water conservation Clearinghouse was developed, along with a web-based conservation planning and reporting software application called EZ Guide. The University of Florida's Department of Environmental Engineering Sciences hosts the Clearinghouse and EZ Guide (http://www.conservefloridawater.org).

Districtwide Comprehensive Water Conservation Program

The SFWMD's overall water conservation goal is to prevent and reduce wasteful, uneconomical, impractical, or unreasonable uses of water resources, while instilling a year-round water conservation ethic in end users. Water savings achieved through water conservation measures are the most cost-efficient way to expand current water supplies.

The District developed its Comprehensive Water Conservation Program (CWCP) in coordination with the 2007 Water Conservation Summit hosted by the Water Resources Advisory Commission, an advisory body to the District's Governing Board. The summit was called to begin to develop a series of tools that could be used to create a year-round water conservation ethic in end users.

A variety of stakeholders were invited to participate in developing the CWCP, lending expert knowledge and real-world experience to the water conservation planning process. Meeting participants highlighted case studies and identified practical components, successes, and obstacles, aiding in the design and implementation of the program. These efforts culminated in the District's Governing Board approval of the CWCP in September 2008.

The CWCP is a series of recommendations and implementation strategies designed to bring about a permanent reduction in water use throughout the District. The program is organized into regulatory, voluntary and incentive-based, and educational and marketing water conservation initiatives. Under the umbrella of these initiatives, the SFWMD and other coordinating water management districts and agencies provide numerous water conservation tools. The District has implemented many programs in each category.

From a regulatory perspective, greater emphasis has been placed on water conservation in the water use permitting process, which encourages municipalities to adopt and enforce effective water conservation measures. Goal-based water conservation allows utilities to achieve a goal, such as a specified reduction in per capita use or overall reduction in pumpage, using any one of a suite of methods and practices.

From a local perspective, other regulatory measures, such as local landscape ordinances and year-round irrigation conservation measures, generally advance water use efficiency; promote water conservation as the least-cost source of new water; protect the natural environment; and result in quantifiable water savings. The SFWMD has sample ordinances available for municipalities to use in implementing such regulations in their areas. These can be found on the SFWMD's conservation website available from http://www.sfwmd.gov/conserve.

Voluntary and incentive-based initiatives, such as financial and technical assistance and recognition programs, can supplement regulations; leverage investments; bring wider environmental benefits; and significantly improve the quality of life in local communities.

Partnerships have been established with other outreach and educational sponsors, such as the Florida Section of the American Water Works Association, University of Florida/Institute of Food and Agricultural Sciences, Florida Nursery Growers and Landscape Association, and the FDEP.

Regulatory Initiative Programs and Implementation

This section presents programs supporting regulatory-driven water conservation measures. **Chapter 4** of this Support Document provides information about the mandatory requirements for water

NAVIGATE

Chapter 4 of this document describes the eight mandatory elements of a water conservation plan for Public Water Supply utilities.

conservation in water use permitting for Public Water Supply, Commercial and Industrial, Recreation/Landscape, and Agricultural users.

Public Water Supply Utilities

All Public Water Supply utilities within the SFWMD are required to develop and implement a water conservation plan when applying for or renewing a water use permit. The following sections provide additional information about some of the water conservation ordinances and measures discussed in **Chapter 4** of this Support Document.

Adoption of an Ultralow Volume Fixtures Ordinance

Public Water Supply utilities are required to adopt an ultralow volume (ULV) fixtures ordinance for all new construction. **Table 8** shows the costs and potential water savings of retrofitting homes of various ages with ULV fixtures.

Table 8. Representative water use and cost analysis for ultralow volume fixtures by housing stock characteristics.

Housing Stock Characteristic	Water Conservation Measure	Water Savings per Retrofit Use	Annual Savings per Measure[a] (in gallons)	Cost per Fixture[b]
Homes with pre-1984 fixtures, replaced with ultralow volume fixtures of the *Energy Policy Act of 1992*	Toliet Retrofit (5 gal/flush)	3.4 gal/flush	15,570	$300
	Showerhead Retrofit (5 gal/min)	1.67 gal/min	7,930	$20
	Faucet Aerators (4 gal/min)	1.2 gal/min	8,730	$5
Homes with 1984–1994 fixtures, replaced with ultralow volume fixtures of the *Energy Policy Act of 1992*	Toilet Retrofit (3.5 gal/flush)	1.9 gal/flush	8,700	$300
	Showerhead Retrofit (4 gal/min)	1.0 gal/min	4,760	$30
	Faucet Aerators (3 gal/min)	0.5 gal/min	3,880	$5

Notes: gal/flush=gallons per flush; gal/min=gallons per minute; min=minute, ULV=ultralow volume. Fixture service lives: toilets–40 years; showerheads–40 years; and faucets–15 years. Source: *Study of Life Expectancy of Home Components*, National Association of Home Builders, 2007.

a. Savings per household assuming 2.46 persons per household. Water use for ULV plumbing devices are as follows: toilets–1.6 gal/flush; showerheads–2.5 gal/min; faucet aerators–2.5 gal/min; actual flow rates for showerheads and faucets equal to 66% of rated flows were used for calculations. Frequency rates per person per day: toilet–5.1 flushes; shower–5.3 min; faucet–8.1 min.

b. Assumes materials and installation costs.

WaterSense

In 2006, the U.S. Environmental Protection Agency established the national WaterSense program. The SFWMD does not require WaterSense-labeled products in local fixture ordinances. However, local governments are encouraged to amend or enact local plumbing ordinances to require WaterSense fixtures in new construction and in retrofit programs.

WaterSense-labeled fixtures offer additional savings over those under the current federal standards. WaterSense-labeled fixtures must be at least 20 percent more efficient than the current federal standards without sacrificing the end user's performance expectations. Maximum flow volumes for WaterSense-approved indoor plumbing fixtures are as follows:

- Toilets, 1.28 gal/flush
- Showerheads, 2.0 gal/min
- Residential Lavatory Faucets, 1.5 gal/min
- Urinals, 0.5 gal/flush

Many WaterSense-approved models are now available at lower flow rates (more efficient than maximum flow rates). Conversely, it is possible to purchase fixtures at flow rates lower than the WaterSense standards. However, fixtures at or below the WaterSense maximum flow rates without the WaterSense label may fail to meet end user performance expectations. Therefore, the District recommends the use of WaterSense-labeled products in conservation programs. The WaterSense website maintains a search engine to identify all approved models. **Table 9** shows the costs and potential water savings of retrofitting homes of various ages with WaterSense-labeled fixtures at the maximum allowed flow rate.

Table 9. Representative water use and cost analysis for maximum allowable flow rate WaterSense fixtures by housing stock characteristics.

Housing Stock Characteristic	Water Conservation Measure	Water Savings per Retrofit Use	Annual Savings per Measure[a] (in gallons)	Cost per Fixture[b]
Homes with pre-1984 fixtures, replaced with WaterSense-labeled fixtures at the maximum allowed flow rate	Toliet Retrofit (5 gal/flush)	3.72 gal/flush	17,035	$300
	Showerhead Retrofit (5 gal/min)	2.00 gal/min	9,520	$30
	Faucet Aerators (4 gal/min)	1.67 gal/min	12,120	$5
Homes with 1984–1994 fixtures, replaced with WaterSense-labeled fixtures at the maximum allowed flow rate	Toilet Retrofit (3.5 gal/flush)	2.22 gal/flush	10,170	$300
	Showerhead Retrofit (4 gal/min)	1.33 gal/min	6,350	$20
	Faucet Aerators (3 gal/min)	1.0 gal/min	7,270	$5
Homes with post–1994 fixtures, replaced with WaterSense-labeled fixtures	Toilet Retrofit (1.6 gal/flush)	0.32 gal/flush	1,460	[c]$300
	Showerhead Retrofit (2.5 gal/min)	0.3 gal/min	1,570	$30
	Faucet Aerators (2.5 gal/min)	0.5 gal/min	3,400	$5

Notes: gal/flush=gallons per flush; gal/min=gallons per minute; min=minute, ULV=ultralow volume.

a. Savings per household assuming 2.46 persons per household. Water use for maximum flow WaterSense plumbing devices are as follows: toilets–1.28 gal/flush; showerheads–2.0 gal/min; faucet aerators–1.5 gal/min; actual flow rates for showerheads and faucets equal to 66% of rated flows were used for calculatons. Frequency rates per person per day: toilet–5.1 flushes; shower–5.3 min; faucet–8.1 min.
b. Assumes materials and installation costs.
c. Retrofitting newer toilets with some WaterSense toilets may not be cost-effective.

Adoption of a Rain Sensor Device Ordinance

All automatic sprinkler systems must have a rain sensor device or an automatic shut-off device (Section 373.62, F.S.). Rain sensor devices interrupt scheduled irrigation during or soon after it rains. A properly functioning rain sensor device can bypass between 15 percent and 34 percent of scheduled irrigation events.

Smart Irrigation Systems

Although not required, the soil moisture sensor, which is an automatic shut-off device, prevents the use of sprinkler systems when there is sufficient water content in soil. Smart irrigation systems, if properly installed and monitored, provide a more efficient irrigation method and save substantially more water than conventional time-controlled irrigation systems. A properly working soil moisture sensor can bypass a significant number of scheduled irrigation events, depending primarily on local weather conditions, as well as other factors (Dukes 2009).

The efficiency of an irrigation system is also affected by the design, condition, and management of the system components and the plant materials in the landscape. Assisting large area irrigators, such as homeowner associations, public parks, and commercial operations, as well as residential homeowners to improve irrigation efficiency can provide the significant returns on investment for many utilities in south Florida.

INFO

Funded in part by the SFWMD, in partnership with Orange County Utilities, the St. Johns River Water Management District, and the Water Research Foundation, a University of Florida study is currently under way in Orange County to investigate the impact of smart irrigation technology on reducing water consumption in real-world settings. A total of 160 homes and businesses were selected to participate in this three-year study. The study will evaluate two types of smart irrigation controllers: 1) evapotranspiration-based controllers, which collect temperature, relative humidity, wind, and other data to determine when to schedule irrigation events; and 2) soil moisture sensor controllers, which gauge moisture content in the soil relative to a user-selected optimum level to determine when to activate the irrigation system.

Adoption of a Water Conservation-Based Rate Structure

Most utilities use a water conservation-based rate structure to provide users with a financial incentive to reduce demands. These rates may include:

- **Increasing block rates** The marginal cost of water to the user increases in two or more steps as water use increases.
- **Seasonal pricing** Water consumed during peak season (October through May) is billed at a higher rate than water consumed in the off-peak season.
- **Quantity-based surcharges** Charges applied to users after a threshold use level is reached
- **Time-of-day pricing** Higher rates charged during the day (when evapotranspiration rates are greater) to discourage watering during those hours.

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

Implementation of a Utility Leak Detection and Repair Program

The SFWMD requires utilities to implement a leak detection program if their unaccounted-for water losses exceed 10 percent. The leak detection program must include water auditing procedures and in-field leak detection and repair. In addition, 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 or messages to educate citizens about water conservation. Such programs create awareness of water use behavior, teach water-saving techniques and technologies, and inform consumers about water conservation benefits, such as lower water bills.

Targeted education, public information, and social marketing provide opportunities to build a water conservation culture, instill a stewardship ethic, and reduce individual, industrial, and commercial water use.

The SFWMD and other participating state agencies have consistently provided assistance to a wide range of water users through outreach and educational programs. Successful efforts usually depend on cooperation between multiple agencies and organizations. For example, outreach through partnering with schools can provide a foundation for long-range acceptance of water conservation ideals and resulting action by future generations. Public Water Supply utilities can perform an important public service by including simple messages with their customer service and billing communications.

Although water saved through an educational and outreach effort may not be readily measurable, outreach and education are crucial to any successful water conservation program. The *Education, Marketing, and Outreach* section of this chapter further describes the District's efforts.

Voluntary and Incentive-Based Water Conservation Measures

Voluntary and incentive-based water conservation measures are an integral part of the CWCP. Financial and technical assistance and recognition programs often surpass the effectiveness of the traditional command-and-control approach, which relies solely on rule enforcement. In addition, initiatives can supplement regulations and build goodwill, leverage investments, bring wider environmental benefits, and improve the quality of life in local communities.

This section describes water conservation program planning tools and incentives that Public Water Supply utilities can implement to fulfill water conservation goals. Note that individual programs are subject to annual funding availability.

Public Water Supply Planning Tools

The SFWMD encourages Public Water Supply utilities to use a water conservation planning tool to develop water conservation plans with a numerical goal for achievable water savings.

The Conserve Florida Water Clearinghouse (CFWC) EZ Guide generates estimates of indoor water use and savings for utility service areas using data from entities such as county property appraiser offices and the Florida Department of Revenue. The entities maintain detailed data on all land parcels in the state. For each parcel, these data typically include the age of a structure, number of bathrooms, total square footage of the parcel, and total square footage of the built structure on the parcel. These data, along with population estimates, are used to create estimates of water consumption for structures built during each plumbing code era and each water use sector (e.g., single- and multi-family residential, industrial, commercial, institutional). The EZ Guide output results include water savings, costs, and net benefits for each recommended conservation option, for each water use sector, sub-divided by plumbing code dates. In addition, the EZ Guide produces a ranked and optimized list of conservation actions based on cost benefits and gallons of water saved. The EZ Guide is available free from http://www.conservefloridawater.org/ez_guide.asp.

The Alliance for Water Efficiency (AWE) Water Conservation Tracking Tool is a Microsoft® Excel-based model, which uses baseline demand data for each water use sector (customer class) and avoided-cost data to evaluate and design utility conservation programs. It contains a library of pre-defined water conservation measures that users can select for evaluation. Water savings, costs, and benefits of each measure can be examined and tracked for each year of the proposed program. The tool features comprehensive and highly developed economic analyses of each water conservation option, accounting for program costs using time-valued dollars. Yearly peak and off-peak demands and savings are calculated to identify specific point(s) of capacity deferment and present value benefits. The tool's avoided-cost calculator includes analysis of short-term avoided costs and long-term avoided or deferred capacity expenses. The analysis functions of the tool include utility revenue and rate impact calculations. The AWE tool recently concluded a beta-testing period and is now available free of charge to AWE members available from http://www.allianceforwaterefficiency.org.

Water Savings Incentive Program

The SFWMD offers a cooperative funding program, which provides matching funds up to $50,000 to implement water saving hardware and technology-based conservation projects. Known as the Water Savings Incentive Program, or WaterSIP, the program provides seed money to foster non-capital water efficiency improvement projects, such as installation of signal and sensor-based controllers for irrigation systems; high-efficiency plumbing retrofits; automatic line flushing devices for utility distribution lines; and rain harvesting systems.

Landscape Irrigation

Nationally, 58 percent of average annual water use is for outdoor purposes (AWWA 1999), and 80–90 percent of outdoor water use is for landscape irrigation (USEPA 2011). Many landscape irrigation systems are not efficient. The WaterSIP Program encourages the purchase and installation of high-efficiency irrigation sprinklers, sensor-based devices, and smart controllers. As **Table 10** shows significant annual water savings can be realized by upgrading existing irrigation systems to these more efficient devices.

Table 10. Estimated water savings from soil moisture and rain sensors for residential irrigation systems.

Sensor Type	Cost per Device**	Water Savings per Device	Annual Water Savings* (in gallons)	Water Saved over Device Life (in gallons)
Rain Sensor	$100	15–34% Annual Irrigation Savings	35,000–80,000	175,000–400,000
Soil Moisture Sensor	$150	15–90% Annual Irrigation Savings	35,000–211,000	175,000–1,055,000

* Assumes a quarter-acre lot containing five irrigation zones, irrigating each zone for 30 minutes at 15 gallons per minute in a locality under two-day-per -week irrigation watering restrictions. Savings rates for rain and soil moisture sensors are based on Dukes (2009). Actual results may be affected by local weather and soil conditions.

** Assumes materials and installation costs.

The WaterSIP requires the use of WaterSense-approved plumbing fixtures, which are required for new construction under the *Energy Policy Act of 1992* (Public Law 102-486). A household of 2.46 persons switching from pre-1980s plumbing fixtures to WaterSense-approved fixtures can save an estimated 42,000 gallons of water per year at the following flow rates: toilets – 1.28 gallons per flush; showerheads – 1.75 gallons per minute; and faucet aerators – 1.0 gallons per minute.

From 2003 to 2012, the WaterSIP has allocated funding to support 151 local water conservation projects, representing a total estimated water savings of approximately 2.6 billion gallons of water per year, at a cost of $4.4 million to the SFWMD. In FY 2012, the SFWMD allocated $250,000 in support of nine local projects. These projects represent more than 44 million gallons per year (MGY) in potential water savings. Details on the WaterSIP are provided for each planning area in its respective Plan Update.

Florida Water Star℠

Florida Water Star℠ is a voluntary, points-based recognition program that improves water efficiency in residential properties by encouraging the use of appropriate water-saving landscapes, irrigation systems, and household appliances and fixtures.

The Florida Water Star℠ Program offers three residential certification levels:

- Standard Silver certification
- Gold certification (for additional water savings)
- Community (for master-planned communities, currently in pilot phase)
- Commercial/Institutional buildings (offices, retail and service establishments and institutional and non-industrial commercial buildings)

Local governments that adopt Florida Water Star℠ Silver criteria as their water conservation standard for new residential properties can expect new residential homes in their jurisdictions to use as much as 35 percent less water than their current residential stock of single-family homes with permanent in-ground irrigation systems. Savings of up to 45 percent may be anticipated for homes built to Florida Water Star℠ Gold criteria.

Leading by Example

Leading by Example is a CWCP initiative to lead state and local governments in water conservation. The program aims to reduce indoor and outdoor water use in all municipal buildings within the SFWMD's jurisdiction. To lead by example, the District conducted comprehensive indoor and outdoor water audits of its own facilities in 2009. The audits evaluated water use and efficiency, and identified opportunities for water conservation. The District is phasing in the recommendations outlined in the water audits as funding is made available.

In addition, the District began an effort to have its owned-facilities achieve Florida-friendly Yard certification. Such landscapes follow and maintain Florida-friendly Landscaping principles as outlined by the University of Florida/Institute of Food and Agricultural Sciences' (UF/IFAS) Florida-friendly Landscaping Program

Water Efficiency Improvement Guide

Developed by the SFWMD in 2011, the *Water Efficiency Self-Assessment Guide for Commercial and Institutional Building Facility Managers* (SFWMD 2011c) offers facility managers guidance to help reduce water use, lower operating costs, and protect regional water resources.

Designed as a self-conducted water use assessment tool, this guide walks facility managers through detailed, step-by-step instructions for common water use at commercial and institutional facilities. The guide covers indoor and outdoor water use and is accompanied by a series of water use and savings calculators to help facility managers quantify potential water savings and investment recovery periods. This information can then be used by facility managers to develop a plan to increase water efficiency without sacrificing performance.

INFO

One facility has already identified significant conservation opportunities. Lake Stevens Middle School in Hialeah worked with the SFWMD and Miami-Dade County Public Schools on water conservation options. In all, the assessment identified potential water savings of 1.9 million to 2.1 million gallons and an operating cost reduction of $10,785 to $12,730 annually. It was estimated the school could recoup its investment in retrofits in six to 27 months.

Utilities are encouraged to incorporate this guide into their outreach efforts for commercial and institutional water users. The manual and the companion water use and savings calculators are available for download from the SFWMD's conservation website at http://www.sfwmd.gov/conserve under "Businesses."

Water CHAMP

The Water Conservation Hotel and Motel Program (Water CHAMP) is a recognition program established specifically for the lodging industry. It was originally launched in 2002 by the Southwest Florida Water Management District. In 2009, the SFWMD implemented a pilot release of a Water CHAMP program in the Florida Keys, and in 2011, the program was expanded to Martin and St. Lucie counties. The program recognizes lodging facilities that conduct voluntary linen and towel reuse programs and install high-efficiency (1 gal/min) faucet aerators in guest bathrooms. It is estimated this program can save approximately 20 gallons of water per occupied room per night, and hotels participating in Water CHAMP are fulfilling part of the criteria needed to be a designated provider under the FDEP's Florida Green Lodging Program. Potential savings for each planning area are given as relevant in each water supply plan update's Chapter 4.

Florida Automated Weather Network

The Florida Automated Weather Network (FAWN) is a statewide research and data project operated by the University of Florida/Institute of Food and Agricultural Sciences (UF/IFAS) The FAWN management tools provide decision support functions to growers, using historical weather data and crop modeling technology to help farmers maximize irrigation efficiency. When funds are available, the SFWMD assists in expanding the database's scope. Access to the database is available from http://fawn.ifas.ufl.edu/data.

Agricultural Mobile Irrigation Labs

Agricultural mobile irrigation labs (MILs) evaluate the performance of irrigation systems and encourage the adoption of efficient irrigation management practices that conserve water. In 2010, four agricultural MILs dedicated to improving irrigation efficiency for agricultural water users were operating throughout the District. The agricultural MILs provide irrigation audits for St. Lucie and Martin counties in the UEC Planning Area; Lee and Collier counties in the LWC Planning Area; and Palm Beach, Broward, and Miami-Dade counties in the LEC Planning Area. In 2009, the SFWMD discontinued funding of the MIL program.

Of the 404 evaluations performed in FY 2008 by these four agricultural MILs, a potential water savings of 978 MGY is possible if all water conservation audit recommendations are implemented. Details about agricultural MILs in each planning area are provided in each water supply plan update.

Urban Mobile Irrigation Labs

Landscape water audits performed by urban MILs measure the performance of a landscape irrigation system. In addition, urban MILs provide recommendations for operation and management of the system to improve efficiency. Recommendations 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
- Installing rainfall and soil moisture sensors

In FY 2008, eight urban MILs (excluding the MIL serving the Big Cypress Basin area) performed 1,207 MIL audits Districtwide. A potential water savings of 464 MGY is possible if all water conservation audit recommendations are implemented.

As of FY 2012, one urban MIL is in operation in the Big Cypress Basin. Although the SFWMD discontinued funding the MIL program in 2009, local municipalities are encouraged to investigate opportunities to expand the deployment of MILs.

Education, Marketing, and Outreach

Education, marketing, and outreach are indispensable tools for accomplishing measurable changes in water use among residents and businesses.

Targeted educational and marketing initiatives and public information provide opportunities for building a water conservation culture; instilling a stewardship ethic; and reducing individual, industrial, and commercial water use.

The SFWMD has sponsored a variety of educational and marketing programs, subject to annual funding allocation. Partnerships have been established with other outreach and educational sponsors, such as the Florida Section of the American Water Works Association, University of Florida/Institute of Food and Agricultural Sciences, Florida Nursery Growers and Landscape Association, and the FDEP. The following is an overview of some of the educational and public information water conservation programs the District has supported.

Water Conservation Public Service Announcements The SFWMD entered into Water Conservation Public Service Announcement Airport Campaign partnerships with five regional airports: Southwest Florida International Airport, Orlando International Airport, Miami International Airport, Fort Lauderdale-Hollywood International Airport, and Palm Beach International Airport. The public service announcement campaign encourages visitors to conserve water during their stay in Florida.

WaterSense This U.S. Environmental Protection Agency program is designed to encourage water efficiency by affixing a special label on consumer products. As a promotional partner for the program, the SFWMD recommends the use of WaterSense-labeled products through several agency outreach efforts.

The Great Water Odyssey In a cooperative effort between the District and Florida Atlantic University's Center for Environmental Studies (FAU/CES), elementary school students use a computer-based interactive curriculum to learn about water resources and their protection and conservation. Using the Odyssey program, third-, fourth- or fifth-grade students can be taught science, history, geography, social studies, reading, and math in an engaging way that correlates to the Next Generation Sunshine State Standards. Odyssey nurtures a greater awareness and appreciation of Florida's watersheds and their ecosystems, and promotes responsible actions for the health, protection, and use of Florida's water resources.

Teacher Training The SFWMD works with school districts, local governments, and regional organizations to identify school-based curricula that educate students on water resource issues. Florida Atlantic University's Center for Environmental Studies provides teacher training workshops for elementary, middle, and high school teachers for *The Great Water Odyssey* and *Everglades: An American Treasure* science-based curricula programs. Information about the FAU/CES teacher training programs is available from http://www.ces.fau.edu/education.

SFWMD Xtreme Yard Makeover The SFWMD Xtreme Yard Makeover Program encourages Florida-friendly landscaping. It also works to create a year-round water conservation ethic. The program shows how an unremarkable, water-hungry landscape can be turned into a lush, Florida-friendly landscape that will save time, money and water, while contributing less pollution-laden stormwater runoff.

Xtreme Makeover in Homestead

SFWMD Water Conservation Website A repository of downloadable water conservation educational materials, the SFWMD Water Conservation website is a valuable resource. The website is available from http://my.sfwmd.gov/portal/page/portal/levelthree/Teaching%20Materials.

Big Cypress Basin Conservation Outreach In concert with the District, municipalities, and the Water Symposium of Florida, Big Cypress Basin coordinates Florida-friendly landscaping demonstration projects and other outreach programs in southwest Florida. Big Cypress Basin Service Center staff also gives presentations to civic groups and homeowner associations on basin projects, water management, water supply, irrigation restrictions, and water conservation. Another aspect of the Big Cypress Basin Conservation Outreach effort is staff participation with the Water Symposium of Florida, Inc. in presenting outreach seminars on water supply and water conservation measures.

Florida Gulf Coast University's Wings of Hope Program is funded by the SFWMD. As part of the Wings of Hope Program, college students at Florida Gulf Coast University (FGCU) learn about southwest Florida wildlife species, habitats, water conservation, and environmental sustainability (http://www.fgcu.edu/cas/wingsofhope). In turn, the students share their knowledge with elementary school students throughout Lee and Collier counties.

Student Learning at DuPuis Management Area Teaming with District management efforts, FAU/CES coordinates a student volunteer service-learning program focusing on land stewardship and water conservation projects at the DuPuis Management area. Students provide environmental service to assist partners, learn about native habitats, and develop a volunteer ethic. Student service projects include butterfly gardening, installing native plants, and maintenance of the Habitat Trail.

Challenges to Measuring the Effects of Water Conservation Programs

The primary objectives of most water conservation programs are to use water more efficiently and curb wasteful water use. However, measuring water savings resulting from water conservation programs is difficult and needs to be done under certain conditions and constraints. This is due to numerous external factors that can artificially inflate or mask water savings outside of a controlled environment. For example, population demographics of an area constantly fluctuate (e.g., persons per household). The local economy and its effect on service area water use and vacancy rates can also affect water use independent of retrofit or replacements of water using devices.

Data have been gathered that indicate evaluations of irrigation systems by professionals, such as MIL technicians, and the use of smart irrigation technology can improve system efficiencies and reduce outdoor water use. However, measuring savings from outdoor programs also presents significant challenges. Changes to service area demographics, the local climate, and droughts can mask (or inflate) water use where outdoor efficiency improvements have taken place.

Educational/outreach initiatives and recognition programs are intended to foster changes in behavior leading to a stronger water conservation ethic. Presumably, a population with such an ethic will seize opportunities to conserve water in both predictable and unpredictable ways. These programs can work synergistically and typically in concert with other quantifiable programs, such as retrofits and rebates. These types of programs are vital to conservation planning and implementation as the effects of these qualitative programs can wane with time without subsequent renewal efforts, making savings projections over time less reliable.

While these challenges make it difficult to measure the effect of any single program from one year to the next, the effects of conservation become apparent when looking at per capita use rates of a service area over time. Per capita use rates have trended downward in areas of south Florida where local conservation programs have been active and comprehensive.

NAVIGATE

The latest information about Water Conservation is available from the SFWMD website at http://www.sfwmd.gov/conserve.

Reclaimed Water Pipes

6

Water Quality and Treatment

Chapter 5 introduced the first phase of the Water Delivery and Treatment Process – withdrawal from the water source, along with related costs. This chapter reviews water treatment quality considerations, and the technologies and processes used to treat water supplies from each water source.

Because the chapters are closely related, reading both chapters concurrently is the recommended approach for readers unfamiliar with the subject matter. References to specific sections for related discussions are provided throughout both chapters.

TOPICS

- Water Quality Standards
- Water Treatment Technologies
- Wastewater Treatment Technologies
- Groundwater Contamination

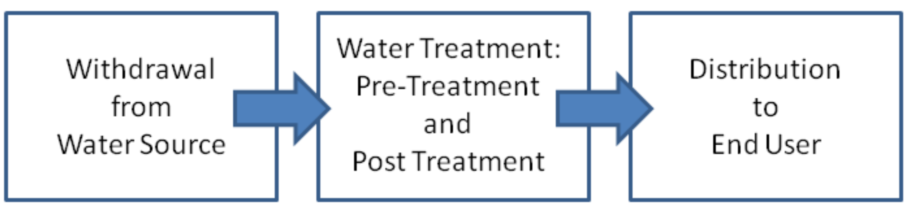


Figure 4. Treatment Process and Water Delivery.

WATER QUALITY STANDARDS

Drinking Water Standards

There are two types of drinking water standards, primary and secondary. Both 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 maximum contaminant level. Secondary drinking water standards, commonly referred to as aesthetic standards, are those parameters that may be characterized by objectionable appearance, odor, or taste of the water, but are not necessarily health hazards. Current MCLs for drinking water in Florida are available from http://www.floridadep.org.

Nonpotable Water Standards

Water for potable (suitable for drinking) and nonpotable water uses have different water quality requirements and treatability constraints. Nonpotable water sources include surface water, groundwater, and reclaimed water. These nonpotable water uses include golf course, landscape, agricultural, and recreational irrigation, and may be acceptable for some industrial and commercial uses. Unlike potable water, with very specific quality standards to protect human health, water quality limits for nonpotable uses are quite variable and 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.


Water Treatment

Irrigation water sources considered for a specific use must be sufficient in quantity and quality compatible with the target crop. Irrigation uses require that the salinity of the water not exceed levels damaging to crops, either by direct application or through salt buildup in the soil profile. In addition, water constituents harmful to irrigation system infrastructure or equipment, such as iron or calcium, must be at acceptable levels or economically removable. Water used for recreation/landscape irrigation purposes, including golf courses, 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. 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).

WATER TREATMENT TECHNOLOGIES

The technologies and processes employed to treat water for safe use are presented in the following sections of this chapter. Several water treatment processes, including chlorination, lime softening, and membrane processes, are currently employed by Public Water Supply water treatment facilities within the District's jurisdiction. The type of treatment needed is generally dependent on the quality and type of source water. Higher levels of treatment are needed to meet increasingly stringent drinking water quality standards. Water treatment is also required wherever lower quality raw water sources are pursued to meet future demand.

Potable Water Treatment Facilities

In the SFWMD, potable water is supplied by three main types of treatment facilities:

1. Public Water Supply, municipal, or privately owned facilities

2. Small developer/homeowner association or utility-owned Public Water Supply treatment facilities

3. Self-supplied domestic wells serving individual residences

It is common for smaller facilities to be constructed as interim facilities until regional potable water becomes available. Once regional water is available, the smaller water treatment facility is typically abandoned upon connection to the regional water system.

The Florida Department of Environmental Protection (FDEP) regulates Public Water Supply systems and water treatment facilities. A Public Water Supply system is a system that provides water for human consumption if the system has at least 350 persons or 150 service connections. The local health department regulates systems not regulated under the auspices of the FDEP [Chapter 62-550, Florida Administrative Code (F.A.C.)].

Water Treatment Facility – Pumps to Membrane Trains

Water Treatment Technology Processes and Components

The goal of water treatment technology processes and components is to remove existing contaminants in the water, or reduce the concentration of contaminants so the water becomes fit for its desired end use. See *Groundwater Contamination and Impacts to Water Supply* section later in this chapter.

Lime softening is an inexpensive treatment process commonly used at water treatment facilities throughout Florida. When these facilities need to be replaced, however, utilities are building facilities that use membrane treatment technology processes. Most water treatment technology processes addressed in this chapter use membranes. Different membrane technologies are used in treating brackish water and fresh water. In membrane filtration, water passes through a thin film of semipermeable membrane, which retains contaminants according to their size. Membrane processes can remove dissolved salts and organic materials that react with chlorine disinfectant by-products (DBP) precursors. These processes can also provide softening. The most commonly used membrane processes to treat drinking water are ultrafiltration (UF), microfiltration (MF), nanofiltration (NF), and reverse osmosis (RO). Each membrane process offers a different solution for different source waters. All membrane processes are pressure-driven, with higher energy costs associated with higher pressure.

Application of a particular membrane technology is dependent on source water quality and characteristics, as well as the desired treated water quality. Membrane technology continues to improve as the U.S. Environmental Protection Agency (USEPA) adopts more stringent water quality regulations.

No single water treatment technology process is applicable for the entire range of inorganic and organic compounds. While the rejection of many inorganic compounds by RO and NF membranes is well documented, the rejection of small organic molecules within the range of the microconstituent category is much more complex. It is not viable to generalize that all organic molecules over a specific molecular weight will be highly rejected by a given RO or NF membrane. Methods to determine the actual rejection rate of a particular microconstituent or group of microconstituents by a particular membrane include bench scale and pilot testing. The process recovery rate depends on the water source and the process set-up as shown in **Table 11**.

Table 11. General water treatment technology process recovery rates.

Process	Recovery Rate	Comments
RO seawater	30–50%	
RO brackish	70–90%	Depends on the source water's total dissolved solids (TDS) level
NF	80–95%	Can remove turbidity, microorganisms, disinfection by-product precursors, and hardness, as well as a fraction of the dissolved salts
UF and MF	85–97%	UF and MF membranes do not have the capability of removing dissolved salts from water; they typically separate larger, non-dissolved materials

Aeration Process Units

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, a process referred to as desorption or stripping. 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 these elements may be removed by further treatment.
- Remove radon gas.
- Remove volatile organic compounds considered hazardous to public health.

Desorption or stripping can be accomplished through packed towers, diffused aeration, or tray aerators.

- **Packed Towers** 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** 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.
- **Tray Aerators** 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.

Filtration Process Units

Filtration process units are used in water treatment to remove particulate matter from the water supply. 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 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 approximately 15–50 feet per hour. Rapid sand filtration typically follows settling basins in conventional water treatment units.
- **Slow Sand Filtration** Slow sand filtration is a biological treatment process. Typically, a slow sand filter has a depth of about 2 feet and operates 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 millimeters (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.
- **Activated Carbon Filtration** Active carbon filters remove organic compounds that impart taste and odor to the water. However, these filters may also affect counts of microbial organisms, including reduction of viruses and parasites. Carbon filtering is a method of filtering that uses activated carbon to remove contaminants and impurities using chemical adsorption. The carbon filter is designed to provide a large section of surface area to allow maximum exposure to the filter media. Carbon filters are most effective in removing chlorine, sediment, and volatile organic compounds from water. They are not effective in removing minerals, salts, and dissolved inorganic compounds. The efficacy of a carbon filter is also based on the flow rate. Carbon filters are used as pre-treatment devices for RO systems and as specialized filters designed to remove chlorine-resistant cysts, such as *Giardia* and *Cryptosporidium*.

Coagulation, Flocculation, and Sedimentation Process Units

Coagulation, flocculation, and sedimentation remove suspended material and color, and may be used as a pretreatment for other processes or technologies, such as RO.

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, which 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.

A high-rate ballasted flocculation/sedimentation process, consisting of a proprietary system with the trade name ACTIFLO®, has replaced the traditional rapid mix coagulation, flocculation, and sedimentation process. This process is used to treat large flow rates with variable raw water quality.

The ACTIFLO® process operates similarly to a conventional flocculation sedimentation design, with the exception that 130–150 micron sand (microsand) is added to the water during the flocculation process to enhance both coagulation and settling. The microsand adds surface area in the coagulation process, which significantly improves the frequency of collision of dispersed or colloidal particles in the raw water with oppositely charged coagulated flocculation. This action accelerates the coagulation and flocculation processes. The microsand also provides "ballast" to the flocculation, resulting in flocculation settling velocities that are 25 to 35 times faster than flocculation produced in conventional flocculation-sedimentation processes. When compared to the conventional flocculation sedimentation process, this combination of improved coagulation efficiency and rapid flocculation settling characteristics provides:

- Higher quality settled water (as measured via particle counts in the 2–4 micron range)
- More stable performance during raw water upset conditions
- Reduced coagulant demand (particularly under high algae conditions)
- Reduced process footprint

Lime Softening Process Units

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. While the lime softening process is effective at reducing hardness for some source water, it is relatively ineffective at controlling contaminants, such as chlorides, nitrates, total trihalomethane (TTHM) precursors, and others (Hamann, McEwen and Myers 1990). Chloride levels of raw water sources expected to serve lime-softening facilities should be below the chloride maximum contaminant levels to avoid possible exceedance of the standard in the treated water. Lime softening facilities with raw water sources and nitrate concentrations exceeding the maximum contaminant level will probably require additional treatment. 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.

Many existing lime softening facilities are modifying their treatment processes because of changing *Safe Drinking Water Act* regulations for TTHMs and DBPs that require utilities to comply with the standards for these groups of compounds. With increasing safety parameters and more stringent MCLs, many utilities are using membrane water treatment processes.

Ultrafiltration and Microfiltration Processes

Ultrafiltration and microfiltration are low-pressure water treatment technology processes. Ultrafiltration 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 removes coarser materials than UF. Although MF removes micrometer and submicrometer particles, it allows dissolved substances to pass through.

Treatment technologies such as UF and MF remove suspended particles by a sieving type of filtration process. The small pore sizes in UF and MF membranes represent a physical barrier to larger-sized contaminants, such as bacteria and *Cryptosporidium*, and *Giardia* cysts. Due to the larger pore size of the membranes used for MF, the process is not as effective as the UF process for removing viruses.

Nanofiltration Process

Nanofiltration is a diffusion-controlled membrane filtration process using nominal pore size and higher pressure than UF or MF. Nanofiltration systems can remove virtually all cysts, bacteria, viruses, synthetic and organic compounds, and humic materials.

Nanofiltration membranes are generally effective for removing particles ranging from 10–100 microns in size, making them well suited for removing high molecular weight molecules (e.g., dissolved organics such as DBP precursors) and hardness ions. Nanofiltration membranes are commonly applied in softening applications; the technology is sometimes referred to as membrane softening. One significant advantage of the membrane softening technology is its effectiveness at removing organics that function as TTHMs and other DBP precursors. In recent years, utilities have been replacing their aging lime-softening facilities with NF processes to accommodate current and projected regulatory standards.

Desalination Processes

Desalination is a process that treats saline water to remove or reduce chlorides and dissolved solids, resulting in the production of fresh water suitable for human consumption or irrigation.

Reverse Osmosis Process

Reverse Osmosis Treatment Facility

Reverse osmosis is a high-pressure process that relies on forcing water molecules (feedwater) through a semipermeable membrane to produce fresh water (product water or permeate). Heavy metals, dissolved salts, and compounds such as leads and nitrates, are unable to pass through the membrane, and therefore, are left behind for disposal as concentrate or reject water.

