SOUTH FLORIDA WATER MANAGEMENT DISTRICT

# SUPPORT DOCUMENT

## for WATER SUPPLY PLAN UPDATES

Reference Document

2021-24

*Cover photos*

*Front: Sawgrass Expressway, Broward County*
*Inset: City of Delray Beach Reclaimed Water Pipeline*
*Back: Lake Okeechobee Herbert Hoover Dike*

# Acknowledgments

The South Florida Water Management District thanks everyone who contributed to the development and production of this *Support Document for the 2021-2024 Water Supply Plan Updates*.

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# Acronyms and Abbreviations

| | |
|---|---|
| AG | Agriculture |
| ASR | aquifer storage and recovery |
| AWS | alternative water supply |
| AWT | advanced wastewater treatment |
| AWWA | American Water Works Association |
| BMP | best management practice |
| C&SF Project | Central and Southern Florida Flood Control Project |
| CERP | Comprehensive Everglades Restoration Plan |
| CFP | Cooperative Funding Program |
| CFWI | Central Florida Water Initiative |
| CII | Commercial/Industrial/Institutional |
| DBP | disinfection byproduct |
| District | South Florida Water Management District |
| DSS | Domestic Self-Supply |
| EQIP | Environmental Quality Incentives Program |
| F.A.C. | Florida Administrative Code |
| F.S. | Florida Statutes |
| FAS | Floridan aquifer system |
| FAWN | Florida Automated Weather Network |
| FDACS | Florida Department of Agriculture and Consumer Services |
| FDEP | Florida Department of Environmental Protection |
| HVAC | heating, ventilation, and air conditioning |
| L/R | Landscape/Recreational |
| LEC | Lower East Coast |
| LKB | Lower Kissimmee Basin |
| LWC | Lower West Coast |
| MCL | maximum contaminant level |
| MF | microfiltration |
| MFL | minimum flow and minimum water level |
| MIL | mobile irrigation lab |
| mg/L | milligrams per liter |

| | |
|---|---|
| mgd | million gallons per day |
| NEEPP | Northern Everglades and Estuaries Protection Program |
| NF | nanofiltration |
| O&M | operations and maintenance |
| PCUR | per capita use rate |
| PG | Power Generation |
| PS | Public Supply |
| RAA | restricted allocation area |
| RES | Residential |
| RO | reverse osmosis |
| SAS | surficial aquifer system |
| SFWMD | South Florida Water Management District |
| TTHM | total trihalomethane |
| UEC | Upper East Coast |
| UF | ultrafiltration |
| UF/IFAS | University of Florida Institute of Food and Agricultural Sciences |
| UKB | Upper Kissimmee Basin |
| USACE | United States Army Corps of Engineers |
| USEPA | United States Environmental Protection Agency |
| USGS | United States Geological Survey |
| UV | ultraviolet |

# 1

# Introduction

TOPICS

- Water Supply Planning
- Legal Authority and Requirements
- Regional Water Supply Plans
- Regional and Local Planning Linkage

This *Support Document for the 2021-2024 Water Supply Plan Updates* (2021-2024 Support Document) supplements the regional water supply plan updates produced by the South Florida Water Management District (SFWMD or District) between 2021 and 2024. The 2021-2024 Support Document provides background information helpful in understanding the SFWMD's water supply planning process and highlights issues to be considered when developing comprehensive water supply plans with a 20-year planning horizon. **Figure 1-1** shows the SFWMD's jurisdiction and planning areas.

The SFWMD encompasses nearly 18,000 square miles, divided into five planning areas: Upper East Coast (UEC), Lower West Coast (LWC), Lower East Coast (LEC), Lower Kissimmee Basin (LKB), and Upper Kissimmee Basin (UKB). The SFWMD prepares water supply plans on a rolling annual basis for the UEC, LWC, LEC, and LKB planning areas. Development of comprehensive water supply plans specific to each region is key to identifying and understanding current and future water needs. This 2021-2024 Support Document complements the cycle of plans developed starting in 2021 with the UEC, followed by the LWC in 2022, the LEC in 2023, and the LKB in 2024. The UKB is within the boundaries of the Central Florida Water Initiative (CFWI), where the South Florida, St. Johns River, and Southwest Florida water management districts meet. The CFWI planning area includes Orange, Osceola, Seminole, Polk, and southern Lake counties. Together, the water management districts work with utilities, county and state agencies, and other stakeholders to develop a single regional water supply plan for this area to implement effective and consistent water resource planning, development, and management. The CFWI regional water supply plan has its own set of supporting documentation, including a Supplemental Applicant's Handbook [Rule 62-41.302, Florida Administrative Code (F.A.C.)].

This 2021-2024 Support Document is organized as follows:

- Chapter 1 – Introduction
- Chapter 2 – Water Conservation
- Chapter 3 – Water Use Permitting
- Chapter 4 – Water Resource Protection
- Chapter 5 – Ecosystem Restoration and Water Resource Development
- Chapter 6 – Water Source Options and Treatment

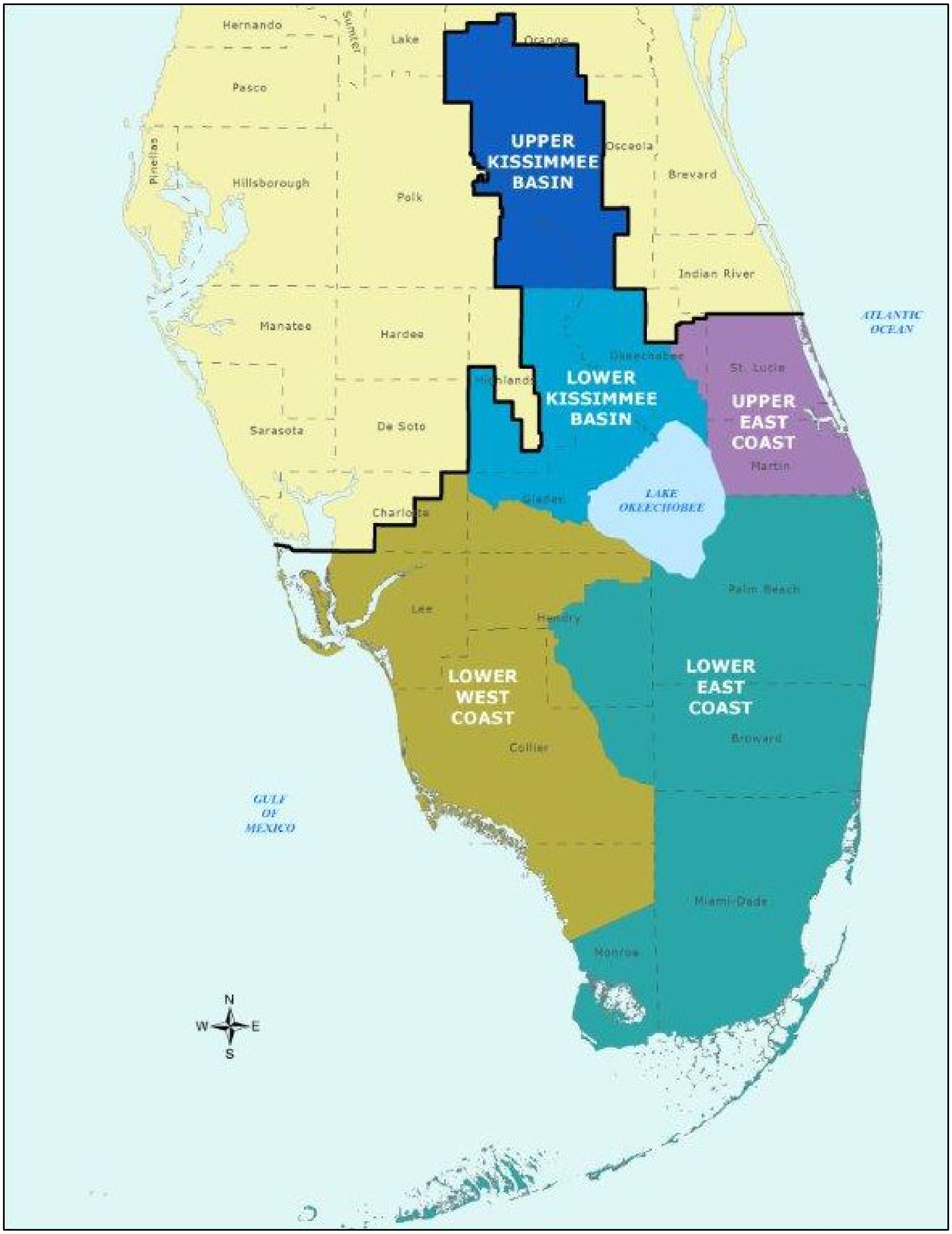


Figure 1-1. Planning areas of the South Florida Water Management District, with county lines for reference.

# WATER SUPPLY PLANNING

More than 9 million people, plus farms and businesses, use on average more than 3.5 billion gallons of water every day in South Florida. By 2045, almost 2 million new residents are expected to make South Florida their home, increasing demand for fresh water. Ensuring an adequate supply of water to protect, enhance, and restore natural systems as well as meet all other existing and projected needs is a fundamental element of the SFWMD's mission. The goal of the water supply planning process is to determine each planning area's water needs and develop sound, workable solutions to meet those needs.

The SFWMD completes water supply planning in coordination with other agencies, local governments and utilities, the agricultural industry, environmental interests, and other stakeholders. Public involvement and understanding of agency responsibilities are critical in developing and implementing long-term plans and strategies. Coordination with local governments establishes a closer link between development decisions and water availability.

Boca Raton

## Legal Authority and Requirements

Approximately 50 years ago, Maloney et al. (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. 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), who has general supervisory authority over the water management districts. One outcome of this legislation was the establishment of Florida's five regional water management districts. **Figure 1-2** shows the current legal framework for water supply planning in Florida.

In 1997, the Florida legislature enacted laws specifying the role of the water management districts 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.*

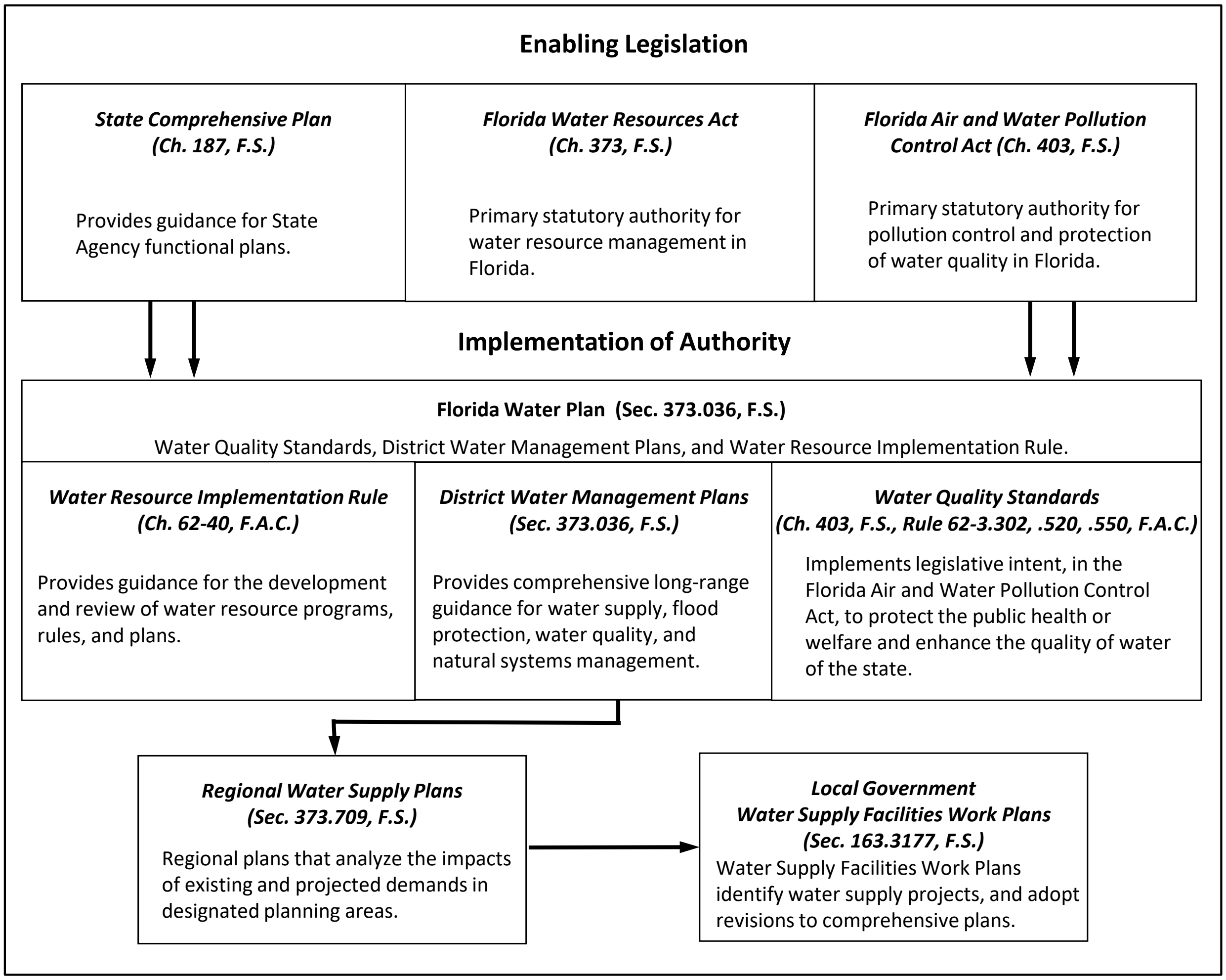


Figure 1-2. Legal framework for Florida water supply planning.

Section 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 the following items:

- FDEP programs and activities related to water supply, water quality, flood protection, 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

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, 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 the following:

- Water Supply Policy Document (SFWMD 1991) – A compilation and discussion of the major water policies of the State of Florida and the SFWMD. This policy framework guided key decisions related to water supply planning and regulation by the District.
- Water Supply Needs and Sources (SFWMD 1992)
- District Water Management Plan (SFWMD 1995) – The SFWMD approved District Water Management Plans 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*, in lieu of the District Water Management Plan. In addition, the SFWMD Strategic Plan contains the long-range planning information formerly reported in the District Water Management Plan.
- Districtwide Water Supply Assessment (SFWMD 1998) – In 1997, Chapter 373, F.S., was modified to require each water management district to prepare a Districtwide Water Supply Assessment in order to identify areas where water demands may exceed available supplies within a 20-year planning horizon. The SFWMD Districtwide Water Supply Assessment confirmed the SFWMD's decision to prepare water supply plans that cumulatively cover the entire District.

The legal authority and requirements for water supply planning are included in Chapters 163, 187, 373, and 403, F.S. In accordance with Florida's Water Protection and Sustainability Program (Section 373.707, F.S.), regional water supply plans and local government Comprehensive Plans must ensure adequate potable water facilities are constructed and concurrently available to meet the demands of new development. The water supply planning region identified in each plan shall be considered a Water Resource Caution Area under Section 403.064, F.S., and affected parties may challenge the designation pursuant to Section 120.569, F.S.

LAW/CODE

**Section 373.709(1), F.S.**

The governing board of each water management district shall conduct water supply planning for a water supply planning region within the district identified in the appropriate district water supply plan under Section 373.036, F.S., where it determines that existing sources of water are not adequate to supply water for all existing and future reasonable-beneficial uses and to sustain the water resources and related natural systems for the planning period.

## Regional Water Supply Plans

Water supply plans and updates provide detailed information and recommended actions to ensure projected water needs can be met within each planning area. The SFWMD updates its regional water supply plans approximately every 5 years. Based on a minimum 20-year planning horizon, current regional water supply plans include the following:

- Population projections and water demand projections for six water use categories
- A water supply development component
- An analysis of the water resources in the planning area
- A water resource development component, including a funding strategy that must be reasonable and sufficient to pay the cost of constructing or implementing all the listed projects
- The minimum flows and minimum water levels (MFLs) and associated prevention and recovery strategies established for water resources within the planning area
- Water reservations adopted by rule, pursuant to Section 373.223(4), F.S.

## Regional and Local Planning Linkage

The SFWMD's water supply planning process is coordinated with and incorporates the known local water supply planning elements and activities of municipal/county governments and utilities. This coordination with water supply planning entities is essential to the regional water supply plan development and approval process. While the SFWMD's regional water supply plans address regional and Districtwide water supply issues, local governments are required to plan for their water supply issues, primarily water and wastewater needs (as well as other infrastructure and public service elements), at the local level. Local water supply planning is accomplished through the comprehensive planning process required by Chapter 163, F.S. Comprehensive Plans, and subsequent amendments, must address water supply demand projections, identify and include details about water sources, and provide information about the availability and capacity of water supply facilities.

### *Local Government Comprehensive Plans*

The Community Planning Act (Section 163.3161, F.S.) 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. Each District water supply plan update contains information on state requirements for local government Comprehensive Plans, including the following guidance for water supply activities:

- 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 plans and amendments on the availability of water and associated public facilities.
- Identify alternative and traditional water supply, conservation, and reuse projects needed to meet the water needs identified in the regional water supply plan for the local government's jurisdiction.

## Work Plans

Local Comprehensive Plans include Water Supply Facilities Work Plans (Work Plans), which are required by statute. Work Plans are part of the link between regional and local water supply planning efforts. They identify water supply, conservation, and reuse projects necessary to meet the local government's water needs for at least a 10-year horizon. Most local governments are required by statute to update their Work Plans and adopt revisions to their Comprehensive Plans within 18 months following the applicable water supply plan's approval [Section 163.3177(6)(c)3., F.S.]. Revisions may include population projections, established planning periods, existing and future water resource projects, intergovernmental coordination activities, conservation and reuse measures, and the capital improvements element.

The SFWMD works with public and private water supply utilities to evaluate the need for water supply development projects based on the most current applicable regional water supply plan update. The water supply projects proposed in the water supply plans for public and private water supply utilities are useful to local governments in the preparation of their Work Plans. The information contained in these Work Plans has assisted the SFWMD in coordinating with local government land use planning staff on future water supply planning and water use permitting. Although Comprehensive Plans, Work Plans, and water use permits (**Chapter 3**) are prepared at different times, each uses the latest and best available data. The regional and local water supply planning process is described below and illustrated in **Figure 1-3**.

PROCESS

**Regional and Local Water Supply Planning Process**

On an annual basis, the SFWMD receives input from public water supply utilities identifying water supply projects needed to meet projected future demands. The SFWMD also considers water supply projects in local government Water Supply Facilities Work Plans, Tribal Work Plans, and adopted Sector Plans, which are required to identify needed water supplies and available water sources [Section 163.3245(3)(a)2., F.S.].

The SFWMD is required to notify each utility of the water supply projects that have been included in the water supply plan update for the utility's consideration. Utilities then must respond to the SFWMD about their intentions to develop and implement the identified projects or provide a list of other projects (or methods) to meet projected demands [Section 373.709(8)(a), F.S.].

By November 15 of every year, all utilities are required to submit a progress report to the SFWMD regarding the status of their water supply projects (e.g., completed, under way, planned for implementation).

Pursuant to the 1987 Water Rights Compact, the Seminole Tribe of Florida submits Work Plans and amendments to the SFWMD describing new projects on a Tribal Reservation or Tribal Trust Lands.

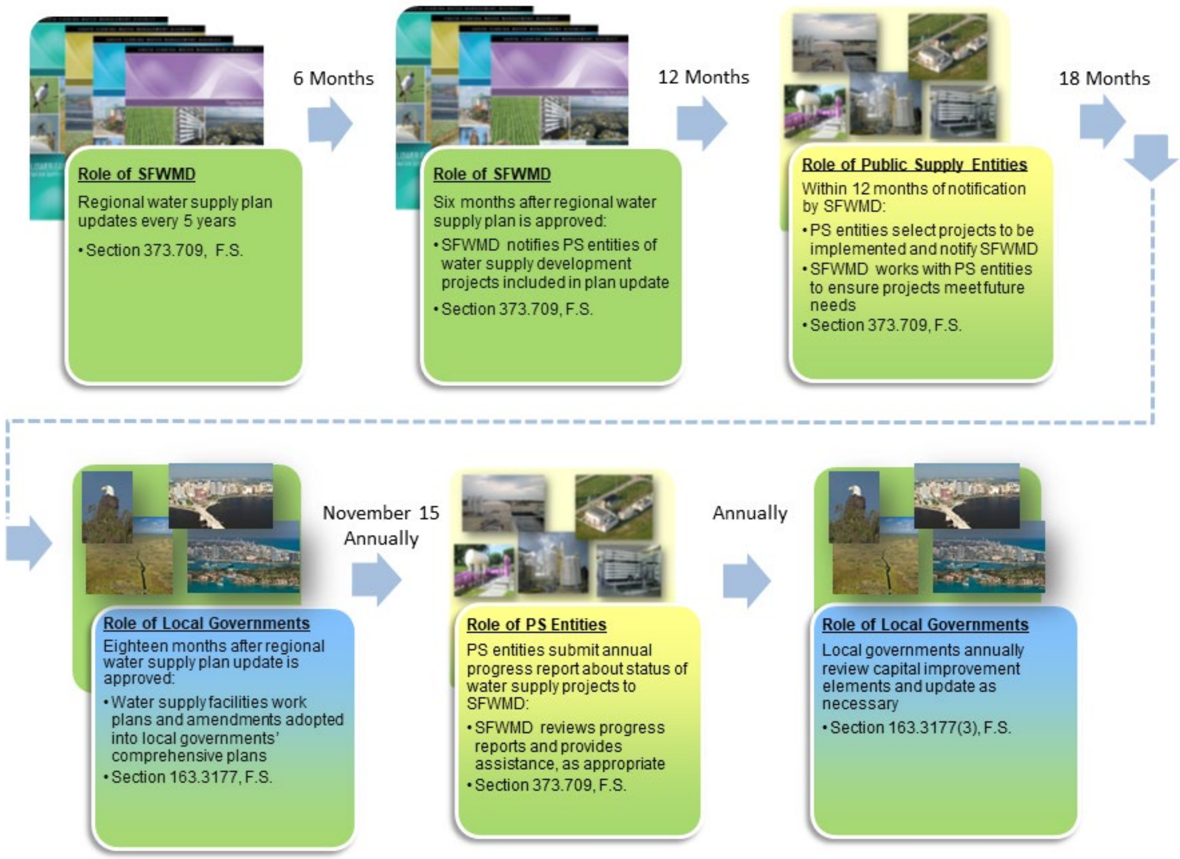


Figure 1-3. Linking regional water supply planning with local government comprehensive planning.

To assist local governments in updating their Comprehensive Plans and Work Plans, the SFWMD has developed technical assistance tools and informational documents, which are available on the SFWMD website (https://www.sfwmd.gov/doing-business-with-us/work-plans). Additional information about developing a Work Plan is available from the Florida Department of Economic Opportunity website (www.floridajobs.org/community-planning-and-development/programs/community-planning-table-of-contents/water-supply-planning).

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# 2

# Water Conservation

| TOPICS |
|---|
| Cost Effectiveness of Conservation |
| Conservation in Water Supply Planning |
| Conservation Measures |
| Conservation Practices |
| Conservation Programs |
| Education, Outreach, and Marketing |
| Regulatory Initiatives |
| Conservation Actions by Use Category |
| Summary |
| Other Resources |

Water conservation (conservation) includes any activity or action that reduces the demand for water, including those that prevent or reduce wasteful or unnecessary uses and those that improve efficiency for necessary uses. Conservation (a key component of demand management) is an integral part of water supply planning and water resource management; it can reduce, defer, or eliminate the need for expansion of water supply sources to meet current or future demands.

The South Florida Water Management District (SFWMD or District), along with stakeholders, detailed conservation activities and initiatives in its Comprehensive Water Conservation Program (SFWMD 2008). The program is organized into three initiative areas: 1) education and marketing; 2) voluntary and incentive-based measures; and 3) regulatory initiatives. Each initiative has corresponding goals and strategies. The scope and implementation schedule outlined in the program are subject to funding levels and voluntary participation by user groups. This chapter addresses some of those same initiative areas.

For the purposes of this chapter, conservation will be addressed through five elements:

- Conservation **measures** typically are related to replacement of inefficient hardware or system components such as toilets, faucets, and showerheads. Hardware replacement is a preferred method of conserving water because once the more efficient hardware is installed, it will produce water savings throughout its service life.
- Conservation **practices** are activities or actions voluntarily undertaken to conserve water, such as water audits and limiting irrigated areas. Normally, practices are associated with the expenditure of time and labor to produce a water-saving result. A conservation practice can be a one-time effort that results in enduring water savings or may be a behavioral decision to use water in a manner that routinely results in water savings.

- Conservation **programs** are a more formalized combination of measures and practices, such as Florida Water Star or Mobile Irrigation Labs. A program may target a specific user groups (e.g., homeowners, commercial buildings, agriculture) or be created for a particular purpose (e.g., distributing funding for conservation measures).
- **Education, outreach, and marketing** are essential to make water users aware of efficient water use principles they can employ and to instill an enduring conservation ethic. Although it relies on changing user behaviors, education frequently is the least expensive way to realize water savings.
- The first four elements can be undertaken voluntarily. The last element, **regulatory initiatives**, includes involuntary activities to strengthen water savings where necessary. Regulatory initiatives include mandated measures, practices, and programs.

This chapter is organized such that each conservation element is described in general terms, and a discussion of the elements by water use category is provided after. The **Appendix** contains a glossary of the measures and practices discussed in this chapter.