Reverse osmosis membranes are effective in desalination of brackish and seawater raw water supplies. In addition to treating a wide range of salinities, RO rejects naturally occurring and synthetic organic compounds, metals, and microbiological contaminants effectively.

Due to the level of removal efficiency, a typical RO application may require a raw water blend stream (bypassing the RO process) with the finished water, or the post-treatment addition of calcium hardness, alkalinity, and a corrosion inhibitor to produce a stable finished water that does not present corrosion concerns for the downstream distribution system.

Electrodialysis and Electrodialysis Reversal Process Units

Electrodialysis 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 is a similar process, but provides for the reversing of the electrical current, which causes a reversing in the direction of ion movement. Electrodialysis and electrodialysis reversal processes are useful in desalting brackish water with TDS concentrations of up to 10,000 milligrams per liter (mg/L). However, electrodialysis and electrodialysis reversal are generally not considered efficient and cost-effective organic removal processes and therefore usually not considered for TTHM precursor removal applications (AWWA 1988).

Distillation Process Units

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.

- **Multistage Flash Distillation** In the multistage flash distillation 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 multistage flash facility 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.
- **Multiple Effect Distillation** In multiple effect distillation, there are a number of evaporation stages in a 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 found in a typical large facility. The vapor resulting from the last stage is condensed into fresh water.
- **Vapor Compression** The vapor compression distillation process is generally used for small- and medium-scale facilities. 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.

Distillation treatment processes in Florida are uncommon.

Water Treatment Technology Costs

The following discussion serves as an overview of several water treatment technology processes and components. It includes cost estimates related to building new facilities, specifically for RO and NF.

Water Treatment Cost Information

Cost information presented in this chapter, unless otherwise noted, was obtained from the Cost Study (CDM 2007a). All costs in the Cost Study are adjusted to August 2006 dollars and are still considered valid (see **Chapter 5** of this Support Document). Costs presented throughout this chapter are considered order-of-magnitude estimates for planning purposes. These estimates are not a substitute for the detailed evaluation that should accompany utility-specific feasibility and design studies needed to assess and construct such facilities.

The total capital costs for the water supply and wastewater system components are the sum of the construction and nonconstruction costs. Probable capital costs include raw water supply; pretreatment and post treatment; process equipment; transfer pumping; plant infrastructure; residuals disposal; yard piping; electrical; instrumentation and controls; site work; general requirements; contractor overhead and profit; project and construction contingency; technical services; and owner administration. Unless otherwise noted, total capital costs do not include costs for land and land acquisition, operations and maintenance (O&M); permitting; development-related; inflow and outflow transmission, well construction; production costs, and disinfection.

The following are additional points to consider in estimating potential water treatment costs:

- Capital costs for new facilities will be much greater than costs for facility expansions as new facilities are generally not phased; most costs are upfront and not incremental.
- Brackish water sources will incur a well cost and a desalination cost.
- Costs for raw water transmission mains are usually included in well construction costs.
- Well construction and O&M costs are difficult to estimate due to the variation in costs by planning region; various well types depending on aquifer source (differences in sizes, depths, and wellhead equipment requirements); and economy of scale (cost per well is usually reduced in multiple-well projects). Nevertheless, well construction or surface water intake costs are included in the estimation of capital costs for each water treatment technology process.
- Facility infrastructure related costs, such as yard piping, electrical, instrumentation, and controls are estimated by a factor applied to the treatment process component subtotal and included in the estimation of a treatment technology process capital cost.
- Land acquisition, permitting, and development-related costs are not provided, as these costs are site-specific and highly dependent on local conditions.
- For specific projects, refer to the appropriate regional water supply plan update for more information.

Ultrafiltration and Microfiltration Water Treatment Technology

This cost estimate for UF and MF water treatment processes includes components for a completed, functioning facility: raw water supply; pretreatment; typical UF or MF process component; post-treatment; finished water stabilization; intermediate (in-plant) storage; transfer pumping; back-up power generation; and general facility infrastructure. This estimate does not include capital costs, such as land acquisition, rights-of-way, transmission mains, and utilities. Related costs do not include unusual site work, such as wetland mitigation, demucking, and pilings; finished water storage and high service pumps; and distribution mains.

The probable costs for UF or MF technology are shown in **Table 12**.

Additional considerations:

- The intake includes slotted intake screens, pump basin, and vertical turbine intake pumps, and assumes that the intake is located on the facility site.
- The pretreatment includes automatic backwashing 300-micron screens and the addition of a coagulant aid.
- The UF or MF units include the membrane equipment; membrane basins; permeate pumps; backwash; cleaning; and integrity test systems.
- The UF or MF systems are assumed to operate at 90 percent recovery.
- The post-treatment system includes caustic soda, sodium hypochlorite, ammonia, and fluoride systems.
- Facility infrastructure includes the membrane building, as well as miscellaneous structures.
- The residuals treatment system includes an equalization basin, a residuals thickener, and a centrifuge.
- The raw water supply for the UF or MF treatment could be from a surface water source, such as a river or lake (although uncommon in south Florida).
- For cost estimation purposes, it is assumed that:
    - The new facility is built on a virgin site with no issues requiring unusual site work or foundation preparation, such as wetland mitigation, substantial site filling, demucking, pilings, etc.
    - The facility is located directly adjacent to a surface raw water source such that raw water transmission piping is considered included in the yard piping line item cost.
    - The facility is located directly adjacent to a power supply, such that the power transmission system to the facility is considered included in the electrical cost allowance.
    - Project implementation is a traditional design-bid-build approach, with owner operation.
    - O&M costs are based on an assumed unit electrical power cost of $0.10 per kilowatt-hour.
    - The equivalent annual capital cost is based on an annual interest rate of 7 percent.
    - An annual deposit equal to 10 percent of the equivalent annual capital cost is budgeted for a renewal and replacement account.

NAVIGATE

For additional information about the surface water source option, see also the *Surface Water* and *Surface Water Estimated Costs* section of **Chapter 5** of this document.

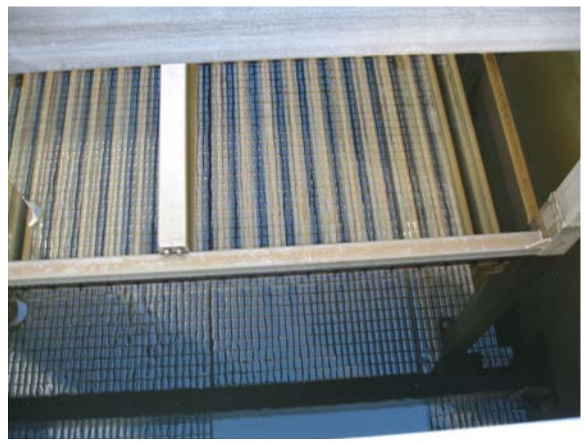
Table 12. Estimated costs associated with ultrafiltration or microfiltration treatment technology.

Facility Capacity (MGD)	Construction Cost	Capital Cost	Equivalent Annual Capital Cost	Annual O&M Cost	Total Annual Production Cost	Cost ($/1,000 gal)
5	$9,786,990	$14,191,000	$1,339,530	$1,078,000	$2,552,000	$2.10
10	$16,825,950	$24,397,000	$2,302,904	$1,720,000	$4,253,000	$1.57
15	$22,802,950	$33,064,000	$3,121,008	$2,289,000	$5,722,000	$1.36
20	$28,293,450	$41,025,000	$3,872,470	$2,841,000	$7,100,000	$1.22

Source: Cost Study (CDM 2007a).

Note: Operations and maintenance cost is included in O&M facility labor.

Nanofiltration Water Treatment Technology



Nanofiltration Technology

Table 13 presents probable costs prepared by CDM for NF technology. For cost estimation purposes, the same assumptions are made as described previously for MF/UF technology. This estimate does not include capital costs, such as land acquisition, rights-of-way, transmission mains, and utilities; unusual site work, such as wetland mitigation, demucking, and pilings; finished water storage and high service pumps; and distribution mains. For related groundwater source discussions and costs, see the *Groundwater* section of **Chapter 5** in this Support Document.

Considerations:

- The raw water supply for the NF treatment facility is assumed shallow aquifer wells.
- The design capacity for each well is approximately 2 MGD of raw water per well.
- The NF process is assumed to operate at an 85 percent recovery rate with no raw water blend.
- The number of wells required depends on the raw water feed to the facility at the rated capacity and assumes 20 percent will be standby wells.
- Pretreatment includes raw water acidification, antiscalant feed, and micron cartridge filtration.
- The membrane system includes stainless steel membrane feed pumps and feed piping; membrane skids (pressure vessels, skid piping, membrane elements, control valves, and instrumentation); a membrane cleaning system; and process

piping. Post-treatment includes packed-tower type degasification, a caustic [sodium hydroxide (NaOH)] feed system for pH adjustment, and application of a corrosion inhibitor.

- Pretreatment and post-treatment chemical systems include bulk storage tanks and containment basins; day tanks; metering pumps; chemical piping; and chemical injection quills and/or diffusers.

Table 13. Estimated costs associated with nanofiltration treatment technology.

Facility Capacity (MGD)	Construction Cost	Capital Cost	Equivalent Annual Capital Cost	Annual O&M Cost	Total Annual Production Cost	Cost ($/1,000 gal)
1	$11,073,000	$16,056,000	$1,515,573	$634,000	$2,302,000	$9.46
3	$14,262,000	$20,680,000	$1,952,046	$1,141,000	$3,288,000	$4.50
5	$16,674,000	$24,178,000	$2,282,232	$1,646,000	$4,156,000	$3.42
10	$23,156,000	$33,576,000	$3,169,337	$2,836,000	$6,322,000	$2.34
15	$28,670,000	$41,573,000	$3,924,197	$3,913,000	$8,229,000	$1.95
20	$34,612,000	$50,188,000	$4,737,392	$4,992,000	$10,203,000	$1.75

Source: Cost Study (CDM 2007a).

Note: Operations and maintenance cost is included in O&M facility labor.

Brackish Groundwater Reverse Osmosis Water Treatment Technology

The pretreatment, process, and post-treatment components provided for brackish groundwater RO technology are essentially the same as for the NF system. Exceptions include minor differences for items such as pipe pressure ratings. See also the *Groundwater* section of **Chapter 5**.

Considerations:

- The raw water supply for the brackish groundwater RO treatment technology is assumed for Upper Floridan aquifer wells.
- The design capacity for each well is approximately 2 MGD of raw water per well.
- The lower pressure RO process (compared to NF) is assumed to operate at a 75 percent recovery rate, with no raw water blend.
- The number of wells required depends on the raw water feed to the facility at the rated capacity and assuming 20 percent standby wells.

The probable costs for the brackish groundwater RO technology is shown in **Table 14**. This estimate does not include capital costs, such as land acquisition, rights-of-way, transmission mains, and utilities; unusual site work, such as wetland mitigation, demucking, and pilings; finished water storage and high service pumps; and distribution mains.

Table 14. Estimated costs associated with brackish groundwater reverse osmosis treatment technology.

Facility Capacity (MGD)	Construction Cost	Capital Cost	Equivalent Annual Capital Cost	Annual O&M Cost	Total Annual Production Cost	Cost ($/1,000 gal)
1	$14,406,000	$20,889,000	$1,571,774	$588,000	$2,757,000	$11.33
3	$20,407,000	$29,590,000	$2,793,087	$1,171,000	$4,243,000	$5.81
5	$23,926,000	$34,693,000	$3,274,774	$1,758,000	$5,361,000	$4.41
10	$33,503,000	$48,579,000	$4,585,514	$3,181,000	$8,226,000	$3.04
15	$44,197,000	$64,086,000	$6,049,265	$4,526,000	$11,180,000	$2.65
20	$54,536,000	$79,077,000	$7,464,309	$5,910,000	$14,120,000	$2.42

Source: Cost Study (CDM 2007a).

Notes: Operations and maintenance cost is included in O&M facility labor. Estimated costs are planning-level cost estimates made without detailed engineering design and with a margin of error from +50 percent to -30 percent.

NAVIGATE

The cost estimates provided for developing brackish groundwater RO water treatment technology represent only one component in the water treatment process. Additional process technologies and components, with some related costs for treating and delivering brackish groundwater, are also included in this Support Document:

See also the following section in **Chapter 5** of this document:

- Seawater, Estimated Costs

See also the following sections in this chapter:

- Saltwater Intrusion
- Nanofiltration Process
- Nanofiltration Water Treatment Technology
- Reverse Osmosis Process
- Electrodialysis and Electrodialysis Reversal Process Units
- Water Treatment Technology Process Components

The District's website provides a more detailed discussion about desalination http://my.sfwmd.gov/portal/page/portal/xweb%20-%20release%203%20water%20supply/desalination.

Brackish Surface Water Reverse Osmosis Water Treatment Technology

The pretreatment, process, and post-treatment components provided are essentially the same as previously described for the groundwater NF systems, with the exception of an additional pretreatment step of media filters required upstream due to higher levels of suspended particulate contaminants present in a surface water supply. See also the *Surface Water* section of **Chapter 5** for related background information and costs.

Considerations:

- The raw water supply for the brackish surface water RO treatment technology is assumed to be from a surface water source, such as a brackish river or estuary.
- The intake includes slotted intake screens, pump basin, and vertical turbine intake pumps and assumes that the intake is located on the facility site.
- The brackish surface water RO process is assumed to operate at a 75 percent recovery rate, with no raw water blend.

Table 15 presents the probable costs for brackish surface water RO technology. Related costs do not include capital costs, such as land acquisition, rights-of-way, transmission mains, and utilities; unusual site work, such as wetland mitigation, demucking, and pilings; finished water storage and high service pumps; and distribution mains.

Table 15. Estimated costs associated with brackish surface water reverse osmosis treatment technology.

Facility Capacity (MGD)	Construction Cost	Capital Cost	Equivalent Annual Capital Cost	Annual O&M Cost	Total Annual Production Cost	Cost ($/1,000 gal)
5	$25,927,000	$37,594,000	$3,548,608	$1,846,000	$5,750,000	$4.73
10	$33,768,000	$48,963,000	$4,621,761	$3,371,000	$8,455,000	$3.13
15	$42,883,000	$62,180,000	$5,869,352	$4,818,000	$11,274,000	$2.68
20	$52,464,000	$76,073,000	$7,180,753	$6,310,000	$14,209,000	$2.43

Source: Cost Study (CDM 2007a).

Notes: Operations and maintenance cost is included in O&M facility labor. Estimated costs are planning-level cost estimates made without detailed engineering design and with a margin of error from +50 percent to -30 percent.

Seawater Reverse Osmosis Water Treatment Technology – Surface Intake Co-Located with a Power Plant

The pretreatment, process, and post-treatment components provided are essentially the same as previously described for the brackish surface water RO system, including media filter pretreatment. There are some differences in equipment, pipe pressure ratings, etc., due to the increased operating pressure of seawater RO systems versus brackish water RO systems.

- The raw water supply for the seawater RO water treatment technology is assumed taken from a saltwater bay or Intracoastal Waterway.
- The intake uses the existing cooling water intake for the power plant, and concentrate is discharged to the cooling water outfall.
- The seawater RO process is assumed to operate at a 50 percent recovery rate.

Probable costs for the seawater RO water treatment technology with the surface intake co-located with a power plant is shown in **Table 16**. This estimate does not include capital costs, such as land acquisition, rights-of-way, transmission mains, and utilities; unusual site work, such as wetland mitigation, demucking, and pilings; finished water storage and high service pumps; and distribution mains. For more information, refer to the *Seawater* and *Seawater Estimated Costs* section of **Chapter 5**.

Table 16. Estimated costs associated with seawater reverse osmosis treatment technology.

Facility Capacity (MGD)	Construction Cost	Capital Cost	Equivalent Annual Capital Cost	Annual O&M Cost	Total Annual Production Cost	Cost ($/1,000 gal)
5	$27,192,000	$39,429,000	$3,721,819	$3,145,000	$5,750,000	$5.95
10	$44,203,000	$64,094,000	$6,050,020	$6,230,000	$8,455,000	$4.77
15	$64,019,000	$92,828,000	$8,762,307	$9,248,000	$11,274,000	$4.48
20	$79,610,000	$115,436,000	$10,896,342	$12,432,000	$14,209,000	$4.18

Source: Cost Study (CDM 2007a).

Notes: Operations and maintenance cost is included in O&M facility labor. Estimated costs are planning-level cost estimates made without detailed engineering design and with a margin of error from +50 percent to -30 percent.

Water Treatment Technology Process Components

This section addresses water treatment process units that provide incremental treatment process capacity to an existing water treatment facility. It includes cost estimates for accommodating brackish groundwater, brackish surface water, and seawater.

Nanofiltration Process Units

Nanofiltration process units can be used as: 1) an incremental water treatment facility capacity increase for an existing facility originally designed to accommodate future capacity increases, or 2) a pretreatment process unit for a high-pressure RO treatment facility, such as a seawater desalination facility. The NF process unit consists of cartridge filters; membrane feed pumps; pretreatment chemicals (acid and antiscalant); the membrane units (membrane pressure vessels, frames, and piping); piping inside the membrane building, cleaning system, instruments and controls; and electrical equipment.

The probable costs for NF process addition are shown in **Table 17**. This estimate does not include capital costs, such as land acquisition, rights-of-way, transmission mains, and utilities; unusual site work, such as wetland mitigation, demucking, and pilings; finished water storage and high service pumps; and distribution mains.

Table 17. Estimated costs associated with nanofiltration process addition.

Facility Capacity (MGD)	Construction Cost	Capital Cost	Equivalent Annual Capital Cost	Annual O&M Cost	Total Annual Production Cost	Cost ($/1,000 gal)
1	$10,562,000	$15,315,000	$1,445,628	$615,000	$2,206,000	$9.07
3	$12,728,000	$18,455,000	$1,742,021	$1,086,000	$3,002,000	$4.11
5	$14,389,000	$20,863,000	$1,969,320	$1,646,000	$3,812,000	$3.13
10	$18,666,000	$27,066,000	$2,554,839	$2,836,000	$5,647,000	$2.09
15	$23,050,000	$33,424,000	$3,154,989	$3,913,000	$7,384,000	$1.75
20	$26,951,000	$39,080,000	$3,688,876	$4,992,000	$9,050,000	$1.55

Source: Cost Study (CDM 2007a).

Note: Operations and maintenance cost is included in O&M facility labor.

Brackish Water Reverse Osmosis Process Units

The brackish water RO process unit can be used as: 1) an incremental water treatment facility capacity increase for an existing facility originally designed to accommodate future capacity increase, or 2) a replacement process unit during the conversion of an existing water treatment facility to a different water source, such as a conversion from a NF to a RO treatment facility with the source changing from a shallow freshwater aquifer to a brackish aquifer. The brackish water RO process unit consists of cartridge filters; membrane feed pumps, pretreatment chemicals (acid and antiscalant); the membrane units (membrane pressure vessels, frames, and piping); piping inside the membrane building, cleaning system, instruments and controls; and electrical equipment.

Table 18 presents probable costs for the RO process addition. Related costs do not include capital costs, such as land acquisition, rights-of-way, transmission mains, and utilities; unusual site work, such as wetland mitigation, demucking, and pilings; finished water storage and high service pumps; and distribution mains.

Table 18. Estimated costs associated with brackish water reverse osmosis process addition.

Facility Capacity (MGD)	Construction Cost	Capital Cost	Equivalent Annual Capital Cost	Annual O&M Cost	Total Annual Production Cost	Cost ($/1,000 gal)
1	$12,959,000	$18,791,000	$1,773,737	$574,000	$2,525,000	$10.38
3	$16,065,000	$23,294,000	$2,198,789	$1,128,000	$3,547,000	$4.86
5	$18,136,000	$26,297,000	$2,482,251	$1,757,000	$4,488,000	$3.69
10	$21,923,000	$31,788,000	$3,000,562	$3,180,000	$6,481,000	$2.40
15	$26,830,000	$38,905,000	$3,672,357	$4,525,000	$8,565,000	$2.03
20	$31,379,000	$45,500,000	$4,294,878	$5,909,000	$10,633,000	$1.82

Source: Cost Study (CDM 2007a).

Note: Operations and maintenance cost is included in O&M facility labor.

Distribution Process Components

Distribution process components are likely to be common among the various water treatment technology processes. Process components listed in this section include finished water storage and high service pumping.

Finished Water Storage

Finished water storage facilities, such as ground storage tanks, towers, and reservoirs, provide storage of treated water before it is distributed to users. The storage provides a reserve of water to avoid service interruption during system emergencies; helps maintain uniform system pressure; permits reduction in sizes of distribution mains; and helps meet peak system demands while allowing a water treatment facility to operate at a relatively constant rate. The finished water storage requirements and associated costs are assumed the same for various treatment technologies for each facility capacity. Costs include a prestressed concrete (Crom-type) ground storage tank sized to provide approximately 50 percent of the rated facility capacity daily flow. For example, for a 10 MGD facility, a 5.0 million gallon storage tank is provided.

Probable costs for the finished water storage component are shown in **Table 19**.

Table 19. Estimated costs for finished water storage.

Facility Capacity (MGD)	Construction Cost	Capital Cost	Equivalent Annual Capital Cost	Total Annual Production Cost	Cost ($/1,000 gal)
5	$1,045,000	$1,515,000	$143,005	$143,000	$0.12
10	$1,899,000	$2,754,000	$259,958	$260,000	$0.10
15	$2,562,000	$3,715,000	$350,670	$351,000	$0.08
20	$3,036,000	$4,402,000	$415,518	$416,000	$0.07

Source: Cost Study (CDM 2007a).

Note: Operations and maintenance cost is included in O&M facility labor.

High Service Pumping

High service pumps are used to pump treated water into the water distribution system. The high service pumping requirements and associated costs are assumed the same for various treatment technologies for each facility capacity. Costs include a high service pumping system with a firm pumping capacity equal to 200 percent of the facility capacity rating to meet peak hour demands. This corresponds to a peak hour demand-to-maximum day demand peaking factor of 2.0.

Table 20 presents probable costs for the high service pumping component. This cost estimate does not include distribution system piping and the finished water storage component costs.

Table 20. Estimated costs for high service pumping.

Facility Capacity (MGD)	Construction Cost	Capital Cost	Equivalent Annual Capital Cost	Annual O&M Cost	Total Annual Production Cost	Cost ($/1,000 gal)
5	$633,000	$918,000	$86,653	$86,000	$182,000	$0.15
10	$930,000	$1,350,000	$127,430	$182,000	$327,000	$0.12
15	$1,099,000	$1,594,000	$150,462	$290,000	$455,000	$0.11
20	$1,399,000	$2,029,000	$191,523	$401,000	$612,000	$0.10

Source: Cost Study (CDM 2007a).

Note: Operations and maintenance cost is included in O&M facility labor.

Disinfection Process Components

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

Public Water Supply facilities 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. The use of free chlorine as a disinfectant often results in the formation of unacceptable levels of TTHMs and other DBPs when free chlorine combines with naturally occurring organics 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, 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, and on-site generation of sodium hypochlorite. 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.

The construction costs for a chlorination system using on-site generation of sodium hypochlorite include equipment and installation. Operations and maintenance costs include energy and chemicals, but do not include labor and normal maintenance, which are covered under the facility O&M labor (CDM 2007a).

Probable costs associated with a chlorination system using on-site generation of sodium hypochlorite are shown in **Table 21**.

Table 21. Estimated costs for chlorination disinfection by on-site generation of sodium hypochlorite.

Facility Capacity (MGD)	Construction Cost	Capital Cost	Equivalent Annual Capital Cost	Annual O&M Cost	Total Annual Production Cost	Annual Production Cost ($/1,000 gal)
5	$1,745,000	$2,530,000	$238,814	$18,000	$281,000	$0.23
10	$2,941,000	$4,264,000	$402,491	$36,000	$478,000	$0.18
15	$3,985,000	$5,778,000	$545,402	$54,000	$654,000	$0.16
20	$4,946,000	$7,172,000	$676,986	$72,000	$817,000	$0.14

Source: Cost Study (CDM 2007a).

Note: Operations and maintenance cost is included in O&M facility labor.

Ultraviolet Light

The 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 rendering the microorganisms harmless. Ultraviolet light inactivates microbes by damaging their nucleic acids, 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*. 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).

The probable costs for UV disinfection were derived from technology cost estimates for complying with new drinking water regulations under the U.S. Environmental Protection Agency (USEPA) (2005). All capital cost estimates were derived directly from the USEPA capital cost tables, with appropriate adjustments for inflation, contractors, and project mark-ups. The O&M costs (except for replacement parts and materials) were developed by CDM using standard unit costs for power and labor.

Table 22 presents probable costs for UV disinfection.

Table 22. Estimated costs for ultraviolet light disinfection.

Facility Capacity (MGD)	Construction Cost	Capital Cost	Equivalent Annual Capital Cost	Annual O&M Cost	Total Annual Production Cost	Cost ($/1,000 gal)
1	$436,998	$633,998	$60,000	$11,800	$77,800	$0.37
3	$496,999	$720,999	$68,000	$21,200	$96,000	$0.14
5	$627,000	$909,000	$86,000	$28,200	$122,800	$0.10
10	$1,244,000	$1,804,000	$170,000	$46,700	$233,700	$0.09
15	$1,995,000	$2,893,000	$273,000	$65,400	$365,700	$0.09
20	$2,700,000	$3,915,000	$370,000	$86,300	$493,300	$0.08

Source: Cost Study (CDM 2007a).

Note: Operations and maintenance cost is included in O&M facility labor.

Ozonation

Ozonation is a water disinfection method that uses the same type of 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 taste and odor issues within a Public Water Supply (AWWA 2003).

Ozonation is widely used in Western Europe. However, in the United States, use of ozonation is more limited. The Orlando Utilities Commission has been using ozonation since 2002. Other community water suppliers using ozonation are located in California, Colorado, Michigan, Maine, New Jersey, Oklahoma, Pennsylvania, Texas, Wisconsin, and Wyoming. The cost of ozonation is approximately four times higher than that of traditional chlorine disinfection because of the much greater amount of electricity needed for water treatment. Another disadvantage of this technology is that unlike chlorine, ozone dissipates quickly in water supplies; contaminants entering the water after it is disinfected and leaves the facility could go untreated. Ozonation does not produce the DBPs associated with chlorine disinfection.

The probable costs for ozonation were derived from technology cost estimates for complying with new drinking water regulations (USEPA 2005).

Considerations:

- All capital cost estimates were derived directly from the USEPA capital cost tables, with appropriate adjustments for inflation and contractor and project mark-ups.
- The O&M costs (except for replacement parts and materials) were developed by CDM using standard unit costs for power, liquid oxygen, and labor.

- The USEPA cost tables assumed:
  - A design dose of 4.5 mg/L
  - Contact time of 12 minutes
  - N+1 equipment redundancy for achieving 0.5-log *Cryptosporidium* inactivation credit under the USEPA (2005)
- These assumptions also represent conservative design criteria for providing 3-log *Giardia* inactivation for water supplies with moderate ozone demand and decay rates, based on CDM's ozone design experience.
- The ozone generation building cost was based on a unit cost of $150 per square foot, based on CDM's design experience, which was significantly higher than the unit cost used in the USEPA estimates.
- Power and liquid oxygen chemical costs for O&M cost were calculated based on:
  - Average process flows for each design capacity
  - An average ozone dose of 2.5 mg/L
  - Constant ozone-in-oxygen concentration of 10 percent by weight
- The required O&M labor for the ozone system assumes that this process is an add-on process to a fully staffed conventional water treatment facility with no additional staff positions required.

Table 23 shows probable costs for ozonation disinfection.

Table 23. Estimated costs for ozonation.

Facility Capacity (MGD)	Construction Cost	Capital Cost	Equivalent Annual Capital Cost	Annual O&M Cost	Total Annual Production Cost	Cost ($/1,000 gal)
1	$743,998	$1,078,998	$102,000	$50,800	$163,000	$0.78
3	$1,369,999	$1,984,999	$187,000	$60,200	$265,900	$0.39
5	$1,994,000	$2,892,000	$273,000	$69,500	$369,800	$0.30
10	$3,068,000	$4,448,000	$420,000	$101,600	$563,600	$0.21
15	$4,048,000	$5,869,000	$554,000	$133,700	$743,100	$0.18
20	$4,892,000	$7,094,000	$670,000	$167,300	$904,300	$0.15

Source: Cost Study (CDM 2007a).

Note: Operations and maintenance cost is included in O&M facility labor.

WASTEWATER TREATMENT TECHNOLOGIES

Treatment facilities that use reclaimed water for public access irrigation must provide filtration and high-level disinfection (advanced secondary treatment). The following information includes an overview of advanced treatment and processes used to produce higher quality reclaimed water. It does not include related components such as transmission systems, storage, alternative disposal, and modifications to the application area for wastewater treatment. See also **Chapter 5** of this Support Document.

Wastewater Treatment Facilities

Wastewater treatment in the SFWMD is provided by:

- Regional, municipal, or privately owned wastewater treatment facilities
- Small developer/homeowner association or utility-owned wastewater treatment facilities
- Septic tanks

Many of the smaller wastewater treatment facilities are constructed on an interim basis until regional wastewater facilities become available. Upon connection to the regional wastewater system, the smaller wastewater treatment facility is typically abandoned.

Wastewater treatment in the SFWMD is regulated by the FDEP. Pursuant to Chapter 62-600, F.A.C., the following wastewater treatment facilities are exempt from the FDEP regulation and are regulated by the local health department for each county:

- 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
- 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

All of the FDEP-regulated facilities within the SFWMD use the activated sludge treatment process.

Wastewater treatment facilities use integrated processes to treat wastewater to a desired quality. At a minimum, wastewater facilities in Florida provide secondary treatment. These facilities typically dispose of effluent via deep injection wells or ocean outfalls. Ocean outfall is further discussed in the *2013 Lower East Coast Water Supply Plan Update* (SFWMD 2013a).

Advanced Secondary Treatment

Advanced secondary treatment typically refers to the addition of filtration and high-level disinfection to a secondary treatment facility. Most of the water from these facilities is reused for irrigation of public access areas.

Granular Media Filters Followed by Ultraviolet Disinfection

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. Granular media filtration, typically sand, is a polishing step that lowers the levels of suspended solids and associated contaminants in treated wastewater. This filtration, followed by UV disinfection, kills pathogenic microorganisms in the wastewater before being discharged into the environment. Types of granular media filters include slow sand, rapid sand, deep bed, upflow, pulsed bed dual, and multimedia.

To achieve high-level disinfection in an advanced secondary treatment process, monitoring and chemical feed equipment is also needed.

The costs associated with granular media filters followed by UV disinfection are presented in **Table 24**. The construction costs include all equipment, material, and installation, and the O&M costs include all energy, labor, and other maintenance.

- The following assumptions were applied to develop the cost estimates: granular media filter construction cost is based on deep bed filters. Cost includes equipment, concrete, and installation.
- UV construction cost is based on an in-vessel medium pressure system.
- The facility infrastructure includes building to house process equipment.

Table 24. Estimated costs for granular media filters followed by UV disinfection.

Facility Capacity (MGD)	Construction Cost	Capital Cost	Equivalent Annual CapitalCost	Annual O&M Cost	Total Annual Production Cost	Cost ($/1,000 gal)
5	$4,309,000	$6,247,000	$590,000	$421,000	$1,070,000	$0.59
10	$8,376,000	$12,145,000	$1,146,000	$841,000	$2,102,000	$0.58
15	$12,485,000	$18,103,000	$1,709,000	$1,262,000	$3,142,000	$0.57
20	$15,832,000	$22,957,000	$2,167,000	$1,683,000	$4,067,000	$0.56

Source: Cost Study (CDM 2007a).

Note: Operations and maintenance cost is included in O&M facility labor.

Advanced Wastewater Treatment

Advanced wastewater treatment (AWT) involves the upgrade of an existing wastewater treatment facility from advanced secondary treatment to AWT to achieve nitrogen and phosphorus removal. Advanced wastewater treatment refers to a level of treatment that meets effluent limits of 5 mg/L total suspended solids, 5 mg/L carbonaceous biochemical oxygen demand, 3 mg/L total nitrogen, and 1 mg/L total phosphorus on an annual average basis.

In the past, AWT was associated with facilities that use stream discharge for effluent disposal. However, AWT is now employed to allow use of reclaimed water for wetland restoration, groundwater recharge systems, and other advanced uses of reclaimed water.

Five-stage Bardenpho Process

Many AWT process configurations have been developed to accomplish biological nutrient removal from advanced secondary treatment effluent. One configuration commonly used in Florida to provide high levels of nitrogen and phosphorus removal is the five-stage Bardenpho process.

Table 25 presents the costs for AWT that include a five-stage Bardenpho process and deep bed filters after secondary clarification to further remove total suspended solids.

Table 25. Estimated costs for advanced wastewater treatment – five-stage Bardenpho process.

Facility Capacity (MGD)	Construction Cost	Capital Cost	Equivalent Annual Capital Cost	Annual O & M Cost	Total Annual Production Cost	Cost ($/1,000 gal)
5	$17,326,320	$25,123,000	$2,371,000	$1,417,000	$4,025,000	$2.21
10	$27,809,760	$40,323,000	$3,806,000	$2,738,000	$6,925,000	$1.90
15	$38,291,880	$55,524,000	$5,241,000	$4,037,000	$9,802,000	$1.79
20	$48,252,600	$69,967,000	$6,604,000	$5,322,000	$12,586,000	$1.72

Source: Cost Study (CDM 2007a).

Note: Operations and maintenance cost is included in O&M facility labor.

Membrane Bioreactor Process

One of the most important technological advances in biological wastewater treatment is the development and application of a membrane bioreactor process for full-scale municipal wastewater treatment. The membrane bioreactor is a suspended growth-activated sludge system that uses microporous membranes for solid and liquid separation instead of secondary clarifiers. The membrane component uses low-pressure MF or UF membranes and eliminates the need for clarification and tertiary filtration. The membranes are typically immersed in an aeration tank; however, some applications use a separate membrane tank.

One of the key benefits of a membrane bioreactor system is that it effectively overcomes the limitations of poor settling of sludge in conventional activated sludge processes.

The construction costs developed for a membrane bioreactor facility are based on the following process modules: influent pumping; preliminary treatment; aeration tanks; membrane tanks; UV disinfection; effluent pump station; and sludge treatment and handling.

Process construction cost includes estimates for anoxic and aeration tanks; process blowers; return activated sludge pumps; membrane tanks; air scour blowers; permeate pumps; and membrane cleaning system. The Modified Ludzack-Ettinger process is assumed for the membrane bioreactor configuration.

Table 26 shows the costs for the membrane bioreactor process.

Table 26. Estimated costs for advanced wastewater treatment – membrane bioreactor process.

Facility Capacity (MGD)	Construction Cost	Capital Cost	Equivalent Annual Capital Cost	Annual O&M Cost	Total Annual Production Cost	Cost ($/1,000 gal)
5	$50,896,000	$73,799,000	$6,966,000	$2,219,000	$9,882,000	$5.41
10	$78,338,000	$113,591,000	$10,722,000	$3,645,000	$15,439,000	$4.23
15	$104,142,000	$151,006,000	$14,254,000	$5,109,000	$20,788,000	$3.80
20	$122,715,000	$177,937,000	$16,796,000	$6,890,000	$25,366,000	$3.47

Source: Cost Study (CDM 2007a).

Note: Operations and maintenance cost is included in O&M facility labor.

Microfiltration/Reverse Osmosis Process

Another advanced wastewater process to treat existing secondary effluent is the addition of MF and RO systems to the secondary treatment facility.

Reverse Osmosis Trains

The construction costs for the MF and RO process include pretreatment facilities, a MF system, and a RO system. The following assumptions are used to develop cost estimates for the MF and RO option:

- Pretreatment construction cost includes estimates for rotary drum 2 mm fine screens.
- MF system cost is based on a submerged MF system. Cost includes equipment, concrete, and installation.
- RO system cost includes membranes, break tank, in-line pump station, and chemical feed and storage systems for pH adjustment and corrosion protection. The cost estimate is based on a RO system with an 80 percent recovery rate.
- Concentrate disposal is based on a deep injection well, which is included in the cost estimate.

Table 27 presents the costs for the MF and RO process.

Table 27. Estimated costs for advanced wastewater treatment – microfiltration/reverse osmosis.

Facility Capacity (MGD)	Construction Cost	Capital Cost	Equivalent Annual Capital Cost	Annual O&M Cost	Total Annual Production Cost	Cost ($/1,000 gal)
5	$45,234,000	$65,590,000	$6,191,000	$3,311,000	$10,121,000	$5.55
10	$73,636,000	$106,772,000	$10,079,000	$6,256,000	$17,343,000	$4.75
15	$97,911,000	$141,972,000	$13,401,000	$7,194,000	$21,935,000	$4.01
20	$118,615,000	$171,992,000	$16,235,000	$9,592,000	$27,451,000	$3.76

Source: Cost Study (CDM 2007a).

Note: Operations and maintenance cost is included in O&M facility labor.

GROUNDWATER CONTAMINATION AND IMPACTS TO WATER SUPPLY

Some contaminants can be costly and difficult for water treatment facilities to remove from drinking water supplies. The cost and degree of difficulty depends upon the contaminant. Contaminant means any physical, chemical, biological, or radiological substance or matter in water (Section 403.852(9).

An effective groundwater monitoring program is critical for accurate determination of groundwater degradation. Improperly located monitor wells can result in the oversight of a contaminant plume. In addition, certain unacceptable parameters may not be observed in the groundwater for many years, depending on soil adsorption capacities and groundwater gradient.

The following discussion reviews major groundwater contamination sources.

Groundwater Contamination Sources

Aquifers can be contaminated in several ways. Activity occurring on ground surfaces can contaminate the surficial aquifer system (SAS), while saltwater intrusion presents a potential threat to aquifers. Once a contaminant enters the aquifer, it may be difficult to remove. In many cases, leaks, spills, or discharges of contaminants result in contamination of large areas of the aquifer. Therefore, preventing contamination of the aquifer by protecting Public Water Supply wells and wellfields from activities that present a possible contamination threat is preferable. Many counties have enacted well-protection ordinances.

Saltwater Intrusion

Saltwater intrusion is the movement of saline water into fresh water aquifers and can occur laterally or vertically. This movement of saline water has the potential to occur in most coastal aquifers that are hydraulically connected to seawater. Within the District, salinity control structures have been installed in all canals that connect to tidal basins to limit saltwater encroachment and maintain freshwater heads on the inland side.

Freshwater aquifers that overlie saline aquifers also have the potential for contamination from saline water. As the freshwater aquifer is pumped, upconing of the saline water may occur. This can be a significant threat because of its potential to degrade water supplies. Public Water Supply utilities, as well as other use classes, establish monitor wells to provide information about the quality of the water in the aquifers.