INFO ⓘ

The following water use categories are used in regional water supply planning:

- Public Supply (PS)
- Domestic Self-Supply (DSS)
- Agriculture (AG)
- Landscape/Recreational (L/R)
- Commercial/Industrial/Institutional (CII)
- Power Generation (PG)

Conservation elements normally target the end user(s) of the water, regardless of the water source, which may be a Public Supply (PS) utility, groundwater, or surface water. As a result, these elements may apply to users in more than one water use categories. For example, PS utilities provide water to other use categories, which may result in a measure, practice, or program being promoted by the PS utility even if it does not directly affect the utility. A measure to improve irrigation efficiency could apply to multiple water use categories, for example, to irrigate a yard [PS or Domestic Self-Supply (DSS)], a crop [Agriculture (AG)], or landscaping around a nonresidential property [Commercial/Industrial/Institutional (CII)]. Because residential users are included in the PS and DSS water use categories, conservation measures and practices for residential users are presented in this chapter as Residential (RES). The PS measures and practices presented herein apply specifically to the utility and not to the end users.

# COST EFFECTIVENESS OF CONSERVATION

As stated previously, water conservation can reduce, defer, or eliminate the need for expansion of water supply sources, including alternative water supplies, to meet current and future demands. From a water supply perspective, demand reductions through conservation can result in fewer or smaller projects needed to meet future water needs. All water sources, both traditional and alternative, should be used efficiently, and water waste minimized.

If a utility or other industry expects additional water will be needed to meet future needs, one of three avenues must be taken:

1) Reduce current and/or future demands through increased efficiency (conservation) to extend water supply volumes.
2) Increase withdrawals from the current water source to meet the projected needs.
3) Develop an alternative water supply source to meet the projected needs.

Implementation of conservation measures and programs often is among the lowest-cost solutions to meet future water needs and has been shown to reduce costs over the long term, if properly planned and implemented. **Table 2-1** compares the costs of saving 1,000 gallons through conservation and of developing 1,000 gallons of water supply through new facility construction or expansion of an existing facility.

Table 2-1. Comparison of conservation costs and alternative water supply development costs for 1,000 gallons of water.

| Conservation* | New Treatment Facility Construction** | | | | Expansion of Existing Treatment Facility** | | | |
|---|---|---|---|---|---|---|---|---|
| Typical Conservation Programs | Nanofiltration Capacity | | Low-Pressure RO Capacity | | Nanofiltration Process Train Capacity | | Low-Pressure RO Train Capacity | |
| | 1 mgd | 5 mgd | 1 mgd | 5 mgd | 1 mgd | 5 mgd | 1 mgd | 5 mgd |
| $0.07 – $3.00 | $9.46 | $3.42 | $11.33 | $4.41 | $9.07 | $3.13 | $10.38 | $3.69 |

RO = reverse osmosis.
* Data from Hazen and Sawyer (2013).
** Data from CDM (2007).

Conservation projects exceeding $3.00 per 1,000 gallons of water saved typically are not implemented by PS utilities because that is the point at which developing alternative water supplies becomes price competitive. However, the cost threshold of conservation measures should be compared to the location-specific cost for additional water supply. In some cases, conservation projects may still be the most cost effective and appropriate.

# CONSERVATION IN WATER SUPPLY PLANNING

The SFWMD's regional water supply plans identify sufficient traditional and alternative water supply projects and conservation elements that meet or exceed the projected demands for the planning horizon (20 years or more). Conservation potential for all water use categories is estimated by the SFWMD during the planning process, as described in each water supply plan. In Florida, where irrigation occurs year-round, the largest portion of water used by urban water users often is for irrigation. Moreover, an estimated 50% of water used outdoors is wasted due to inefficient watering methods and systems (United States Environmental Protection Agency 2021). Therefore, improvements to irrigation efficiency are considered a primary conservation focus area for urban water users.

Although conservation can be a more cost-effective method of meeting future water needs, very few conservation projects are proposed by users in the regional water supply plans as a means of meeting future demands. Moreover, most water users, including PS utilities, do not account for increased conservation and efficiency in projecting future water needs. Water supply plans do include a list of conservation projects that received previous cost-share support from the District through its Cooperative Funding Program.

For PS utilities, historical water conservation savings are captured and accounted for in water supply plans through calculation of the per capita use rate (PCUR). For each PS utility, a net (finished) water PCUR is developed using past population estimates and finished water data reported to the Florida Department of Environmental Protection. The PCUR for each utility is a 5-year average, calculated by dividing annual net (finished) water volume by the corresponding service area population for each year. For PS demand projections, PCURs are assumed to remain constant through the planning horizon. Any demand reductions due to historical conservation practices are implicitly factored into the projections by using the 5-year average PCUR. Future water conservation savings are not factored into the demand projections, unless specifically identified by a PS utility.

# CONSERVATION MEASURES

Water use efficiency and conservation measures are actions that encourage use of high-efficiency equipment or hardware that yield water savings. A single conservation measure can be used for multiple applications (e.g., residential, commercial, agricultural) and/or be an element of one or more conservation programs. Conservation measures (hardware) are presented in **Table 2-2**. A glossary of the presented conservation measures is contained in the **Appendix**.

Table 2-2. Conservation measures and applicable water use categories.

| Measure | PS* | AG | RES | CII | L/R | PG |
|---|---|---|---|---|---|---|
| Indoor/Outdoor | | | | | | |
| Air cooled devices | | | | X | | |
| Automatic shut-off valve use | | | | X | | |
| Indoor | | | | | | |
| Clothes washer high-efficiency replacement | | | X | X | | |
| Combination oven high-efficiency replacement | | | | X | | |
| Dishwasher high-efficiency replacement | | | X | X | | |
| Faucet aerator high-efficiency replacement | | | X | X | | |
| Faucet installation, metered-flow | | | | X | | |
| Heating ventilation and air conditioning (HVAC) efficiency improvements | | | | X | | |
| Hot water use (efficient) | | | X | X | | |
| Ice making machines high-efficiency replacement | | | | X | | |
| Metering and submetering (indoor) | | | | X | | X |
| Pre-rinse spray valve high-efficiency replacement | | | | X | | |
| Showerhead high-efficiency replacement | | | X | X | | |
| Steam cooker replacement, high-efficiency | | | | X | | |
| Toilet fill cycle diverters | | | X | X | | |
| Toilet high-efficiency replacement | | | X | X | | |
| Toilet replacement, dual flush | | | X | X | | |
| Toilet, redesigned flapper use | | | X | X | | |
| Toilets, flapperless use | | | X | X | | |
| Urinal replacement high-efficiency | | | | X | | |
| Urinal replacement, waterless | | | | X | | |

| Measure | PS* | AG | RES | CII | L/R | PG |
|---|---|---|---|---|---|---|
| Outdoor | | | | | | |
| Auto pump start/stop | | X | | | | |
| Automated valves | | X | | | X | |
| Car wash equipment, low flow/recirculating | | | | X | | |
| Fully enclosed seepage irrigation system conversion | | X | | | | |
| Gated and flexible pipe for field water distribution systems | | X | | | | |
| Irrigation efficiency nozzle and head use | | X | X | X | X | |
| Irrigation retrofit/replacement | | X | X | X | X | |
| Isolation valve use | | X | | | X | |
| Line flushing, automatic devices | X | | | | | |
| Line flushing, looping | X | | | | | |
| Line flushing, unidirectional | X | | | | | |
| Linear move sprinkler irrigation system conversion | | X | | | | |
| Lining of irrigation canals and on-farm irrigation ditches | | X | | | | |
| Low-pressure center pivot sprinkler irrigation system conversion | | X | | | | |
| Metering and submetering water (outdoor) | | X | | X | X | |
| Micro-irrigation use (drip/bubbler/micro-spray) conversion | | X | X | X | X | |
| Multi-stage greenhouse control systems | | X | | | | |
| On-farm irrigation ditch replacement with pipelines | | X | | | | |
| Rain sensor shutoff device | | X | X | X | X | X |
| Shade control structures | | X | | | | |
| Smart irrigation controllers (evapotranspiration and soil moisture based) | | X | X | X | X | |
| Soil moisture sensor(s) | | X | X | X | X | |
| Tensiometers in field or container blocks | | X | | | | |
| Water control structures | | X | | | | |
| Water table observation well(s) | | X | | | | |
| Weather station with evapotranspiration measurement | | X | | X | X | |
| Wind blocks | | X | | | | |
| Other | | | | | | |
| Advanced metering infrastructure and advanced metering analytics | X | | | | | |
| Treatment system efficiency increases | X | | | | | |

AG = Agriculture; CII = Commercial/Industrial/Institutional; L/R = Landscape/Recreational; PG = Power Generation; PS = Public Supply; RES = Residential.
* PS measures apply specifically to the utility and not the end user(s).

# CONSERVATION PRACTICES

Conservation practices normally are voluntary activities associated with the expenditure of time and/or labor to produce water savings. Practices can be a one-time effort or a recurring behavioral decision to use water in an efficient manner. A single conservation practice may apply to a single user group, to many user groups (e.g., residential, commercial, agricultural), and/or be part of a conservation program(s). Conservation practices are presented in **Table 2-3**. A glossary of the presented conservation practices is contained in the **Appendix**.

Table 2-3. Conservation practices and applicable water use categories.

| Practice | PS* | AG | RES | CII | L/R | PG |
|---|---|---|---|---|---|---|
| Indoor/Outdoor | | | | | | |
| Facility water use assessment/audit | | | | X | | |
| On-site generated gray water reuse | | | X | X | | |
| Process water control and recycling | | | | X | | |
| Indoor | | | | | | |
| Dish and clothes washer practices | | | X | X | | |
| Food preparation and washing | | | X | X | | |
| Garbage disposal efficient usage | | | X | X | | |
| HVAC cycles of concentration | | | | X | | |
| Indoor high-efficiency codes adoption | | | X | X | | |
| Indoor residential water use assessment/audit | | | X | | | |
| Restriction of one-pass (once-through) equipment | | | | X | | |
| Retrofit at resale requirement | | | X | X | | |
| Steam boiler efficiency | | | | X | | |
| Water use ethic | X | X | X | X | X | X |
| Water use survey | | | X | | | |
| Outdoor | | | | | | |
| Allow lawn to go dormant | | | X | X | X | |
| Brush control/management | | X | | | | |
| Contour farming | | X | | | | |
| Conversion of supplemental irrigated farmland to dry-land farmland | | X | | | | |
| Crop residue management and conservation tillage | | X | | | | |
| Cyclic scheduled irrigation | | X | | | X | |
| Distribution system audits, leak detection and repair | X | | | X | | X |
| Fertilization efficiency practices | | X | X | X | X | |
| Furrow dikes | | X | | | | |
| Green roofs | | | | X | | |
| Group plants according to water needs | | X | X | X | X | |
| Irrigation codes, adoption of higher efficiency | | | X | X | X | |
| Irrigation scheduling | | X | X | X | X | |
| Irrigation system audit/evaluation | | X | X | X | X | |
| Landscape codes, adoption of water efficiency | | | X | X | X | |
| Laser land leveling | | X | | | | |
| Licensed irrigation and design (professional, working with) | | | X | X | X | |
| Limiting high-volume irrigation areas | | | X | X | X | |
| Limiting irrigated areas | | | X | X | X | |
| Limiting turf traffic on golf courses | | | | | X | |
| Limiting use of turfgrass | | | X | X | X | |
| Mowing heights adjustment | | | | X | X | |
| Net irrigation requirement-based irrigation determination | | X | X | X | X | |
| On-site rain harvesting and reuse | | | | X | | |
| Routine system maintenance | | X | X | X | X | |
| Sidewalk and driveway cleaning practices | | | X | X | X | |
| Soil amendment use for water efficiency | | X | X | X | X | |
| Soil cultivation techniques (spiking, slicing, and core aerification) | | X | | | X | |

| Practice | PS* | AG | RES | CII | L/R | PG |
|---|---|---|---|---|---|---|
| Surge flow irrigation use for field water distribution systems | | X | | | | |
| Swimming pool and hot tub water use efficiency | | | X | X | X | |
| Turfgrass maintenance for water efficiency | | | X | X | X | |
| Turfgrass, improved cultivar uses | | | X | X | X | |
| Volumetric measurement of irrigation water use | | X | | | | |
| Water use efficiency improvement plan development | | X | X | X | X | |
| Other | | | | | | |
| Conservation analysis using a planning tool | X | | | | | |
| Goal-based water conservation planning | X | | | | | |
| Improved billing and accounting software | X | | | | | |
| Other proven water conservation techniques and ideas | X | X | X | X | X | X |
| Rate structure | X | | | | | |
| Water budget development | | X | X | X | X | |

AG = Agriculture; CII = Commercial/Industrial/Institutional; HVAC = heating, ventilation, and air conditioning; L/R = Landscape/Recreational; PG = Power Generation; PS = Public Supply; RES = Residential.
* PS practices apply specifically to the utility and not to the end user(s).

# CONSERVATION PROGRAMS

Conservation programs are a combination of education, measures, activities, and practices to increase water use efficiency within specific user groups. PS utilities and local governments are the primary entities that develop specific conservation programs, but other agencies or organizations may assume a leadership role in promoting conservation at the local, regional, and state level.

Voluntary and incentive-based water conservation programs, initiatives, and measures are an integral part of conservation programs. This type of program offers support and guidance for users looking to conserve water. Other benefits include public recognition for having taken steps to improve efficiency, getting ahead of future utility rate increases, and investing in efficiency measures before regulatory changes are imposed. Some programs provide financial incentives to users who upgrade to more efficient water-using devices. This is important because implementing conservation measures and practices often requires capital investments, and many water users have little discretionary income for efficiency upgrades. AG users operate under fluctuating market conditions and are subject to outside pressures, including weather, pests, and pathogens. To attain higher levels of efficiency, significant capital costs are often required. Non-agriculture business owners can experience similar difficulties as well. Therefore, financial incentives and assistance for these water users may be necessary to ease the financial burden of making critical investments. Conservation programs are presented in **Table 2-4** and further described below.

Table 2-4. Conservation programs and applicable water use categories.

| Program | PS | AG | RES | CII | L/R | PG |
|---|---|---|---|---|---|---|
| Indoor | | | | | | |
| Green Restaurant Association Program | | | | X | | |
| Outdoor | | | | | | |
| Agricultural Mobile Irrigation Labs | | X | | | | |
| Florida-Friendly Landscaping Program | | | X | X | X | |
| Environmental Quality Incentives Program | | X | | | | |
| Urban Mobile Irrigation Labs | | | X | | | |
| Holistic | | | | | | |
| Florida Green Building Coalition | | | | X | | |
| Florida Green Lodging Program | | | | X | | |
| Green Globes | | | | X | | |
| Florida Water Star | | | X | X | | |
| Leadership in Energy and Environmental Design | | | | X | | |
| WaterSense Program | | | X | X | | |

AG = Agriculture; CII = Commercial/Industrial/Institutional; L/R = Landscape/Recreational; PG = Power Generation; PS = Public Supply; RES = Residential.

## Certification and Recognition Programs

There are several national and statewide certification and recognition programs that direct builders, property owners, and building managers toward meeting environmentally friendly standards. Some are holistic programs that include criteria affecting water use, energy efficiency, climate-adaptive landscaping, sustainable building materials, site selection, indoor environmental quality, and/or greenhouse gas emissions. In addition, there are some single-focus programs that target one area of impact and/or one industry. Single-focus certification or recognition programs usually are less expensive than holistic programs. There also are programs that focus on water auditing and programs that provide partial funding for conservation projects. Local governments, utilities, and water management districts can collaborate to promote and incentivize participation in certification and recognition programs or have their own facilities meet the program standards.

### *Florida Water Star*

Florida Water Star is a voluntary, points-based certification program that improves water efficiency in the built environment by encouraging the use of appropriate water-saving landscapes, irrigation systems, and household appliances and fixtures. Florida Water Star is endorsed by all water management districts in Florida and offers the following certification levels:

- **Standard Silver** – for new and existing residential buildings
- **Gold** – for additional water savings in residential buildings
- **Community** – for master-planned communities
- **Commercial/Institutional** – for new and existing non-residential buildings (e.g., offices, retail and service establishments, institutional and non-industrial commercial buildings)

Local governments that adopt Florida Water Star Standard Silver criteria as their water conservation standard for new residential properties can expect new homes in their jurisdictions to use up to 35% less water than their current residential stock of single-family homes with permanent in-ground irrigation systems. Savings of up to 45% may be attainable for homes built to Florida Water Star Gold criteria. This program is linked to the Florida-Friendly Landscaping and Florida Green Building Coalition programs (described below) such that efforts that meet the criteria of one program may be credited toward certification in one or both of the other programs.

In partnership with the Florida Nursery Growers and Landscapers Association and the Florida Irrigation Society, the SFWMD provides accredited training on Florida Water Star program criteria to irrigation and landscape professionals. Once accredited, these professionals are certified as knowledgeable in the design and installation of water-efficient irrigation systems.

### *Florida-Friendly Landscaping Program*

The Florida-Friendly Landscaping Program is a joint venture of the Florida Department of Environmental Protection and the University of Florida Institute of Food and Agricultural Sciences (UF/IFAS). The program works in cooperation with the state's five water management districts as well as other agencies and organizations to achieve the common goals of water conservation and water quality protection. The nine principles of Florida-friendly landscaping are contained in Section 373.185(1)(b), Florida Statutes (F.S.). These principles guide property owners on how to design and maintain a beautiful landscape using minimal water, pesticide, and fertilizer inputs while preserving local water resources and wildlife. Watering efficiently and planting the right plant in the right place are two of the nine program principles that conserve water. The program promotes low-maintenance and drought-tolerant plants, environmentally sustainable landscaping, and high-efficiency irrigation practices. This program incorporates the replacement of turf and shrubs that require large amounts of water with climate-adaptive species. When landscaping with plant material appropriate for local soils and natural hydrology, outdoor irrigation can be greatly reduced or eliminated. By reducing irrigation, a Florida-friendly landscape can also reduce the amount of stormwater runoff. Landscapes are evaluated based on a checklist of program practices and receive a yard sign to display and a recognition certificate. Recognitions are offered for three different categories of landscapes: home, commercial, and new construction. More information is available on the program's website (https://ffl.ifas.ufl.edu/).

### *WaterSense*

WaterSense is a partnership and certification program developed by the United States Environmental Protection Agency. The program promotes and provides information on improving water use efficiency and certifies (through a third party) water-efficient products. Products and services that have earned the WaterSense label are certified to be at least 20% more efficient than standard or conventional equivalent models without sacrificing performance. More information about the program is available on the WaterSense website (http://www.epa.gov/watersense).

### Green Restaurant Association Program

The Green Restaurant Association Program certifies restaurants that have implemented a suite of sustainability actions, including water use efficiency measures and practices. The water use efficiency criteria include measures for landscaping, kitchens, restrooms, and other areas.

### Florida Green Building Coalition

The Florida Green Building Coalition's certification program applies holistic efficiency standards to residential and commercial buildings. Facilities are evaluated using a points-based system that governs sustainability practices and hardware at the facility. This program is functionally linked to the Florida Water Star program described earlier.

### Florida Green Lodging Program

The Florida Department of Environmental Protection's Green Lodging recognition program identifies lodging facilities that have made a commitment to conserve and protect Florida's natural resources. Water conservation is one of the areas of sustainable operations criteria. Facilities are evaluated using a points-based system governing sustainability practices and hardware.

### Green Globes

Green Globes is an online green building rating and certification tool for a wide range of commercial, institutional, and multi-residential building types. It is a points-based system that applies standards and design principles to water efficiency, energy, indoor environment, materials, project management, and site selection.

### Leadership in Energy and Environmental Design

The United States Green Building Council's Leadership in Energy and Environmental Design (LEED) certification program is a points-based program that certifies buildings, homes, and neighborhoods that are using environmentally friendly strategies and practices. The program applies indoor and outdoor water efficiency standards and design principles.

## Water Auditing Programs

### *Agricultural Mobile Irrigation Labs*

The Florida Department of Agriculture and Consumer Services (FDACS) administers Florida's agricultural Mobile Irrigation Lab (MIL) program, which performs free evaluations of agricultural irrigation system efficiency and makes recommendations for physical and operational improvements that conserve water. Recommendations may include modification of irrigation systems and equipment, alteration of irrigation scheduling, and other aspects of system management. System design, maintenance, efficiency, uniformity, and/or operations costs are evaluated. Presently, five operating MILs cover all counties within the District except Monroe County. Local municipalities are encouraged to investigate opportunities to expand the deployment of MILs. Further information about MILs can be found at: https://www.fdacs.gov/Agriculture-Industry/Water/Mobile-Irrigation-Labs.

### *Water Use Audits for Urban Landscapes*

Landscape and irrigation water audits measure the performance of a landscape irrigation system and provide insight on the appropriate use and placement of plants. In addition, the audit can provide recommendations for operation and management of the irrigation system to improve water use efficiency. Recommendations may include adjusting irrigation timers to follow a water-conserving schedule; replacing sprinkler heads to ensure the system is providing adequate coverage and not spraying impervious surfaces; installing computerized irrigation controllers with rainfall and soil moisture sensors; and suggesting changes to the plants used in a particular landscape. Local municipalities are encouraged to investigate opportunities to expand the deployment of landscape audit programs. At the time of publication, the SFWMD is aware of the following local audit programs within its boundaries.

Broward County's Environmental Planning and Community Resilience Division administers the NatureScape Irrigation Service program, which audits large-scale irrigation systems at schools, parks, and residential areas using utility-supplied water for irrigation. The audits are provided for the 19 municipal partners of the Broward Water Partnership.

Miami-Dade County's Water and Sewer Department also supports an irrigation audit program, the Urban Conservation Unit. This program targets single-family homes (at no cost to the homeowner) and homeowners' associations to evaluate irrigation systems, recommend efficiency improvements, and provide monetary incentives to implement recommendations. This program is a partnership between Miami-Dade County's Water and Sewer Department, the Florida Yards and Neighborhoods program, and the University of Florida's Cooperative Extension Service.

While not specifically a water audit program, Toho Water Authority offers a free outdoor water usage analysis, which includes checking the irrigation system for leaks and breaks, checking and resetting the system controller for proper operation, and providing a free rain sensor, if needed. For customers with high water usage, Orange County Utilities offers a similar program, which checks for irrigation system leaks and breaks, irrigation of hardscapes, functioning rain sensors, and proper scheduling of irrigation controllers. The Orlando Utilities Commission also offers its customers a free water conservation audit, which includes checking the irrigation system and timer.

## Funding Programs

Local governments and utilities are encouraged to take advantage of cost-share funding and other collaborative opportunities to implement conservation strategies and programs. Such entities may wish to provide their own cost-share funding in the form of rebates or other incentives to individual homeowners and businesses for deployment of water-conserving devices or hardware. Larger users like homeowners' associations, businesses, and agricultural operations should research available funding programs for conservation activities. Two funding programs available within the District are discussed here. More information about the programs can be found on their individual program webpages and on the SFWMD's water conservation webpage (www.sfwmd.gov/conserve).

### *SFWMD Cooperative Funding Program*

For nearly two decades, the SFWMD has provided funding to local governments, special districts, utilities, homeowners' associations, water users, and other public and private organizations for alternative water supply and water conservation projects that are consistent with the District's core mission. The SFWMD's Cooperative Funding Program (CFP) provides partnership opportunities and financial incentives to implement local projects that complement regional flood control, environmental restoration, water quality, and water supply efforts. The CFP provides partial funding for technology and hardware-based water conservation measures and programs. Funding for the CFP is considered annually during the SFWMD's budget development. Additional information regarding the CFP can be found on the SFWMD's website (https://www.sfwmd.gov/doing-business-with-us/coop-funding).

### *Environmental Quality Incentives Program*

The United States Department of Agriculture – Natural Resources Conservation Service promotes agricultural production and environmental quality through the Environmental Quality Incentives Program (EQIP). Financial and technical assistance is offered to voluntary participants to install or implement structural changes and management practices that address impaired water quality and conservation of water resources on eligible agricultural land. The program is expected to continue, although future funding levels are uncertain.

# EDUCATION, OUTREACH, AND MARKETING

Education, outreach, and marketing are essential to promote adoption of conservation-based behaviors and accomplish a measurable reduction in water use. Education and outreach efforts deliver important knowledge about the water supply challenges that water managers and municipalities face as well as formulated solutions and the need for regulatory measures. Education and technical assistance programs with an education component inform people about the impact of improved water efficiency and instill a lasting conservation ethic. Additionally, an educational component can be part of a rebate or audit program. Without education, even motivated water users may lack the knowledge to properly implement conservation measures and practices.

Although water savings attributed to educational campaigns are difficult to quantify, these campaigns are vital to a successful conservation program and behavioral adoption among users. Campaigns are normally tailored to a specific user group or subgroup (e.g., residents, schools, commercial properties). The SFWMD provides support to PS utilities, local governments, and others in their efforts to promote, develop, and implement conservation. Throughout the District's 16 counties, active partnerships provide opportunities for conservation workshops, outdoor community events, and collaborative public forums that help raise awareness and inform residents about long-term protection and conservation of water resources.

The SFWMD has established partnerships with other conservation sponsors, including the Florida Department of Environmental Protection, Florida section of the American Water Works Association, UF/IFAS, Florida Nursery Growers and Landscape Association, United States Environmental Protection Agency, and other water management districts.

Combined with conservation measures and practices, educational and outreach elements, including those listed below, can yield substantial water savings.