In the past, cross-contamination of shallow aquifers has occurred from some of the Floridan aquifer system (FAS) wells within the District. This can occur in several ways. A number of artesian wells were drilled into the FAS for agricultural water supply and oil exploration from the 1930s through the 1950s. These wells were constructed with casings that extend to about 200 feet or less below land surface (bls). This construction method exposed shallower freshwater zones to invasion by more saline Floridan water.

Over time, some wells that were constructed properly have had their steel casings corrode, allowing interaquifer exchange through the deteriorating casings. Occasionally, an abandoned well was plugged improperly or simply left open, free flowing on the land surface and recharging the SAS with saline water. In addition, as Floridan water is used as a supplemental source for agriculture during periods of water shortage, this brackish water can infiltrate the SAS.

The *Water Quality Assurance Act* passed in 1981 requires Floridan wells to be equipped with a valve capable of controlling the discharge from the well. Property owners are responsible for wells located on their land. Permit holders are required to maintain their wells and properly abandon them when necessary.

The SFWMD Water Use Regulatory Database includes compliance data associated with respective water use permits. Saltwater intrusion data are maintained as a component of this compliance data, and include information about chlorides, specific conductance, and water levels from the monitoring network information contained in the Water Use Regulatory Database. The monitoring network receives monitor well data supplied by Public Water Supply utilities and the U.S. Geological Survey (USGS).

The effects of saltwater intrusion, upconing, aquifer cross-contamination, and connate water can create complex and somewhat unpredictable scenarios for local groundwater quality. Although monitor wells provide a great deal of information where they exist, there are limits as to how many wells can be installed. Where more saltwater interface data are required, additional methods must be considered. Geophysical surveys can provide useful information about the extent of saltwater intrusion (Benson and Yuhr 1993).

Microconstituents

Microconstituents comprise a relatively new group of compounds whose health effects are presently unknown. The FDEP defines microconstituents as follows:

> Microconstituents, sometimes known as "emerging pollutants of concern," are chemicals found in a wide array of consumer goods, including pharmaceuticals and personal care products. Some of the microconstituents are considered "endocrine disrupters" (compounds such as synthetic estrogen, PCBs, dioxin, and some pesticides that may interfere with or modify hormone processes within an organism) (FDEP 2009).

The number of constituents that fall within the microconstituent definition is well beyond the number of contaminants currently monitored in drinking water. As technology has advanced to the point that trace quantities of these chemicals can now be detected, a significant amount of research activity is devoted to determining the distribution and occurrence of these substances in drinking water, the associated health implications, and methods of treatment for contaminants that may be considered a health risk. Microconstituent removal may become a performance standard in the future.

The USGS performed a national water quality survey of microconstituents. The survey, *Water-Quality Data for Pharmaceuticals, Hormones, and Other Organic Wastewater Contaminants in U.S. Streams, 1999–2000* (USGS 2002) is available from http://toxics.usgs.gov/pubs/OFR-02-94/index.html.

Solid Waste Sites

Although groundwater monitoring began in the early 1980s for landfills, inactive sites may still pose a potential threat to groundwater resources. Many of Florida's older landfills and dumps were used for years with little or no controls over the types of material disposed.

Leachate is the contaminant-laden liquid that drains from a landfill. Leachates often contain high concentrations of nitrogen and ammonia compounds, iron, sodium, sulfate, total organic carbon, biological oxygen demand, and chemical oxygen demand. 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 contaminants in the leachate 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

The FDEP is responsible for rule development, solid waste policy, and implementation of Florida's solid waste management program. More information about solid waste is available from http://www.floridadep.org/waste/categories/solid_waste.

Hazardous Waste Sites

The FDEP sponsors several programs that provide support for hazardous waste site cleanup, including:

- Early Detection Incentive Program
- Petroleum Liability and Restoration Program
- Abandoned Tank Restoration Program
- Petroleum Cleanup Participation Program
- Preapproved Advanced Cleanup Program

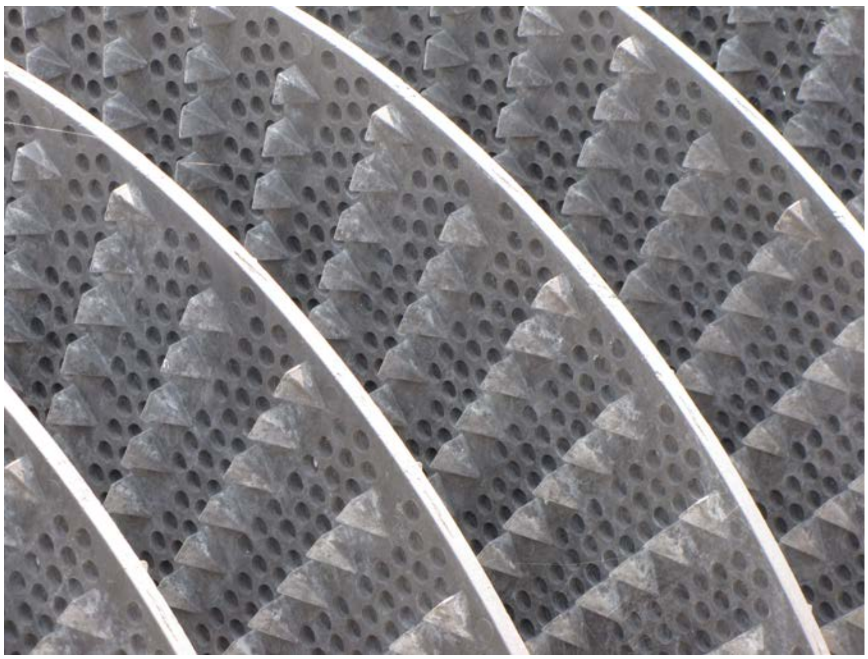
Locations and cleanup status can be obtained through the FDEP Waste Management Section. The FDEP website provides current listings of hazardous waste sites, available from http://www.floridadep.org.

Superfund Program Sites

The *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, commonly known as "Superfund," authorized the 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 USEPA's Superfund Program is available from http://www.epa.gov.

Septic Tanks

Septic systems are a common method of on-site waste disposal for single-family homes or small commercial facilities. Septic tanks exist throughout the District's planning areas and are a threat to groundwater resources used as drinking water sources. 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 are a particular threat. In many neighborhoods served by septic tanks, centralized wastewater collection systems are being installed.


Wastewater Treatment Facility

7

Kissimmee Basin Planning Area

TOPICS
Planning Area Boundaries
Physical Features
Water Resources and System Overview
Ecosystem Restoration Efforts

This chapter describes characteristics of the Kissimmee Basin (KB) Area. For 2011–2014 planning purposes, this region is divided into two basins and addressed in two different water supply plans. The Upper Kissimmee Basin (UKB) is a part of the Central Florida Coordination Area (CFCA), which includes Seminole, Orange, and Osceola counties and south Lake County within the St. Johns River Water Management District; Orange, Osceola, and Polk counties within the South Florida Water Management District; and Polk County within the Southwest Florida Water Management District. As a part of the Central Florida Water Initiative (CFWI) mission to implement a long-term approach to water resource management in central Florida, a single water supply plan for the CFCA region is being developed, called the *2014 Central Florida Water Initiative Regional Water Supply Plan* (SJRWMD, SWFWMD and SFWMD 2014). The Lower Kissimmee Basin (LKB), which includes Glades, Highlands, and Okeechobee counties, is addressed in the *Lower Kissimmee Basin Water Supply Plan* (LKB Plan) (SFWMD in process).

PLANNING AREA BOUNDARIES

Lake Kissimmee, S-65 Structure

In the SFWMD, the KB Planning Area extends from southern Orange County, south along the Kissimmee Chain of Lakes and the Kissimmee River, to the north shore of Lake Okeechobee. Located in central Florida, the area includes portions of Orange, Osceola, Polk, Highlands, Okeechobee, and Glades counties as shown in **Figure 5**. 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

Water bodies and wetlands together cover about a quarter of the KB Planning Area. Most wetland systems in the KB Planning Area drain into the Kissimmee River and, subsequently, into Lake Okeechobee.


Taylor Creek/Nubbin Slough Basin

Major features of the KB Planning Area include the Kissimmee Chain of Lakes, Kissimmee River and its floodplain, and Lake Istokpoga – Indian Prairie. Shingle Creek Swamp and Reedy Creek Swamp, two large forested wetlands in the northernmost reaches of the KB Planning Area, start the headwaters of the Kissimmee Chain of Lakes.

Fisheating Creek, west of Lake Okeechobee, marks the southernmost boundary of the KB Planning Area. The Fisheating Creek Basin extends from west-central Highlands County (from just south of State Road 66) southward into the northern portion of Glades County. The creek collects runoff from the Lake Wales Ridge, located in Highlands County, as well as some runoff from Glades County. Fisheating Creek is the only remaining naturally flowing tributary to Lake Okeechobee.

The Taylor Creek/Nubbin Slough Basin, located north and northeast of Lake Okeechobee, respectively, is considered within the KB Planning Area because of its hydrologic relationship to the Kissimmee River and Lake Okeechobee.

Water Bodies and Landscapes

The Upper Kissimmee Basin contains hundreds of lakes; however, the Kissimmee Chain of Lakes is the dominant hydrologic feature (see the *Kissimmee Chain of Lakes* section of this chapter). Outflow from Lake Kissimmee enters the Kissimmee River and the channelized C-38 Canal before continuing southward to Lake Okeechobee (see the *Lower Kissimmee Basin* section of this chapter).

The Kissimmee River and its floodplain are characterized by forested, wetland shrub, and marsh wetlands. The federally authorized Kissimmee River Restoration Project is modifying more than 39 square miles of river/floodplain. When completed, more than 40 miles of meandering river channel will once again receive reestablished flow. (See **Chapter 3** of this document, the upcoming LKB Plan (SFWMD in process), and the *South Florida Environmental Report – Volume I*, available from http://www.sfwmd.gov/sfer for more information about Kissimmee River Restoration.)

The Lake Istokpoga – Indian Prairie Basin is located within the Lower Kissimmee Basin. Lake Istokpoga is 44 square miles and the fifth-largest lake in Florida (see the *Lake Istokpoga – Indian Prairie Basin* section of this chapter). Lake Istokpoga receives water from Arbuckle and Josephine creeks, which collect runoff from the western portion of the planning area and from areas within the SWFWMD.

Encompassing 730 square miles, Lake Okeechobee is the largest lake in the southeastern United States and a central component of the hydrology and environment of south Florida.

Lake Istokpoga – Cypress

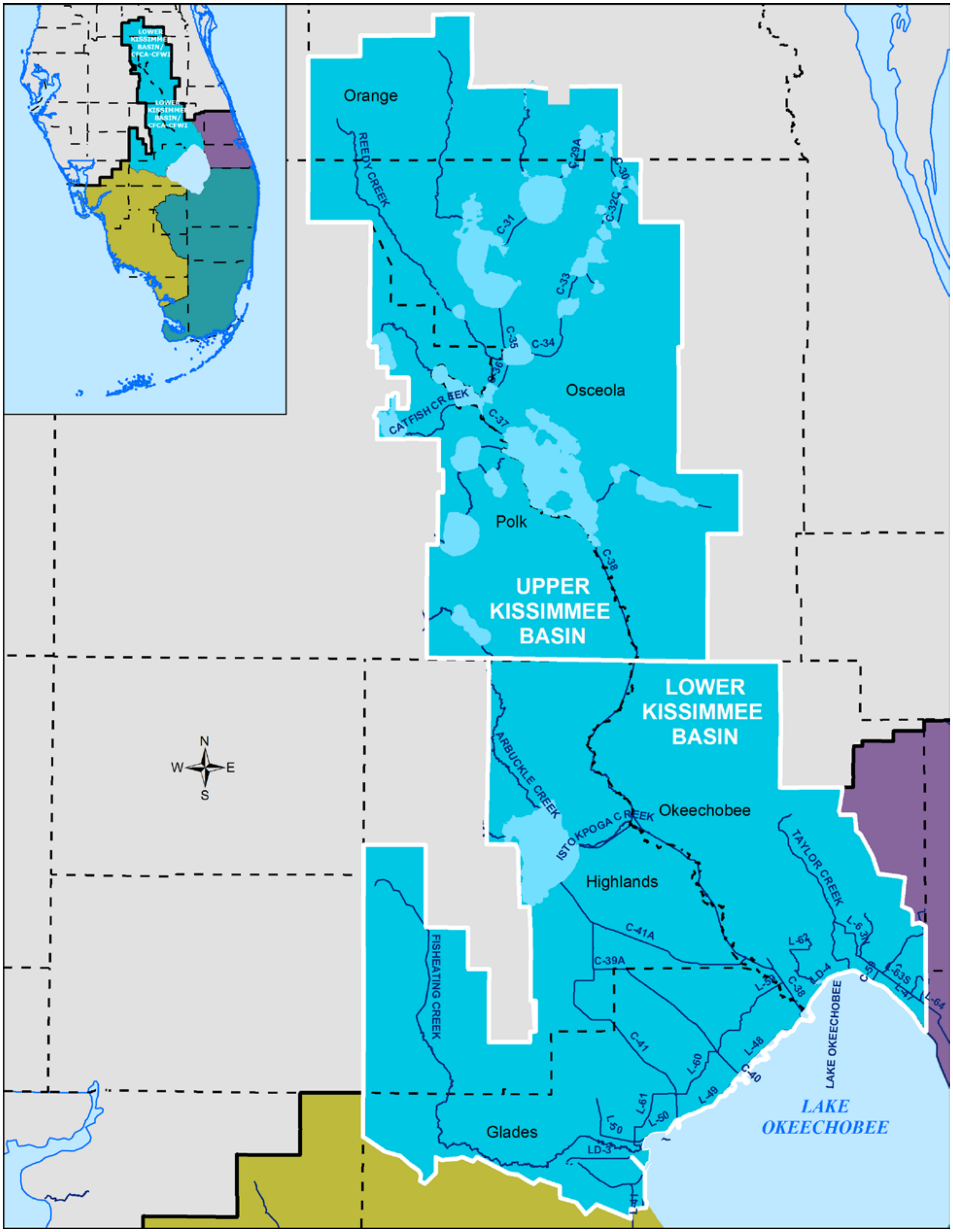


Figure 5. Kissimmee Basin Planning Area.

Geography and Climate

The KB Planning Area encompasses 3,488 square miles in central Florida, and its average elevation is 63 feet above mean sea level (MSL).

Average seasonal temperatures for the area range from 41°F to 86°F. Annual rainfall averages between 45 inches and 50 inches (see also the *Precipitation and Evapotranspiration* section).

Physiography

The KB Planning Area has three major physiographic zones: 1) Lake Wales Ridge, 2) Osceola Plain, and 3) Okeechobee Plain (**Figure 6**). In general, the physiographic features in the region were formed as the land mass gradually emerged from a receding ocean. Several million years ago, the Lake Wales Ridge was a peninsula that existed when much of Florida was under water.

The Lake Wales Ridge is a relict beach and sand dune system that runs along the western edge of the KB Planning Area. Bounded on the east by the Osceola and Okeechobee plains, the ridge stretches approximately 100 miles from Orange County to southern Highlands County, and ranges from 4 miles to 10 miles in width.

Elevations generally exceed 100 feet above MSL, but may reach over 200 feet above MSL 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, although the base of the ridge is used as the district boundary. Most of the surface waters to the east of the ridge drain toward the Kissimmee River region.

Lake Kissimmee

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

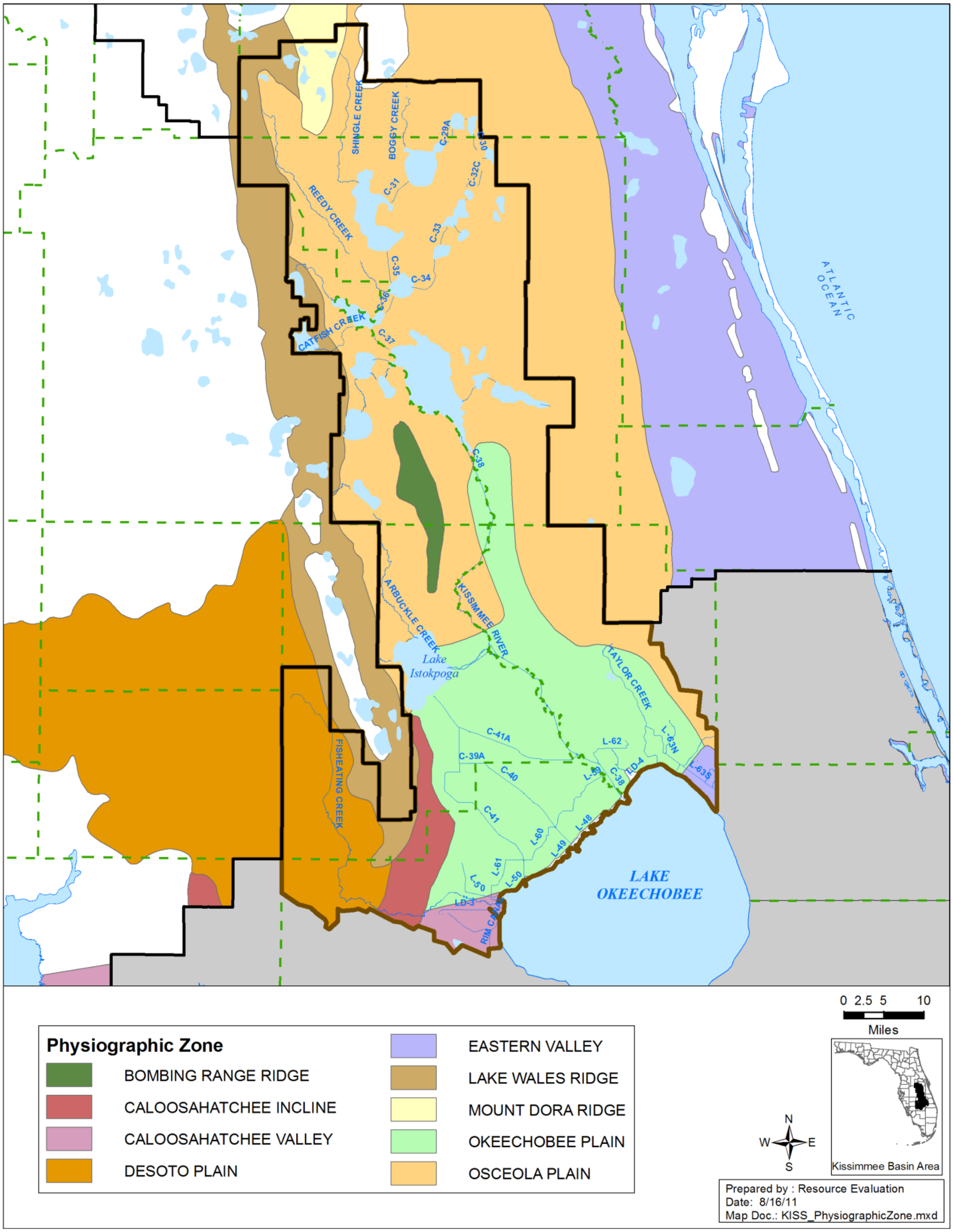


Figure 6. Physiography of the Kissimmee Basin Planning Area.

The Avon Park Bombing Range Ridge is a distinctive feature within the Osceola Plain and part of an important conservation and recreational area within the KB Planning Area. This region is centrally located, linking the Three Lakes, Kissimmee Prairie, and Lake Wales Ridge conservation areas to create one of the largest preservation areas north of Lake Okeechobee. This north/south trending sand ridge extends from southeastern Polk County into northeastern Highlands County, where it reaches its maximum altitude of 146 feet.

Numerous lakes are located within the Osceola Plain, including the Kissimmee Chain of Lakes (see *Kissimmee Chain of Lakes* section of this chapter). Most of the area's natural lakes may have formed from depressional areas in the original limestone deposition.

The lakes on the Osceola Plain drain into the Kissimmee River. Water flows into the southern end of Lake Hatchineha, runs southward through Lake Kissimmee, and continues south through the Osceola and Okeechobee plains, before entering Lake Okeechobee. Where the Kissimmee River flows across the Osceola Plain, it occupies a floodplain valley about 1.5 miles wide. However, where the river flows in the Okeechobee Plain, the distinction between the valley and upland surface is difficult to perceive.

The Caloosahatchee Incline borders the southeastern portion of the Lake Wales Ridge and the western portion of the Okeechobee Plain. This long, narrow inclines gently slopes eastward and ranges in altitude between 30 and 40 feet above MSL.

The Okeechobee Plain is adjacent to Lake Okeechobee and spans an area about 30 miles wide and 30 miles long, with less local relief than the Osceola Plain. The Okeechobee Plain gradually slopes southward from an elevation of 30 feet to 40 feet above MSL near the top of its boundary, to about 20 feet above MSL at the north shore of Lake Okeechobee. The Fisheating Creek and Indian Prairie basins are within the Okeechobee Plain. Fisheating Creek remains largely undisturbed as a natural flow-way to Lake Okeechobee.

WATER RESOURCES AND SYSTEM OVERVIEW

In the following sections, surface water and groundwater resources are addressed as separate entities. Surface water resources in the KB Planning Area include lakes, rivers, springs, and canals. Groundwater resources include the Floridan aquifer, and to a lesser extent, the surficial aquifer.

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 region's wet season is June through October; the dry season starts in November and continues through May. The planning area's annual rainfall averages between 45 inches and 50 inches.

On average, 62 percent of the rainfall in the Upper Kissimmee Basin and 64 percent of the rainfall in the Lower Kissimmee Basin occur during the wet season. The Upper Kissimmee Basin's heaviest rainfall month is July, with monthly rainfall averaging 7.44 inches. The Lower Kissimmee Basin's heaviest rainfall month is June, with monthly rainfall averaging 7.26 inches. The lightest rainfall month for both basins is December, when monthly rainfall averages 1.73 inches (SFWMD 1999).

Hydrologic and meteorological methods are available to measure and 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 groundwater recharge. The estimate of potential evapotranspiration (ETp) from open water and wetlands in the Kissimmee Basin is 49 inches (Abtew et al. 2003). Potential evapotranspiration represents the total estimated passive water use of an area under maximum conditions. While actual evapotranspiration varies due to temperature, soil moisture, and other factors, ETp estimates are important landscape-level factors in water balance calculations to determine if enough water will be available for all uses during different environmental conditions.

Surface Water Inflow and Outflow

Surface water flow includes inflow from areas adjacent to the planning basin and rainfall within the basin and storage, and outflow to Lake Okeechobee via the Kissimmee River, and Indian Prairie and Fisheating Creek basins. 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 Kissimmee Chain of Lakes act as the primary surface water features in northern Osceola County. Each of these hydrologic features eventually connects to the Kissimmee River, which is the primary drainage feature of the basin. Lakes located along the Lake Wales Ridge generally drain internally, providing important recharge for the intermediate and Floridan aquifer systems.

In general, stormwater runoff within the KB Planning Area is directed to one of the hydrologic features mentioned previously. However, three sources of natural inflow come from areas adjacent to the planning area. 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.

Groundwater Flow

Three major hydrogeologic units underlie the KB Planning Area: the surficial aquifer system (SAS), the intermediate confining unit (ICU), and the Floridan aquifer system (FAS). The surficial aquifer is primarily recharged by rainfall, and interacts with surface water features, such as rivers, canals, and lakes. The surficial aquifer also provides temporary storage for infiltrating water that eventually percolates down to the underlying aquifers or moves laterally to discharge areas.

Surface Water Resources

Hydrologically, the entire Kissimmee Basin lies within the Lake Okeechobee Watershed, which consists of four tributary basins: Kissimmee River, Taylor Creek/Nubbin Slough, Lake Istokpoga – Indian Prairie/Harney Pond, and Fisheating Creek. With the exception of Fisheating Creek, all major inflows to Lake Okeechobee are controlled by gravity-fed or pump-driven water control structures.

Lake Rosalie draining to Lake Kissimmee at Structure G-103

For water management and flood control purposes, the Kissimmee Basin is divided into upper and lower basins at the outlet of Lake Kissimmee (S-65) to the Kissimmee River (See **Figure 7**.)

Upper Kissimmee Basin

The Upper Kissimmee Basin covers approximately 1,633 square miles and encompasses more than two dozen lakes in the Kissimmee Chain of Lakes (KCOL), their tributary streams, and associated marshes. This basin forms the headwaters of Lake Okeechobee and the Everglades, and comprises the uppermost section of the historic Kissimmee–Okeechobee–Everglades (KOE) system. The Kissimmee Chain of Lakes (**Figure 8**) is the most prominent surface feature in the basin among central Florida's hundreds of lakes. Water released from the KCOL flows southward to Lake Kissimmee, the southernmost feature in the basin. Lake Kissimmee is the largest lake in the Upper Kissimmee Basin and acts as a buffer for flows before their release into the Kissimmee River at S-65 (**Figure 8**).

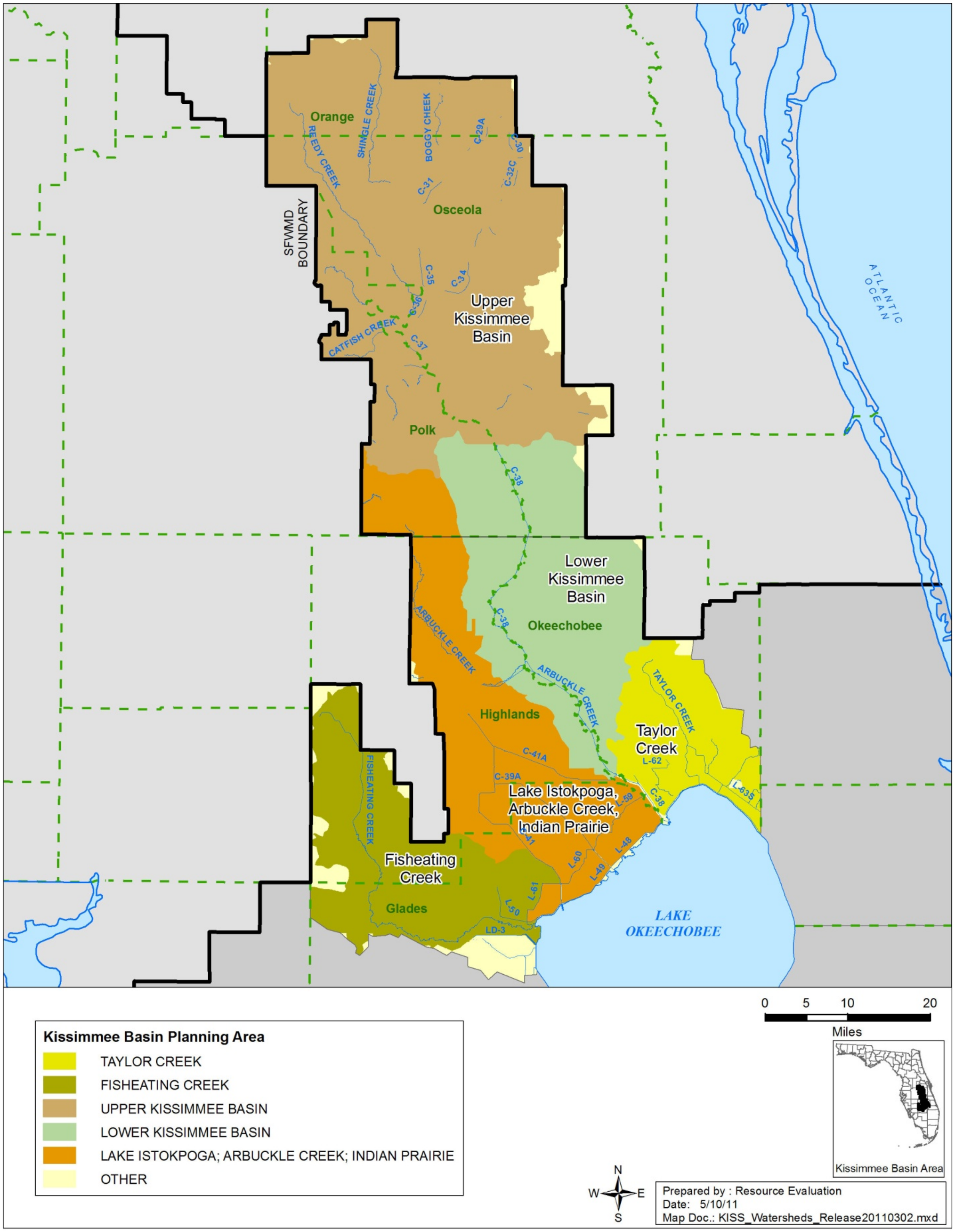


Figure 7. Kissimmee Basin watersheds.

Kissimmee Chain of Lakes

The Kissimmee Chain of Lakes (KCOL) forms an integrated system of lakes with interconnecting canals and water control structures operated by the SFWMD to maintain seasonal fluctuations in water levels. This lake system comprises 19 controlled water bodies grouped into the following seven Lake Management Areas:

- **Alligator Chain of Lakes (Alligator, Brick, Lizzie, Coon, Center, and Trout)** Located at the topographic top of the KCOL, these lakes are linked together by canals. Water control structures direct water from the Alligator Chain to flow north or south, but generally water is discharged south through the C-33 Canal to Lake Gentry. The north end of Trout Lake acts as the drainage divide for flows through the Kissimmee Chain of Lakes.
- **Lake Gentry** Inflows from the Alligator Chain enter Lake Gentry through the C-33 Canal. Lake Gentry also receives surface water from the Big Bend Swamp along the eastern shore of the lake. Lake Gentry discharges through the C-34 Canal to Lakes Kissimmee, Hatchineha, and Cypress.

Sandhill Crane on Lake Cypress

- **Lakes Kissimmee, Hatchineha, and Cypress** This group comprises the largest Lake Management Area, and is tied to a number of secondary lakes including Lake Russell, Tiger Lake, Lake Marion, Lake Pierce, Lake Rosalie, Lake Weohyakapka, Lake Jackson, and Lake Marian—through natural and artificial conveyances. These lakes receive inflows from Reedy Creek, the largest tributary, and via the C-35 Canal from Lake Tohopekaliga. Lake Kissimmee discharges to the Lower Kissimmee Basin through the C-38 Canal.
- **Lakes Myrtle, Preston, and Joel** At the northern end of the Alligator Chain, the C-32 Canal connects Trout Lake to Lake Joel. However, the main source of water to these lakes is rainfall and runoff from the surrounding watershed. Water levels in these lakes are controlled to flow north through the C-30 Canal toward Lake Mary Jane.
- **Lakes Hart and Mary Jane** Inflows from Lakes Myrtle, Preston, and Joel are directed through the C-30 Canal to Lakes Mary Jane and Hart. Water is discharged from these lakes through the C-29A Canal to the East Lake Tohopekaliga, Fells Cove, and Lake Ajay Lake Management Area.
- **East Lake Tohopekaliga, Fells Cove, and Lake Ajay** Major inflows come from Boggy Creek, which enters the lake in the northwestern corner, and the C-29A Canal from Lakes Hart and Mary Jane. Discharge is through the C-31 Canal to Lake Tohopekaliga.

- **Lake Tohopekaliga** Inflows to this lake come from Shingle Creek and the C-31 Canal from East Lake Tohopekaliga. Lake Tohopekaliga discharges into Lakes Cypress, Hatchineha, and Kissimmee through the C-35 Canal.

Kissimmee Chain of Lakes Regulation Schedules

Kissimmee River at Mouth of Lake Okeechobee

Water control structures in the Kissimmee Chain of Lakes direct flows according to regulation schedules established by the U.S. Army Corps of Engineers (USACE) and managed by the SFWMD. **Figure 8** shows the location of the water control structures and the primary direction of the flow through the Kissimmee Chain of Lakes.

Outflows from the Alligator Chain of Lakes (Alligator, Brick, Lizzie, Coon, Center, and Trout) are controlled by the S-58 Structure (northern structure) and S-60 Structure (southern structure). The S-58 Structure is located in the C-32 Canal, which connects Trout Lake and Lake Joel. North of Trout Lake, the S-57 Structure in the C-30 Canal regulates Lakes Joel, Myrtle, and Preston. The C-30 Canal connects Lake Myrtle to Lake Mary Jane in the next lake group. Lakes Mary Jane and Hart are regulated by the S-62 Structure, located in the C-29 Canal, which discharges into Lake Ajay. East Lake Tohopekaliga and Lake Ajay are regulated by the S-59 Structure, located in the C-31 Canal between East Lake Tohopekaliga and Lake Tohopekaliga. Lake Tohopekaliga is regulated by the S-61 Structure, located in the C-35 Canal at the south shore of the lake.

At the southern end of the Alligator Chain, the S-60 Structure in the C-33 Canal connects Alligator Lake to Lake Gentry. Lake Gentry is regulated by the S-63 and S-63A structures, located in the C-34 Canal that connects Lake Gentry to Cypress Lake. Lakes Kissimmee, Hatchineha, and Cypress are regulated by S-65, located at the outlet of Lake Kissimmee and the head of the Kissimmee River (C-38 Canal).

The C-37 Canal Widening Project is part of the Kissimmee River Restoration Project. The project is located between Lake Hatchineha and Lake Kissimmee, and when completed, will increase the conveyance capacity of water between the two lakes to maintain the authorized flood reduction benefits of the Central and Southern Florida Flood Control Project (C&SF Project) under the Kissimmee River Restoration Project. This project is expected to be completed in late 2014.

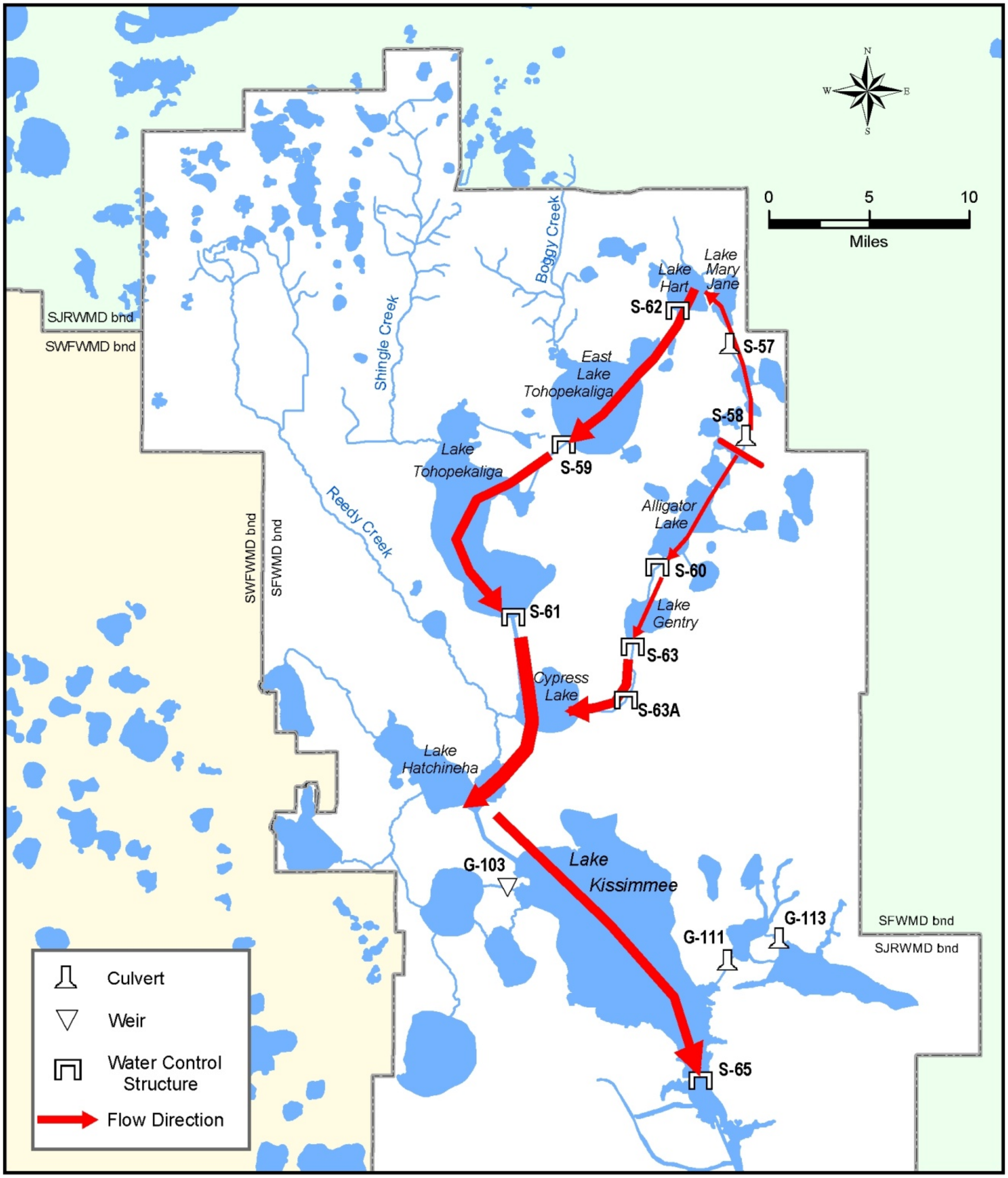


Figure 8. Water control structures that regulate flows in the Kissimmee Chain of Lakes. The line at the S-58 Structure indicates where water is discharged south from the Alligator Chain of Lakes. The S-57 Structure controls water levels north of the Alligator Chain of Lakes.

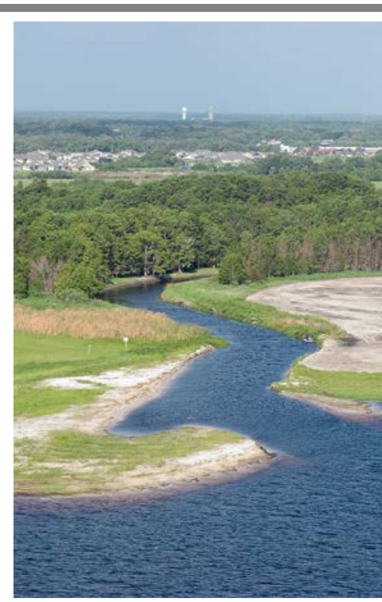
The details of the plan for the Kissimmee River are contained in the *Master Water Control Manual for Kissimmee River – Lake Istokpoga* (USACE 1994) with the exception of operations for the S-65 Structure. The USACE approved an interim operating schedule for S-65 that provides for environmental releases to the Kissimmee River when water levels in Lake Kissimmee are within Zone B of the regulation schedule. The interim schedule maintains flow through the restored portion of the Kissimmee River. It will be in use until completion of the restoration project in late 2014. The Headwaters Revitalization Schedule (or a revision) for S-65 is expected to be implemented in 2015. Environmental (Zone B) releases according to the interim schedule were approved by the USACE in August 2000 and began in July 2001 after Phase I of the Kissimmee River Restoration Project was completed (see **Chapter 3** of this Support Document).