- Educational programs for elementary to high school students
- Media campaigns (e.g., social media, radio, television, billboards, newspaper inserts, printed materials) for the general public
- Creation of a dedicated local or regional conservation position
- Informative and user-friendly conservation webpages
- Informative billing inserts and descriptive billing (explaining conservation rate structures, comparison to similar users, etc.) for end users
- Providing speakers for local events and community organizations
- Water use efficiency training for landscape, irrigation, and building management professionals
- Florida-friendly landscaping demonstration gardens
- Conservation workshops and exhibits for targeted groups and the general public

# REGULATORY INITIATIVES

Regulations and mandates can be used to shift improved practices or efficiency devices into mainstream use and, when applied at the regional or state level, simplify working conditions for commercial users operating in multiple counties. Regulations may require users to make investments in efficiency improvements, so some regulations could be matched with financial assistance programs.

Regulations, mandates, and ordinances can be adopted statewide by statute, regionally through water management districts by rule, or locally through city and county governments by ordinance. In addition, PS utilities may be able to require that builders or homeowners meet efficiency codes as a condition of service. Conservation-related ordinances that local governments can adopt include those requiring greater water efficiency in construction, such as the International Green Construction Code and standards derived from the Florida Water Star program and Florida Green Building Coalition. Ordinances and codes can be adopted wholly or partially, depending on existing conditions in the locality or within a service area.

The SFWMD has promulgated two rules (regulatory-based actions) to reduce water demands: consumptive use permitting [Chapter 40E-2, Florida Administrative Code (F.A.C.)] and the Mandatory Year-round Landscape Irrigation Conservation Measures Rule (Chapter 40E-24, F.A.C.).

## Consumptive Use Permitting Process

Use-specific water conservation practices are required to be addressed by water use permit applicants for their proposed use to be considered reasonable-beneficial. The SFWMD's (2021) water use permitting criteria include specific water conservation requirements for PS, CII, and Landscape/Recreational (L/R) uses. More information about water use permitting and conservation requirements are provided in **Chapter 3**.

## Year-round Landscape Irrigation Rule

As mentioned earlier, a large percentage of water demand in South Florida is for landscape irrigation. Most water needs for turf and landscape material are met by natural rainfall. Some supplemental irrigation is required at times to maintain healthy plant growth. However, most homeowners do not know the appropriate amount of water to apply, so the frequency and duration of irrigation often leads to overwatering.

Lawn Irrigation

The SFWMD initially adopted the Mandatory Year-round Landscape Irrigation Conservation Measures Rule (Year-round Irrigation Rule) in 2003 (Chapter 40E-24, F.A.C.). The rule was updated in 2010 to provide a framework for consistent implementation of conservation measures Districtwide in order to ensure long-term sustainability of water resources, increase water use efficiency, and prevent and curtail wasteful water use practices for landscape irrigation by all users. The Year-round Irrigation Rule places permanent limits on landscape irrigation throughout the District. The rule includes the following provisions:

- Landscape irrigation frequency is limited to 2 days per week, with a 3-days-per-week provision in some counties.
- No irrigation is allowed on any day between 10 a.m. and 4 p.m. (when evapotranspiration rates are the highest).
- Irrigation using reclaimed water, rain-harvesting systems, and various low-volume methods, such as micro-irrigation, container watering, and hand watering with a hose and automatic shutoff nozzle, can be conducted at any time.
- Additional watering is allowed for up to 90 days following the installation of new lawns and landscaping, with specific limits.

## Rain-Canceling Devices

Section 373.62, F.S., requires automatic lawn and landscape irrigation systems be properly equipped with technology that inhibits or interrupts operation of the system during periods of sufficient rainfall (moisture). These devices typically take the form of a rain shutoff switch but may also incorporate soil moisture sensors and/or weather station technology.

Weather Station

## Local Ordinances

Ordinances help local governments and other governing bodies expedite adoption of conservation-oriented standards in new construction areas and where major renovations of existing structures occurs. Appropriate water conservation ordinances include the following:

- **Building Codes** – Implements standards requiring high-efficiency fixtures and devices (indoor use) and/or standards for high-efficiency irrigation design (outdoor use). Fixture and device standards typically set an allowable flow rate for toilets, faucets, and showers. Examples of irrigation standards include water-efficient or pressure-regulating sprinkler heads, requiring head-to-head coverage, the use of micro-irrigation (where applicable), and irrigating plants with similar water needs separately from other plant types with different water needs.
- **Permanent Year-round Landscape Irrigation** – Promotes consistency across South Florida between local government rules/ordinances and the SFWMD's Year-round Irrigation Rule so residents can understand and comply with all irrigation requirements. The local ordinance may be more restrictive than the SFWMD's rule in terms of allowable irrigation days and times.

- **Sensing Devices on Automatic Landscape Irrigation Systems** – Requires the proper installation, repair, and operation of moisture-sensing devices on automatic lawn and landscape irrigation systems by licensed contractors and property owners or managers, provides for licensing of contractors that work on such irrigation systems, and imposes penalties.
- **Florida-Friendly Landscaping** – Requires implementation of one or more principles in landscape design at residential and commercial properties.
- **Landscaping** – Requires high-efficiency landscape design. Examples include the use of plants adapted to the local environment, limiting the use of plants/turf with large water needs, and requiring some part of the landscape to remain unirrigated.

SFWMD staff are available to review local government conservation ordinances and provide feedback during ordinance development.

# CONSERVATION ACTIONS BY USE CATEGORY

The following subsections address conservation measures, practices, and programs that may be applicable to one or more of the six water use categories. A single measure or a combination of these can be part of a robust conservation program. The design and selection of conservation programs depends on the target group and is directed by a conservation strategy created to effectively reach that group.

## Public Supply

PS per capita water use demand reduction has occurred gradually across the country since the 1980s, largely because of passive savings. Passive water savings are a result of the introduction of water-efficient fixtures and appliances into the marketplace via national and local ordinances and through the natural replacement of existing water-using devices with more water-efficient models. However, relying on passive savings alone would delay or ignore substantial conservation savings potential. Active implementation of conservation measures to increase water use efficiency among specific user groups could realize conservation savings more expeditiously. One such tool is development and implementation of a goal-based conservation plan.

To receive a water use permit from the SFWMD, all PS utilities are required to meet the regulatory criteria found in Section 2.3.2.F of the *Applicant's Handbook for Water Use Permit Applications within the South Florida Water Management District* (Applicant's Handbook; SFWMD 2021). In general, the conservation requirement is to have a standard or goal-based conservation plan in place. A standard plan contains five elements: 1) a public education program, 2) an outdoor conservation program, 3) an indoor conservation program, 4) a water-conserving rate structure, and 5) a water loss reduction program (if water losses exceed 10%). A goal-based plan must contain the measures selected for implementation and an explanation of why the standard conservation program elements were not selected.

An effective PS conservation plan should include the following:

- Clear demand management goals (e.g., lowering peak demand, reducing overall per capita demand)
- Full water system auditing, including an evaluation of supply sources and existing utility infrastructure
- A demand forecast based on population projections, end user characteristics, and age of facilities in the service area
- Identification and selection of potential conservation measures that would provide the greatest return on investment
- An implementation strategy based on available budget, staffing, and desired timeline

This information will drive the structure of the conservation plan and its individual components. Conservation measures and practices that could be employed by PS utilities are identified in **Tables 2-2** and **2-3**. As stated earlier in the chapter, the PS measures and practices apply specifically to the utilities, not the end users served by the utilities. A glossary of conservation measures and practices is contained in the **Appendix**.

A PS utility can reduce demands further by creating its own water conservation program targeting specific end users. As PS utilities provide water to the other user groups, selecting measures or practices that apply to those groups may be appropriate in the overall PS conservation program. PS utilities are strongly encouraged to use a conservation planning tool (e.g., the Alliance for Water Efficiency Tool) when creating a conservation program. Planning tools can help a utility evaluate and compare the costs and benefits of various conservation measures, show projected water savings, and create a goal-based conservation program.

There are many options available for PS utilities to design and implement effective conservation programs. Many PS conservation programs feature rebates and incentives to replace older, less efficient indoor plumbing fixtures and appliances in existing residential and commercial buildings. Programs may also facilitate reductions in outdoor water use through irrigation system performance audits or through the distribution of rain and soil moisture sensors as well as computerized irrigation controllers. For new construction, utilities and local governments could mandate (through ordinance) or provide rebates to incentivize water-efficient construction standards. The Florida Water Star program could provide a pre-packaged framework for such an effort. PS utilities may also consider providing funding for landscape and irrigation water audits, which measure the performance of landscape irrigation systems and provide insight on the appropriate use and placement of plants.

## Agriculture

Local and regional efforts to increase water conservation in the AG use category should focus on row and field crops, aquaculture, orchards, nurseries, and livestock operations. Moderate efficiency gains, resulting in lower water use, could be realized in the AG sector by replacing outdated or inefficient irrigation systems with newer, more efficient ones. The selection of a more efficient system depends on the crop type, soil composition, water source, and water availability. In addition to converting to more efficient irrigation systems, many AG operations can benefit from optimizing the operation, management, and maintenance of existing irrigation systems. Regulating irrigation scheduling (e.g., time between irrigation events, amount of water applied) based on crop needs, soil conditions, and weather can improve irrigation water use efficiency. Precision irrigation devices such as soil moisture sensors, automated pump controls, and weather-sensing devices can improve agricultural irrigation scheduling, including operations currently using efficient irrigation delivery systems. The FDACS agricultural MIL program (described earlier) can assist with these efforts. EQIP may also be able to provide technical and financial assistance. Conservation measures, practices, and programs that could be employed in the AG sector are identified in **Tables 2-2** to **2-4**. A glossary of conservation measures and practices is contained in the **Appendix**.

Because the costs associated with moving water affect profitability, most agricultural operations presumably are as efficient as practical with their existing irrigation systems and growing methods. Also, profit margins may limit growers' ability to transition to new irrigation systems or methods. Growers should investigate the feasibility of self-funding or seek financial assistance through cost-share programs or other sources of funding, including those discussed earlier. Funding sources for the implementation of these projects may be shared between the grower, FDACS, water management districts, legislative appropriations, soil and water conservation districts, local governments, resource conservation and development districts, the United States Department of Agriculture – Natural Resources Conservation Service, and other partners where funding is made available.

### *Florida Automated Weather Network*

The Florida Automated Weather Network (FAWN) is a statewide research and data project operated by the UF/IFAS. FAWN provides weather information throughout the state at 15-minute intervals. While not a true conservation element, FAWN management tools provide decision support functions to growers, using historical weather data and crop modeling technology to help maximize irrigation efficiency. The SFWMD has supported FAWN with funding for more than a decade. Access to the FAWN database is available via http://fawn.ifas.ufl.edu/data.

### *Agricultural Best Management Practices Program*

FDACS develops and adopts agricultural best management practices (BMPs), by rule, for different types of agricultural operations. The BMPs were designed primarily to reduce negative impacts on water quality while maintaining or enhancing agricultural production. However, some BMPs (e.g., for aquaculture, citrus, dairy, nurseries, sod, specialty fruit and nut crops, vegetable and agronomic crops) also improve water use efficiency and could reduce the amount of water needed to meet crop demands in average to wet years. All AG users are encouraged to enroll in the FDACS BMP program.

### *Additional Practices*

Some additional conservation measures exist for AG for deployment during times of cold or freezing weather. The volume of water conserved is difficult to quantify because there are few water use records for frost/freeze events and such events are sporadic in nature. Additional measures specific to frost/freeze events, as defined in the **Appendix**, include the following:

- Crop row covers/frost blankets
- Selective inverted sinks
- Sprinkler heads and spacing retrofits
- Use of fog for cold protection in greenhouses/shade houses
- Wind machines

## Residential

Residential users are included in both the PS and DSS water use categories for regional water supply planning. This section discusses residential indoor and outdoor water conservation strategies, regardless of whether the water is supplied by a PS utility or DSS source (i.e., private well). Therefore, for the purposes of this chapter, these end users are discussed together under the RES category. Potential conservation strategies for RES users include replacing old plumbing fixtures and water-using appliances with water-efficient models, detecting and repairing household water leaks, and installing smart irrigation devices. Local governments are encouraged to conduct educational outreach to promote and incentivize conservation for RES users. All domestic users must limit landscape irrigation to the hours and days specified in Chapter 40E-24, F.A.C., or in local ordinances. Some PS utilities offer programs to reduce the areal coverage of irrigated turf through turf “buyback” programs. Conservation measures, practices, and programs that could be employed by RES users are presented in **Tables 2-2** to **2-4**. A glossary of conservation measures and practices is contained in the **Appendix**.

## Commercial/Industrial/Institutional

From a water conservation standpoint, CII water use includes users in office buildings, industrial facilities, restaurants, movie theaters, long-term care facilities, and hospitals. This definition is slightly different from that used in the water use permitting process. These users typically receive water from PS utilities, but some may receive utility-supplied water for domestic uses and self-supplied water for other uses (e.g., landscape irrigation, industrial processes). Larger CII users outside a PS utility service area are more likely to be self-supplied. Industrial water uses encompass a wide variety of activities, including process water at industrial plants, dust suppression, some parts of agricultural production, and commodity manufacturing.