Tributary Creeks

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 open channels and wetlands into their respective lakes. In addition to these creeks, the Lake Mary Jane/Lake Hart Basin contributes surface water flows to the Kissimmee Chain of Lakes for the most northeastern portion of the basin. Flows from these areas are directed to the Alligator Chain of Lakes or directly to East Lake Tohopekaliga.

Shingle Creek

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 was substantially modified in the 1920s with channelization of 13 miles and subsequent crossing of utility transmission lines and access roads. The SFWMD began an aggressive land purchase program in the Shingle Creek Basin in the 1980s after the State of Florida established the Save Our Rivers (SOR) Program.



Shingle Creek – Lake Tohopekaliga

The District has undertaken several successful restoration projects within Shingle Creek Swamp funded as mitigation sites to offset wetland impacts associated with the construction of the Orlando Beltway. The District manages the Shingle Creek Management Area with Osceola County. See the *Shingle Creek Management Area Five-Year General Management Plan (2005–2010)*, (SFWMD 2005) for additional information. The plan is available from http://www.sfwmd.gov.

Reedy Creek

Reedy Creek in Osceola County is the least disturbed of the area's three major creeks. Originating on the grounds of 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. For most of its course, the creek flows through Reedy Creek Swamp. Reedy Creek also receives water from the Butler Chain of Lakes during periods of high lake levels.

Boggy Creek

Boggy Creek consists of east and west branches. The 12-mile-long east branch is the main watercourse, and its headwaters form in metro-Orlando in the southern part of Lake Conway. The east branch runs through Boggy Creek Swamp and empties into East Lake Tohopekaliga. The headwaters of the west branch originate in Lake Jessamine, located in another highly urbanized area of Orlando, and extend to Boggy Creek Swamp.

Lower Kissimmee Basin

The Lower Kissimmee Basin covers 758 square miles and includes the tributary watersheds of the Kissimmee River between the outlet of Lake Kissimmee (S-65 Structure) and Lake Okeechobee. The Kissimmee River is the major surface water feature in the lower basin.

Restored Kissimmee River at Filled-in Section of C-38

Kissimmee River

The Kissimmee River was originally 134 miles long, which included a 103-mile span between Lake Kissimmee and Lake Okeechobee. Construction of the C&SF Project to improve flood protection in the Kissimmee Basin took place between 1962 and 1971. This effort resulted in channelizing the Kissimmee River into a 56-mile canal. Today, a series of combined locks and water control structures manage the canal's flow into Lake Okeechobee. The restoration effort currently in progress will ultimately restore the ecological function of about one-third of the historic river/floodplain ecosystem.

Lower Kissimmee Basin Regulation Schedules

The Lower Kissimmee Basin system includes the Kissimmee River and the C-38 Canal, and four water control structures (S-65A, S-65C, S-65D, and S-65E), (**Figure 9**). The C-38 structures are operated in conjunction with S-65 at the outlet of Lake Kissimmee. Structures S-65A, S-65D, and S-65E are operated to maintain optimum stages; S-65C is used to vary stages in the lower end of Phase I of the restoration project. The optimum stages for S-65A, S-65C, S-65D, and S-65E are 46.3, 34.0, 26.8, and 21.0 feet above MSL, respectively.

The Kissimmee River Restoration Project is being implemented in four phases. Three of the four restoration phases of the project have been completed. These phases have backfilled 14 miles of the C-38 flood control canal, recarved six miles of river channel, and removed a water control structure (S-65B). These efforts have reestablished flow to 24 miles of continuous river channel and allowed intermittent inundation of 7,710 acres of floodplain. The final construction phase is scheduled to begin in 2012 and be complete in late 2014. A revised regulation schedule to operate the S-65 Structure is expected to be implemented in 2015.

Lake Istokpoga – Indian Prairie Basin

Lake Istokpoga

The 613-square-mile Lake Istokpoga Basin is located to the west and north of Lake Istokpoga, and is the source of all surface water inflows to Lake Istokpoga, one of the largest lakes in Florida. Extending approximately 27,700 acres, the lake is shallow, averaging between 4 feet and 6 feet in depth. Major tributaries to Lake Istokpoga are Josephine Creek and Arbuckle Creek, located in the northwestern and northern areas of the lake, respectively. Outflows from Lake Istokpoga are directed either to the Kissimmee River or Lake Okeechobee through a system of canals and water control structures. The 622-square-mile Indian Prairie Basin drains the area south of Lake Istokpoga to Lake Okeechobee.

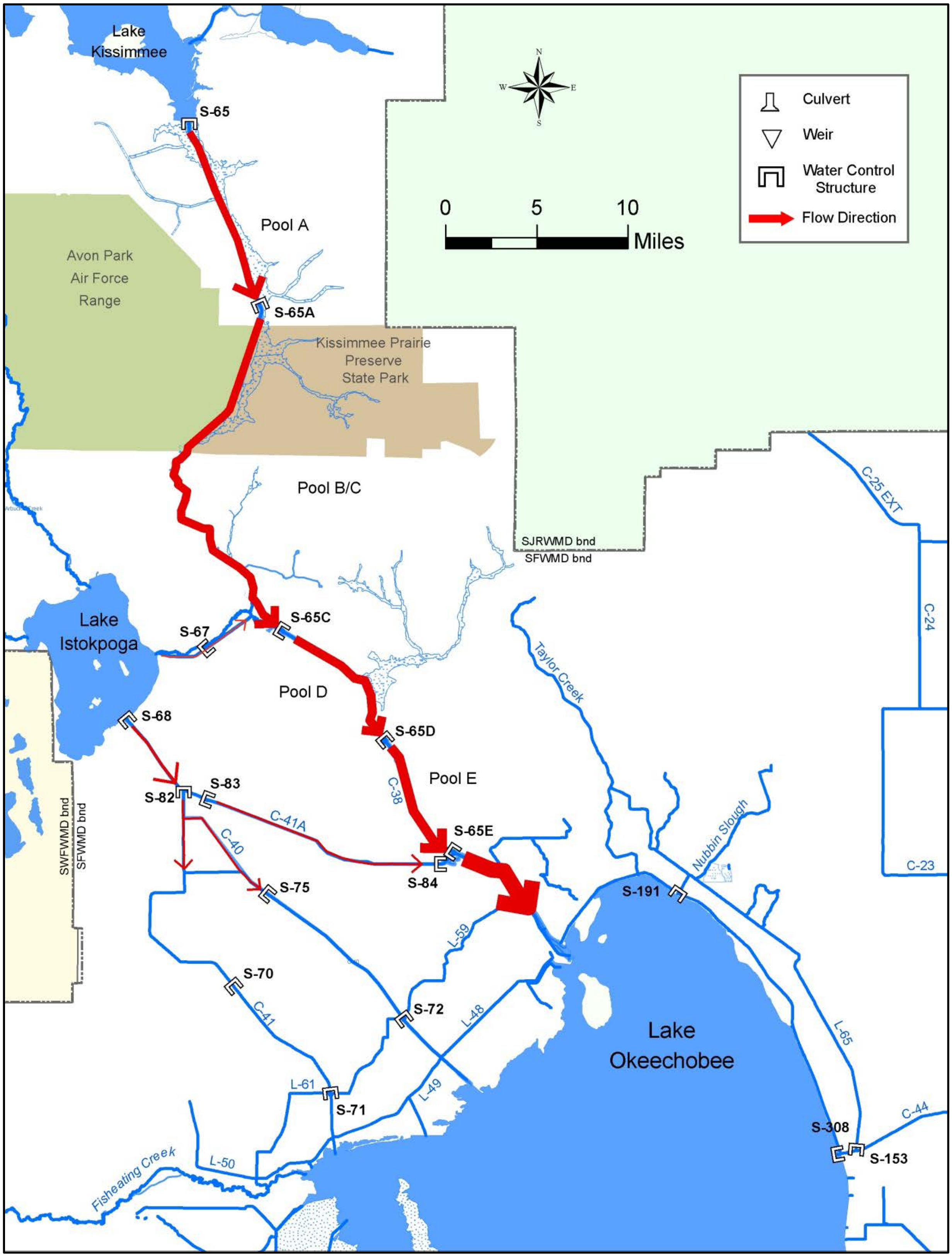


Figure 9. Water control structures that regulate flows out of Lake Kissimmee and Lake Istokpoga and in the Kissimmee River.

Lake Istokpoga Regulation Schedule

Stages in Lake Istokpoga are primarily regulated by the S-68 Structure at the southern end of the lake in accordance with a regulation schedule that varies seasonally, ranging from 37.5 feet to 39.5 feet above MSL. The canals and structures are shown in **Figure 9**.

The S-68 Structure discharges water from Lake Istokpoga to the C-41A Canal (the Slough Canal). The C-41 Canal (Harney Pond Canal), the C-40 Canal (Indian Prairie Canal), and the C-39A Canal (State Road 70 Canal) provide secondary conveyance capacity for the regulation of floods in the Lake Istokpoga water management basin. The C-40 and C-41 canals flow into Lake Okeechobee, and the C-41A Canal discharges to the C-38 Canal south of S-65E, the southernmost structures in the Kissimmee River.

When high water levels in the Kissimmee River restrict Lake Istokpoga Basin discharges via the Istokpoga Canal, the new addition to the S-68 Structure offsets the loss of discharge capacity by re-routing flows down the C-41A Canal. This additional structure was constructed adjacent to and northeast of the existing S-68 Structure to increase conveyance capacity. The USACE also constructed the S-67 Structure to replace the G-85 Structure, which controls water discharges from Lake Istokpoga through the Istokpoga Canal to the C-38 Canal. As of July 2012, the USACE completed work on the S-67 Structure. Transfer of the structure from the USACE to the SFWMD is expected in the fall of 2012.

The details of the Lake Istokpoga plan are contained in the *Master Water Control Manual for the Kissimmee River – Lake Istokpoga* (USACE 1994). The regulation schedule also takes into consideration the Minimum Flow and Level (MFL) established by the District in December 2005.

Taylor Creek / Nubbin Slough Basin

Taylor Creek and Nubbin Slough are interconnected basins that cover 104 and 84 square miles, respectively, which drain into Lake Okeechobee from the north and northeast. The Kissimmee River and its floodplain lie directly west of these natural systems. Land use in this basin is primarily agricultural, consisting of intensive dairy and beef cattle farms whose animals graze on improved pastures that are surface drained and fertilized. More information about water storage projects in the Taylor Creek/Nubbin Slough Basin can be found in the upcoming LKB Plan.

Fisheating Creek Basin

The 440-square-mile Fisheating Creek Basin originates in western Highlands County and flows south through Cypress Swamp and into Glades County, where it marks the southernmost boundary of the KB Planning Area. From central Glades County, the water leaves the creek channel and flows east through Cowbone Marsh into Lake Okeechobee. Fisheating Creek is the only basin with an uncontrolled “natural” discharge to Lake Okeechobee.

Groundwater Resources

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 10** and **Figure 11**. The FAS includes the Upper Floridan aquifer (UFA), composed of two production zones separated by lower permeability strata (confining unit 1) and the Lower Floridan aquifer (LFA), composed of two or more productive units separated by less permeable materials. The UFA and LFA are separated by a much less permeable middle confining unit (confining unit 2). **Table 28** presents the groundwater systems, hydrogeologic units, and relative aquifer yields in the KB Planning Area.

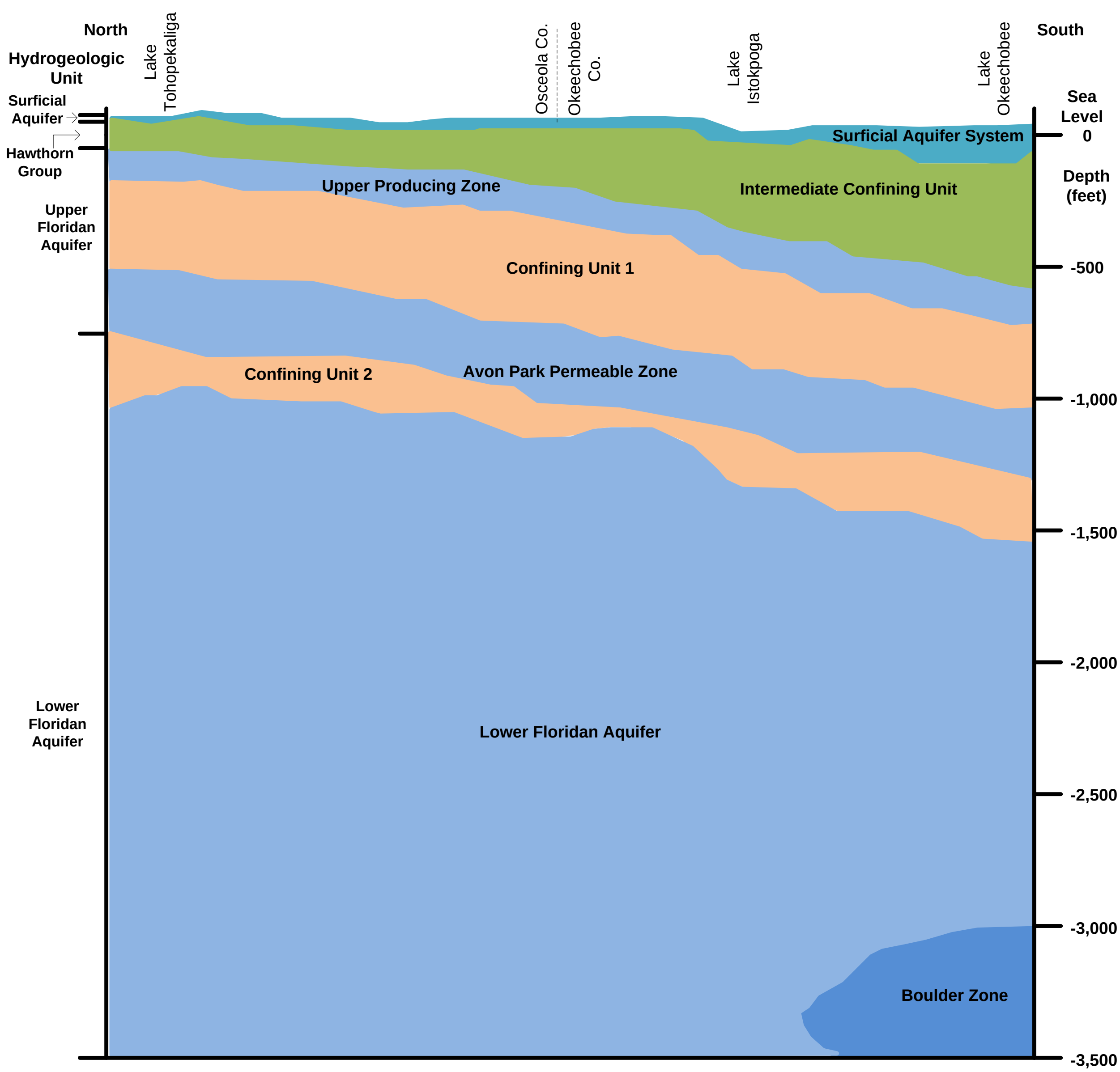


Figure 10. Generalized hydrogeologic cross-section (north to south) of the Kissimmee Basin Planning Area.

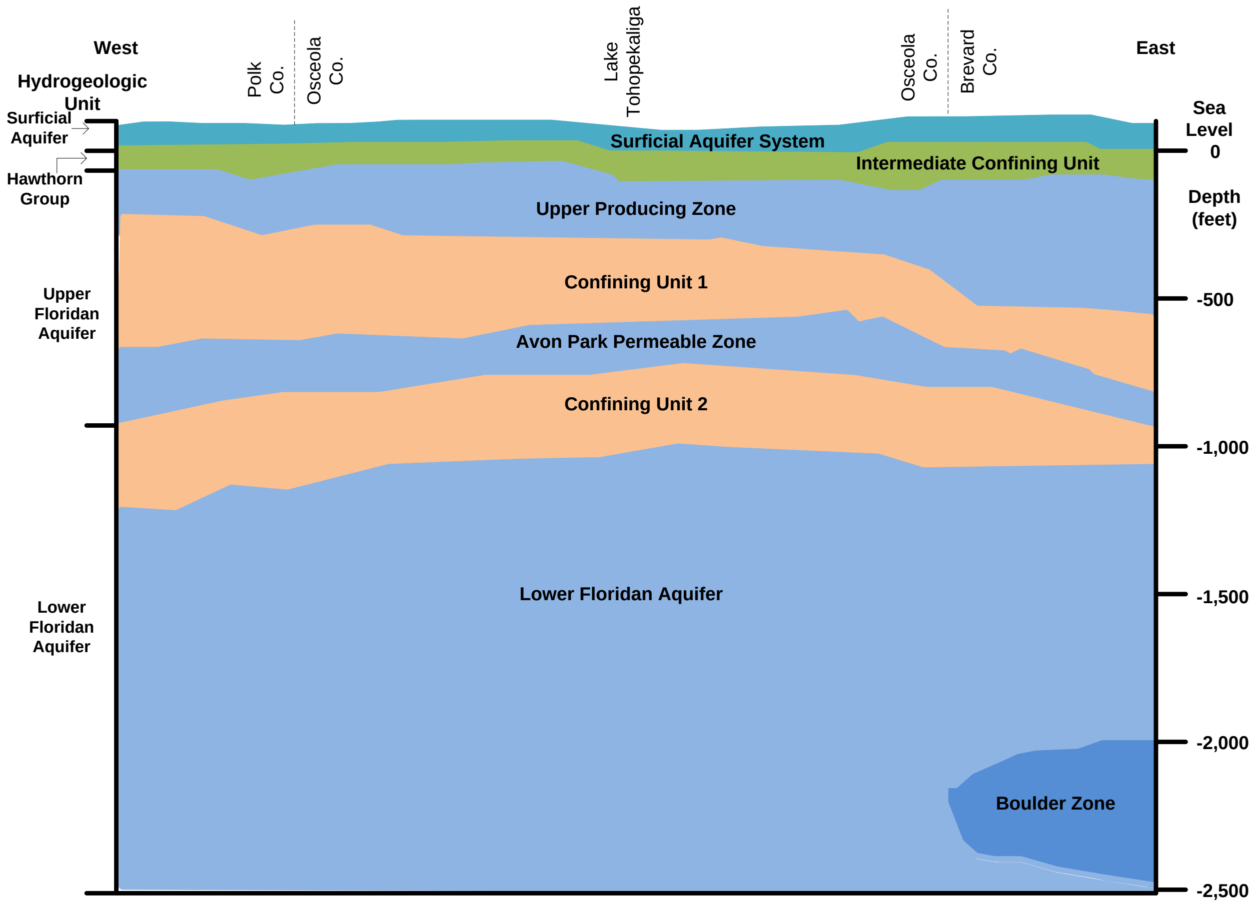


Figure 11. Generalized hydrogeologic cross-section (west to east) of the Kissimmee Basin Planning Area.

Table 28. Groundwater systems in the Kissimmee Basin Planning Area.

Aquifer System	Hydrogeologic Unit	Aquifer Yield A=Absent L=Low M=Moderate H=High					
		Orange	Osceola	Polk	Highlands	Okeechobee	Glades
Surficial Aquifer System	Undifferentiated Clastic Deposits	L	L	L-M	L-M	L-M	L-M
Floridan Aquifer System	Upper Floridan Aquifer	H	H	H	H	H	H
	Lower Floridan Aquifer	H	M-H	M	M-H	M-H	M-H

Surficial Aquifer System

The surficial aquifer system (SAS), also known as the Water table aquifer in the Kissimmee Basin, is unconfined and consists of fine-to-medium grained quartz sand with varying amounts of silt, clay, and crushed shell that range from Pliocene to Holocene in age. The thickness of the surficial aquifer generally ranges from less than 10 to 150 feet within the planning area. The thickness of these sediments is generally less than 50 feet in the northern part of the planning area, thickening to the south and southwest. The thickness of surficial aquifer sediments reaches almost 300 feet in Polk County along the Lake Wales Ridge, but the depth to water may be several tens of feet below land-surface in this region.

The surficial aquifer 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. This groundwater source contains relatively high chloride and dissolved solids concentrations toward the western part of Okeechobee County and near the Caloosahatchee River in Glades County.

Intermediate Confining Unit

Below the SAS lies a mixture of sands and clay collectively known as the intermediate aquifer system (IAS). The IAS acts as a confining unit for the underlying Upper Floridan aquifer in the KB Planning Area. This intermediate confining unit (ICU) consists of an interbedded sequence of sands, calcareous silts and clays, shell, and phosphatic limestone and dolomite of late-to-middle Miocene age (Hawthorn Group), although the top of the unit can also include the clayey sediments of early Pliocene age. It restricts vertical movement of water between the surficial aquifer and the Upper Floridan aquifer. West of the Lake Wales Ridge, multiple discrete producing zones can be found within the ICU, but these are absent within the KB Planning Area. The thickness of the ICU 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

Below the IAS is the Floridan aquifer system (FAS). The FAS acts as a confined or partially confined aquifer and the primary source for potable water in the Upper KB Planning Area. The FAS is traditionally divided into the Upper Floridan and Lower Floridan aquifers, which are separated by less permeable rocks (a middle confining unit) that restrict their interaction. The FAS is composed of a sequence of highly permeable carbonate rocks (limestone and dolomite) of Oligocene, Eocene, and late Paleocene age. The FAS has an average thickness of approximately 2,300 feet within the KB Planning Area, but because of variability in productivity and water quality, only a portion of this thickness is useful for water supply.

The elevation of the top of the Upper Floridan aquifer (UFA) ranges from less than 100 feet below MSL in northeastern Polk County, to more than 500 feet below MSL in the southwestern portion of the basin. The UFA is thicker in Glades and Okeechobee counties, averaging approximately 1,000 feet. Chloride, total dissolved solids, and sulfate concentrations increase with depth and distance to the south and west.

The UFA can be subdivided into three hydrogeologic units: 1) a moderately productive upper producing zone, 2) a semi-confining unit, and 3) a highly permeable fractured crystalline dolostone in the Avon Park Formation, referred to as the Avon Park permeable zone. The carbonate section of the Upper Avon Park Formation can be moderately productive as well (USGS 2010).

West of the Highlands Ridge, the upper producing zone is largely composed of rocks of the Suwannee Limestone. East of the ridge, this unit is absent, having undergone significant aerial exposure and erosion during past glacial periods. In the SJRWMD, the top of the deeper Ocala Limestone is often used as a surrogate for the top of the Upper Floridan, and the Ocala can be quite productive in this area. The permeability of the Ocala diminishes to the south and west. In most of Polk and Osceola counties, it comprises the semi-confining unit between the upper producing zone and Avon Park permeable zone. In these areas, where the Suwannee is also absent, the upper producing zone may be reduced to a thin region of enhanced dissolution around the contact between the Ocala and overlying units.

The Lower Floridan aquifer (LFA) is present throughout east-central Florida. The top of the LFA ranges from about 1,000 feet below MSL to more than 1,600 feet below MSL in the Lower Kissimmee Basin. The LFA consists of the lower part of the Avon Park and Oldsmar formations of middle Eocene age and the upper part of the Cedar Keys Formation of late Paleocene age. Like the UFA, the Lower Floridan aquifer is characterized by multiple productive zones with alternating lower permeability beds of varying degrees of confinement. In Orange County, the LFA is slightly brackish, but highly productive, characterized by abundant fractures and solution cavities.

Surface Water and Groundwater Relationships

The relationship between a surface water feature and the underlying groundwater system is complex. 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 surface water and groundwater.

The surficial aquifer is primarily recharged by rainfall and interacts with surface water features, such as rivers, canals, and lakes. The surficial aquifer provides temporary storage for infiltrating water that eventually recharges underlying aquifers or moves laterally to discharge areas.

The Upper Floridan aquifer in the Upper Kissimmee Basin is recharged primarily by downward leakance from the surficial aquifer and, where present, through the intermediate confining unit (ICU). Higher rates of recharge occur in areas with abundant sinkholes where the ICU is thin or breached by collapse into underlying dissolution cavities. These areas represent locations where the differences in surface and Upper Floridan water levels are greatest, and the thickness of the ICU is thinnest or breached by karst activity.

Karst / Sinkhole Features

The chemical processes by which rock is dissolved by interactions with water are commonly referred to as solution processes. The past and continuing solution of the limestone beneath the land surface by groundwater results in a landform called karst (USGS 1998).

The development of karst features is primarily expressed at the surface as “sinkhole lakes.” These occur within the Upper Kissimmee Basin and along the eastern side of Lake Wales Ridge. Surface water–groundwater exchange can occur through the bottom sediments of these lakes, depending on the thickness, composition, and the porousness of the lake bottom/sinkhole collapse sediments. As a result, water can seep from lakes into the Upper Floridan aquifer (FDEP 2006).

Drainage Wells

Hundreds of drainage wells in the metro-Orlando area receive water from stormwater runoff, lake and wetland overflow, and street runoff. These drainage wells discharge into the FAS, providing recharge to the system. Constructed up until the 1970s, these wells are generally limited to closed drainage basins in the Orlando area.

ECOSYSTEM RESTORATION EFFORTS

Information about ecosystem restoration efforts for the Lower Kissimmee Basin Planning Area will be available in the upcoming LKB Plan (SFWMD in process).

More information and the status of these restoration projects can be found in the *South Florida Environmental Report* available from http://www.sfwmd.gov/sfer. Project descriptions, status, and further documentation about other projects are available from http://www.evergladesplan.org, http://www.sfwmd.gov/northerneverglades, and http://www.sfwmd.gov/everglades.

Horses in Restored Kissimmee River Area

8

Upper East Coast Planning Area

This chapter describes characteristics of the Upper East Coast (UEC) Planning Area. An overview of the region's physical features and water resources, including surface water and groundwater, is presented in this Support Document, which supplements the *2011 UEC Water Supply Plan Update* (2011 UEC Plan Update) (SFWMD 2011b). For a comprehensive review of water supply status and issues in the UEC Planning Area, refer to the 2011 UEC Plan Update.

TOPICS

- Planning Area Boundaries
- Physical Features
- Water Resources and System Overview
- Ecosystem Restoration Efforts

PLANNING AREA BOUNDARIES

The UEC Planning Area includes Martin and St. Lucie counties and a small portion of Okeechobee County, as shown in **Figure 12**. 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) canals. Its northern boundary corresponds to the St. Lucie–Indian River County line, which is also the jurisdictional boundary between the SFWMD and the St. Johns River Water Management District (SJRWMD). The planning area's southern boundary is the Martin–Palm Beach county line.

St. Lucie Estuary and Indian River Lagoon

PHYSICAL FEATURES

Major water features in the UEC Planning Area include Lake Okeechobee, canal systems, St. Lucie River and Estuary, Five Mile Creek, Ten Mile Creek, and Southern Indian River Lagoon.

The Loxahatchee River is located in Martin and Palm Beach counties and has three major branches: the Northwest Fork, the North Fork, and the Southwest Fork. The 2011 UEC Plan Update (SFWMD 2011b) contains information about this system relative to water supply and projects within the UEC Planning Area. **Chapter 10** of this Support Document and the *2013 Lower East Coast Water Supply Plan Update* (SFWMD 2013a) contain information about the Loxahatchee River relative to water supply and projects within the Lower East Coast Planning Area.

NAVIGATE

For more information about the Loxahatchee River Watershed, see **Chapter 10** of this document.

Water Bodies and Landscapes

Lake Okeechobee is a key component of the south Florida hydrologic system. The lake has many functions, including flood protection, urban and agricultural water supply, navigation, and fisheries and wildlife habitat. Lake Okeechobee is critical for flood control during wet seasons and water supply during dry seasons. Releases from Lake Okeechobee flow into the St. Lucie (C-44) Canal, which discharges to the South Fork of the St. Lucie River.

Okeechobee Waterway (St. Lucie C-44 Canal)

The St. Lucie River flows through Martin and St. Lucie counties. The river is 35 miles long and has two major forks, the North Fork and the South Fork (**Figure 12**). Danforth and Mapp creeks are tributaries to the South Fork downstream of the St. Lucie Canal. Ten Mile Creek is the major freshwater tributary to the North Fork of the St. Lucie River, which is approximately 10 miles long. Several miles downstream, Five Mile Creek contributes relatively limited inflows to the North Fork. The North Fork is a freshwater system upstream and a brackish system near the St. Lucie Estuary.

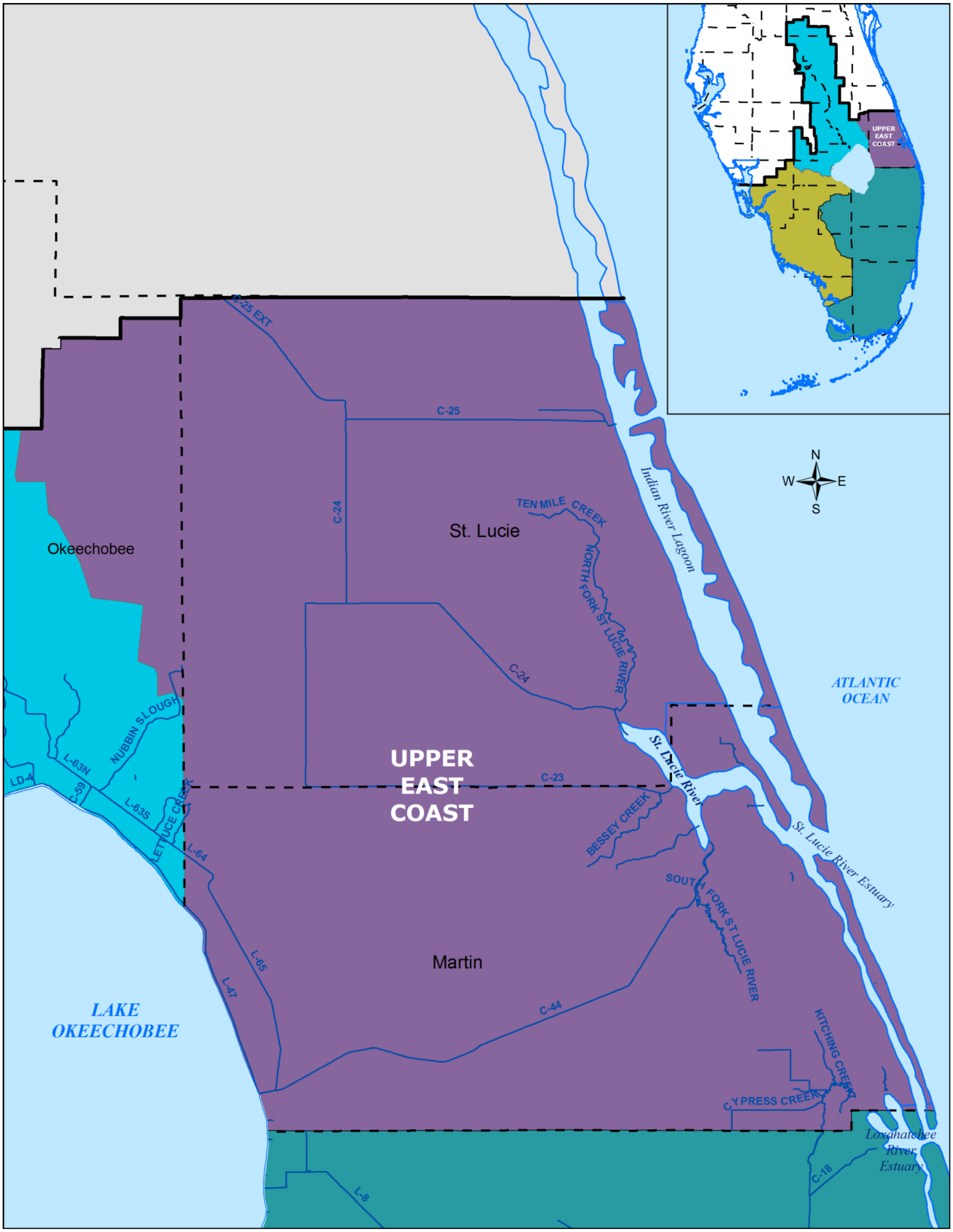


Figure 12. Upper East Coast Planning Area.

The North Fork and the South Fork come together in the St. Lucie River (**Figure 12**), a primary tributary to the Southern 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 Southern Indian River Lagoon (**Figure 12**) spans an area of approximately 48 square miles from Fort Pierce to Jupiter Sound.


Indian River Lagoon

Geography and Climate

The UEC Planning Area encompasses approximately 1,231 square miles in southeastern Florida, and its average elevation is 20 feet above mean sea level (MSL).

Average seasonal temperatures for the area range from approximately 64°F to 81°F. Estimated annual rainfall in the planning area averages 54 inches (see also the *Precipitation and Evapotranspiration* section).

Physiography

The UEC Planning Area is characterized by three principal physiographic zones with differing land characteristics (**Figure 13**), 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 is composed of flatwoods, savanna-like wetlands, and relict beach ridges and sand bars. In the UEC Planning Area, the ridge varies in elevation from sea level to 86 feet above MSL at its highest point in Jonathan Dickinson State Park. The ridge's extensive upland/wetland systems provide a source of groundwater flow for the South Fork of the St. Lucie River and North Fork of the Loxahatchee River. This area is important for aquifer recharge and water supply to the coastal portion of Martin County, where the groundwater and ground elevations are higher than the surrounding lands.

West of the Atlantic Coastal Ridge is the Eastern Valley (also known as the Eastern Flatwoods), which encompasses most of the UEC Planning Area. The Eastern Valley is a generally low plain between 1 foot and 5 feet above MSL, averaging 30 miles in width. The Eastern Valley features long, low, narrow ridges ranging from 15 feet to 30 feet above MSL. The Green Ridge in south-central Martin County and the Ten Mile Ridge in north-central Martin County are two such ridges.

The Eastern Valley consists of wetland communities, including tidal and floodplain swamp and forest. These areas are characteristically pocketed with shallow lakes and marshes and have limited natural drainage. Prior to development and the 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; Pal-Mar; Loxahatchee Slough; the Allapattah, St. Lucie, and Osceola flats; and portions of St. Johns Marsh. The North Fork of the St. Lucie River is also located within the Eastern Valley.

The Osceola Plain lies west of the Eastern Valley in St. Lucie County and intrudes into the Eastern Valley in Martin County. The plain then extends into the eastern portion of Okeechobee County. The Osceola Plain is a relatively flat area that slopes from east to west. The elevation ranges from about 70 feet above MSL along the eastern boundary to 40 feet above MSL in the Martin County area. The landscape is a matrix of extensive open prairie, small ponds or depressions, swales, partially wooded sloughs, and hammocks.

St. Lucie River Estuary

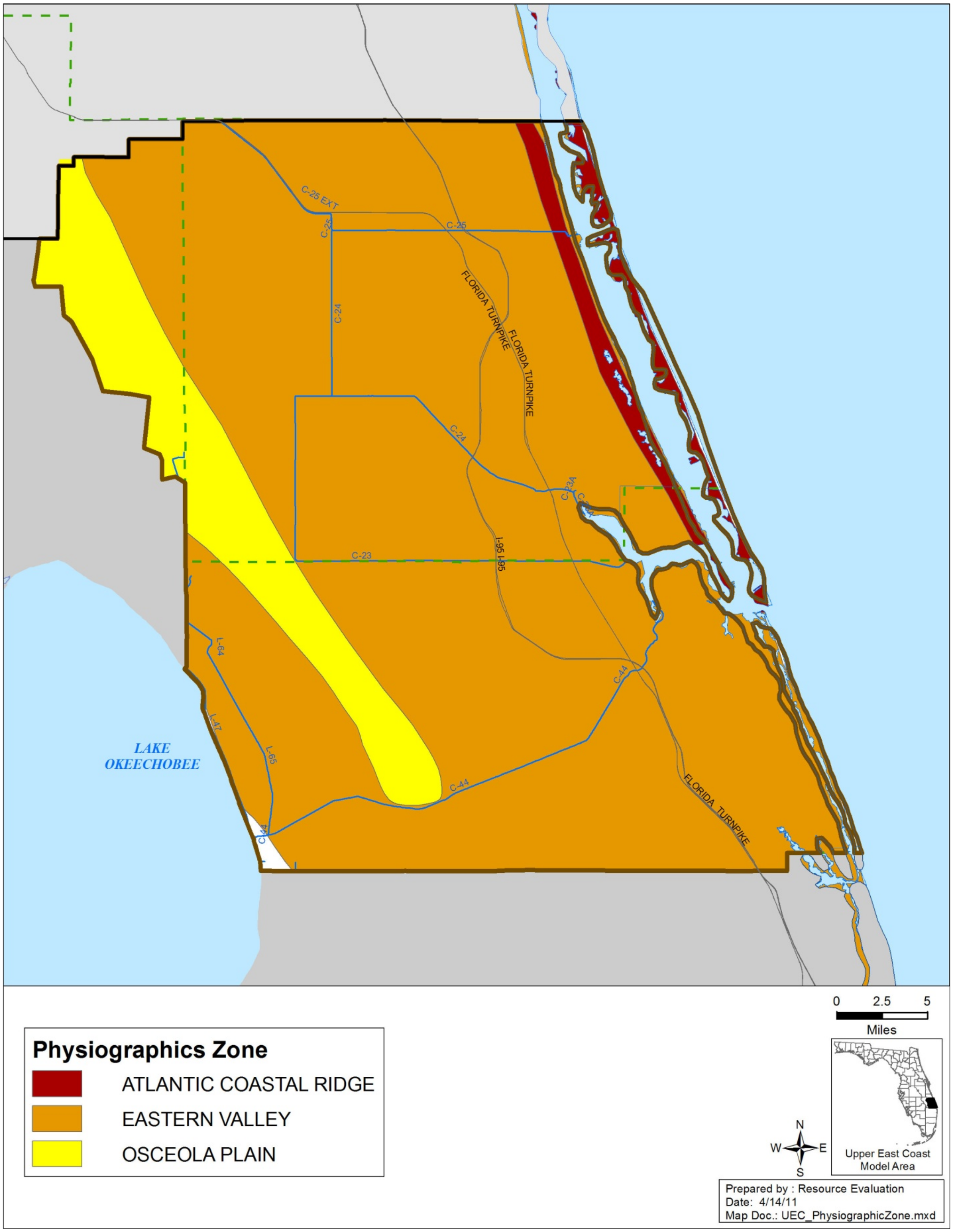


Figure 13. Physiography of the Upper East Coast Planning Area.

WATER RESOURCES AND SYSTEM OVERVIEW

Allapattah Flats

Before development, most of the UEC Planning Area was characterized by nearly level, poorly drained lands subject to frequent flooding. Most of these surface water systems, especially those with poor drainage, were altered to make the land suitable for development and to provide flood protection. The natural surface drainage systems included large expanses of sloughs and marshes, such as St. Johns Marsh, Allapattah Slough (also known as Allapattah Flats), Cane Slough, and the Savannas. Drainage systems with higher conveyance included the North Fork and South Fork of the St. Lucie River, and a vast marsh system that included Ten Mile Creek, Five Mile Creek, the Loxahatchee River, and Bessey Creek.