Due to the diverse use of water by industrial entities, development of water-efficiency programs can be challenging. A broad approach could seek to increase efficiency in water use areas common to most CII users, such as domestic indoor water uses and heating, ventilation, and air conditioning (HVAC) applications. Other conservation elements may only be applicable to certain operations or facility types. Specific examples include autoclaves in hospitals, food steamers in restaurants, and process water in a metal finishing plant. CII users should explore ways to accomplish desired tasks using the minimum amount of water necessary to meet performance expectations. A thorough, site-specific water use audit (discussed below) is the first step in understanding how a facility uses water and identifying conservation opportunities that will provide the best return on investment. Conservation strategies could also target outdoor water use (irrigation) at CII facilities. There are recognition programs applicable to CII users, and funding may be available to users making efficiency upgrades at their facilities that would result in water savings. Conservation measures, practices, and programs that could be employed by CII users are presented in **Tables 2-2** to **2-4**. A glossary of conservation measures and practices is contained in the **Appendix**.

### *Water Use Audits for Commercial and Institutional Users*

A water use audit is a systematic and comprehensive survey of all water-using fixtures, appliances, equipment, and practices at a facility, campus, or residence. This voluntary investigation should always precede an efficiency improvement program at any large facility. Specifically, water audits can:

- Identify leaks and wasteful use
- Identify inefficient devices
- Ensure new (efficient) devices are operating properly
- Recommend improvements that will provide the best returns on investment
- Provide a benchmark for measuring water-efficiency program successes

To assist users conducting water use audits at commercial and institutional facilities, the SFWMD (2013) published the *Water Efficiency and Self-Conducted Water Audits at Commercial and Institutional Facilities, A Guide for Facility Managers*. This guide assists facility managers through detailed, self-conducted water use assessment procedures and an evaluation of water use and conservation potential for the most common points of water use at commercial or institutional facilities. Conservation professionals are encouraged to incorporate this guide into their outreach efforts toward CII water users. While SFWMD staff cannot conduct audits as a standing service, staff will meet with large users to help acquaint them with the guidebook and its companion water use and savings spreadsheet calculators.

To receive a water use permit from the SFWMD, all CII users are required to meet the regulatory criteria found in Section 2.3.2.D of the Applicant's Handbook (SFWMD 2021). In general, the requirements are to perform a water audit, develop an employee and consumer education program regarding water conservation, and provide a time frame for implementation.

## Landscape/Recreational

The L/R use category includes irrigation water at parks, athletic fields, golf courses, landscaped areas (e.g., homeowners' association common areas, greenspace at commercial centers and office buildings), roadway medians, and cemeteries. Under the L/R use category, conservation is possible through implementation of Florida-Friendly Landscaping Program principles, rain or soil moisture sensors, advanced irrigation technology, proper irrigation system design and scheduling, and maintenance of automatic irrigation systems.

Irrigation systems using smart controllers (computerized controllers that use precision irrigation methods to calculate evapotranspiration and/or soil moisture) can achieve savings beyond those achieved using rain sensors and simple timer-based irrigation control systems. An estimated 30% to 40% reduction in water use can be achieved with weather-based controllers in residential settings (from a timer-based controller) if they are properly installed and programmed (Water Research Foundation 2016). Savings in non-residential applications are anticipated but have not been determined.

Golf Course Irrigation

Golf courses typically have a high degree of water use efficiency; however, opportunities to improve efficiency may exist. The Golf Course Superintendents Association of America (2007) published best management practices for golf course managers, with many focused on efficient water use.

Conservation measures, practices, and programs that could be employed by L/R users are presented in **Tables 2-2** to **2-4**. A glossary of conservation measures and practices is contained in the **Appendix**.

To receive a water use permit from the SFWMD, all L/R users are required to meet the regulatory criteria found in Section 2.3.2.E of the Applicant's Handbook (SFWMD 2021). In general, the requirements are to use Florida-Friendly Landscaping Program principles, where applicable; install and use rain sensors or other methods to override irrigation systems when adequate rainfall has occurred; and limit irrigation to the hours and days specified in Chapter 40E-24, F.A.C. (the Year-round Irrigation Rule), or as allowed under local government ordinance.

## Power Generation

Power Generation (PG) facilities use large quantities of water for cooling, but most of the water is returned to the source from which it was obtained; therefore, there are minimal efficiency gains to be had in the process. While minimal, indoor water use at PG facilities should be optimized by using high-efficiency water-using fixtures and equipment. Additional gains may be available using high-efficiency HVAC equipment. Conservation measures and practices that could be employed by PG users are presented in **Tables 2-2** and **2-3**. A glossary of conservation measures and practices is contained in the **Appendix**.

# SUMMARY

Water conservation is part of the solution to meet long-term water supply needs throughout the District. Because conservation typically is less expensive to implement than developing new water sources, including expansion of treatment capacity at existing facilities, conservation should be maximized before more costly development options are implemented, regardless of water source.

The Comprehensive Water Conservation Program outlines the SFWMD's conservation efforts, including the administration and support of several programs working directly with end users. Local governments and utilities are encouraged to review the programs and opportunities discussed in this chapter as well as the Comprehensive Water Conservation Program to help establish local conservation programs. SFWMD staff can assist local governments, utilities, and large end users wishing to develop long-term water use efficiency programs. SFWMD assistance can include technical support, collaborative educational campaigns, ordinance review, and long-term demand management planning. Upon request, the SFWMD can provide technical assistance on water-efficient technology, hardware, and practices to water users in all categories. Water conservation technical documents and educational materials can be found on the SFWMD's website (www.sfwmd.gov/conserve).

# OTHER RESOURCES

The following water conservation resources are recognized by the SFWMD to provide services to conservation professionals and others through standards, information, and other resource materials.

- **Alliance for Water Efficiency** – Provides information on water-efficient products and programs, maintains a web-based water conservation resource library, provides assistance to conservation professionals, and offers use of its Water Conservation Tracking Tool free to members (www.allianceforwaterefficiency.org).
- **Consortium for Energy Efficiency** – Provides energy-efficient products and services, with water-efficiency crossover benefits (www.cee1.org).
- **ENERGY STAR –** Provides information on energy-efficient practices and certifies energy-efficient products. Program standards now consider water use efficiency for water-using appliances and equipment (www.energystar.gov).
- **Florida Golf Course Superintendents Association** – Promotes sustainable turf management and engages in communication and education efforts with various interested organizations and regulatory and governmental agencies (https://floridagcsa.com).
- **Florida Nursery Growers and Landscape Association** – Represents Florida's environmental horticulture industry. The association spearheads marketing programs, provides promotional and educational venues for members, and has a history of partnering with Florida's water management districts to promote water-efficient landscaping and irrigation practices (www.fngla.org).
- **Food Service Technology Center –** Industry leader in commercial kitchen energy and water efficiency and appliance performance (www.fishnick.com).

- **Irrigation Association –** Promotes efficient irrigation technologies, products, and services. The Irrigation Association is the leading membership organization for irrigation equipment and system manufacturers, dealers, distributors, designers, consultants, contractors and end users (https://www.irrigation.org).
- **Florida Irrigation Society** – Promotes sound irrigation practices through awareness and education. Members include irrigation contractors, designers, and consultants as well as educators and students, equipment manufacturers and distributors, and municipalities (www.fisstate.org).
- **Florida Section of the American Water Works Association Water Use Efficiency Division** – Strives to assist PS utilities in implementing a cost-effective water conservation program and conforming to requirements for a water use permit (www.fsawwa.org).

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# 3

# Water Use Permitting

This chapter provides information related to water use permitting in the South Florida Water Management District (SFWMD or District), including statutory requirements. Water use permitting is an important part of water supply and water resource protection. Water use permitting authorizes the right to use water via a permit, while preventing harm to the water resource, including related natural systems. Harm is defined in Rule 40E-8.021, Florida Administrative Code (F.A.C.), as the temporary loss of water resource functions, as defined for consumptive use permitting in Chapter 40E-2, F.A.C., that results from a change in surface or groundwater hydrology and takes a period of 1 to 2 years of average rainfall conditions to recover. The water resource protection criteria contained in the conditions for permit issuance enumerated in Rule 40E-2.301, F.A.C., and the *Applicant's Handbook for Water Use Permit Applications within the South Florida Water Management District* (Applicant's Handbook; SFWMD 2021) include, among others, three additional mechanisms to protect water resources: 1) implementation criteria for regulatory components of an adopted minimum flow and minimum water level (MFL) prevention or recovery strategy, 2) implementation criteria for water reservations, and 3) restricted allocation area (RAA) criteria. These resource protection mechanisms are described in **Chapter 4**.

**TOPICS**

- Water Use Permitting
- Coordination with Water Supply Plans
- Water Conservation in Water Use Permitting

## WATER USE PERMITTING

Water use, or the consumptive use of water, is 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 (i.e., chlorides, turbidity) of groundwater and surface water resources by requiring permit applicants to demonstrate that their proposed use 1) is reasonable-beneficial, as defined in Section 373.019, Florida Statutes (F.S.); 2) will not interfere with any existing legal use of water; and 3) is consistent with the public interest [Section 373.223(1), F.S.].

SFWMD rules classify water use permits for activities such as the following:

- Agricultural irrigation
- Golf course irrigation
- Landscape irrigation
- Nursery irrigation
- Livestock and aquaculture
- Public water supply
- Dewatering (construction and mining)
- Diversion and impoundment
- Commercial and industrial uses

Water use permits are issued by water management districts and the Florida Department of Environmental Protection (FDEP) pursuant to Chapter 373, F.S. The specific conditions of issuance 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 0.10 million gallons per day (mgd) on an annual basis that meet facility and geographic restrictions based on source
- **Individual –** For uses with a cumulative average daily use greater than 0.10 mgd on an annual basis or otherwise do not meet Noticed General Permit thresholds

A water use permit is not required for strictly domestic use at a single-family dwelling or duplex provided that the water is obtained from one withdrawal facility for each single-family dwelling or duplex or for water used strictly for firefighting purposes. Individual permits for more than 15 million gallons per month and Master Dewatering permits require approval from the SFWMD's Executive Director or designee. All other permits are approved by SFWMD staff.

## Changes to Water Use Permitting

Water supply plans published in 2000 recommended incorporation of resource protection criteria [e.g., MFLs, water reservations, RAAs (**Chapter 4**)], level of certainty, special designations, and permit durations into water use permitting criteria. A series of rulemaking efforts was completed in September 2003, resulting in amendments to various rules, including Chapters 40E-1, 40E-2, 40E-5, 40E-8, and 40E-21, F.A.C. Among the most notable changes were amendments to permit duration, permit renewal, wetland protection, supplemental irrigation requirements, saltwater intrusion, aquifer storage and recovery, and model evaluation criteria.

In 2011, the FDEP led a statewide initiative to improve consistency in the water use permitting programs implemented by the state's five water management districts. The initiative resulted in changes to SFWMD water use permitting rules and criteria, which became effective in 2014 and are listed in the Applicant's Handbook. The Applicant's Handbook was updated in 2021 to incorporate new criteria for the Kissimmee River and Chain of Lakes water reservations as well as the Everglades Agricultural Area Reservoir water reservation.

## Permitting Criteria

As stated above, to obtain a water use permit, a permit applicant must provide reasonable assurances the requested use is reasonable-beneficial, will not interfere with any existing legal use of water, and is consistent with the public interest, pursuant to Section 373.223, F.S. As part of the reasonable-beneficial use test, relevant portions of the State Water Resource

Implementation Rule (Chapter 62-40, F.A.C.), adopted by the FDEP, must be reviewed and addressed. The SFWMD implements this test pursuant to rules adopted in Chapter 40E-2, F.A.C., and the criteria in the Applicant's Handbook (SFWMD 2021). Permits are written 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.).

Considerations for issuance of a water use permit include impact evaluation criteria that establish the hydrologic change that can occur without causing harm. For the purposes of water use permit applications, SFWMD staff consider water resource availability, the harm standard (Chapter 40E-8, F.A.C.), and other environmental considerations:

- Saltwater migration
- Wetland and other surface water body drawdown
- Pollution movement
- Impacts to off-site land uses
- Use of lowest-quality water available
- Interference with existing legal uses
- MFLs
- Water reservations
- RAAs

Detailed criteria concerning proposed water uses and evaluation of potential impacts are contained in Section 3.0 of the Applicant's Handbook (SFWMD 2021).

SFWMD water use permitting rules and criteria require planning and implementation of water conservation measures by public water supply utilities (and associated local governments), commercial/industrial/institutional users, landscape and golf course irrigation users, and some agricultural users. Further information about conservation efforts is provided later in this chapter and in **Chapter 2**.

The level of certainty planning goal established in Section 373.709, F.S., is a 1-in-10-year drought event. To be consistent, the SFWMD implemented the level of certainty planning goal in its water use permitting program. Permit applicants must demonstrate the conditions for issuance of a permit are satisfied during 1-in-10-year drought conditions. Demands are calculated, assuming 1-in-10-year drought conditions for relevant uses (e.g., Public Supply, Agriculture, Landscape/Recreational), and impacts resulting from a proposed withdrawal are analyzed.

## Permit Duration and Renewal

Water use permits typically are issued for a period of 20 years unless circumstances warrant a shorter or longer permit duration. For example, permits for new uses of water, increased allocations, or from a source of limited availability often have a duration of 5 years. If an application for renewal is submitted before the permit expiration date, the existing permit remains in effect until the pending application is processed. Some permits, depending on allocation and site-specific conditions, may require compliance monitoring and reporting, which may include calibrated pumpage, wetland monitoring, saline water monitoring, water level monitoring, 10-year compliance reports, or other project-specific restrictions.

# COORDINATION WITH WATER SUPPLY PLANS

Water supply plans address many areas of water management (e.g., planning, permitting, restoration, science), which requires significant coordination during plan development. The importance of this coordination is underscored by a 2012 FDEP memorandum to the water management districts that provides guidance on improving linkages between regional water supply plans and consumptive use permitting. Key objectives in the memorandum included ensuring that water supply projects identified in the regional water supply plans have a likelihood of being permittable and that staff would be knowledgeable of these projects to facilitate permitting. By increasing internal coordination during the water supply planning process, both planning and permitting staff are more familiar with proposed projects and able to facilitate the permitting process.

In the SFWMD, proposed projects for each water supply plan are screened by water use permitting and water supply planning staff to determine if a proposed project is likely to be permittable by using the following set of questions:

- Does the proposed project use a source of limited availability?
- Is the project located in an RAA?
- Is the proposed source an MFL water body or is it connected, directly or indirectly, to an MFL water body? If yes, is the proposed use consistent with the MFL recovery or prevention strategy?
- What other environmental water needs [e.g., Comprehensive Everglades Restoration Plan (CERP) targets, water reservations] may be impacted?
- What resource issues have been identified in recent permit applications in the general area for the same source (e.g., wetlands, saltwater intrusion, pollution, MFL)?
- Have existing legal users of the same source had resource-related compliance issues?
- Have any new technical studies been completed related to source availability?

Each proposed use of water must meet the conditions for permit issuance found in Section 373.223, F.S., and the implementing rules found in Chapter 40E-2, F.A.C. Water use permits typically are required for water supply development projects, which are outlined in each regional water supply plan update. Permitting requirements (and exemptions) are found in Section 373.219, F.S.; Rule 40E-2.051, F.A.C.; and the Applicant's Handbook (SFWMD 2021).

The availability of water from some surface water and groundwater sources is restricted due to existing water demands, source limitations, and resource issues such as saltwater intrusion, environmental needs, and aquifer protection criteria. New or increased allocations from these sources will be evaluated on an application-by-application basis to determine if the proposed use meets water use permitting criteria. The permitting of small volumes from these sources may be feasible given local conditions, reductions in historical water use, and availability of new resources.

# 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 SFWMD's water use permitting criteria in Section 2.3.2 of the Applicant's Handbook (SFWMD 2021) include specific water conservation requirements for public water supply, commercial/industrial/institutional, and landscape/recreational uses. More information about statewide and Districtwide conservation programs and objectives are provided in **Chapter 2**.

## Public Water Supply

All public water supply utilities applying for a water use permit are required to develop and implement a standard or goal-based water conservation plan [Sections 2.3.2.F.1.a and 2.3.2.F.1.b, respectively, of the Applicant's Handbook (SFWMD 2021)] that maintains or increases overall utility-specific water conservation effectiveness. For standard water conservation plans, permit applicants are required to implement the following five elements, as necessary, to achieve efficient use to the extent economically, environmentally, and technically feasible:

1) 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) A water loss reduction program, if required
5) An indoor water conservation program

The water conservation plan is 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 can request a permit modification, if necessary, to revise the plan to address the deficiency [Section 2.3.2.F.1 of the Applicant's Handbook (SFWMD 2021)]. A permittee can extend the duration of their permit based on quantifiable savings attributed to water conservation.

A goal-based water conservation plan allows a permit applicant to select plan elements that differ from the standard plan but are appropriate to the applicant's service area. If any standard plan elements are not included, the applicant must provide reasonable assurances that the alternative elements will achieve effective conservation at least as well as the standard plan.

## Agriculture

Agricultural conservation generally focuses on the irrigation system. Standard irrigation systems include micro-irrigation, overhead sprinkler, and flood/seepage irrigation. For certain crops such as citrus and container nurseries, water use permit holders are required to use micro-irrigation or other systems of equivalent efficiency for new uses. The irrigation method should be matched to the specific needs of each crop type. This rule applies to new installations or modifications of existing irrigation systems. Flood/seepage irrigation systems typically are used for small vegetables, corn, rice, and sugarcane production.

## Landscape/Recreational

Applicants for landscape and golf course projects are required to develop a conservation program and submit it with the permit application. The program must include the installation and use of rain sensor devices, automatic switches, or other automated mechanisms that can override operation of the irrigation system when adequate rainfall has occurred. Other mandatory elements include the use of Florida-Friendly Landscaping principles for new or modified projects and limitations to irrigation hours to comply with local government ordinances.

## Commercial/Industrial/Institutional and Power Generation

Similar to public water supply, all commercial/industrial/institutional and power generation water use permit applicants are required to submit a water conservation plan to the SFWMD at the time of permit application. Water conservation plans for power generation and commercial/industrial/institutional permit applicants must include the following:

- An audit of water use
- An implementation plan for water conservation measures if found to be cost-effective during the audit, including leak detection/repair programs, 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 audit examines historical water use, identifies on-site water sources and potential opportunities for reducing unnecessary water use, measures or calculates all on-site water consumption, detects leaks, and calculates a facility's true cost of water.

# SUMMARY

Water use permitting is an important resource protection tool as it prevents harm to water resources, including related natural systems. The SFWMD's water use permitting program protects water supply and quality by requiring permit applicants to demonstrate that their proposed use meets the conditions discussed in this chapter. Many factors are considered when reviewing permit applications, including source limitations, existing legal users, and regulatory protection criteria. Additionally, water conservation practices must be included as part of the permit.

# REFERENCES

SFWMD. 2021. *Applicant's Handbook for Water Use Permit Applications within the South Florida Water Management District*. South Florida Water Management District, West Palm Beach, FL. March 2021.

# 4

# Water Resource Protection

| TOPICS |
| --- |
| Water Resource Protection Standards |
| Natural Systems Protection |
| Summary |

Florida's Water Resource Implementation Rule [Chapter 62-40, Florida Administrative Code (F.A.C.)] outlines specific factors to consider when 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 use regulatory mechanisms, such as water use permitting (**Chapter 3**), minimum flows and minimum water levels (MFLs), water reservations, and restricted allocation areas (RAAs), to protect natural system water (i.e., wetlands, rivers, lakes, estuaries, and aquifers) from consumptive use.

## WATER RESOURCE PROTECTION STANDARDS

The intent of Chapter 373, Florida Statutes (F.S.), is to promote the availability of sufficient water for all existing and future reasonable-beneficial uses and natural systems [Section 373.016(3)(d), F.S.]. The South Florida Water Management District (SFWMD or District) developed water resource protection standards consistent with legislative direction that are implemented to prevent various levels of harm (no harm, harm, significant harm, and serious harm). Each standard plays a role in achieving sustainable water resources. For instance, programs regulating surface water management and water use permitting must prevent harm to the water resource, including related natural systems. **Figure 4-1** represents the conceptual relationship among water resource protection tools and standards, observed impacts, and water shortage severity.

## WATER RESOURCE PROTECTION STANDARDS

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

**Harm** – The temporary loss of water resource functions, as defined for consumptive use permitting in Chapter 40E-2, F.A.C., that results from a change in surface or groundwater hydrology and takes a period of 1 to 2 years of average rainfall conditions to recover.

**Significant Harm** – The temporary loss of water resource functions, resulting from a change in surface or groundwater hydrology, that takes more than 2 years to recover but which is considered less severe than serious harm. The specific water resource functions addressed by an MFL and the duration of the recovery period associated with significant harm are defined for each priority water body based on the specific MFL's 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.

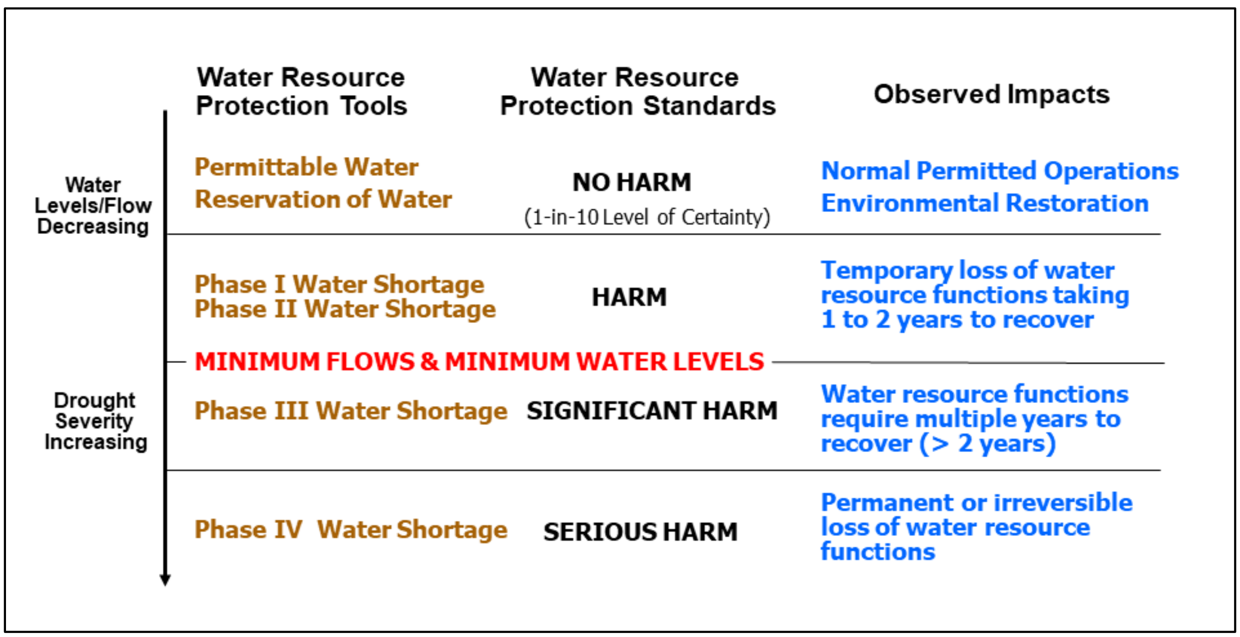


Figure 4-1. Conceptual relationship among water resource protection standards at various levels of water resource harm (Modified from: Rule 40E-8.421, F.A.C.).

| TOOLS 🛠 | |
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| **Resource Protection Tools** | |
| Water Use Permitting (**Chapter 3**) | Unless exempt by statute or identified in the Water Rights Compact of 1987, the right to use water is authorized by permit, which allows for the use of water for reasonable-beneficial uses while protecting natural systems from harm. The conditions of permit issuance are more specifically enumerated in Rule 40E-2.301, F.A.C. To provide reasonable assurances that the conditions of permit issuance are met, applicants must meet the technical criteria in the *Applicant's Handbook for Water Use Permit Applications within the South Florida Water Management District* (Applicant's Handbook; SFWMD 2021). Potential impacts from the use of water proposed in a water use permit application are evaluated to prevent:<br>- Saltwater intrusion<br>- Wetland and other surface water body impacts<br>- Pollution movement<br>- Impacts to off-site land uses<br>- Interference with existing legal users<br>- Violation of regulatory components of MFLs<br>- Exceedance of water resource availability |
| Minimum Flows and Minimum Water Levels (MFLs) | MFL criteria are flows or water levels at which the water resources or the ecology of the area would experience significant harm from further withdrawals. If the existing flow or level in a water body is below, or is projected within 20 years to fall below, the applicable MFL established pursuant to Section 373.042, F.S., the SFWMD must simultaneously adopt a recovery or prevention strategy [Section 373.0421, F.S.; Subsection 62-40.473(5), F.A.C.]. |
| Water Reservations | A water reservation sets aside a volume of water for the protection of fish and wildlife or public health and safety (Section 373.223, F.S.). Reserved volumes of water are unavailable for allocation to consumptive uses. However, any unreserved volumes of water may be certified as available and allocated to consumptive uses. Water reservations are developed based on existing water availability or in consideration of future water supplies made available by water resource development projects. The Water Resources Development Act of 2000 and Section 373.470(3)(c), F.S., require the SFWMD to legally allocate or reserve the increase in water supplies resulting from a Comprehensive Everglades Restoration Plan (CERP) project before execution of a cost-share agreement with the United States Army Corps of Engineers to construct the project. |
| Restricted Allocation Areas (RAAs) | RAA criteria are established by rule for specific sources where there are water resource limitations. RAA criteria established for specific sources or areas of the SFWMD are listed in Section 3.2.1 of the Applicant's Handbook (SFWMD 2021), which is incorporated by reference in Rule 40E-2.091, F.A.C. |
| Water Shortage | Water shortages are declared by the District's Governing Board when available groundwater or surface water is insufficient to meet user needs or when conditions require temporary reductions in total use to protect the resource from serious harm. The SFWMD's Water Shortage Plan and regional water shortage plans are contained in Chapters 40E-21 and 40E-22, F.A.C. The water shortage plans 1) ensure 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; 2) provide advance knowledge of the means by which water apportionments and reductions will be made during times of shortage; and 3) promote greater security for water use permittees. |

# NATURAL SYSTEMS PROTECTION

The overall goal of Chapter 373, F.S., is to ensure the sustainability of water resources in Florida (Section 373.016, F.S.). Chapter 373, F.S., provides Florida's water management districts with the authority to develop and adopt MFLs, water reservations, and RAAs.