In the following sections, surface water and groundwater resources are addressed as separate entities. Surface water resources in the UEC Planning Area include natural and artificial systems, such as canals. Groundwater resources include the surficial aquifer system and the Florida aquifer system.

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. The interaction between surface water and groundwater is expressed as either recharge to, or discharge from, the aquifer system.

Precipitation and Evapotranspiration

The region has a wet season from June through October, and a dry season from November through May. Annual rainfall in the UEC Planning Area averages 54 inches, but varies considerably from year to year. About 62 percent of the area's annual rainfall occurs during the June through October wet season.

Hydrologic and meteorological methods are available to measure and 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 groundwater recharge. The estimate of potential evapotranspiration (ETp) from open water and wetlands in the UEC Planning Area is 50 inches (Abtew et al. 2003). Potential evapotranspiration represents the total estimated passive water use of an area under maximum conditions. While actual evapotranspiration varies due to temperature, soil moisture, and other factors, ETp estimates are important landscape-level factors in water balance calculations to determine if enough water will be available for all uses during different environmental conditions.

Surface Water Inflow and Outflow

Almost all surface water inflows and outflows in the planning area are derived from rainfall. The exception is the St. Lucie (C-44) Canal, which receives water from Lake Okeechobee as well.

Most of the flows and stages in the region's canals are regulated for water supply 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. Surface water is mainly stored in the canals themselves. Management of surface water storage capacity involves balancing two conflicting extreme conditions: 1) providing flood protection during the wet season, and 2) meeting water supply needs during the dry season. Management of surface water systems and meteorological events are key factors affecting the movement of water through the regional hydrologic cycle.

Groundwater Flow

Two aquifer systems, the surficial aquifer system (SAS) and the Floridan aquifer system (FAS), lie beneath the UEC Planning Area. Groundwater inflows from outside the planning area contribute insignificant recharge to the SAS; the main source of recharge to the SAS is rainfall. The FAS receives most of its recharge from outside the UEC Planning Area in central and northern Florida.

Surface Water Resources

Surface water bodies in the UEC Planning Area include canals, natural water bodies, and wetlands. The St. Lucie Watershed is hydrologically divided into 15 sub-watersheds, each of which drains into a specific tributary or canal that connects to the St. Lucie Estuary. These sub-watersheds can be further divided into basins based on hydrologic and/or geographic divides. **Figure 14** shows the watersheds in the UEC Planning Area. The C-23, C-24, C-25, and C-44 (St. Lucie) canals are part of the Central and Southern Florida Flood Control Project (C&SF Project), and are important sources of irrigation water within their respective drainage basins. These canals also discharge directly to coastal waters.

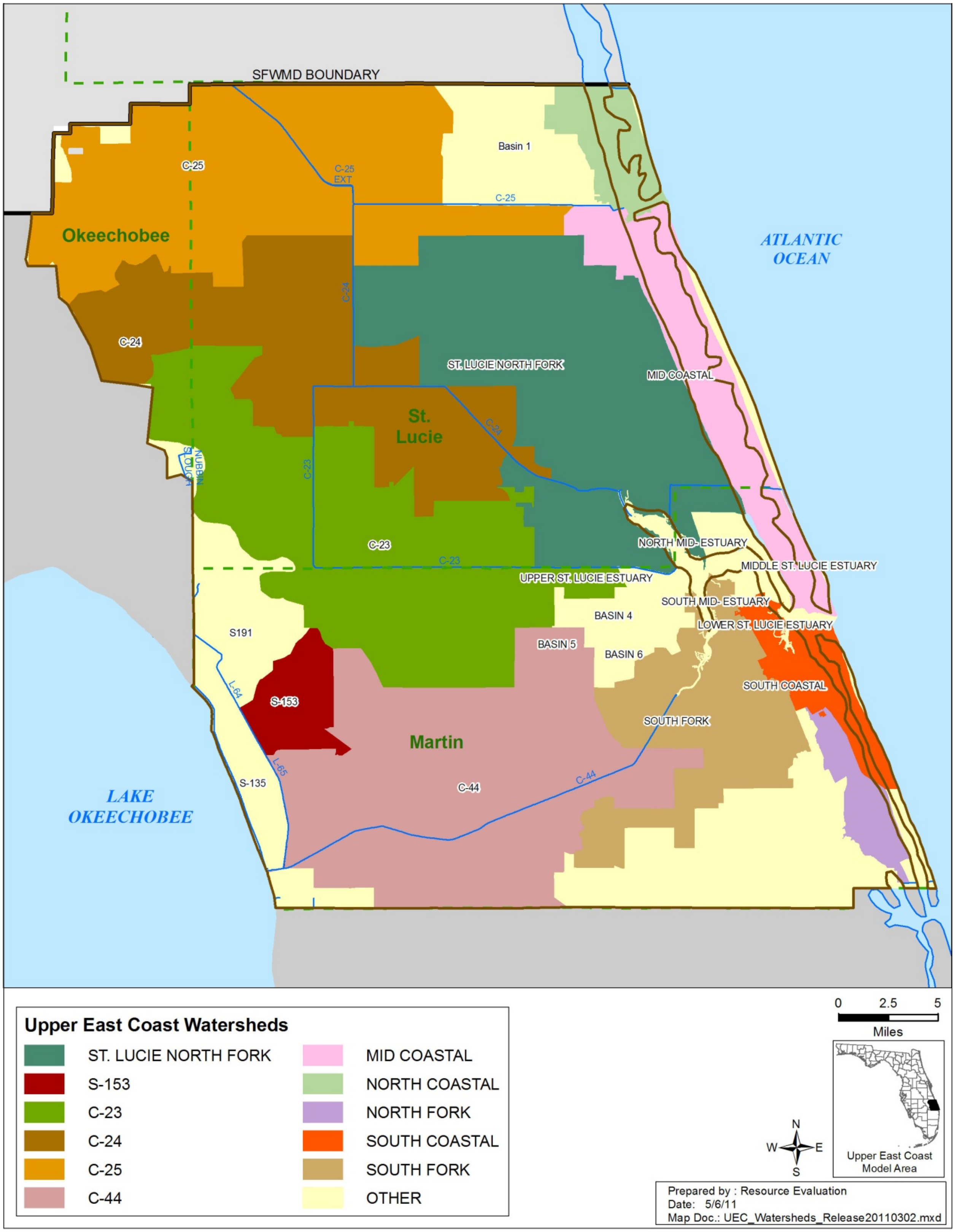


Figure 14. Upper East Coast Planning Area watersheds.

C-25 Sub-watershed

The C-25 Sub-watershed is located in northern St. Lucie County. A small portion of the C-25 Sub-watershed also falls within the St. Johns River Water Management District. The C-25 Basin may be divided into two subbasins based on where water may be discharged, western C-25 and eastern C-25. Together, these areas cover approximately 112,300 acres.

The major drainage canals in the C-25 Sub-watershed include the C-25, C-25 South Leg, and the C-25 Extension. The C-25 South Leg is connected to the C-24 Canal by water control structure G-81. The C-25 Extension Canal parallels the Florida Turnpike and then turns south to the confluence of the C-25 and C-25 South Leg canals. Excess water is discharged from the basin to tidewater in the Indian River Lagoon west of the Fort Pierce Inlet by way of the S-99 and S-50 structures, or to a much lesser extent, to the C-24 Canal by way of the G-81 Structure. The Turnpike Canal and Orange Avenue Borrow Canal provide flood protection and drainage in the western portion of the C-25 Sub-watershed. The Turnpike Canal is continuous with the C-25 Extension and extends west along the Turnpike. The Orange Avenue Borrow Canal makes an open channel connection with C-25 South Leg (SFWMD 2010b).

C-24 Sub-watershed

The C-24 Sub-watershed comprises the C-24 Canal system and basin, which has a total drainage area of approximately 87,706 acres. Most of the C-24 Sub-watershed is located in St. Lucie County, with a small portion in eastern Okeechobee County. This sub-watershed has two prominent canals: the Rim Ditch Canal and the Diversion Canal. The major water control structures are the G-79, G-81, and S-49 structures. The G-79 Structure serves as a basin divide and enables the discharge of water from the C-23 Sub-watershed into the C-24 Sub-watershed when conditions allow. The G-81 Structure is at the drainage divide between the C-24 and C-25 sub-watersheds.

S-49 Water Control Structure

The Rim Ditch Canal is connected to the C-25 South Leg Canal by way of the G-81 Structure. At its south end, the Rim Ditch Canal is connected to C-23 by way of the G-79 Structure and to the Diversion Canal by an open channel. Flow in the Rim Ditch Canal is usually to the south. If G-81 is opened to discharge water to the C-25 basin, flow in the Rim Ditch Canal may be to the north. The Diversion Canal extends from its intersection with the Rim Ditch Canal on the west to the North Fork of the St. Lucie River.

The S-49 Structure discharges from the C-24 Sub-watershed into the C-23A Canal, which is uncontrolled and discharges from the North Fork of the St. Lucie River to the St. Lucie Estuary.

C-23 Sub-watershed


C-23 in St. Lucie Agricultural Area

The C-23 Sub-watershed comprises the C-23 Canal system and basin, which has a total drainage area of approximately 112,675 acres. Most of the C-23 Sub-watershed is located in southwestern St. Lucie County and northern Martin County, with a small portion in eastern Okeechobee County. The C-23 Canal is the main drainage canal. Water flows south from the C-24 Sub-watershed to the Martin–St. Lucie county line, then heads east, discharging into the North Fork of the St. Lucie River. Three structures control flow in the C-23 Sub-watershed: S-48, located at the outlet of the C-23 Canal to the North Fork of the St. Lucie River; S-97, located at the Florida Turnpike's crossing of the C-23 Canal; and G-78, located southwest of the convergence of C-23 and C-24. Water in the north–south leg of the C-23 Canal may occasionally be diverted to the C-24 Sub-watershed for water supply and flood protection purposes (SFWMD, FDEP, and FDACS 2009).

North Fork Watershed

The North Fork Sub-watershed comprises the North Fork and North Mid-Estuary basins in eastern St. Lucie County and northeastern Martin County. The sub-watershed has a total drainage area of approximately 119,168 acres. The C-24 and C-23A canals, along with the S-49 Structure, regulate water levels in the North Fork Basin and the C-24 Basin (SFWMD, FDEP, and FDACS 2009).

C-44 Sub-Watershed

The C-44 Sub-watershed includes the C-44 and S-153 basins, and has a drainage area of approximately 129,719 acres. The St. Lucie (C-44) Canal connects Lake Okeechobee to the South Fork of the St. Lucie River. Two control structures are located in the C-44 Canal: the S-80 (St. Lucie Lock and Spillway) and the S-308 (Port Mayaca Lock and Spillway/Dam). The C-44 Canal is a primary outlet from Lake Okeechobee for flood control. Water levels in the C-44 Sub-watershed are regulated by the S-80 Structure, and regulatory releases from Lake Okeechobee are through the S-308 Structure (SFWMD, FDEP, and FDACS 2009).

The S-153 basin discharges into the western end of the C-44 Canal. Secondary drainage in the basin is provided by natural streams.

South Fork Sub-watershed

The South Fork Sub-watershed (otherwise known as Tidal St. Lucie) includes the South Fork and South Mid-Estuary basins, and has a total drainage area of approximately 49,965 acres. Located east of the C-44 Basin, the South Fork Sub-watershed includes the South Fork of the St. Lucie from south of the Roosevelt Bridge, including the City of Stuart, to a portion of the area to the southwest and upstream of the S-80 Structure. The C-44 is the only major drainage canal in the Tidal St. Lucie/South Fork Sub-watershed.

Coastal Sub-watersheds

Three coastal sub-watersheds span St. Lucie and Martin counties: 1) North Coastal, 2) Middle Coastal, and 3) South Coastal. In general, these watersheds contain barrier islands, the Intracoastal Waterway, and mainland beaches. Most of the surface water in these watersheds is tidal and not used for water supply.

Groundwater Resources

The major hydrogeologic units underlying the UEC Planning Area are: 1) the SAS, 2) the intermediate confining unit (ICU) (low-permeability sediments of the Hawthorn Group), and 3) the FAS (**Figure 15**). The SAS extends to the top of the ICU, and the ICU extends to the top of the FAS. **Table 29** lists the groundwater systems, hydrogeologic units, and relative aquifer yields for each county in the UEC Planning Area.

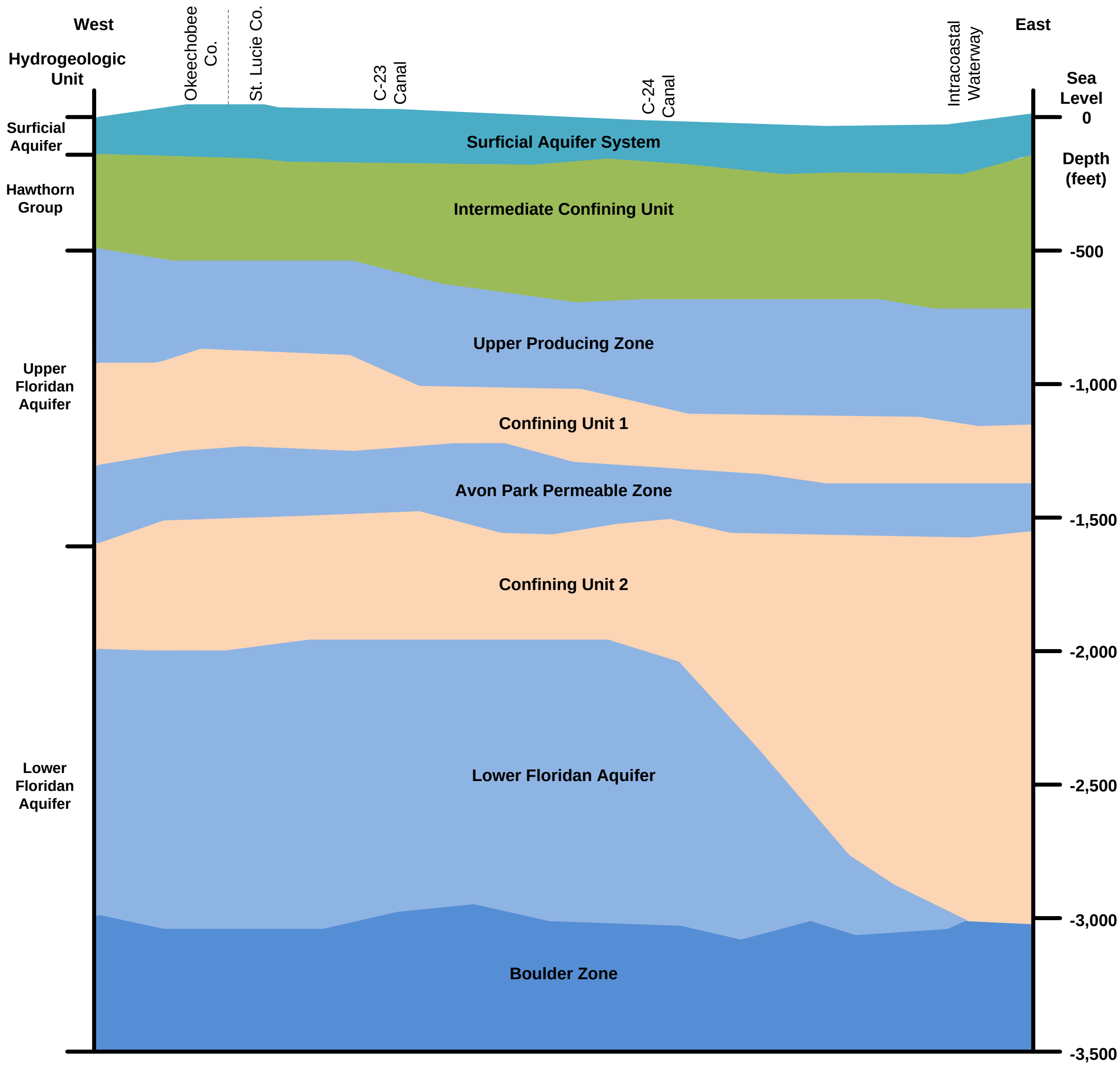


Figure 15. Generalized hydrogeologic cross-section of the Upper East Coast Planning Area.

Table 29. Groundwater systems in the Upper East Coast Planning Area.

Aquifer System	Hydrogeologic Unit	Aquifer Yield L=Low M=Moderate H=High		
		Martin	St. Lucie	Okeechobee
Surficial Aquifer System	Surficial Aquifer	M	L–M	L
Intermediate Confining Unit	Hawthorn Group	L	L	L
Floridan Aquifer System	Upper Floridan Aquifer	H	H	M–H
	Lower Floridan Aquifer	H	H	H

Surficial Aquifer System

The SAS is one of the sources of water for urban uses, including potable water, within the UEC Planning Area. The system includes all saturated rock and sediment from the water table to the top of the underlying ICU, and ranges in thickness from 50 feet to 250 feet in this area (Brown and Reece 1979). Its lithology consists of quartz sand, silts, clay, shell beds, coquina, calcareous sandstone, and limestone with shells. 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 ICU comprises relatively impermeable phosphatic clays, silts, and limestones of the Hawthorn Group in the northwest corner of St. Lucie County. The top of this confining unit lies approximately 80 feet below MSL. It dips slightly to the southeast, reaching a maximum depth of more than 200 feet below MSL 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 ICU has low permeability, does not yield significant quantities of water to wells, and separates the overlying SAS from the underlying FAS.

Floridan Aquifer System

The FAS ranges in thickness from 2,700 feet to 3,400 feet within the UEC Planning Area. The top of the FAS lies approximately 300 feet below MSL in the northwest corner of the planning area. It then dips to more than 900 feet below MSL in southeastern Martin County. The elevation of the top of the FAS corresponds to the top of the Hawthorn/Suwannee basal unit. The FAS includes rocks of middle Eocene (Oldsmar and Avon Park), Upper Eocene (Ocala Limestone), Oligocene (Suwannee Limestone), and Miocene (Hawthorn Group) age (Parker, Gorginsen, and Love 1955).

The FAS is divided into three aquifers based on the vertical occurrence of two regionally persistent zones: the Upper and Lower Floridan aquifers. The Upper and Lower Floridan aquifers are separated by a low-permeability interval, labeled the middle confining unit by Miller (1986) (confining unit 2 in **Figure 15**).

However, water from the FAS requires blending with surface water prior to irrigation because of the chloride levels in the water.

Upper Floridan Aquifer

The Upper Floridan Aquifer (UFA) is an artesian aquifer (meaning it flows at land surface without the aid of pumping) within the UEC Planning Area. The UFA is greater than 500 feet thick within the planning area. It is characterized by two distinct and regionally correlatable producing zones. Although these units occur together, they are not homogenous because both are composed of multiple smaller producing zones with intervening semi-confining units.

The upper producing zone is best developed along the lithologic contacts between the Suwannee Formation and the Ocala Group, and the Ocala Group and the Avon Park Formations. A lower-permeability semi-confining unit (**Figure 15**, confining unit 1) separates the upper producing zone from the Avon Park permeable zone. The Avon Park permeable zone is 800 feet or more below land surface (Rupert 1992). This zone is associated with fractured and solutioned dolomites within the Avon Park Formation.

Within the UFA, the deeper Avon Park permeable zone is generally more productive than the upper producing zone, but its productivity is also less predictable and varies widely across the planning area. The presence of the lower-permeability rock separating the upper producing zone from the Avon Park permeable zone allows for variations in water quality between these two units as well. In most cases, the deeper unit is more brackish than the upper. Many users of the UFA within the UEC Planning Area construct wells to use both the upper producing and Avon Park permeable zones, but must balance water quality with improved productivity.

The productivity of the UFA is considerably greater than that of the SAS throughout most of the planning area. Total dissolved solids concentrations in the upper producing zone average about 900 milligrams per liter (mg/L) and increase toward the southeast to 3,000 mg/L in southeastern Martin County. Total dissolved solids concentrations in the Avon Park permeable zone water average about 3,000 mg/L and increase toward the southwest as much as 5,000 mg/L in southwestern Martin County.

The UFA is an important source of agricultural irrigation water, particularly in the northern portion of the planning area and especially when surface water availability is limited. In parts of Martin and St. Lucie counties, the UFA is used for drinking water, and as the area continues to grow, use of the UFA to augment urban supply is expected to increase. The UFA's chloride concentrations are within a reasonable range for current desalination technology. Where chlorides are sufficiently low, UFA water can be blended with SAS water for use by Public Water Supply utilities as well. A number of utilities are using, or have immediate plans to use, desalinated UFA water to supply their service areas

Lower Floridan Aquifer

The deeper producing zones of the FAS are associated with the basal unit of the Floridan aquifer, a hard, porous, crystalline dolomitic limestone, with stringers of chalky fossiliferous limestone.

There are multiple flow zones within the upper part of the Lower Floridan aquifer (LFA), but these are generally not used as supply sources within the UEC Planning Area due to the high salinity (greater than 10,000 mg/L) and mineral content of the water.

An area of extremely high transmissivity, known as the Boulder Zone, occurs at the base of the LFA. A thick confining layer of dense limestones and dolomites impedes flow between the Boulder Zone and the transmissive zones at the top of the LFA. The base of the LFA generally coincides with the top of the evaporite beds in the Cedar Keys Formation (Miller 1986). The Boulder Zone is to dispose of wastewater effluent that is not reused and concentrate from desalination water treatment facilities.

Surface Water and Groundwater Relationships

In many ways, surface water and groundwater resources are interdependent. Although surface water management systems are a major source of water supply, in terms of interaction with groundwater, the systems within the UEC Planning Area function primarily as aquifer drains. 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, may be lost to evapotranspiration, or is discharged to tide.

Although the FAS is not hydraulically connected to surface water within the UEC Planning Area, FAS water has become a primary source of water for Public Water Supply. The FAS is usually diluted with surface water to achieve an acceptable quality for agricultural irrigation.

ECOSYSTEM RESTORATION EFFORTS

Information about ecosystem restoration efforts for the UEC Planning Area is available in the 2011 UEC Plan Update (SFWMD 2011b).

More information and the status of these restoration projects can be found in the *South Florida Environmental Report* available from http://www.sfwmd.gov/sfer. Project descriptions, status, and further documentation about other projects are available from http://www.evergladesplan.org, http://www.sfwmd.gov/northerneverglades, and http://www.sfwmd.gov/everglades.

Roseate Spoonbills – Savannas Preserve State Park

9

Lower West Coast Planning Area

This chapter describes characteristics of the Lower West Coast (LWC) Planning Area. An overview of the region's physical features and water resources, including surface water and groundwater, is presented in this Support Document, which supplements the *2012 LWC Water Supply Plan Update* (2012 LWC Plan Update) (SFWMD 2012). For a comprehensive review of water supply status and issues in the LWC Planning Area, refer to the 2012 LWC Plan Update.

TOPICS

- Planning Area Boundaries
- Physical Features
- Water Resources and System Overview
- Ecosystem Restoration Efforts

PLANNING AREA BOUNDARIES

The Lower West Coast Planning Area includes all of Lee County, most of Collier County, and portions of Charlotte, Glades, Hendry, and Monroe counties (**Figure 16**). The boundaries of the LWC Planning Area generally reflect the drainage patterns of the Caloosahatchee River Basin to the north and the Big Cypress National Preserve to the south. The northern boundary corresponds roughly to the northerly watershed area of the Caloosahatchee River, which is generally the SFWMD and Southwest Florida Water Management District (SWFWMD) jurisdictional boundary in Charlotte County. The eastern boundary of the LWC Planning Area is along the western edge of the historic Everglades Watershed, dividing the Big Cypress and Lake Okeechobee drainage basins. At the southern end of the region, the LWC Planning Area encompasses a coastal portion of Everglades National Park and ends just north of Shark River Slough.

Brown Pelicans

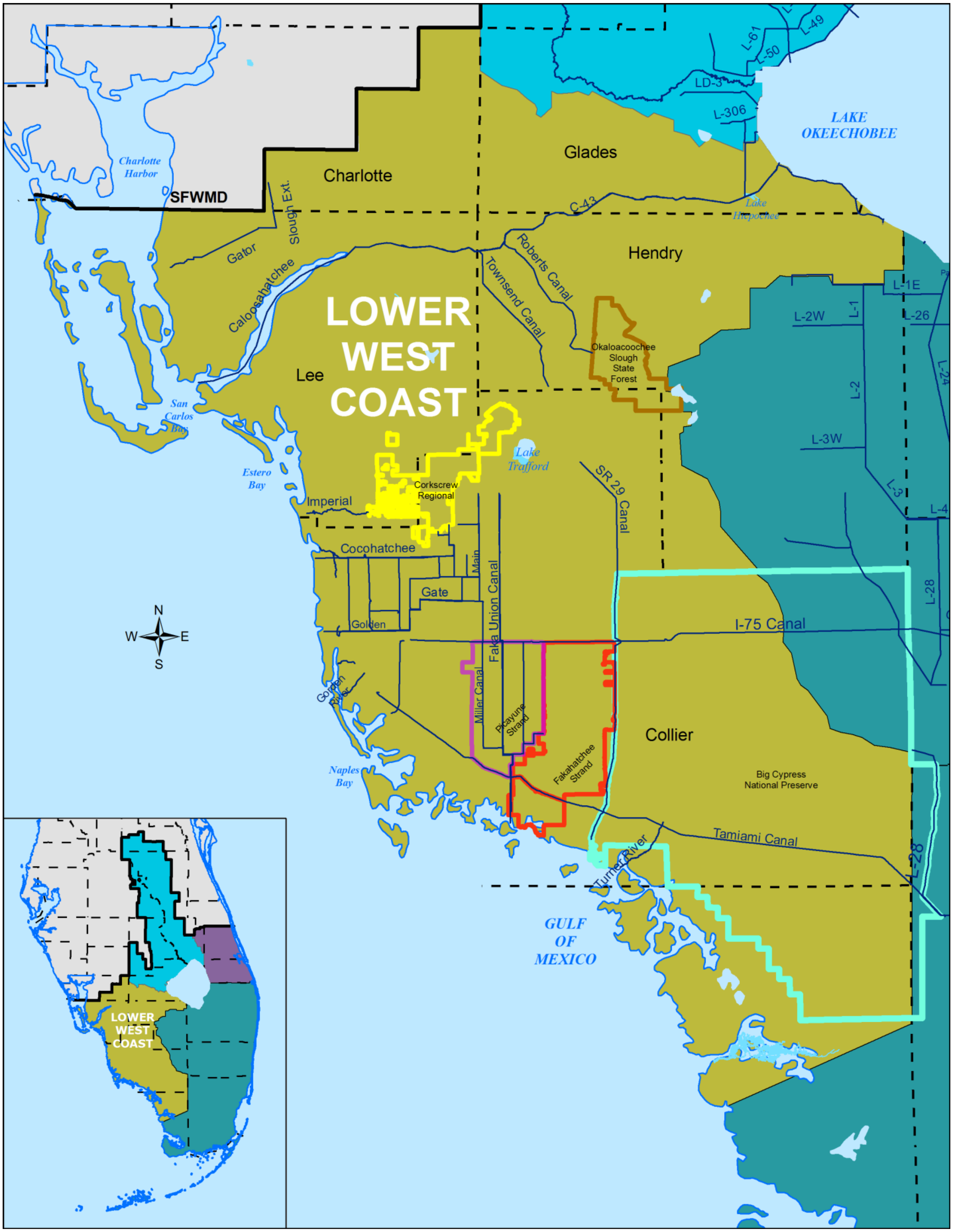


Figure 16. Lower West Coast Planning Area.

PHYSICAL FEATURES


Big Cypress National Preserve

Major features of the LWC Planning Area include the Caloosahatchee River and Estuary; Lake Okeechobee; Lake Trafford; Corkscrew Regional Ecosystem Watershed (CREW); Big Cypress Swamp; and along the west coast, Southern Charlotte Harbor; Estero Bay; Naples Bay; Ten Thousand Islands and Rookery Bay; and the Fakahatchee Estuary. Elevation differences in Florida are generally minimal, with low coastal ridges and sloughs the most common topography, especially in the southern part of the state. Because of these low-relief elements, water generally flows from north to south within the SFWMD, with excess surface water runoff discharging to the coasts.

The Fisheating Creek Basin in the adjacent Kissimmee Basin Planning Area impacts the northeastern boundary of the LWC Planning Area. The basin is an extensive riverine swamp system that forms a watershed covering 440 square miles. It is the only free-flowing tributary to Lake Okeechobee and lessens the intensity of discharges to the lake that flow from north to south during heavy storm events. Flows from the Fisheating Creek Basin affect surface water flows in the LWC Planning Area through lake and river discharges and sheetflow events.

Water Bodies and Landscapes

Lake Okeechobee is one of the largest freshwater lakes in the nation, and provides the major storage for surface water in south Florida. It lies east of the LWC Planning Area, discharges through water control systems west to the coast through the Canal-43 Canal and Caloosahatchee River.

The Caloosahatchee River receives inflows from Lake Okeechobee and runoff from within its own watershed. West of the S-79 structure, the river mixes freely with estuarine water as it empties into the Gulf of Mexico, forming an important tidal estuary (see the *Coastal Ecosystems* section of this chapter). Lake Hicpochee connects to Lake Okeechobee via a canal for drainage, creating an avenue for lake water discharges to the west coast through the river. Later modifications to the Caloosahatchee River allowed development in the watershed, resulting in a network of local secondary and tertiary canals. This network provides conveyance for drainage, flood control, and irrigation to accommodate agricultural and urban needs.

Lake Trafford is the largest lake south of Lake Okeechobee. The lake is in the central portion of the LWC Planning Area and forms the inland headwaters of the Corkscrew Swamp and

Imperial and Cocohatchee river watersheds that drain into the Ten Thousand Islands and Estero Bay estuary systems on the coast.

In the areas surrounding most of Lake Trafford's shores is the Corskcrew Regional Ecosystem Watershed (CREW), which extends west-southwest through Lee and Collier counties toward Naples. Pine flatwoods, marshes, and slough areas characterize CREW, with small bald cypress stands interspersed throughout. Of the approximately 94 square miles of watershed area, about 78 square miles have been designated as preserve. The *South Florida Environmental Report – Volume II* (available from http://www.sfwmd.gov/sfer) annually updates the status of this ecosystem restoration project.

Okaloacoochee Slough is an important surface water flow-way in Collier County. The headwaters of this 13,382-acre pristine slough originate in northern Hendry County. The slough runs north to south through the 32,039-acre Okaloacoochee Slough State Forest.

Composed largely of herbaceous plants with trees and shrubs scattered along its fringes and central portions, the Okaloacoochee Slough provides a large roaming area of contiguous habitat for a variety of wildlife species. The forest is home to listed, threatened, and endangered species, such as the Florida panther, Florida black bear, sandhill crane, wood stork, and gopher tortoise.

The natural systems of the Fakahatchee Strand Preserve and Big Cypress Preserve are dependent on the water supplied by the Okaloacoochee Slough.

South of Lake Trafford and CREW, roughly from west to east, are the Picayune Strand State Forest, Fakahatchee Strand Preserve State Park, Big Cypress Natural Preserve, and the Florida Panther National Wildlife Refuge, which sits on the north end of Fakahatchee Strand. Picayune Strand State Forest is located in the heart of the greater Big Cypress Basin. The forest encompasses two major tracts of land, Belle Meade and Southern Golden Gate Estates.

Picayune Strand State Forest

Fakahatchee Strand is a long, narrow forest with an unusual natural slough. The park covers about 100 square miles between the Picayune Strand State Forest and Big Cypress National Preserve. Within a dense bald cypress and royal palm canopy, Fakahatchee Strand shelters a slow-flowing river, several lakes, and a range of wet and dry landscapes. The trees and slough create a microclimate within the region that is more temperate than surrounding areas. Because of this, a large diversity of rare tropical plants, such as the ghost orchid, are often found. Prairie Canal currently defines the western border of Fakahatchee Strand, which has hastened the drainage of water from the natural areas.

Big Cypress National Preserve protects almost half of the Big Cypress Swamp. The preserve spans about 1,125 square miles (720,000 acres) of the 2,400-square-mile swamp basin. Dominated by cypress trees, Big Cypress Swamp is mainly in Collier County. The swamp's fresh waters are essential to the health of the Everglades, and support the estuaries along Florida's southwest coast. Fresh water from the preserve flows south and west into the Ten Thousand Islands region.

Coastal Ecosystems

Coastal areas are dominated by large estuarine systems where the waters of the Gulf of Mexico mix with the freshwater inflows from numerous river systems, sloughs, and overland sheetflow. These estuarine areas are characterized by shallow bays, extensive seagrass beds, and sand flats. Extensive mangrove forests dominate undeveloped areas of the shoreline. Coastal areas subject to tidal inundation support extensive mangrove forests and salt marsh areas. These brackish water communities were once commonly distributed along the entire coastline, but are now found in greatest abundance in southwestern Collier County and southern Lee County.

Mangroves in Estero Bay

Two large open water estuarine systems, Charlotte Harbor and the Caloosahatchee Estuary, dominate the northwest portion of the LWC Planning Area. Charlotte Harbor is Florida's second-largest open water estuary, characterized by a broad barrier island chain. Only the southern portion of this system lies within the District's boundaries, which includes the Caloosahatchee Estuary, San Carlos Bay, and most of Pine Island Sound and Matlacha Pass. Southern Charlotte Harbor is mostly preserve, and adjoins the J.N. "Ding" Darling National Wildlife Refuge on Sanibel Island. The harbor consists of mangroves, salt flats, oyster bars, and seagrasses. It is monitored regularly as part of a national aquatic preserve program. Economically important fisheries thrive in Southern Charlotte Harbor, and numerous endangered and threatened species can be found here.

At the tip of Southern Charlotte Harbor and north of Estero Bay is the Caloosahatchee River Estuary, a large estuarine ecosystem where the waters of the Gulf of Mexico mix with the freshwater inflows from the Caloosahatchee River and its watershed (C-43 Basin), as well as the largely urban tidal basin surrounding the estuary itself.

Estero Bay is a long, narrow, and very shallow body of water. Estero Bay's 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 major wetland and associated upland systems are located within the central and eastern parts of the basin.

The Estero Bay Watershed includes central and southern Lee County, as well as parts of northern Collier and western Hendry counties. The watershed contains all of Estero Bay and adjacent barrier islands. The Estero Bay Aquatic Preserve protects the water, inlets, and islands along 10 miles of Estero Bay. Hendry Creek, Mullock Creek, the Estero River, areas of the CREW, Spring Creek, and the Imperial River are major surface water features and principal sources of freshwater inflows in the basin. The natural flow path between the Estero and Imperial river watersheds is through the Flint Pen Strand, part of the CREW. Flint Pen Strand has been disrupted by urban and agricultural development that hampers aquifer recharge and affects these natural systems. Restoring sheetflow through the region is part of the restoration effort for this watershed.

Naples Bay originates at the mouth of the Gordon River in downtown Naples. Several miles to the south, the bay connects to the Gulf of Mexico through Gordon Pass. South of Gordon Pass, at the southern lobe of the Naples Bay system, Dollar Bay connects to Rookery Bay and the Marco River through a shallow waterway with a dredged channel.

The 120-square-mile Naples Bay Basin lies within the greater Big Cypress Basin, and shares borders with the Corkscrew-Cocohatchee Basin to the north, the Faka-Union Canal Basin to the east, and the Henderson Creek Basin and Rock Creek, Winter Park Outlet, Haldeman Creek, Lely Canal, and Eagle Creek subbasins along the southeast. Fresh water flows into Naples Bay from the Golden Gate Canal, Gordon River, Rock Creek to the north, Haldeman Creek to the east, and runoff from the urban areas that surround the bay.

Rookery Bay, just south of Naples Bay, is in the northern edge of the Ten Thousand Islands estuary region in Collier County, between Naples and Marco Island. The bay is part of a national estuary preserve program, and is downstream of the Comprehensive Everglades Restoration Plan (CERP) Picayune Strand Restoration Project (previously referred to as the Southern Golden Gate Estates Restoration Project).


Rookery Bay

Golden Gate Weir No. 3 on the Golden Gate Canal was relocated and rebuilt in 2010. When coupled to a connecting canal, this weir will divert water to Henderson Creek, a tributary to Rookery Bay. The main goals of this weir are to restore more natural flows to both Naples and Rookery bays by restoring seasonal flows through Henderson Creek, and retain more water upstream during the dry season to assist in aquifer recharge. Golden Gate Weirs No. 6 and No. 7 were replaced in 2012 to improve flood protection and create additional groundwater storage capacity in the canal to during the dry season. These weirs will also help improve salinity by reducing freshwater flows to Naples Bay and the Ten Thousand Islands area.

Ten Thousand Islands

The Ten Thousand Islands estuarine ecosystem, located in the southern portion of Collier County contains bays, interconnected tidal embayments, lagoons, and tidal streams. Sources of freshwater drainage include sloughs, strands, a series of tidal creeks and channels, surface and sub-surface sheetflow, and canals.

Ten Thousand Islands is one of the world's largest remaining intact mangrove forests. The habitat extends from just south of Marco Island to Flamingo and Florida bays. Two-thirds of the area lie within the Everglades National Park's Whitewater Bay. Cape Romano/Ten Thousand Islands Aquatic Preserve and Ten Thousand Islands National Wildlife Refuge protect the areas outside the Everglades National Park boundaries.

For scientific study, the Fakahatchee Estuary may include Rookery Bay, the Ten Thousand Islands National Wildlife Refuge, and smaller embayments south through to Fakahatchee Bay. However, for the sake of water supply planning, Fakahatchee Estuary is narrowed to the north-to-south region beginning at Blackwater Bay and extending through Fakahatchee Bay into the northern coastal regions of Everglades National Park.

Geography and Climate

The LWC Planning Area extends approximately 5,129 square miles across southwestern Florida, and its average elevation is about 16 feet above mean sea level (MSL). The landscape slopes gently westward, in keeping with the overall topography of the state, which slopes away from the peninsular ridge that extends from the Georgia border and ends just above Lake Okeechobee. Within the LWC Planning Area, fresh water drained across the landscape from the historic Everglades and Lake Okeechobee and from the Immokalee Rise to the estuaries on the west coast.

Average seasonal temperatures for the area range from approximately 64°F to 82°F. Estimated annual rainfall in the LWC Planning Area averages 53 inches (see also the *Precipitation and Evapotranspiration* section). Nearly two-thirds of the area's rainfall occurs during the six-month wet season from May through October.

Physiography

South Florida is characterized by low topographic relief and a high water table. With this type of flat terrain, a few vertical feet may have a profound effect on surface water drainage, vegetation, and settlement patterns.

Physiographically, the LWC Planning Area includes the Caloosahatchee River and Big Cypress watersheds. The Caloosahatchee Watershed encompasses the Caloosahatchee River Valley, Caloosahatchee Incline, DeSoto Plain, and Immokalee Rise (USDOI 1984). The Big Cypress Watershed contains all or parts of the Immokalee Rise, Big Cypress Spur, Southwestern Slope, and Coastal Swamps and Lagoons (USDOI 1984) (**Figure 17**).

In the Caloosahatchee River Watershed, the Caloosahatchee River Valley is the dominant physiographic feature. The valley follows the Caloosahatchee River from Lake Okeechobee to San Carlos Bay.

The valley “wall” is known as the Caloosahatchee Incline, which slopes gradually upward to the north of the river (USDOI 1984). At the peak of the valley wall lies the DeSoto Plain, a very flat terrace extending down from central Florida. The Immokalee Rise forms the valley wall south of the Caloosahatchee River.

The Immokalee Rise is an elevated flat area of predominantly sandy soils (USDOI 1984). This area is located primarily in Hendry County but extends into eastern Lee County and northeastern Collier County. The Immokalee Rise is bounded on the east by the Everglades, on the south-southeast by the Big Cypress Spur, and on the southwest by the Southwestern Slope. The Immokalee Rise ranges in elevation from 25 to 42 feet above MSL (FGS 1988).

The Big Cypress Spur is a sloping, transitional area between the Immokalee Rise, the Everglades to the east, and the Southwestern Slope to the west (USDOI 1984). This area receives runoff from the Immokalee Rise and drains to the Everglades and the Southwestern Slope. Elevations are only slightly higher than 25 feet MSL.

Big Cypress Swamp

The Southwestern Slope lies at elevations below approximately 25 feet MSL between the Gulf of Mexico and the western edges of the Immokalee Rise and Big Cypress Spur (FGS 1988). This area is a northwest-southeast trending area that tilts toward the Gulf of Mexico (USDOI 1984).

The Collier County coastline consists of quartz sand-dominated barrier islands and lagoons, with Cape Romano forming the southern end of these barrier islands. The Ten Thousand Islands are located south of Cape Romano, and are transitional between the barrier islands and shoreline to the south. The Reticulate Coastal Swamps border the Gulf Coast in the southern portion of Collier County. These swamps consist of channeled mangrove swamps and coastal marshes (FGS 1988).

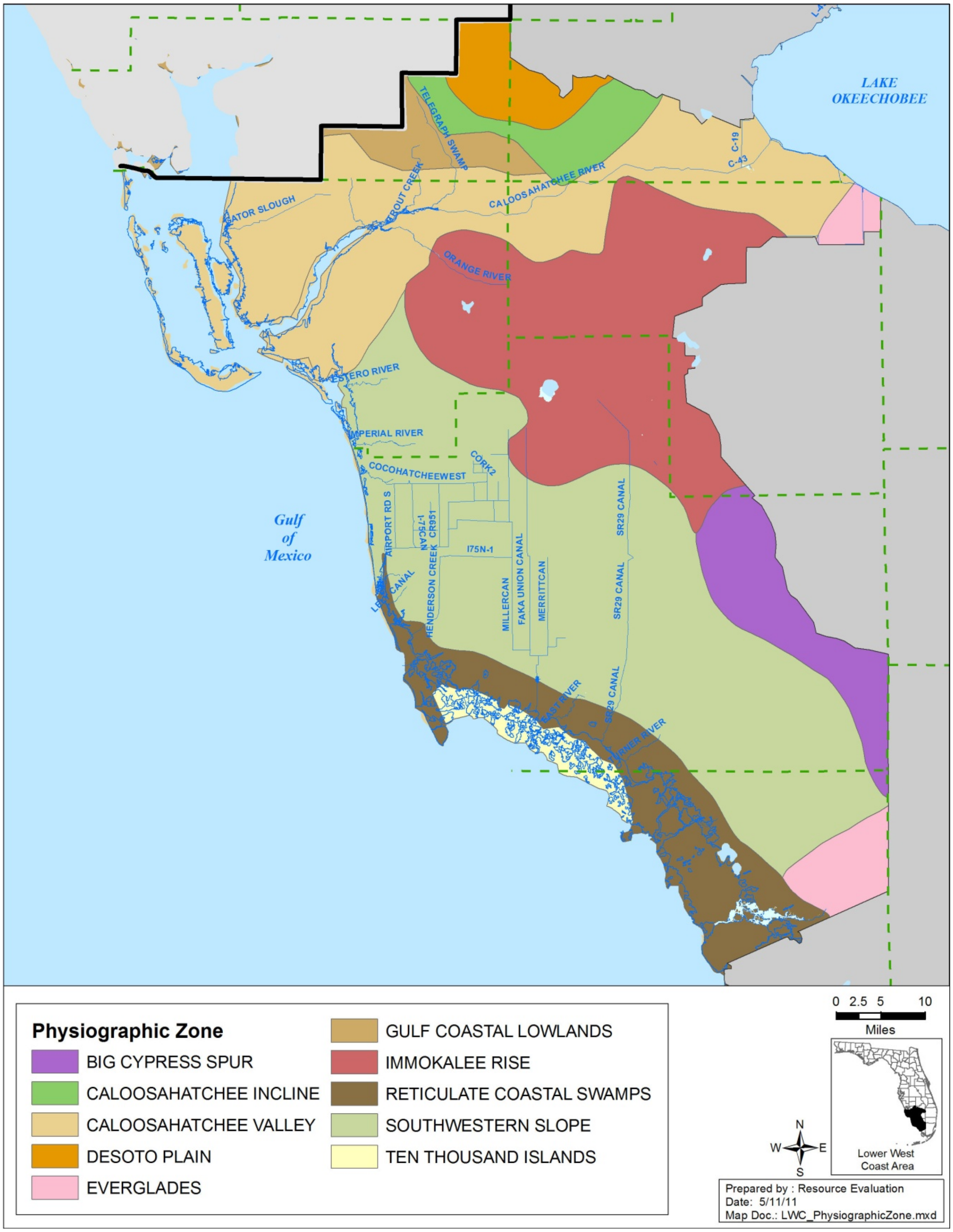


Figure 17. Physiography of the Lower West Coast Planning Area.

WATER RESOURCES AND SYSTEM OVERVIEW

Before development, most of the LWC 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 Telegraph Cypress Swamp, Corkscrew Swamp, Flint Pen Strand, Camp Keais Strand, Six Mile Cypress Slough, Okaloacoochee Slough, and Twelve Mile Slough.

In the following sections, surface water and groundwater resources are addressed as separate entities. Surface water resources in the LWC Planning Area include natural systems and canals. Groundwater resources include the surficial aquifer system, intermediate aquifer system, and the Floridan aquifer system.

Regional Hydrologic Cycle

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

Precipitation and Evapotranspiration

Hydrologic and meteorological methods are available to measure and 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 groundwater recharge. The estimate of potential evapotranspiration (ETp) from open water and wetlands in the LWC Planning Area is 52 inches (Abtew et al. 2003). Potential evapotranspiration represents the total estimated passive water use of an area under maximum conditions. While actual evapotranspiration varies due to temperature, soil moisture, and other factors, ETp estimates are important landscape-level factors in water balance calculations to determine if enough water will be available for all uses during different environmental conditions.

Mouth of Caloosahatchee River
and San Carlos Bay

Surface Water Inflow and Outflow

With the exception of the Caloosahatchee River and C-43 Canal, most surface water in the LWC Planning Area originates from rainfall. The Caloosahatchee River also receives water from Lake Okeechobee. Historic flow-ways in the region were natural drainage features, consisting of a series of flat wetlands or swamps, connected by shallow drainage ways or sloughs separated by low ridges. These features were dry for a portion of the year, and overtopped by water in periods of seasonal high rainfall.

Most of the canals in the LWC Planning Area were constructed as surface water drainage systems. The C-43 Canal and Caloosahatchee River are key sources of fresh water for consumptive use and the estuary. The amount of stored water is of critical importance to both the natural ecosystems and developed areas in the LWC Planning Area. Management of surface water storage capacity involves balancing two conflicting conditions: 1) drought conditions may occur during periods of deficient rainfall, and 2) flooding may occur due to excessive rainfall, especially during the wet season.

Groundwater Flow

Three major aquifer systems underlie the LWC Planning Area: the surficial aquifer system (SAS), the intermediate aquifer system (IAS), and 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

Surface water bodies in the LWC Planning Area include rivers and canals that provide storage and conveyance of surface water. However, the area's two largest lakes, Lake Trafford and Lake Hicpochee, are not considered suitable water supply sources. Lake Hicpochee changes dramatically in size on a seasonal basis as it receives overflows from Lake Okeechobee during times of high lake levels. The dynamic nature of Hicpochee makes it unsuitable as storage. The inflows are not of potable quality, and the water would require relatively expensive treatment for use. In addition, construction of the C-43 Canal through the center of Lake Hicpochee has resulted in lower lake water levels the lake does not provide enough storage to be considered a major water supply source.

The Caloosahatchee River, the region's most important surface water source, extends across seven of the 10 drainage basins in the LWC Planning Area. The river is provided by runoff from within its own basin and supplemented inflows from Lake Okeechobee. The freshwater portion of the river (C-43 Canal) 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 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 (**Figure 18**). These basins are:

1. North Coastal Basin
2. Tidal Caloosahatchee Basin
3. Telegraph Swamp Basin
4. West Caloosahatchee Basin
5. East Caloosahatchee Basin
6. S-4 Basin
7. S-236 Basin
8. Estero Bay Basin
9. West Collier Basin
10. East Collier Basin

North Coastal Basin

The North Coastal Basin, in southwestern Charlotte County and northwestern Lee County, contains numerous creeks. 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, which is a 115-square-mile area and Florida's third-largest city (as measured by land mass). Approximately 295 miles of the canal system are considered fresh water and about 105 miles are brackish water. The system drains a large area, affecting the hydrology of the Matlacha Pass and Caloosahatchee estuaries.

Tidal Caloosahatchee Basin

The Tidal Caloosahatchee Basin extends on both sides of the saltwater portion of the Caloosahatchee Basin and northerly into Charlotte County. Numerous creeks drain into the Caloosahatchee River in this basin.

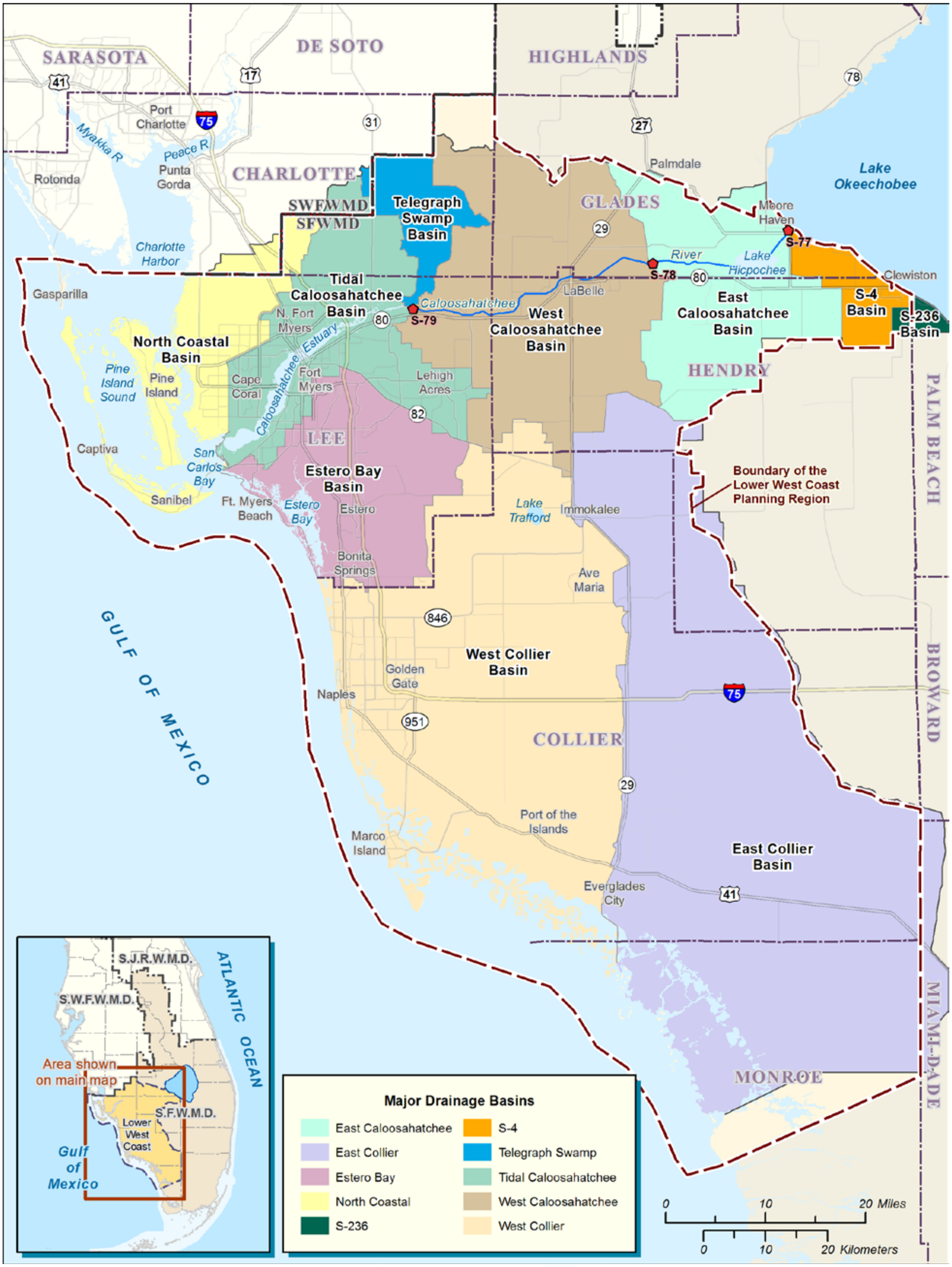


Figure 18. Lower West Coast Planning Area basins.

Telegraph Swamp Basin

The Telegraph Swamp Basin extends from Charlotte County southward to the Caloosahatchee River. Telegraph Cypress Swamp, which drains via sheetflow into Telegraph Creek in Lee County, is the basin's major feature. The approximately 92-square-mile watershed with sheetflow discharge is potentially suitable as a water supply recharge area (Johnson Engineering et al. 1990).

West and East Caloosahatchee Basins

The West and East Caloosahatchee basins are located along the freshwater portion of the C-43 Canal. These 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 canal has multiple purposes including navigation, water supply, drainage, and 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 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 water for Lee County's Olga Wastewater Treatment Facility.

C-43 Canal Operations

Three structures (S-77, S-78, and S-79) provide navigation and water control in the C-43 Canal. These structures are operated by the U.S. Army Corps of Engineers. They 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 above MSL and 3 feet above MSL 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.

Estero Bay Basin

The Estero Bay Basin is located in southern Lee County. The basin includes Hendry Creek, Mullock Creek/Ten Mile Canal/Six Mile Cypress Slough, Kehl Canal/Imperial River, Estero River, and Spring Creek. These waterways are influenced in varying degrees by tides. Within the Estero Bay Basin, a twofold water management problem exists: 1) overdrainage in areas due to development, and 2) lack of conveyance in other areas resulting in flooding.

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, it was determined that saltwater barriers (weirs) could be used to increase water levels within the basin for recharge (Johnson Engineering et al. 1990). Several waterworks projects to increase water levels in the western part of the basin and to protect the water resources against saltwater intrusion have been completed or are under way. 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.


Estero Bay

The Estero River east of U.S. Highway 41 and the Imperial River east of Interstate-75 are both considered good recharge areas. The Kehl Canal is connected to this river and drains the water levels within this basin.

West Collier Basin

The West Collier Basin extends west from State Road 29 to the Gulf of Mexico, and north to the Lee County border. The basin also includes a portion of Hendry County. The West Collier Basin does not have an external 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 West Collier Basin flows into the Gulf of Mexico near the Ten Thousand Islands. The Gordon and Cocohatchee rivers are the two remnant natural rivers in this basin. Both rivers are tidally influenced and connect to the canal system within this basin. This canal system, operated and managed by the Big Cypress Basin Board, serves primarily as a drainage network. The Big Cypress Basin Board retrofitted many old weirs and constructed new water control structures in the canals to prevent overdrainage of the basin. Because the primary source of water for this system is rainfall, the canals have little or no flow during the dry season, but produce considerable freshwater discharge during wet conditions.

The West Collier Basin has extensive wetland systems including the CREW, Picayune Strand State Forest, Fakahatchee Strand Preserve State Park, and Collier-Seminole State Park.

East Collier Basin

The East Collier Basin extends east from State Road 29 to the LWC Planning Area boundary, north approximately 3 miles into southern Hendry County, and south into Monroe County. Sheetflow from this basin flows south-southwest into 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 the East Collier Basin.

Groundwater Resources

Three major aquifer systems—the surficial, intermediate, and Floridan—lie beneath southwestern Florida. As **Figure 19** illustrates**,** these systems are composed of multiple, discrete aquifers separated by confining units with low permeability.

Because hydraulic properties (i.e., ability to yield water to wells) and water quality may vary both vertically and horizontally within each individual aquifer, groundwater supply potential is uneven throughout the planning area.

Table 30 lists the aquifer systems, hydrogeologic units, and aquifer yields in the LWC Planning Area.

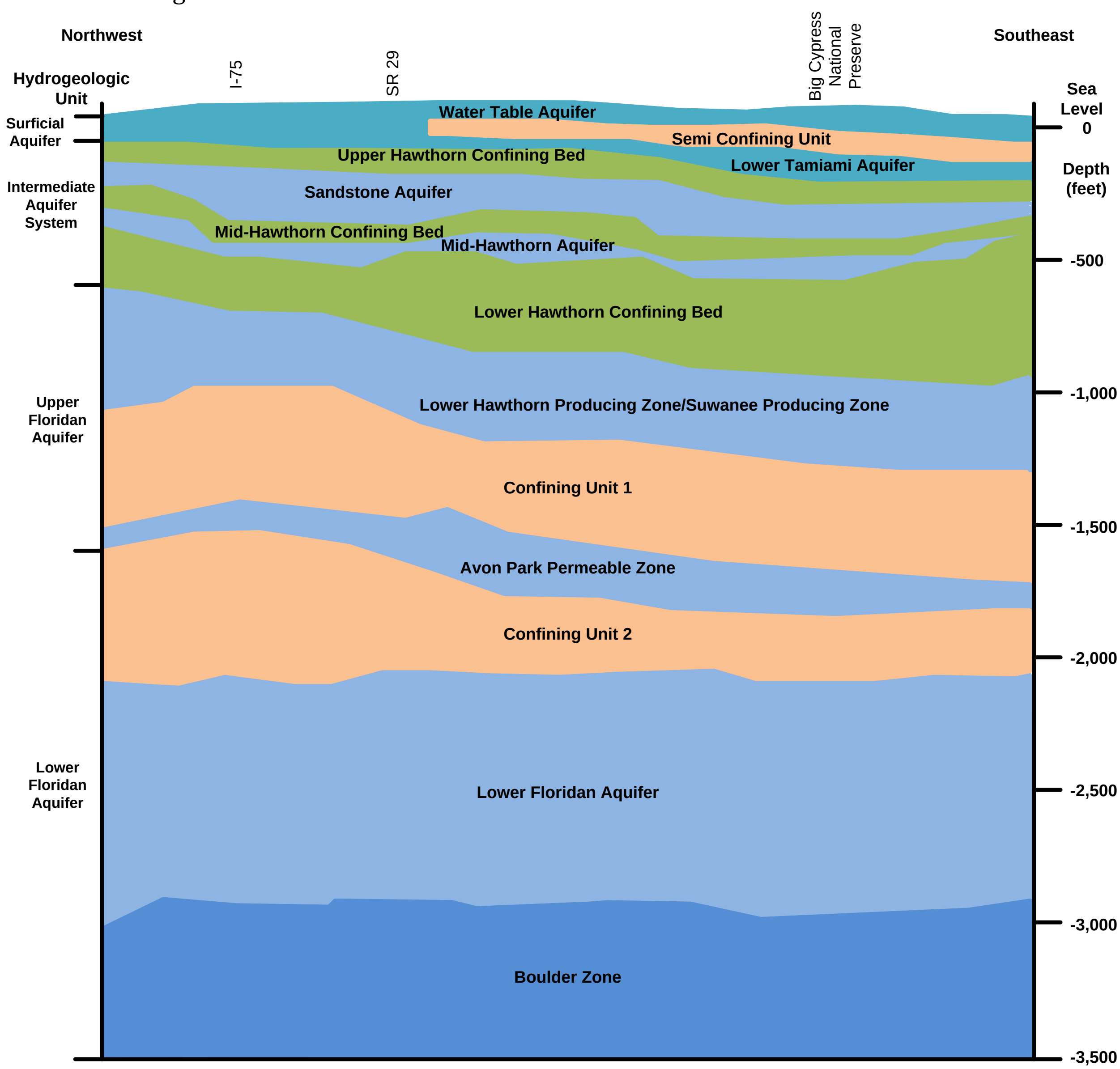


Figure 19. Generalized hydrogeologic cross-section of the Lower West Coast Planning Area.

Table 30. Groundwater systems in the Lower West Coast Planning Area.

Aquifer System	Hydrogeologic Unit	Aquifer Yield A=Absent L=Low M=Moderate H=High				
		Charlotte	Glades	Lee	Hendry	Collier
Surficial	Water Table Aquifer	L	L-M	L-M	L-M	M-H
	Lower Tamiami Aquifer	A	A-L-M	A-M	A-M-H	H
Intermediate	Sandstone Aquifer	A-L	A-L-M	A-L-M	A-L-M	A-L
	Mid-Hawthorn Aquifer	L	A-L	L	L	M
Floridan	Upper Floridan Aquifer	H	H	H	M-H	M-H
	Avon Park Permeable Zone Middle Confining Unit (Confining Unit 2)	L	L	L	L	L
	Lower Floridan Aquifer	H	H	M	M	M

Surficial Aquifer System

In the LWC Planning Area, the surficial aquifer system (SAS) consists of the Water table aquifer, confining beds, and the Lower Tamiami aquifer with Holocene- to Pliocene-age materials. 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 by precipitation, seepage from canals and other surface water bodies, and upward leakance from the 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 water for agricultural and landscape irrigation. The Water table aquifer supports natural hydroperiods of wetland systems. Consequently, SFWMD water use permitting criteria limits water availability from this aquifer due to potential harm to wetlands.

Although the Water table aquifer in Hendry County may yield abundant quantities of water in isolated areas, it is generally used only where no suitable alternative is available. The aquifer produces potable quality water. However, in areas near LaBelle and the Caloosahatchee River, concentrations of chlorides and total dissolved solids may be elevated above drinking water standards. High iron concentrations exist in some isolated areas. In some locations, the Water table aquifer may not be appropriate for irrigation.

Lower Tamiami Aquifer

The Lower Tamiami aquifer is a major water producer in most of the LWC Planning Area. The aquifer supplies water to several Public Water Supply wellfields, agricultural uses, and Domestic Self-suppliers in the region. The potential for saltwater intrusion and water level drawdowns in wetland areas exists in the Lower Tamiami aquifer along the Collier County coast. Chapter 3 of the 2012 LWC Plan Update (SFWMD 2012) discusses the rules for Maximum Developable Limits (MDLs) in the LWC Planning Area, including the Lower Tamiami aquifer (see also SFWMD 2010a).

Intermediate Aquifer System

The intermediate aquifer system (IAS) consists of those units underlying the SAS and overlying and confining the Floridan aquifer system (FAS). It consists of three relatively impermeable confining units and the Sandstone and Mid-Hawthorn aquifers (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). Leakance between the Sandstone and Mid-Hawthorn aquifers within the IAS is minimal. In Lee and Hendry counties, the IAS is a source of fresh water. In Collier County, the IAS is brackish and requires desalination to meet drinking water standards.

Sandstone Aquifer

The Sandstone aquifer has variable thickness and production. The aquifer's average thickness is approximately 100 feet near Immokalee and portions of central Lee County.

In Lee County, the Sandstone aquifer provides the water used by several Public Water Supply wellfields. In western Hendry County, where the Lower Tamiami aquifer is absent, the Sandstone aquifer is an important source of water for agricultural irrigation. Water from the Sandstone aquifer is only marginally acceptable for potable uses in Hendry and Collier counties due to salinity. In the LaBelle area, flowing Floridan aquifer wells in some areas have raised salinity levels in the Sandstone aquifer, making water unsuitable for irrigation in these locations. For more information about MDLs, see Chapter 3 of the 2012 LWC Plan Update (SFWMD 2012).

Mid-Hawthorn Aquifer

Although the Mid-Hawthorn aquifer is present throughout the LWC Planning Area, it is not always productive. The Mid-Hawthorn aquifer is used for Domestic-Self-Supply, landscape irrigation, and some agricultural irrigation, depending on location.

The aquifer's thickness is variable and relatively thin—and in some areas may include interbedded low-permeability layers, which results in the aquifer's low productivity.

In addition to its low productivity, the Mid-Hawthorn aquifer experiences degradation in water quality as the aquifer dips to the south and east, yielding only brackish water in much of the planning area.

Floridan Aquifer System

In southwest Florida, the FAS is situated between 400 feet and 800 feet below MSL. 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 (Avon Park permeable zone), and Lower Floridan aquifers. The FAS produces brackish water throughout most of the LWC Planning Area. Salinity and hardness of water in the FAS increases from north to south and vertically with depth.

Upper Floridan Aquifer

The Upper Floridan aquifer (UFA) may include portions of the lower part of the Hawthorn Group, Suwannee Limestone, Ocala Limestone, and upper part of the Avon Park Formation. Production zones in the lower part of the Hawthorn Group and Avon Park permeable zone are not always present. The UFA consists of multiple thin water-bearing zones interlayered with thick zones of much lower permeability.

With reverse osmosis (RO) treatment, the UFA is a principal source of potable water in the LWC region. The UFA also supplies water for frost and freeze protection for some agricultural users, and irrigation water (blended with other water sources) for landscape and golf courses in the LWC.

Middle (Floridan) Confining Unit

The middle confining unit (**Figure 19**, confining unit 2) is relatively less permeable than both the UFA and the Lower Floridan aquifer (LFA). This portion of the Floridan aquifer separates the brackish water of the UFA from the more saline water of the LFA.

Lower Floridan Aquifer

Like the UFA, the LFA is characterized by multiple thin producing zones, (fractured or solutioned rock) sandwiched between lower permeability carbonate confining units. The lower portion of the LFA contains a highly transmissive fracture-riddled dolomite known as the Boulder Zone, typically about 2,800 feet below MSL, and is found in a section of rock approximately 400 feet thick (Reese 2000). This unit serves as a primary repository for residual brines from RO treatment and a back-up disposal of effluent from wastewater treatment facilities. The base of the LFA ranges between 3,500 feet and 4,000 feet below MSL (Miller 1986).

Surface Water and Groundwater Relationships

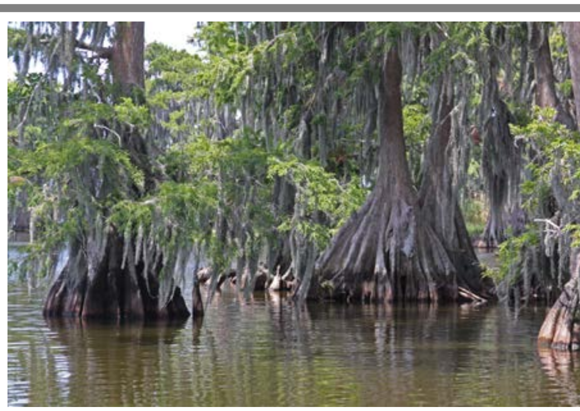
The construction and operation of surface water management systems affect the quantity and distribution of recharge to the surficial aquifer system. Surface water management systems within the LWC Planning Area function primarily as SAS drains, because ambient groundwater levels generally exceed surface water elevations within the region. The Caloosahatchee River and the Gulf of Mexico act as regional groundwater discharge points. Groundwater seepage represents part 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 and stormwater ponds, 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 aquifer. Once diverted, this water may contribute to aquifer recharge elsewhere in the system, supply downstream consumptive uses, be lost to evapotranspiration, or discharged to tide.

ECOSYSTEM RESTORATION EFFORTS

Information about ecosystem restoration efforts for the LWC Planning Area is available in the 2012 LWC Plan Update (SFWMD 2012).

More information, as well as the status of these projects, can be found in the *South Florida Environmental Report* available from http://www.sfwmd.gov/sfer. Project descriptions, status, and further documentation about other projects are available from http://www.evergladesplan.org, http://www.sfwmd.gov/northerneverglades, and http://www.sfwmd.gov/everglades.



Cypress Trees – LWC Planning Area

10

Lower East Coast Planning Area

This chapter describes characteristics of the Lower East Coast (LEC) Planning Area. An overview of the region's physical features and water resources, including surface water and groundwater, is presented in this Support Document, which supplements the *2013 LEC Water Supply Plan Update* (2013 LEC Plan Update) (SFWMD 2013a). For a comprehensive review of water supply status and issues in the LEC Planning Area, refer to the 2013 LEC Plan Update.

TOPICS

- Planning Area Boundaries
- Physical Features
- Water Resources and System Overview
- Ecosystem Restoration Efforts

PLANNING AREA BOUNDARIES

Within SFWMD, the LEC Planning Area includes Palm Beach, Broward, and Miami-Dade counties, most of Monroe County, and the eastern portions of Hendry and Collier counties (**Figure 20**). The LEC's boundaries follow the spreading north-to-south sheetflow pattern of the historical Everglades, draining eventually to Florida Bay at the southern tip of the peninsula, and encompassing the Florida Keys island chain south and west to the end of the state. Most of the Lake Okeechobee Service Area (LOSA) (see the Lake Okeechobee Basin/LOSA section later in this chapter) lies within the LEC Planning Area boundary. For consistency, all Lake Okeechobee and LOSA analyses are performed within the LEC planning process.

PHYSICAL FEATURES

Major features in the LEC Planning Area include Lake Okeechobee and hydraulically connected surface water bodies, the Loxahatchee River and Estuary, Lake Worth Lagoon, the Everglades Agricultural Area, Water Conservation Areas, portions of Everglades National Park, Biscayne Bay, and Florida Bay. Elevation differences in the LEC are slight, with the highest elevations along the Atlantic Coastal Ridge that runs along the east coast, and lowest along the southern coastline.

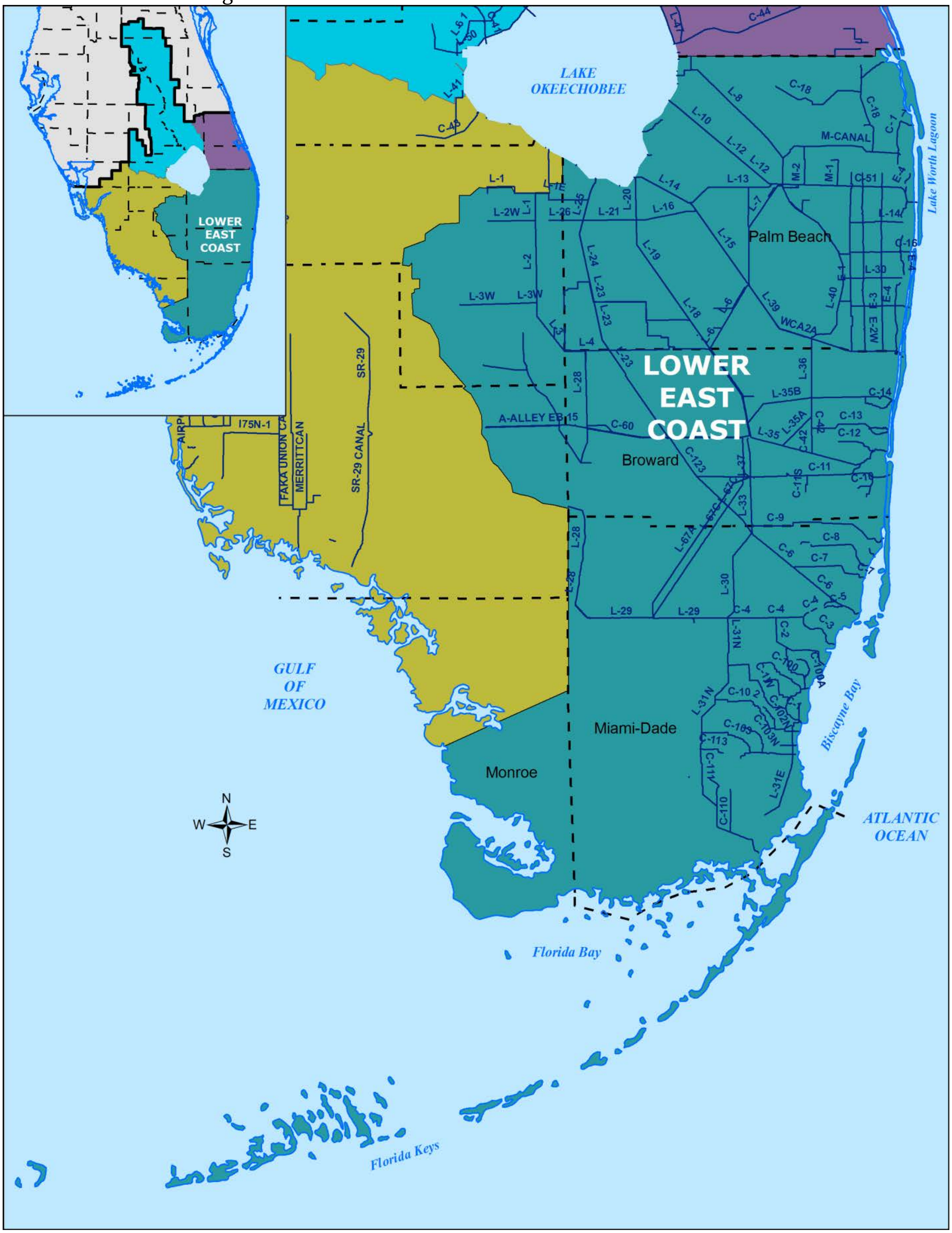
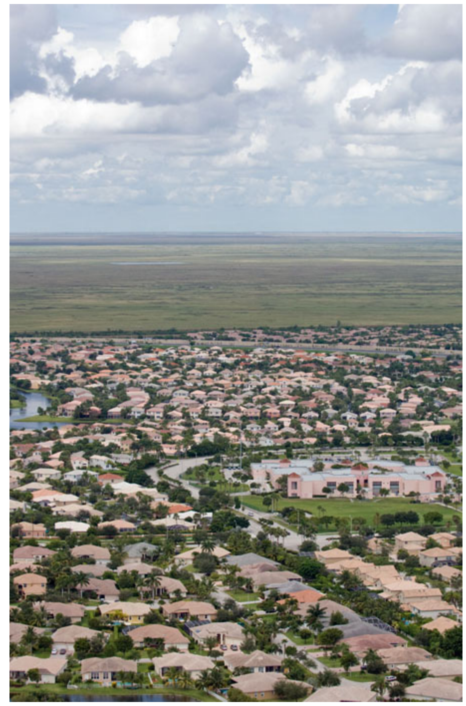


Figure 20. Lower East Coast Planning Area.

Water Bodies and Landscapes

The Central and Southern Florida Flood Control Project (C&SF Project) links Lake Okeechobee and the Everglades with the agricultural and urban areas, and other major ecosystems. The following significant freshwater systems and coastal ecosystems comprise the LEC Planning Area.



Western Broward County

Significant Freshwater Systems

Lake Okeechobee is the largest lake in the southeastern United States, and the major source of water storage and supply for the LEC Planning Area. Lake Okeechobee receives water from rainfall and its major tributaries – the Kissimmee River, Fisheating Creek, and Taylor Creek/Nubbin Slough. Downstream of the lake, outflows from Lake Okeechobee are received by the C-43 and C-44 canals, and ultimately the Caloosahatchee and St. Lucie estuaries, Everglades Agricultural Area (EAA), Everglades Stormwater Treatment Areas (STAs), C-139 and L-28 basins, and Water Conservation Areas (WCAs) in the LEC Planning 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 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 most of the Everglades National Park, which includes Florida Bay.

The C&SF Project divided the remaining Everglades south of Lake Okeechobee and north of U.S. 41 in Palm Beach, Broward, and Miami-Dade counties into three hydrologic units known as the WCAs (WCA-1, WCA-2A/WCA-2B, and WCA-3A/WCA-3B). These diked areas are operated and maintained for flood control, environmental habitat, and water supply to the LEC Planning Area. The Arthur R. Marshall Loxahatchee National Wildlife Refuge west of Boynton Beach is contained within WCA-1. The WCAs serve as the first source of supplemental water to the coastal canals that recharge the Biscayne aquifer.

The Rotenberger Wildlife Management Area is a conservation area in the southern EAA. This area contains sawgrass marsh, tree islands, sloughs, wet prairies, and cattail marsh. The Holey Land Wildlife Management Area, to the east of Rotenberger, is composed of marsh and scattered tree island communities, including a red maple forest on the western edge, providing essential habitat for many plant and wildlife species.

Regulatory discharges from Lake Okeechobee and runoff from the EAA are treated by stormwater treatment areas (STAs) before being delivered to the WCAs. Water from the WCAs then enters Everglades National Park and flows through Shark River Slough to Whitewater and Florida bays and the Ten Thousand Islands area. Some water enters the panhandle of Everglades National Park and Taylor Slough, which is an important tributary to northeastern Florida Bay.

C&SF Project canals in the LEC Planning Area move water from Lake Okeechobee and the Everglades to coastal counties to recharge the SAS during dry times. The canals are also a crucial component of the flood control system for the region, discharging water to tidal waters.

Wetlands extend across 3.2 million acres of the LEC Planning Area. Approximately 2 million acres are freshwater wetlands and 1.2 million are generally classified as estuarine or marine. The remnant Everglades represent the majority of the region's wetlands. In addition to Everglades National Park and the WCAs, key wetlands in the LEC Planning Area include Holey Land Wildlife Management Area, Rotenberger Wildlife Management Area, Grassy Waters Preserve, and other wetlands in the Loxahatchee River watershed. The region also has extensive constructed wetlands within the Everglades STAs. Finally, isolated wetlands can be found throughout the LEC Planning Area.

Significant Coastal Ecosystems

Significant coastal ecosystems in the LEC Planning Area include the Northwest Fork of the Loxahatchee River, Lake Worth Lagoon, the North Fork of the New River, Biscayne Bay, Florida Bay, and the Florida Keys, described as follows.

The Loxahatchee River and Estuary extend across an approximately 200-square-mile area in southern Martin and northern Palm Beach counties and overlap slightly into the Upper East Coast (UEC) Planning Area. A system of inland wetlands, known locally as Grassy Waters Preserve and the Loxahatchee and Hungryland sloughs, forms the headwaters of the watershed that drains into the Northwest Fork of the Loxahatchee River, federally designated as a Wild and Scenic River. The Loxahatchee River has two other branches—the North Fork and the Southwest Fork. All three branches discharge in the central embayment area, which flows through the Jupiter Inlet into the Atlantic Ocean. The downstream section of each fork is brackish water. Flows from all three forks drain into the Loxahatchee River Estuary—the southernmost tributary to the Indian River Lagoon. See **Chapter 8** of this Support Document and the *2011 UEC Water Supply Plan Update* (SFWMD 2011b) for more information about the Indian River Lagoon.

Lake Worth Lagoon drains into the Lake Worth and South Lake Worth inlets in Palm Beach County. The lagoon is a long, narrow body of brackish water, divided into three geographical segments (north, central, and south), and located along the heavily urbanized Intracoastal Waterway. The north segment includes waters north of Flagler Memorial Bridge to PGA Boulevard. The central segment includes waters south from the Flagler Memorial Bridge to Lake Worth Bridge, and the south segment includes waters south from

Lake Worth Bridge to the Boynton Beach Bridge at Ocean Avenue. Sources of freshwater runoff include primary and secondary canal systems. The major sources of fresh water are the C-17 Canal (Earman River), C-51 Canal (West Palm Beach Canal), and the C-16 Canal (Boynton Canal).

The North Fork of the New River is a remnant tributary that drained the eastern Everglades and now flows through the City of Fort Lauderdale, where it eventually joins the river's main branch and empties into the Atlantic Ocean via the inlet at Port Everglades.

Biscayne Bay covers approximately 428 square miles located on the southeastern coast near Miami-Dade County. Everglades National Park shares some of the watershed along the southwestern boundary. The bay is an aquatic preserve and an Outstanding Florida Water. The southern half of the bay is within Biscayne National Park. This is the largest marine park in the National Park system and supports diverse flora and fauna, including many endangered species.

Florida Bay is a large, shallow, marine-estuarine lagoon between the southern edge of the Everglades and the Florida Keys. Most of the bay is within Everglades National Park.

The chain of islands known as the Florida Keys runs along the southeastern tip of the state south and west. Because of the unique marine ecosystems, the Florida Keys area is protected by the Florida Keys National Marine Sanctuary, three national parks – Everglades, Biscayne, and Dry Tortugas, and several state parks.

Geography and Climate

The LEC Planning Area encompasses approximately 6,500 square miles in southeast Florida. The bottom of Lake Okeechobee is approximately at sea level and the land immediately surrounding Lake Okeechobee ranges from 20 feet to 25 feet above mean sea level (MSL). Parts of the Atlantic Coastal Ridge are higher than 25 feet above MSL. Along the shoreline, the mangrove and coastal glades region is at or below sea level and often flooded by tides or freshwater runoff.

Land elevations in the WCAs generally range from about 16 feet above MSL at the northern end of WCA-1 to approximately 10 feet above MSL at the southern end of WCA-3. The topography of Everglades National Park is extremely low and flat, with most of the area lying 4 feet below MSL. The land surface generally slopes from 8 feet to 9 feet above MSL at the northern end, to below MSL as the freshwater wetlands of the Everglades merge with the saltwater wetlands of Florida Bay. Average seasonal temperatures for the area range from approximately 60°F to 80°F. Estimated annual rainfall in the planning area averages 57 inches (see also the *Precipitation and Evapotranspiration* section).

Physiography


Florida Bay

The LEC Planning Area is characterized by lakes, rivers, and canals, including Lake Okeechobee; coastal ridges, remnant Everglades and wetlands in the Everglades Protection Area; and coastal swamps and bays, including Biscayne Bay and Florida Bay. Except for the coastal and beach ridges, the region is flat in appearance, and slopes vary gradually from approximately 25 feet above MSL near Lake Okeechobee to sea level or below at the coastline. Physiographic regions include the Eastern Valley, Atlantic Coastal Ridge, Everglades, Immokalee Rise, Big Cypress Spur, Reticulate Coastal Swamps, and Florida Bay Mangrove Islands (**Figure 21**).

The Eastern Valley consists of wetland communities, including tidal and floodplain swamp and forest. These areas are characteristically pocketed with shallow lakes and marshes and have limited natural drainage. Prior to development and the 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.

The Atlantic Coastal Ridge, composed of relict beach ridges and sand bars, is mostly underlain by thin sand and Miami Limestone that are highly permeable and moderately to well-drained. West of the coastal ridge, soils contain fine sand and loamy material and have poor natural drainage. Rockland areas on the coastal ridge in Miami-Dade County are characterized by weathered limestone surfaces and karst features such as solution holes and sinkholes. The Atlantic Coastal Ridge covers 12,300 acres of diverse community types, including scrub, pine flatwoods, and forested sloughs. The Southern Slope of the Atlantic Coastal Ridge contains small, pine-covered hammocks.

The Everglades is located west of the Atlantic Coastal Ridge, and extends southward from Lake Okeechobee and the Loxahatchee Slough to the mouth of the Shark River Slough at Florida Bay. The Everglades has an almost imperceptible slope to the south, which averages less than 2 inches per mile. Elevations range from 14 feet MSL near Lake Okeechobee to sea level at Florida Bay. Under predeveloped conditions, the Everglades was seasonally inundated, and water drained slowly to the south.

Much of the Everglades are underlain by peat and muck soils that developed in a shallow basin with poor natural drainage under prolonged conditions of flooding. Beneath these surface layers of organic material is the Fort Thompson Formation of interbedded sand, shell, and limestone. Bedrock in the Everglades is almost entirely limestone. Higher elevation marshes in the Southern Everglades on either side of Shark River Slough are characterized by calcitic marl soils deposited by algal mats, and exposed limerock surfaces with karst features.

The Immokalee Rise is bounded on the east by the Everglades, on the south-southeast by the Big Cypress Spur, and the on the southwest by the Southwestern Slope. This area, composed of predominantly sandy soils, ranges in elevation from 25 to 42 feet above MSL (FGS 1988).

The Big Cypress Spur is a sloping, transitional area between the Immokalee Rise, the Everglades to the east, and the Southwestern Slope to the west (USDOI 1984). This area receives runoff from the Immokalee Rise and drains to the Everglades and the Southwestern Slope. Elevations are only slightly higher than 25 feet MSL.

Mangrove swamps occupy a zone between the open waters of the coast and the uplands and freshwater wetlands of the interior of the Everglades. These mangroves form small, densely packed islands and shoreline jungles, which together form the Reticulate Coastal Swamps of northern Florida Bay. Along the southern shores of Everglades National Park, Florida Bay is underlain by Miami Limestone with variable sediment cover of sand, exposed bedrock, and mudbanks. The bay has an average depth of about 3 feet, and consists of shallow, interconnected basins. It is subject to rapid salinity changes due to mainland Everglades runoff and regional droughts, and is an important habitat for many species. Sand shoals and ancient corals underlie small mangrove keys throughout the bay.

The Florida Keys consist of highly permeable Key Largo Limestone in the Upper Keys and less permeable Miami Limestone on the Lower Keys.

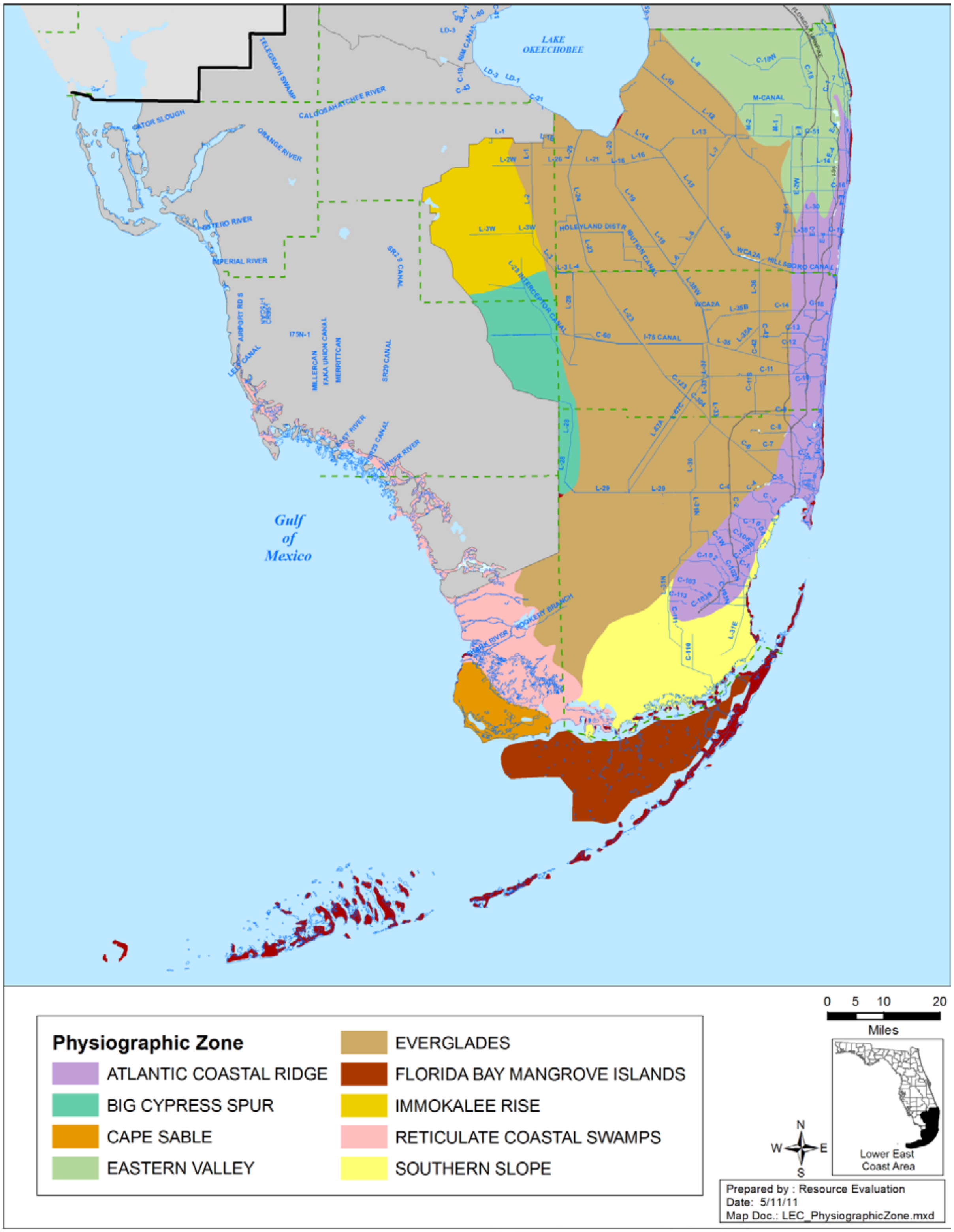
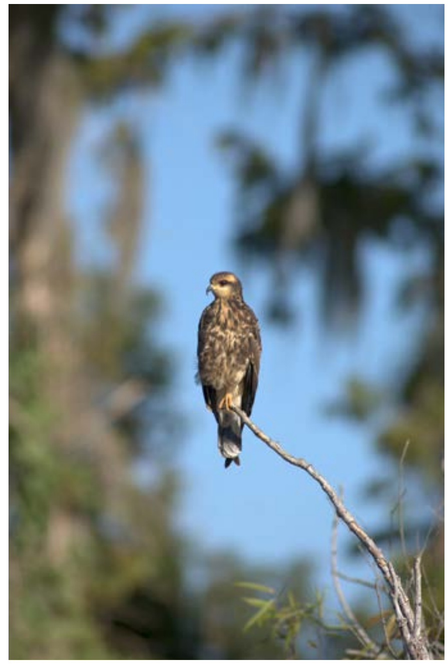


Figure 21. Physiography of the Lower East Coast Planning Area.

WATER RESOURCES AND SYSTEM OVERVIEW

In the following sections, surface water and groundwater resources are addressed as separate entities. Surface water resources in the LEC Planning Area include natural systems, canals, and constructed wetlands. Groundwater resources are the surficial aquifer system, which includes the Biscayne aquifer, and Floridan aquifer system.



Everglade Snail Kite

Regional Hydrologic Cycle

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

Precipitation and Evapotranspiration

Annual precipitation in the LEC Planning Area averages 57 inches. Nearly 75 percent of the rainfall occurs during the six-month wet season from May through October.

Hydrologic and meteorological methods are available to measure and 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 groundwater recharge. The estimate of potential evapotranspiration (ETp) from open water and wetlands in the LEC Planning Area is 53 inches (Abtew et al. 2003). Potential evapotranspiration represents the total estimated passive water use of an area under maximum conditions. While actual evapotranspiration varies due to temperature, soil moisture, and other factors, ETp estimates are important landscape-level factors in water balance calculations to determine if enough water will be available for all uses during different environmental conditions.

Surface Water Inflow and Outflow

Surface water inflows to the LEC Planning Area come through the C&SF Project canals. Outflows of surface water in the LEC Planning Area are largely directed through water control structures, many of which were constructed as part of the Central and Southern Florida Project Flood Control Project (C&SF Project). Flows and stages in Lake Okeechobee and most of the region's canals are operated consistent with regulation schedules for multiple purposes. The amount of stored water is of critical importance to both the natural ecosystems and the developed areas in the LEC Planning Area. Management of surface water storage capacity involves balancing two conflicting conditions: 1) drought conditions may occur during periods of deficient rainfall, and 2) flooding may occur due to excessive rainfall, especially during the wet season.

A regional system of canals provides a means to move water from one location to another (see the *Lower East Coast Canals and Service Areas* section of this chapter). Water is transported from north to south and west to east, from Lake Okeechobee through water control structures to the EAA canals and into the WCAs. Located south of Lake Okeechobee and north of the Everglades, Stormwater Treatment Areas (STAs) reduce excess phosphorus from stormwater runoff through the natural filtering of native vegetation before water enters protected wetlands. Water moves from the WCAs via structures and canals to Everglades National Park and the urbanized coastal basins. Water from WCA-1 also moves through the G-94 culverts, the Hillsboro Canal, and the C-51 Canal to the Lake Worth Drainage District. When canal elevations are greater than surrounding groundwater, water in coastal canals provides recharge to the Biscayne aquifer, enhancing groundwater supplies and helping replenish water in lakes, rivers, and wetlands.


Tree Island in Water Conservation Area 1

Groundwater Flow

Two principal aquifers underlie the LEC Planning Area: the surficial aquifer system (SAS), which includes the Biscayne aquifer and the Floridan aquifer system (FAS).

Rainfall is the main source of recharge to the SAS. Groundwater inflows from the Everglades to the coast form a significant portion of recharge to the SAS. The FAS receives most of its recharge from outside of the LEC Planning Area in central and northern Florida.

Surface Water Resources

The major surface water body storage in the LEC Planning Area is Lake Okeechobee. Lake Okeechobee is a central component of the C&SF Project and an interconnected regional aquatic ecosystem. It serves multiple functions including flood control, agricultural and urban water supply, fulfillment of Seminole Tribe of Florida water rights, navigation, recreation, and fish and wildlife preservation and enhancement. The operation of the lake affects a wide range of environmental and economic issues. Lake operations must carefully consider the entire and sometimes conflicting purposes of the C&SF Project.

The Lake Okeechobee Watershed encompasses a drainage area of over 3.5 million acres (5,500 square miles), and is dominated by agricultural land uses that account for just over 50 percent of the total area. Based on hydrologic and geographic boundaries, the Lake Okeechobee Watershed includes the Upper and Lower Kissimmee basins, Lake Istokpoga/ Indian Prairie Basin, Taylor Creek/Nubbin Slough Basin, Fisheating Creek Basin, Everglades Agricultural Area (EAA), and Lake Okeechobee basins including the C-43 and C-44 basins.


Agricultural Land in Homestead

South of Lake Okeechobee, the Southern Everglades is divided into surface water management basins. In terms of water management, the SFWMD groups the LEC Planning Area into three hydrologically related areas: 1) Lake Okeechobee Basin/Lake Okeechobee Service Area (encompassing portions of Martin, Okeechobee, Palm Beach, Hendry, Glades, and Lee counties) including the EAA; 2) Water Conservation Areas (WCAs), and Everglades National Park; and 3) Lower East Coast Canals and Service Areas.

Figure 22 shows the Lake Okeechobee Service Area; areas outside the LEC Planning Area with a significant relationship to the region; Water Conservation Areas; Everglades National Park; and the LEC Service Areas.


Irrigation in the Everglades Agricultural Area

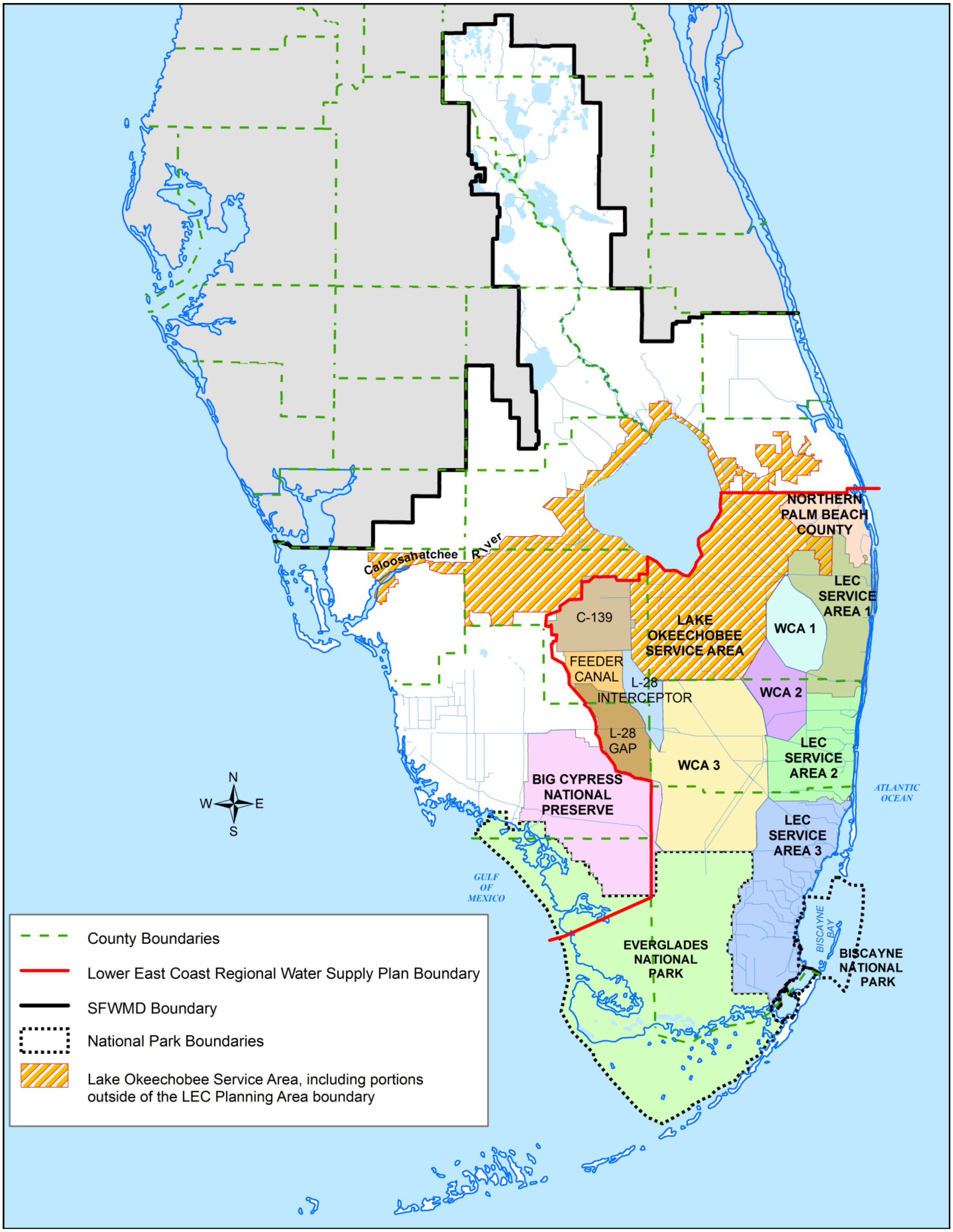


Figure 22. Major features of the Lower East Coast Planning Area.

Lake Okeechobee Basin / Lake Okeechobee Service Area including the Everglades Agricultural Area


Stormwater Treatment Area 1E

Lake Okeechobee is the primary source of supplemental irrigation for numerous adjacent agricultural basins in the SFWMD, including: Northeast Lake Shore; St. Lucie (C-44); West Palm Beach Canal and L-8; East Beach and East Shore water control districts; North New River and Hillsboro Canal; Miami Canal; C-21 and S-236; Caloosahatchee (C-43); Northwest Lakeshore and Southern Indian Prairie; and North Lake Shore. The Everglades Agricultural Area (EAA) is also part of the Lake Okeechobee Basin. Collectively, these basins are known as the Lake Okeechobee Service Area (LOSA). The entire Lake Okeechobee Service Area is considered during the LEC water supply planning process because of its reliance on Lake Okeechobee for water supply.

Everglades Agricultural Area

The Everglades Agricultural Area is located south of Lake Okeechobee in eastern Hendry and western Palm Beach counties. The EAA is composed of rich, organic peat or muck soils. Agriculture within the EAA requires extensive drainage of this soil, which is accomplished by the canals and water control components of the C&SF Project. These canals are also used to provide the EAA with irrigation. In addition to C&SF canals, there is an extensive network of local canals and farm ditches.

Stormwater from the EAA is moved south through stormwater treatment areas (STAs) created by the SFWMD, and into the Everglades Protection Area. The stormwater treatment areas include STA-1 East, STA-1 West, STA-2, STA-3/4, STA-5, and STA-6. As of summer 2012, construction is complete on the expansion of STA-2 and STA-5/6 with pump station commissioning in progress. When operational, these two expansion projects will increase the total effective treatment area to 57,000 acres.

Water Conservation Areas

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 that provide water storage and detention for excess water; water supply for agricultural lands in the LEC Planning Area and Everglades National Park; and recharge for the Biscayne aquifer. The WCAs contain remnants of original Everglades sawgrass marsh, wet prairies, and hardwood swamps. These conservation areas are managed as surface water reservoirs using a set of water regulation schedules.

WCA Regulation Schedules

Water levels in most of the WCAs are managed through inflow and outflow structures using a set of regulation schedules established by the U.S. Army Corps of Engineers (USACE) (1996). These schedules allow for different water levels under different conditions, balancing the needs of the natural system and other water users. These ranges can provide storage of runoff during the wet season for use during the dry season, and flood control during the wet season.

WCA-1

Water Conservation Area 1, located in south-central Palm Beach County, is contained within the Arthur R. Marshall National Wildlife Refuge and includes some of the original sawgrass marshes, wet prairies, and hardwood swamps of the remnant Everglades system. The 221-square-mile WCA-1 is enclosed by 58 miles of canals and levees. The WCA-1 regulation schedule varies from high stages in the late fall and winter to low stages at the beginning of the wet season (Abtew et al. 2007). Inflows to WCA-1 are primarily rainfall and discharges from STA-1W and STA-1E. Outflows from WCA-1 are received by WCA-2, the Hillsboro Canal, and a canal system monitored and controlled by the Lake Worth Drainage District.

WCA-2A and WCA-2B

Water Conservation Areas 2A and 2B comprise about 208 square miles located within southwestern Palm Beach and northwestern Broward counties. Water Conservation Area 2A is much larger than WCA-2B and provides a 167-square-mile shallow impoundment for storing excess water. These WCAs provide wellfield recharge and water supply for urban areas located within Broward County. Inflows to WCA-2 as a whole come from primarily from WCA-1 and STAs 2 and 3/4. Outflows from this WCA generally go to WCA-3A. The regulation schedule for WCA-2A is established by the USACE (1996). A regulation schedule is not used for WCA-2B because of high seepage rates into the underlying surficial aquifer to central Broward County.

WCA-3A and WCA-3B

Together, Water Conservation Areas 3A and 3B represent the largest of the three WCAs at 915 square miles. The Miami Canal traverses WCA-3A from northwest to southeast, and receives most of its water from direct rainfall, WCA-2, STAs 5 and 3/4, and regulatory releases from Lake Okeechobee on a case-by-case basis. This area also receives excess runoff from the Big Cypress Swamp to the west, and flood control discharges from Pump Station S-9 and S-9A in 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 County; irrigation requirements for LEC Agricultural Self-Supply; and environmental water supply for Everglades National Park. The regulation schedule for WCA-3A was established by the USACE (1996). A regulation schedule is not used for WCA-3B because of high seepage rates. 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 (U.S. Highway 41).

Concern for the Cape Sable Seaside Sparrow, an endangered species, prompted the USACE to revise the regulation schedule for WCA-3A and the South Dade Conveyance System in 2002. The purpose of the new schedule, known as the Interim Operating Plan (IOP), was to reduce damaging high water levels within sparrow habitat west of Shark River Slough to the extent possible through water management operations. The IOP improves the opportunity for nesting during the sparrow breeding season. The IOP is accomplished through construction of water control structures associated with the C-111 and Modified Water Deliveries project, a regulation schedule that manages releases from WCA-3A into Shark River Slough, and releases to the South Dade Conveyance System.

In 2009, the USACE and the U. S. Fish and Wildlife Service (USFWS) began a review of the effects of the IOP on threatened and endangered species from 2002–2009. The review focused on operational flexibility within the IOP that would improve conditions for the Everglade snail kite and wood stork in WCA-3A, as well as Cape Sable Seaside Sparrow habitat in Everglades National Park. A series of water depth recommendations were developed for WCA-3A that address the needs of the snail kite, apple snail, and vegetation characteristics of their habitat. These recommendations, proposed as part of the USFWS Multi-Species Management Strategy, form the basis for the proposed revisions to the regulation schedule known as the Everglades Restoration Transition Plan (ERTP).

The ERTP also includes revisions to the WCA-3A regulation schedule to address stakeholder concerns about high water levels in WCA-3A and discharge limitations of the S-12 spillways. Based on a review and analyses conducted in 2010, the USACE identified the 1960 WCA-3A 9.5 to 10.5 feet NGVD Regulation Schedule as interim measure water management criteria for WCA-3A Zone A. These interim criteria and the application of the performance measures and ecological targets addressing endangered species conditions that comprise the ERTP have been documented in the final draft of the ERTP Environmental Impact Statement and Water Control Plan (USACE 2011), released for public and agency review in December 2011. A Record of Decision is pending and expected later in 2012.

Current regulation schedules and daily water levels are available at http://www.saj.usace.army.mil. More information about the WCAs can be found in Chapter 2 of the *South Florida Environmental Report– Volume I*, available from http://www.sfwmd.gov/sfer.

Everglades National Park

Established in 1934 and expanded in 1989, Everglades National Park is the nation's second-largest national park covering over 2,300 square miles. The park is home to a wide variety of species, including some classified as threatened or endangered by the federal government, and has several international preserve-style designations.


Everglades National Park

Much of the water that enters the park from the WCAs flows in a southwest arc through Shark River Slough to Whitewater Bay and the Ten Thousand Islands area. Some water enters through S-12s, S-333, S-343A, S-343B, and S-344 structures. Some water enters the panhandle of Everglades National Park via the S-332D pump station and Taylor Slough or through intentional breaches in the lower C-111 Canal, which were created downstream of structure S-18C. Some water enters through S-12s, S-333, S-34A, S-343B, and S-344 structures. Water is encouraged to remain in Taylor Slough, an important tributary to northeastern Florida Bay, by a series of pumped seepage management features located east of the park's eastern boundary, collectively known as the C-111 South Dade Project.

In addition to the Whitewater Bay and the Ten Thousand Islands area, much of the water entering Everglades National Park ends up in Florida Bay. Florida Bay receives water that passes though the park's numerous tidal creeks and coastal wetlands, including mangrove and buttonwood forests, salt marshes, and coastal prairies, all of which are subject to the influence of salinity from tidal action.

Lower East Coast Canals and Service Areas

The Northwest Fork of the Loxahatchee River is hydrologically considered in the LEC Planning Area because the river's watershed includes a broad area of northern Palm Beach County. The Northwest Fork of the Loxahatchee River flows north into Martin County, continues north and bends east through Jonathan Dickinson State Park. It then flows southeast back into Palm Beach County, where it enters the central embayment area of the Loxahatchee Estuary. The Northwest Fork receives important inflows from three major tributaries, Cypress Creek, Hobe Grove Ditch, and Kitching Creek.

Grassy Waters Preserve (formerly known as the City of West Palm Beach's Water Catchment Area) provides the water resource for Public Water Supply in the City of West Palm Beach, Town of Palm Beach, Town of South Palm Beach, and surrounding unincorporated areas.

Flood control and water management structures 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 coastal canals and water control structures are designed to permit rapid removal of storm water in adjacent drainage areas. The degree of flood protection provided by outlet capacity depends on whether the protected area is urban or agricultural.

The South Dade Conveyance System (SDCS) was added to the existing flood control system to deliver water to areas in south Miami-Dade County. The main design functions of these project canals and structures are to: 1) control flooding; 2) store water in the WCAs; 3) control water elevations; and 4) provide water for Everglades National Park and agriculture in south Miami-Dade County.

For purposes of water supply planning and operations, the SFWMD divides the LEC Planning into the following four service areas:

- **North Palm Beach** Includes all the coastal and inland portions of northern Palm Beach County east of the EAA and north of the West Palm Beach Canal (C-51) Basin. The Southern L-8 Basin and M-Canal/Water Catchment Area basins are in this service area. Natural areas within the North Palm Beach Service Area include DuPuis Reserve, J.W. Corbett Water Management Area, Grassy Waters Preserve, Loxahatchee Slough, Loxahatchee River, and Pal-Mar.

L-8 Reservoir

- **LEC Service Area 1** Includes the portion of Palm Beach County east of WCA-1 and a small portion of northern Broward County. The C-51 Canal and Hillsboro Canal basins are in this service area.
- **LEC Service Area 2** Includes the portion of Broward County east of the WCAs and south of the Hillsboro Canal Basin to the C-9 Basin in northern Miami-Dade County.
- **LEC Service Area 3** Includes the portion of Miami-Dade County south of the C-9 Basin, east of WCA-3B and east of Everglades National Park.

Other Basins within the LEC Planning Area

The C-139 and the Feeder Canal basins in Hendry County are not within the Lake Okeechobee Basin, but are within the LEC Planning Area.

C-139 Basin

The 170,000-acre C-139 Basin is an agricultural area in Hendry County that drains into the Everglades Protection Area. Stormwater runoff enters the northwest corner of WCA-3A in Broward County via stormwater treatment areas.

Feeder Canal Basin

The Feeder Canal Basin is located in Hendry County and divided into three major areas: 1) the McDaniel Ranch area or North Feeder Subbasin (four private property owners), with a total area of 23,150 acres; 2) the West Feeder Subbasin (about 30 private owners) with a total area of 31,900 acres; and 3) a portion of the Big Cypress Seminole Indian Reservation (13,850 acres). The two major canals in this basin are the North Feeder Canal and the West Feeder Canal. These canals merge in the southeastern corner of the basin and discharge south to the L-28 Interceptor Canal and eventually to WCA-3. The Seminole Tribe relies on the Feeder Canal for their water supply.

Basins with Significant Relationship to the LEC Planning Process

St. Lucie Canal and Caloosahatchee River

The St. Lucie Canal (C-44 Canal) in the Upper East Coast (UEC) Planning Area and the Caloosahatchee River (C-43 Canal) in the Lower West Coast (LWC) Planning Area are outside the boundaries of the LEC Planning Area. Because of their hydraulic connection to Lake Okeechobee, these basins are included in the LEC planning process in addition to the UEC and LWC planning processes.

Groundwater Resources

Two aquifer systems, the surficial aquifer system (SAS) and the Floridan aquifer system (FAS), underlie the LEC Planning Area. The Biscayne aquifer is part of the SAS in the southern region. Virtually all of the Public Water Supply in the LEC Planning Area comes from groundwater. The only surface water users for Public Water Supply are Okeechobee County and the City of West Palm Beach, which also serves the Town of Palm Beach, Town of South Palm Beach, and surrounding unincorporated areas. Surface water is very important for recharging the Biscayne aquifer during the dry season.

Figure 23 illustrates a generalized cross-section of the hydrogeology of south Florida, depicting the aquifers. **Table 31** presents the groundwater systems, hydrogeologic units, and relative aquifer yields in the LEC Planning Area.

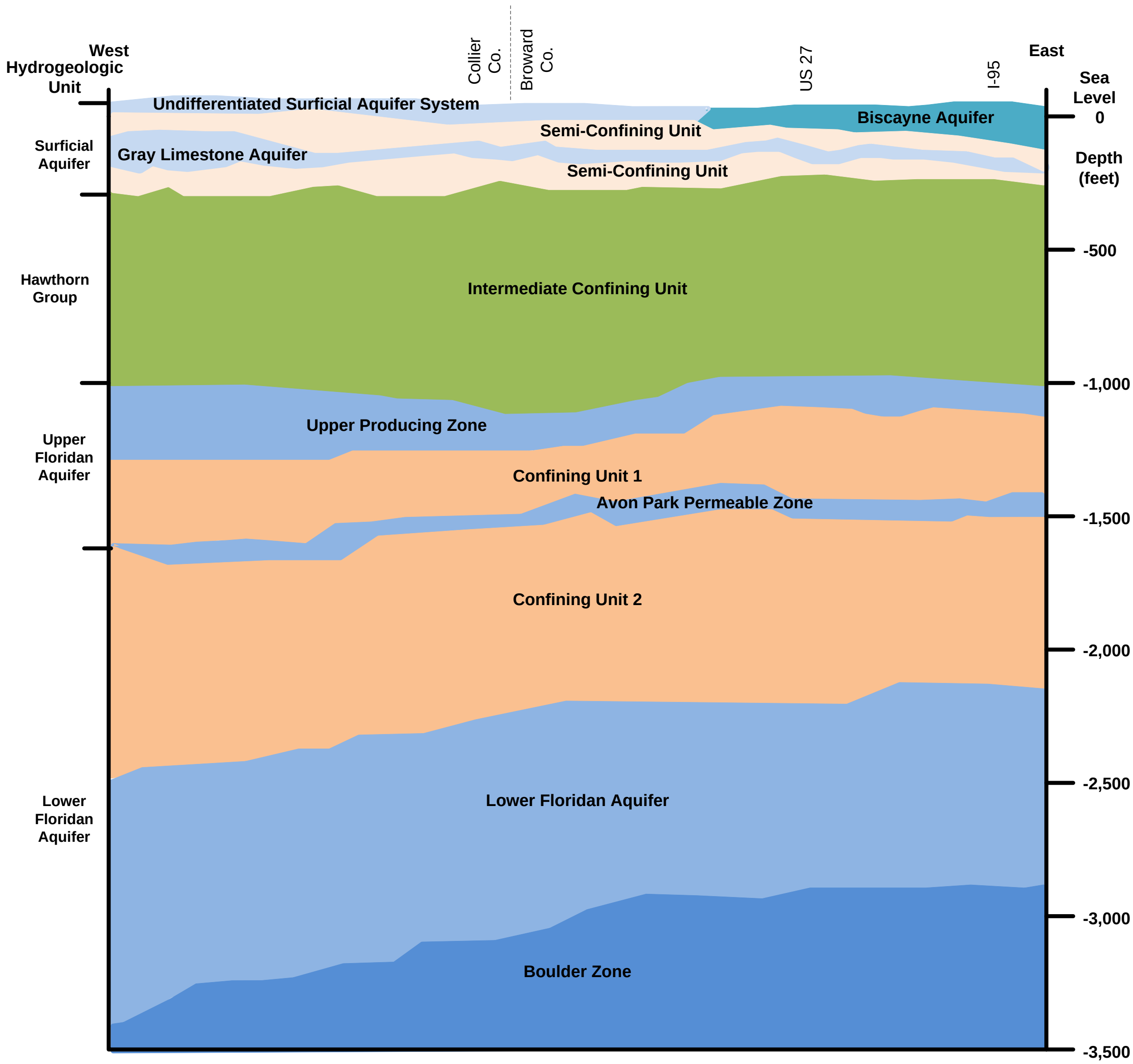


Figure 23. Generalized hydrogeologic cross-section of the Lower East Coast Planning Area.

Table 31. Groundwater systems in the Lower East Coast Planning Area.

Aquifer System	Hydrogeologic Unit	Aquifer Yield L=Low M=Moderate H=High		
		Miami-Dade	Broward	Palm Beach
Surficial Aquifer System	Biscayne Aquifer	H	H	M
	Undifferentiated Surficial Aquifer System	M	M	L-M
Floridan Aquifer System	Upper Floridan Aquifer	M	M	M-H
	Lower Floridan Aquifer	M-H	M-H	M-H

Surficial Aquifer System

The SAS, which extends throughout southeast Florida, provides fresh water for Public Water Supply and supplemental irrigation uses within the LEC Planning Area. The SAS is an unconfined aquifer system 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, which extends south from coastal Palm Beach County through most of Broward and Miami-Dade counties and into portions of southeastern Monroe County. Transmissivities of the surficial aquifer system vary locally, but have a recognizable areal trend. Estimated values generally are about 300,000 feet squared per day or greater in nearly all of central and eastern Miami-Dade County. Transmissivity is lower to the west, decreasing to less than 75,000 feet squared per day in western Miami-Dade County. High transmissivity usually is associated with thick sections of the Fort Thompson Formation within the Biscayne aquifer (Fish and Stewart 1991).

Biscayne Aquifer

The Biscayne aquifer (**Figure 24** and **Figure 25**) is composed of interbedded, unconsolidated sands and shell units with varying thickness of consolidated, highly solutioned limestone and sandstone. In general, the Biscayne aquifer contains less sand and more solutioned limestone than most of the SAS.

The major geologic deposits comprising the Biscayne aquifer include Miami Limestone, the Fort Thompson Formation, the Anastasia Formation, and the Key Largo Limestone. 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.

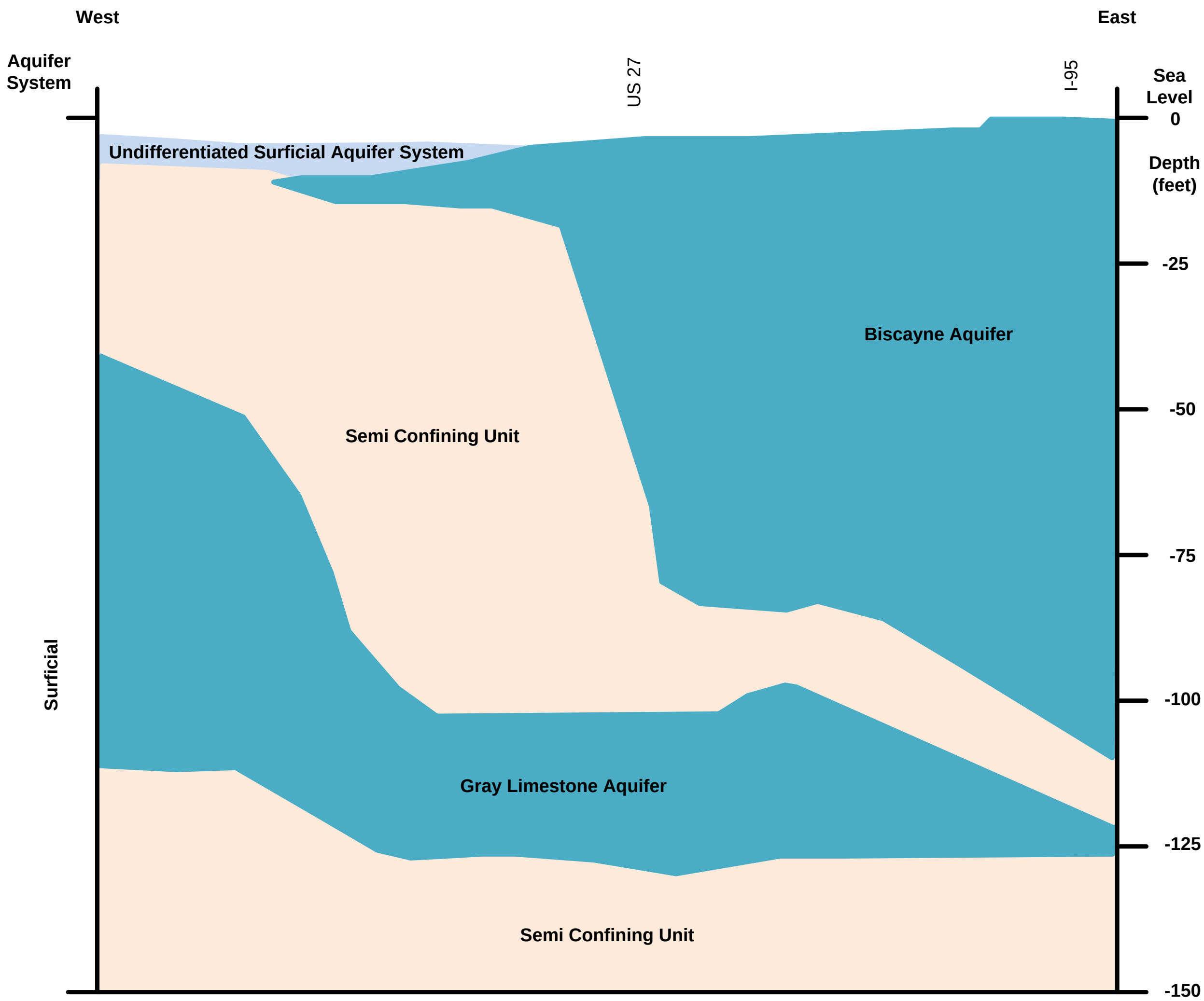


Figure 24. Generalized hydrogeologic cross-section of the surficial aquifer system.

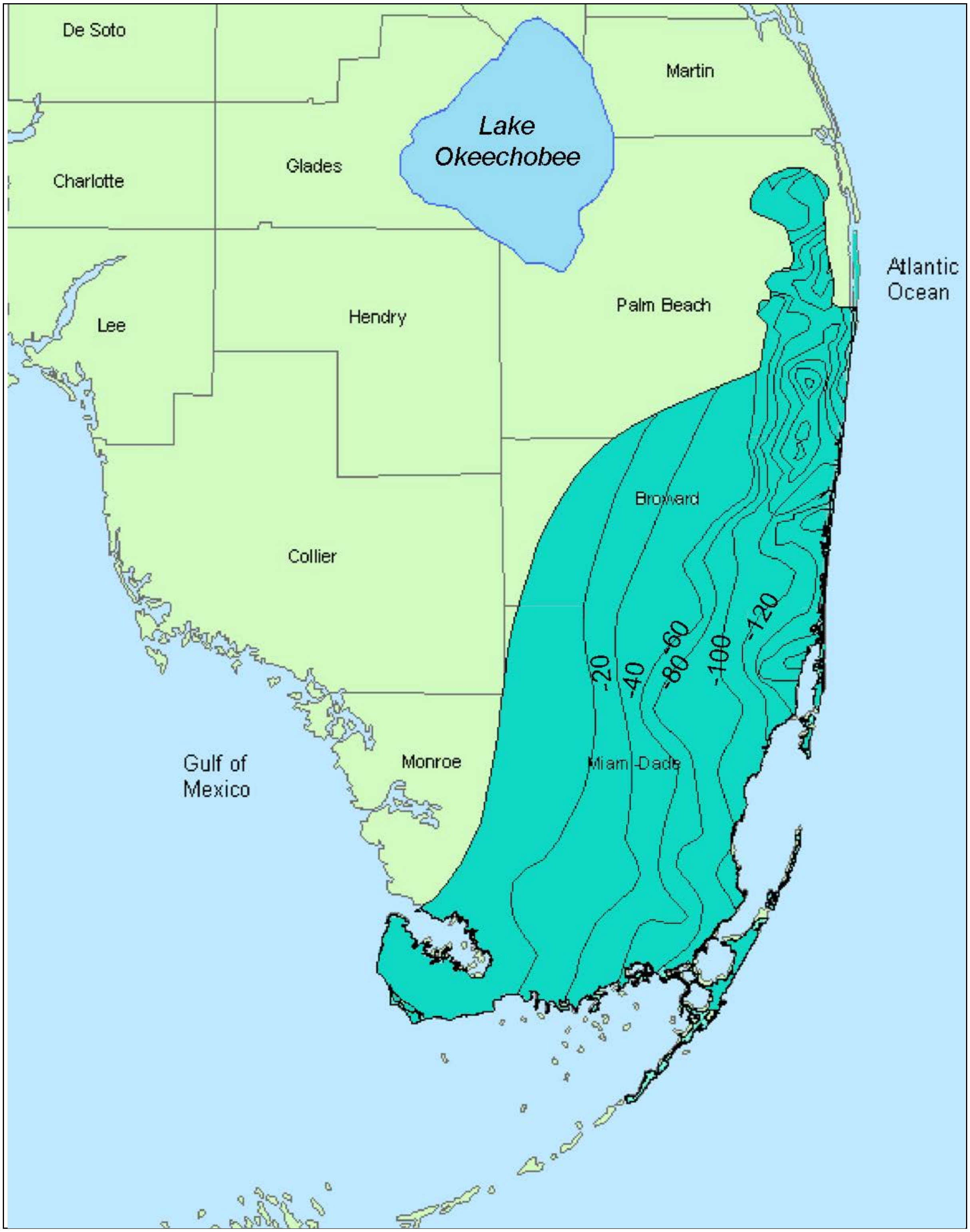


Figure 25. Location of the highly transmissive Biscayne aquifer (dark green) in eastern Miami-Dade, Broward, and Palm Beach counties with average aquifer depth in feet below mean sea level. Compiled from Restrepo et al. 1992, Fish and Stewart 1991, and Shine, Padgett, and Barfknecht 1989.

Gray Limestone Aquifer

The gray limestone aquifer lies below and west of the Biscayne aquifer, extending into Hendry and Collier counties. 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). The thickness of the aquifer is comparatively uniform, generally ranging from 30 to 100 feet. Transmissivity values of the aquifer are commonly greater than 50,000 feet squared per day to the west of Miami-Dade and Broward counties. 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.

> **INFO**
>
> Due to the regional importance of the Biscayne aquifer, it is designated as a Sole Source Aquifer by the U.S. Environmental Protection Agency, under the *Safe Drinking Water Act*. This stringent protection is necessary because the Biscayne aquifer is a principal source of drinking water and is highly susceptible to contamination and saltwater intrusion due to its high permeability and proximity to land surface in many locations.

Intermediate Confining Unit

The intermediate confining unit (ICU) consists of beds of clay, sand, sandy limestone, limestone, and dolostone that dip and thicken to the south and southwest. In much of south Florida, the ICU separates the SAS from the Upper Floridan aquifer. The ICU achieves its maximum development within the LEC, ranging from 600 feet to over 900 feet thick within the planning area.

Floridan Aquifer System

The Floridan aquifer system (FAS) is a confined aquifer system separated from the SAS by the low permeability sediments of the ICU. Within the LEC Planning area, the FAS is composed of a thick sequence (greater than 2,700 feet) of carbonate rocks (limestones and dolostones). However, not all of this thickness is useful for water supply. The FAS is more properly thought of as many discrete aquifers, or productive intervals, separated by lower permeability confining units. Traditionally, the FAS is subdivided into two major, regionally continuous producing zones, the brackish Upper Floridan aquifer (UFA) and more saline Lower Floridan aquifer (LFA), separated by a middle confining unit (**Figure 23**, confining unit 2).

The top of the FAS, which is coincident with the top of the UFA, can be found at depths from approximately 750 feet to 1,100 feet below MSL in the LEC Planning Area. It is shallowest in the northwestern corner of Palm Beach County, and deepens to the south and east. The UFA is under artesian pressure in the LEC Planning Area. The potentiometric heads range from 30 feet to 50 feet above MSL. Although the potentiometric surface of the aquifer is above land surface, the low-permeability units of the ICU prevent significant upward migration of saline waters into the shallower aquifers. This massive confining unit also serves as a protective barrier, isolating surface features from the drawdown effects of FAS withdrawals.

The UFA is composed of limestones from the Suwannee, Ocala, and Upper Avon Park formations. Permeability in these rocks is primarily due to the dissolution of rock material. Carbonate dissolution occurs most rapidly where waters of different chemistry meet. As a result, permeability in the UFA tends to increase from west to east, with the greatest productivity occurring in coastal areas. Salinity follows a similar trend, with the greatest salinity in coastal areas.

The UFA can be further divided into two regional sub-units, the upper producing zone at the top of the FAS and the Avon Park permeable zone in the upper portion of the Avon Park Formation. These two productive horizons are separated by an intervening confining unit (**Figure 23**, confining unit 1). Heads in these two units are very similar, but productivity and salinity may vary considerably. Generally, salinity within the FAS increases with depth, but in the LEC Planning Area, this relationship is inverted in several places, with greater salinity in the upper producing zone than in the Avon Park permeable zone. Throughout the LEC Planning Area, water from all portions of the UFA is non-potable due to salinity, requiring desalination or blending to meet potable standards.

The LFA comprises the limestones and dolostones of the Lower Avon Park, Oldsmar, and Upper Cedar Keys formations. Salinity within the LFA is greater than 10,000 milligrams per liter (mg/L) total dissolved solids, the designated cut-off for an underground source of drinking water. Though not generally considered useful as a water supply source, the LFA still provides some water supply benefit. Because of its salinity, the LFA has been eligible as a repository for underground injection of high-salinity by-product from reverse-osmosis treatment. The LFA is also suitable as a primary means for effluent disposal for several wastewater treatment facilities. At the base of the LFA, cavernous zones with extremely high transmissivities, collectively known as the Boulder Zone, are the target storage interval for these deep injection wells.

Surface Water and Groundwater Relationships

In many ways, surface water and groundwater resources are interdependent. Although surface water management systems are a major source of water supply, in terms of interaction with groundwater, the systems within the LEC Planning Area function primarily as aquifer drains during certain times of the year. 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, may be lost to evapotranspiration, or is discharged to tide.

The groundwater hydrology of the LEC Planning Area has been permanently altered by construction of the C&SF Project, as well as urban and agricultural development. These canals have 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 in some areas. The inland movement of salt water is a major concern in the coastal areas of the LEC Planning Area. Coastal canal water control structures constructed in the 1950s has helped stabilize or slow the advance of saltwater intrusion, although isolated areas still show evidence of continued inland migration of salt water.

ECOSYSTEM RESTORATION EFFORTS

Information about ecosystem restoration efforts for the LEC Planning Area is available in the 2013 LEC Plan Update (SFWMD 2013a).

More information and the status of these restoration projects can be found in the *South Florida Environmental Report* available from http://www.sfwmd.gov/sfer. Project descriptions, status, and further documentation about other projects are available from http://www.evergladesplan.org, http://www.sfwmd.gov/northerneverglades, and http://www.sfwmd.gov/everglades.


Storm over the Everglades

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 occurs, and 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. (See also *Level of certainty.*)

2008 Lake Okeechobee Regulation Schedule (2008 LORS) An interim schedule of required water levels by season and meteorological condition for Lake Okeechobee during evaluation and repairs to the Herbert Hoover Dike.

A

Acre-foot The volume of water that covers 1 acre to a depth of 1 foot; 43,560 cubic feet; 1,233.5 cubic meters; or 325,872 gallons, which is approximately the amount of water it takes to serve two typical families for one year.

Alternative water supply Salt water; brackish surface water 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; conservation programs; 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.).

Applicant's Handbook From the District's publication, *Applicant's Handbook for Water Use Permit Applications* (SFWMD 2014). Read in conjunction with Chapter 40E-2, F.A.C., the Applicant's Handbook 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.

Aquatic Preserve Water body set aside by the state to be maintained in essentially natural or existing condition for the protection of fish, 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 it for use in the future during dry periods.

Aquifer system A heterogeneous body of (interbedded or intercalated) permeable and less permeable material that functions regionally as a water yielding hydraulic unit and may be composed of more than one aquifer separated at least locally by confining units that impede ground-water movement, but do not greatly affect the hydraulic continuity of the system.

Artesian A commonly used expression in aquifer discussions, 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.

B

Base flow Sustained flow of a stream in the absence of direct runoff. It includes natural and human-induced streamflows. Natural base flow is sustained largely by groundwater discharges.

Baseline A specified period of time during which collected data are used for comparison with subsequent data.

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.

Below land surface (bls) Depth below land surface regardless of land surface elevation.

Best management practice (BMP) A practice or combination of practices, based on research, field testing, and expert review, determined to be the most effective and practicable on-farm means of improving water quality in agricultural discharges to a level that balances water quality improvements and agricultural productivity. BMPs may also include measures that reduce on-farm water use, such as tailwater recovery and the use of drought-resistant crops.

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 used to dispose of secondary-treated effluent from wastewater treatment facilities and concentrate from membrane water treatment facilities via deep injection wells.

C

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.

Central Florida Coordination Area (CFCA) The area of central Florida where the boundaries of the South Florida, Southwest Florida, and St. Johns River water management districts meet. Mechanisms for formal coordination and communication were established between the districts in 2006.

Central Florida Water Initiative (CFWI) A collaborative approach to resolve water supply technical and policy issues within the CFCA and address the limitations of the 2006 CFCA Action Plan, while still fulfilling the plan's original water resource objectives.

Coastal Utilities at Risk Utilities with wellfields near the saltwater interface that do not have an inland wellfield, have not developed adequate alternative sources of water, and have limited ability to meet user needs through interconnects with other utilities.

Coastal Utilities of Concern Utilities having wellfields near the saltwater interface, the ability to shift pumpages to an inland wellfield, or an alternative source that is not threatened by saltwater intrusion.

Comprehensive Everglades Restoration Plan (CERP) The federal-state 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.

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, and impedes the vertical movement of water.

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.

Cost Study *Water Supply Cost Estimation Study*, a comprehensive study of the costs associated with various alternative water supply options conducted by Camp, Dresser & McKee, Inc., under contract to the South Florida Water Management District.

Cryptosporidium A protozoan parasite that infects the intestinal tracts of humans and other vertebrates.

Culvert Conveyance structure that provides a means for water to pass under a road or railroad.

D

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.

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.

Dike An embankment to confine or control water, especially one built along the banks of a river to prevent overflow of lowlands; a levee.

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 causes 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.

Domestic Self-Supply (DSS) The water demand use category that includes 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.

Domestic use Use of water for household purposes, such as drinking, bathing, cooking, or sanitation.

Domestic wastewater Wastewater derived principally from residential dwellings, business or commercial buildings, institutions, and the like; sanitary wastewater; sewage.

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 basin Describes the land area where precipitation ultimately drains to a particular watercourse (river, stream) or body of water (lake, reservoir). Drainage basins in south Florida are defined by Rule and are periodically redefined to reflect changes in the regional drainage network.

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 all works needed to implement an adopted water control plan.

Drawdown (1) The vertical distance between the static water level and the surface of the cone of depression. (2) A lowering of the ground-water surface caused by pumping.

Drought A period of below average rainfall, typically longer than a few months, that adversely affects growing or living conditions.

E

Ecosystem restoration The process of reestablishing to as near its recent natural condition as possible, the structure, function, and composition of an ecosystem.

Effluent Water that is not reused after flowing out of any facility 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 a water treatment membrane.

Elevation The height in feet above mean sea level according to National Geodetic Vertical Datum (NGVD) or North American Vertical Datum (NAVD). May also be expressed in feet above mean sea level.

Endangered species A species that is in danger of extinction throughout all or a significant portion of its range.

Estuary A partially enclosed part of the wide lower course of a river where its current is met by open ocean tides or an arm of the sea; where riverine fresh and oceanic salt water meet.

Evapotranspiration (ET) The total loss of water to the atmosphere by evaporation from land and water surfaces and by transpiration from plants.

Everglades America's Everglades is a vast subtropical marsh and mangrove area noted for its wildlife and a critical part of southern Florida's water supply. The Northern Everglades and Estuaries Protection Program (373.4595, F.S.) subdivided the Greater Everglades ecosystem into northern and southern Everglades along the Caloosahatchee and St. Lucie rivers and Lake Okeechobee.

Everglades Agricultural Area (EAA) Highly productive agricultural land, the EAA is an area of histosols (muck) extending south from Lake Okeechobee to the northern levee of Water Conservation Area 3A, from the EAA's eastern boundary at the L-8 Canal to the western boundary along the L-1, L-2, and L-3 levees.

Everglades Construction Project (ECP) Twelve interrelated construction projects located between Lake Okeechobee and the Everglades. The cornerstone of the ECP is the Everglades Stormwater Treatment Areas (Everglades STAs). The STAs are constructed wetlands intended to reduce phosphorus in waters that discharge to the Everglades Protection Area. 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 comprises the Arthur R. Marshall Loxahatchee National Wildlife Refuge, Water Conservation Areas, and Everglades National Park.

Exceedance The violation of the pollutant levels permitted by environmental protection standards.

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.

F

Feasibility study The phase of a project where the purpose is to describe and evaluate alternative plans and fully describe a recommended project.

Filtration The method by which water treatment facilities physically remove constituents to improve water quality for Public Water Supply, irrigation, or other uses.

Finished water Water that has completed a purification or treatment process; water that has passed through all the processes in a water treatment facility and is ready to be delivered to consumers. Contrast with *raw water*.

Fiscal Year (FY) The South Florida Water Management District's fiscal year begins on October 1 and ends on September 30 the following year.

Floodplain Land next to a stream or river that is flooded during high-water flow.

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 Agriculture and Consumer Services (FDACS) The FDACS is the state agency that communicates the needs of the agricultural industry to the Florida legislature, the FDEP, and the water management districts. The FDACS is also charged with handling general consumer problems, such as complaints against businesses. The FDACS oversees Florida's Soil and

Water Conservation districts, which coordinate closely with the U.S. Department of Agriculture–Natural Resources Conservation Service (USDA-NRCS).

Florida Department of Environmental Protection (FDEP) The FDEP is the state agency charged with protecting, conserving, and managing Florida's natural resources and enforcing the state's environmental laws. The SFWMD operates under the general supervisory authority of the FDEP, which includes budgetary oversight.

Florida-Friendly Landscaping Quality landscapes that conserve water, protect the environment, are adaptable to local conditions, and are drought tolerant. The principles of such landscaping include planting the right plant in the right place, efficient watering, appropriate fertilization, mulching, attraction of wildlife, responsible management of yard pests, recycling yard waste, reduction of stormwater runoff, and waterfront protection. Additional components include practices such as landscape planning and design, soil analysis, the appropriate use of solid waste compost, minimizing the use of irrigation, and proper maintenance.

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 FAS is mineralized (total dissolved solids are greater than 1,000 mg/L) along coastal areas and in southern Florida.

G

Geologic unit A geologic unit is a volume of rock or ice of identifiable origin and age range that is defined by the distinctive and dominant, easily mapped and recognizable petrographic, lithologic, or paleontologic features that characterize it.

Geophysical log A record of the structure and composition of the earth with depth encountered when drilling a well or similar type of test or boring hole.

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.

H

Harm As defined in Rule 40E-8, 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.

Headwaters 1) Water that is typically of higher elevation (with respect to tailwater) or on the controlled side of a structure, 2) The waters at the highest upstream point of a natural system that are considered the major source waters of the system.

Hydraulic conductivity A coefficient of proportionality describing the rate at which water can move through an aquifer or other permeable medium.

Hydrogeologic unit Any rock unit or zone that, because of its hydraulic properties, has a distinct influence on the storage or movement of groundwater.

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.

Hypersaline Salinity conditions that are above what is typical of open marine conditions. Salinity conditions in excess of typical marine conditions.

I-J-K

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 (IRL) Extending for 156 miles from north of Cape Canaveral to Stuart along the east coast of Florida, this lagoon is one of America's most diverse estuaries, home to thousands of plant and animal species.

Industrial/Commercial/Institutional (ICI) Self-Supply The water demand use category that includes water used by industrial, commercial, or institutional operations withdrawing a minimum water quantity of 0.1 million gallons per day from individual, on-site wells.

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

Injection well Refers to a well constructed to inject treated wastewater directly into the ground. Wastewater is generally forced (pumped) into the well for dispersal or storage in a designated aquifer. Injection wells are generally drilled below freshwater levels, or into unused aquifers or aquifers that do not deliver drinking water.

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.

Interbedded Said of beds lying between or alternating with others of different character; esp. said of rock material laid down in sequence between other beds, such as a contemporaneous lava flow "interbedded" with sediments.

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.

Invasive species Species of plants or animals that are not naturally found in a region (see also *Nonindigenous*). They can sometimes aggressively invade habitats and cause multiple ecological changes, including the displacement of native species.

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 system efficiency A measure of the effectiveness of an irrigation system in delivering water to a crop for irrigation and freeze protection purposes. It is expressed as the ratio of the volume of water used for supplemental crop evapotranspiration to the volume pumped or delivered for use.

Karst A topography formed over limestone, dolomite, or gypsum and characterized by sinkholes, caves, and underground drainage.

Kissimmee Chain of Lakes (KCOL) The Upper Kissimmee Basin is composed of a diverse group of wetland and lake ecosystems known as the Kissimmee Chain of Lakes. The Upper Basin contains hundreds of lakes and wetlands with the largest lakes occurring along the eastern boundary. These larger lakes include Lake Kissimmee, the third largest lake in the State of Florida. Collectively, these larger lakes are referred to as the Kissimmee Chain of Lakes.

L

Lagoon A body of water separated from the ocean by barrier islands, with limited exchange with the ocean through inlets.

Lake Management Area (LMA) The SFWMD conceptualizes the Kissimmee Basin as (1) a set of Water Control Units that conveys water, and (2) Water Control Catchments that drain into the Water Control Units. Lakes in the Kissimmee Chain of Lakes (KCOL) are organized into seven lake management areas comprising one or many Water Control Units.

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.

Leachate Liquid containing soluble substances that percolates through the ground, such as water seeping through a landfill.

Leaching The process by which soluble materials in the soil, such as salts, nutrients, pesticide chemicals, or contaminants, are washed into a lower layer of soil or are dissolved and carried away by water.

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 zone (1) The zone within a lake that is inundated at least part of the year by changes in lake stage and characterized by littoral wetland vegetation. (2) The area between the perimeter of lake or in shallow areas within a lake that is inundated year-round and contains emergent, floating-leaved, and submerged, rooted plants.

Lower pressure reverse osmosis A reverse osmosis technology where nanofiltration or other alternative membranes are used that result in the ability of a facility use lower pressure when pushing the water to be treated through the system (see also *Reverse osmosis*).

M

Marl A mixture of clays, carbonates of calcium and magnesium, and remnants of shells, forming a loam that is useful as a fertilizer.

Mean sea level (MSL) 1) The level of the surface of the sea between mean high and mean low tide; used as a reference point for measuring elevations. 2) The average height of the sea for all stages of the tide over a 19-year period, usually determined from hourly height observations on an open coast or in adjacent waters having free access to the sea. 3) (FEMA) For purposes of the National Flood Insurance Program (NFIP), the National Geodetic Vertical Datum (NGVD) of 1929 or other datum, to which base flood elevations shown on a community's Flood Insurance Rate Map (FIRM) are referenced.

MFL Exceedance To fall below a minimum flow or level, which is established in Chpater 40E-8, F.A.C., for a duration greater than specified for the MFL water body.

Microconstituents Sometimes known as "emerging pollutants of concern," these are chemicals found in a wide array of consumer goods, including pharmaceuticals and personal care products (FDEP) that may end up in Public Water Supplies. Presence or absence of these may eventually have water quality criteria set for them.

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.

Microirrigation The application of small quantities of water on or below the soil surface as drops or tiny streams of spray through emitters or applicators placed along a water delivery line. Microirrigation includes a number of methods or concepts, such as bubbler, drip, trickle, mist or microspray, and subsurface irrigation.

Minimum flow and level (MFL) The point at which further withdrawals will result in significant harm to water resources or ecology of the area. An MFL is established by a water management district pursuant to Sections 373.042 and 373.0421, F.S., for a given water body and set forth in Parts II and III of Chapter 373.

Model A computer model is a representation of a system and its operations, and provides a cost-effective way to evaluate future system changes, summarize data, and help understand interactions in complex systems. Hydrologic models are used for evaluating, planning, and simulating the implementation of operations within the SFWMD's water management system under different climatic and hydrologic conditions. Water quality and ecological models are also used to evaluate other processes vital to the health of ecosystems.

Monitor well Any excavation by any method to monitor fluctuations in groundwater levels, quality of underground waters, or the concentration of contaminants in underground waters.

N-O-P

National Geodetic Vertical Datum (NGVD) 1929 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.

Net water demand (or user/customer water demand) is the water demand of the end user after accounting for treatment and process losses, and inefficiencies. When discussing Public Water Supply, the term "finished water demand" is commonly used to denote net demand.

Nonindigenous A nonnative species, especially one that tends to out-compete native species and become quickly established, especially in areas of disturbance or where the normal hydroperiod has been altered (see also *Invasive species*).

North American Vertical Datum (NAVD) of 1988 The official civilian vertical control datum (reference for elevation data) for surveying and mapping activities in the United States.

Nutrient loading Discharging of nutrients from the watershed (basin) into a receiving water body (lake, stream, wetland); expressed usually as mass per unit area per unit time (e.g., pounds/acre/year).

Outlet An opening through which water can be freely discharged from a reservoir.

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

Overland flow The flow of rainfall or snowmelt over the land surface toward stream channels. After overland flow enters a watercourse, it becomes runoff.

Parameter Whatever it is you measure; a particular physical, chemical, or biological property that is being measured.

Parts per million (ppm) The number of "parts" by weight of a substance per million parts of water. This unit is commonly used to represent pollutant concentrations. Equivalent to a milligram per liter (mg/L).

Peak flow The maximum instantaneous discharge of a stream or river at a given location. Peak flow usually occurs at or near the time of maximum stage.

Peat Any mass of semi-carbonized vegetable tissue formed by partial decomposition in water of various plants, especially mosses of the genus *Sphagnum*. Peat varies in consistency from turf to slime. As it decomposes its color deepens, old peat being dark brown or black, and keeping little of the plant texture. According to its formation, it is known as Bog Peat (mosses), Heath Peat, or Meadow Peat (grasses and sedges), Forest Peat, or Wood Peat (trees), and Sea Peat (seaweeds).

Per capita use The average amount of water used per person during a standard time period, generally per day.

Percolation (1) The movement of water through the openings in rock or soil. (2) The entrance of a portion of the streamflow into channel materials to contribute to groundwater replenishment.

Performance measure Scientifically measurable indicator or condition that can be used as a target for meeting water resource management goals. Performance measures quantify how well or how poorly an alternative meets a specific objective. Good performance measures are quantifiable, have a specific target, indicate when a target has been reached, and measure the degree to which the goal has been met.

Permeability The capacity of a porous rock, sediment, or soil for transmitting a fluid.

pH A measure of the acidity or alkalinity of a solution, numerically equal to 7 for neutral solutions, increasing with increasing alkalinity and decreasing with increasing acidity. The pH scale commonly in use ranges from 0 to 14.

Planning Area The SFWMD is divided into five areas within which planning activities are focused: Upper Kissimmee Basin (UKB), Lower Kissimmee Basin (LKB), Upper East Coast (UEC), Lower West Coast (LWC), and Lower East Coast (LEC).

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.

Pollutant loading Influx of a chemical or nutrient that contaminates air, soil, or water.

Porosity The percentage of the soil or rock volume that is occupied by pore space, void of material; defined by the ratio of voids to the total volume of a specimen.

Potable water Water that is safe for human consumption.

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.

Power Generation Self-Supply The water demand use category that describes the difference in the amount of water withdrawn by electric power generating facilities for cooling purposes and the water returned to the hydrologic system near the point of withdrawal.

Public Water Supply The water demand use category that includes finished water supplied by water treatment facilities for potable use (drinking quality) with projected average pumpages greater than 0.1 MGD.

Q-R

Raw water (1) Water that is direct from the source — groundwater or surface water — without any treatment. (2) Untreated water, usually that entering the first unit of a water treatment facility. Contrast with *finished 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.

Recharge (canal) The discharge of highly treated wastewater or reclaimed water into canals or surface water bodies for beneficial recharge of groundwater or downstream augmentation.

Recharge (groundwater) The natural or intentional infiltration of surface water into the ground to raise groundwater levels.

Recharge (hydrologic) The downward movement of water through soil to groundwater; the process by which water is added to the zone of saturation; or the introduction of surface water or groundwater to groundwater storage, such as an aquifer. Recharge or replenishment of groundwater supplies consists of three types:

1) Natural recharge, which consists of precipitation or other natural surface flows making their way into groundwater supplies.

2) Artificial or induced recharge, which includes actions by man specifically designed to increase supplies in groundwater reservoirs through various methods, such as water spreading (flooding), ditches, and pumping techniques.

3) Incidental recharge, which consists of actions, such as irrigation and water diversion, which add to groundwater supplies, but are intended for other purposes. Recharge may also refer to the amount of water so added.

Recharge area (groundwater) The land area over which precipitation infiltrates into soil and percolates downward to replenish an aquifer; the area in which water reaches the zone of saturation by surface infiltration. Infiltration moves downward into the deeper parts of an aquifer in a recharge area. Also referred to as a recharge zone.

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.).

Recovery The rate and extent of return of a population or community to some aspect(s) of its previous condition. Because of the dynamic nature of ecological systems, the attributes of a "recovered" system should be carefully defined.

Recreational/Landscape Self-Supply The water demand use category that includes water used for landscape and golf course irrigation. The landscape subcategory includes water used for parks, cemeteries, and other irrigation applications greater than 0.1 million gallons per day (MGD). The golf course subcategory includes those operations not supplied by a Public Water Supply or regional reuse facility.

Regional Water Supply Plan Update Detailed water supply plan developed by the District under Section 373.709, 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.

Restricted Allocation Area Area designated within the District for which allocation restrictions are applied regarding the use of specific sources of water. The water resources in these areas are managed in response to specific sources of water in the area for which there is a lack of water availability to meet the projected needs of the region from that specific source of water.

Retention The prevention of stormwater runoff from direct discharge into receiving waters; included as examples are systems that discharge through percolation, exfiltration, filtered bleed-down, and evaporation processes.

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

Rule Of or pertaining to regulatory programs of the District and other agencies, which are set forth as various prescribed guides for conduct, action, or criteria.

Runoff That component of rainfall, which is not absorbed by soil; intercepted and stored by surface water bodies; evaporated to the atmosphere; transpired and stored by plants; or infiltrated to groundwater, but which flows to a watercourse as surface water flow.

S

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.

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.

Saturated zone The part of the subsurface that is saturated with water. The upper surface of this zone, open to atmospheric pressure, is known as the water table (phreatic surface).

SEAWAT A program developed to simulate three-dimensional, variable-density, transient groundwater flow in porous media. The source code for SEAWAT was developed by combining MODFLOW and MT3DMS into a single program that solves the coupled flow and solute-transport equations.

Seawater or **salt water** Water with a chloride concentration at or above 19,000 mg/L (Applicant's Handbook, SFWMD 2014).

Secondary wastewater treatment Treatment that follows primary wastewater treatment. It involves the biological process of reducing suspended, colloidal, and dissolved organic matter in effluent from primary treatment systems, which generally removes 80 to 95 percent of the oxygen-demanding substances and suspended matter. Secondary wastewater treatment may be accomplished by biological or chemical-physical methods. Activated sludge and trickling filters are two of the most common means of secondary treatment. Disinfection is the final stage of secondary treatment.

Seepage The passage of water or other fluid through a porous medium, such as the passage of water through an earth embankment or masonry wall. Groundwater emerging on the face of a stream bank; the slow movement of water through small cracks, pores, interstices, etc., of a material into or out of a body of surface or subsurface water. The interstitial movement of water that may take place through a dam, its foundation or its abutments. The loss of water by infiltration into the soil from a canal, ditches, laterals, watercourse, reservoir, storage facilities, or other body of water, or from a field. Seepage is generally expressed as flow volume per unit of time. During the process of priming (a field during initial irrigation), the loss is called absorption loss.

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

Seepage irrigation system Irrigation 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-Supply 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, irreversible, or permanent loss of water resource functions resulting from a change in surface water 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 that result from a change in surface water or groundwater hydrology and takes more than two years to recover, but which is considered less severe than serious harm.

Smart irrigation Advanced sensors and other equipment added to irrigation systems that automatically adjust water used to meteorological or site conditions.

Soil moisture Water diffused in the upper part of the soil mantle that is lost by the transpiration of plants or by soil evaporation.

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) Constructed water quality treatment wetland that uses natural biological processes (such as plant uptake) to reduce levels of phosphorus from surface water runoff.

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 Utilities of Concern Cities that are dependent on their present water intakes directly from Lake Okeechobee for potable water supply, as well as cities that rely on surface water lakes and impoundments for water supply.

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.

T

Tailwater that is typically of lower elevation or on the discharge side of the structure.

Total trihalomethanes (TTHMs) A sum of chloroform, bromodichloromethane, dibromochloromethane, and bromoform. Trihalomethanes are any of several synthetic organic compounds formed when chlorine combines with organic materials in water during the disinfection process.

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

Treatment facility Any facility or other works used for the purpose of treating, stabilizing, or holding water or wastewater.

Turbidity The measure of water clarity caused by suspended material in a liquid.

U

Ultralow-volume (ULV) fixtures Water-conserving plumbing fixtures that meet industry standards at a test pressure of 80 pounds per square inch (psi) listed below.

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.

U.S. Army Corps of Engineers (USACE) As part of the U.S. Department of the Army, the Corps has responsibilities in civil and military areas. In civil works, the USACE has authority for approval of dredge and fill permits in navigable waters and tributaries thereof; the USACE enforces wetlands regulations, and constructs and operates a variety of water resources projects, mostly notably levees, dams, and locks.

U.S. Department of Agriculture–Natural Resources Conservation Service (USDA–NRCS) This agency provides technical assistance for soil and water conservation, natural resource surveys and community resource protection. Formerly the U.S. Soil Conservation Service (SCS).

U.S. Environmental Protection Agency (USEPA) Consolidated federal agency that is responsible for a variety of research, monitoring, standard-setting and enforcement activities to ensure environmental protection in the U.S., including water quality.

U.S. Fish and Wildlife Service (USFWS) The USFWS is a bureau within the U.S. Department of the Interior. Its mission is to work with others to conserve, protect, and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people.

U.S. Geological Survey (USGS) The federal agency that classifies public lands and examines the geologic structure, mineral resources, and products of the national domain. As part of its mission, the USGS provides information and data on the nation's rivers and streams that are useful for mitigation of hazards associated with floods and droughts.

Utility Any legal entity responsible for supplying potable water for a defined service area.

Utility interconnections Physical connections between utilities in different service areas. These interconnections are also formal methods by which utilities can move water around during times of high demand, such as during water shortages.

Utilities of Concern Utilities that have wellfields near the saltwater interface, have a non-coastal wellfield, and/or an alternative water source that is not threatened by saltwater intrusion.

Utilities at Risk Utilities with wellfields near the saltwater interface that do not have a non-coastal wellfield, have not developed alternative sources of water, and have limited ability to meet user needs through interconnects with other utilities.

W-X-Y-Z

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 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 over 1,350 square miles, or about 50 percent of the original Everglades.

Water control structure An artificial structure designed to regulate the level/flow of water in a canal or water body (e.g., weirs, dams).

Water quality standards The physical, chemical, and biological condition of water as applied to a specific use. Federal and state guidelines set these criteria based on the water's intended use, whether for recreation, fishing, drinking, navigation, shellfish harvesting, or agriculture.

Water reservation A water reservation is a legal mechanism to set aside water for the protection of fish and wildlife or the public health and safety from consumptive water use. The reservation is composed of a quantification of the water to be protected, which includes seasonal and location components.

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 groundwater storage, and groundwater recharge augmentation; and related technical assistance to local governments and Public Water Supply utilities (Section 373.019, F.S.).

Water Resources Advisory Commission (WRAC) The SFWMD Water Resources Advisory Commission (WRAC) serves as an advisory body to the Governing Board. The WRAC is the primary forum for conducting workshops, presenting information, and receiving public input on water resource issues affecting central and south Florida.

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 water 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 Shortage Plan This effort includes provisions in Rule 40E-8.441(4), F.A.C., and Chapter 40E-21, F.A.C., and identifies how water supplies are allocated to users 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 Lake Okeechobee, demands, time of year, and rainfall forecasts.

Water shortage trigger Water shortage triggers are water levels at which phased restrictions will be declared under the SFWMD's Water Shortage Plan.

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 [Subsection 373.019(24), F.S.].

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 table aquifer An unconfined aquifer within which is found the water table. Synonymous with the surficial aquifer system in certain planning areas.

Watershed A region or area bounded peripherally by a water parting and draining ultimately to a particular watercourse or body of water. Watersheds conform to federal hydrologic unit code standards and can be divided into subwatersheds and further divided into catchments, the smallest water management unit recognized by SFWMD operations. Unlike drainage basins, which are defined by rule, watersheds are continuously evolving as the drainage network evolves.

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.

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.

Wellfield One or more wells producing water from a subsurface source. A tract of land that contains a number of wells for supplying a large municipality or irrigation district.

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).

Wild and Scenic River A river as designated by the U.S. Fish and Wildlife Service under the authority of the of Public Law 90-542, the *Wild and Scenic Rivers Act*, as amended, is a means to preserve selected free-flowing rivers in their natural condition and protect the water quality of such rivers. A portion of the Northwest Fork of the Loxahatchee River was federally designated as the first Wild and Scenic River in Florida on May 17, 1985.

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.

Yield The quantity of water (expressed as rate of flow or total quantity per year) that can be collected for a given use from surface or groundwater sources.

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Purple Gallinule

Pineland Clustervine (Endangered)

Juvenile Anhinga

Phasey Bean Wildflower

Meeting South Florida's water supply needs while safeguarding its natural systems requires innovative solutions, cohesive planning, and a shared vision.

South Florida Water Management District

Committed to managing and protecting our region's water resources

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