## Minimum Flows and Minimum Water Levels

MFLs in the SFWMD are defined and adopted by rule in Chapter 40E-8, F.A.C. MFLs are flows or levels at which water resources, or the ecology of the area, would experience significant harm (as defined above) from further withdrawals. An MFL exceedance occurs when the water level or flow falls below the MFL for longer than the specified duration [Subsection 40E-8.021(17), F.A.C.]. An MFL violation occurs when an MFL exceedance happens more often than the identified return frequency. In natural systems, MFLs should not be exceeded unless rainfall amounts reach 1-in-10-year drought conditions.

When developing and adopting MFLs, the District's Governing Board considers changes and structural alterations to watersheds, surface water bodies, and aquifers as well as the effects such changes or alterations have had and the constraints such changes or alterations have placed on the hydrology of an affected watershed, surface water body, or aquifer (Section 373.0421, F.S.).

The SFWMD continues to fulfill its statutory obligation to identify key water bodies for which MFLs should be developed or re-evaluated. Each water management district must provide an annual Priority Water Body List and Schedule for development of MFLs and water reservations to the Florida Department of Environmental Protection [Section 373.042(3), F.S.]. The SFWMD's priority list is available in the annual updates to Chapter 3 of the *South Florida Environmental Report – Volume II*. The priority list is based on the importance of the water bodies to the state or region and the existence of, or potential for, significant harm to the water resources or ecology of the state or region and includes water bodies that are experiencing or may reasonably be expected to experience adverse impacts.

As of 2021, nine MFLs have been adopted for water bodies in the SFWMD (**Figure 4-2**). Additional information about each MFL is provided in the most recent applicable regional water supply plan update.

- Biscayne Aquifer
- Caloosahatchee River
- Everglades (water conservation areas 1 to 3, freshwater portion of Everglades National Park, and Rotenberger and Holey Land wildlife management areas)
- Florida Bay
- Lake Istokpoga
- Lake Okeechobee
- Lower West Coast Aquifers (Lower Tamiami, Sandstone, and Mid-Hawthorn)
- Northwest Fork of the Loxahatchee River
- St. Lucie Estuary

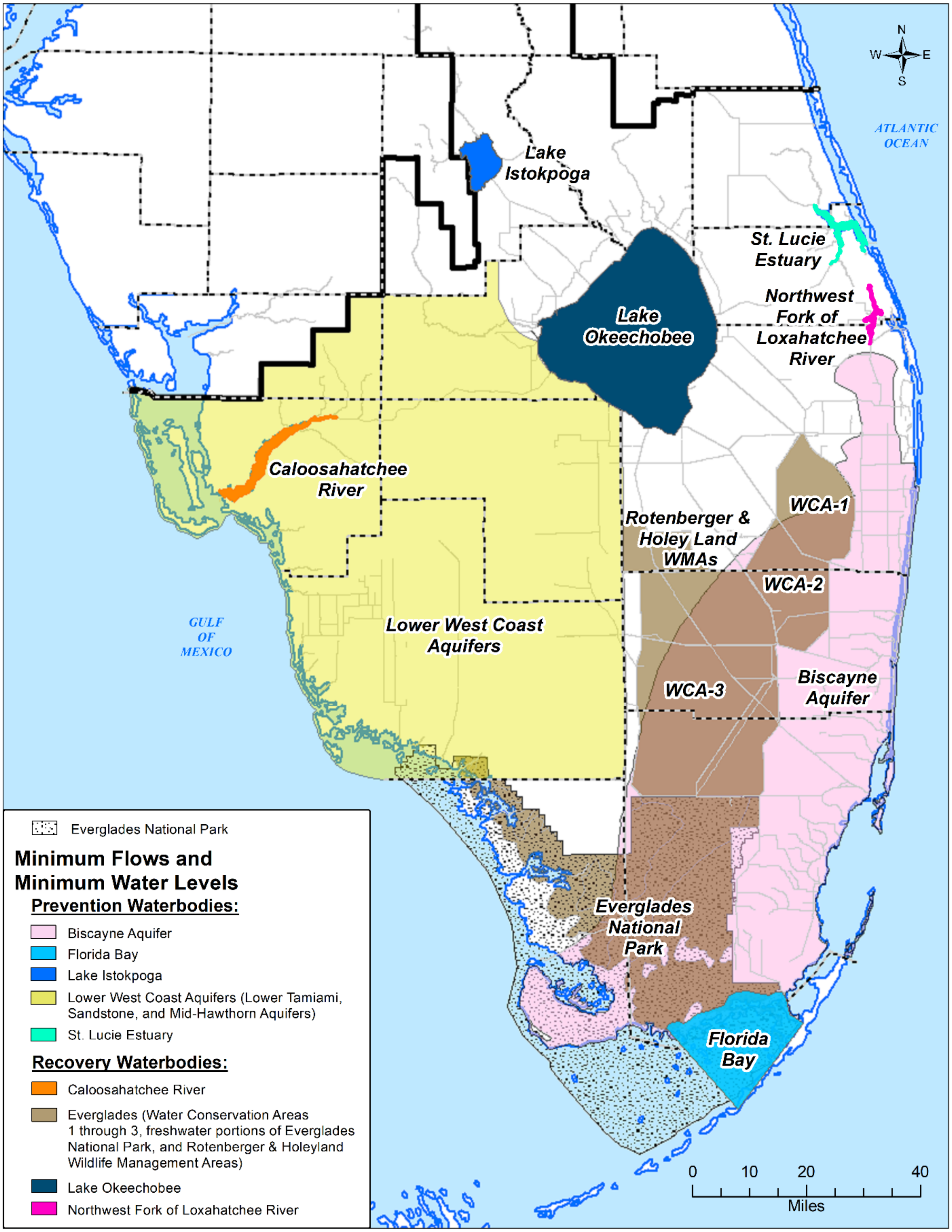



Figure 4-2. Minimum flow and minimum water level (MFL) water bodies within the South Florida Water Management District.

INFO ⓘ

MFL water bodies approaching their MFL threshold criteria are factors the District's Governing Board considers when contemplating water shortage restrictions. The District's Governing Board may impose water shortage restrictions (see *Water Shortage Rules* section) if an MFL exceedance occurs, or is projected to occur, during climatic conditions more severe than a 1-in-10-year drought, to the extent consumptive uses contribute to such exceedance.

## MFL Recovery and Prevention Strategies

Water management districts must adopt and implement a recovery or prevention strategy for water bodies with flows or levels that are below, or are projected to fall within 20 years below, the adopted MFL criteria (Section 373.0421, F.S.). Analyses of current and future conditions are conducted for each water body for which MFL criteria are defined. The SFWMD adopts prevention and recovery strategies when the MFL is initially adopted (Rule 40E-8.421, F.A.C.) and, where needed, when an MFL is re-evaluated or revised.

- Recovery strategies are developed when MFL criteria are currently violated [Subsection 40E-8.021(25), F.A.C.]. The goal of a recovery strategy is to achieve the adopted MFL as soon as practicable.
- Prevention strategies are developed when MFL criteria are not currently violated but are projected to be violated within 20 years of the establishment of the MFL [Subsection 40E-8.021(24), F.A.C.]. The goal of a prevention strategy is to continue to meet the adopted MFL criteria over the next 20-year planning horizon.

Regional water supply plans must contain recovery and prevention strategies needed to achieve compliance with MFLs adopted for priority water bodies in the planning area (Section 373.709, F.S.). MFL recovery and prevention strategies are implemented in phases, with consideration of the SFWMD's missions in managing water resources, including water supply, flood protection, environmental enhancement, and water quality protection, as required by Section 373.016, F.S. The phasing or timetable for each project must be included in the strategy. Section 373.0421(2)(b), F.S. provides the following:

> *The recovery or prevention strategy must include a phased-in approach or a timetable which will allow for the provision of sufficient water supplies for all existing and projected reasonable-beneficial uses, including development of additional water supplies and implementation of conservation and other efficiency measures concurrent with and, to the maximum extent practical, to offset reductions in permitted withdrawals, consistent with this chapter.*

Recovery and prevention strategies must include development of additional water supplies and other actions, consistent with authority granted in Section 373.0421, F.S. These consist of multiple components, including capital projects, regulatory measures and requirements, water shortage measures, conservation and other efficiency measures, environmental projects, and research and monitoring. Additionally, the strategy must include a phased-in approach or a timetable that allows for the provision of sufficient water supplies for all existing and projected reasonable-beneficial uses, including development of additional water supplies and implementation of conservation and other efficiency measures to offset reductions, to the maximum extent practical, in permitted withdrawals.

| TOOLS | |
|---|---|
| **MFL Recovery and Prevention Strategy Components** | |
| Capital Projects | Capital projects include the planning, design, permitting, and construction of features to provide water to meet MFL criteria. The scale of these projects can range from relatively simple water control structures or conveyance improvements to large, regionally important features such as reservoirs, water preserve areas, or wetlands. Many of these projects are established through cost-share agreements or other partnerships among multiple agencies to provide funding and direction that would be impossible for a single agency to support. |
| Regulatory Measures and Requirements | Regulatory criteria may be adopted as part of an MFL prevention or recovery strategy. When a recovery strategy has been adopted for an MFL water body, existing permitted allocations will not be modified or revoked prior to permit expiration unless the permitted use changes or a new or alternative source is in place and operating to supply the water historically provided from the MFL water body. For new, renewed, and modified water use permit applications, applicants are required to comply with all conditions of issuance. The rules implementing water resource protection tools, including Chapters 40E-2 and 40E-8, F.A.C., and Section 3.9 of the Applicant's Handbook (SFWMD 2021), identify the specific criteria and constraints that will be applied to evaluate consumptive uses proposing to withdraw from MFL water bodies. |
| Water Shortage Measures | The SFWMD may impose water shortage restrictions to curb water use withdrawals pursuant to Sections 373.175 and 373.246, F.S. The SFWMD implements its water shortage authority by equitably distributing available water resources among all water users, which includes consideration of the water resources (Chapters 40E-21 and 40E-22, F.A.C.). Under this program, different phases of water shortage restrictions with varying levels of cutbacks are imposed relative to drought conditions. The four phases of water shortage restrictions are based on progressively increasing resource impacts leading up to serious harm.<br><br>Adopted MFLs are considered in the evaluation of current water conditions [Paragraph 40E-21.221(3)(d), F.A.C.] and as one of the criteria for imposing water use restrictions [Paragraph 40E-21.271(3)(d), F.A.C.]. Consistent with Section 373.0421(2), F.S., Chapter 40E-8, F.A.C., does not solely rely on water shortage restrictions for MFL recovery or prevention strategies. However, when a drought occurs, the SFWMD relies on the water shortage plan of Chapter 40E-21, F.A.C., as needed to address regional system water availability.<br><br>To the extent practicable, the SFWMD attempts to implement water deliveries from Lake Okeechobee to reduce or prevent MFL criteria from being exceeded. Approved adaptive protocols for Lake Okeechobee operations provide guidance to water managers for implementation of discretionary water supply deliveries for ecosystem and other benefits when the lake stage is in the low, base flow, and beneficial use sub-bands, as identified in the *Final Adaptive Protocols for Lake Okeechobee Operations* (SFWMD 2010). |
| Environmental Projects and Other Research and Monitoring | Operational protocols and habitat enhancement projects are implemented to improve flows and levels, mitigate impacts from flow or level extremes, and protect key habitats. Periodic assessment of flows and levels, vegetation and infauna population monitoring, and other research and monitoring, may be included to assess the effects of MFLs and ensure sufficient water is available from the regional system to meet the MFLs. |

### *Water Use Permitting Criteria for MFLs*

Unless exempt by statute or identified in the Water Rights Compact of 1987, the right to use water is authorized by permit, which allows for the use of water for reasonable-beneficial uses while protecting natural systems from harm. Water use permit applicants must provide reasonable assurances that the proposed water use 1) is reasonable-beneficial, 2) will not interfere with any existing legal use of water, and 3) is consistent with the public interest [Section 373.223(1), F.S.]. The conditions of permit issuance are more specifically enumerated in Chapter 40E-2.301, F.A.C. The proposed water use must also comply with the water resource protection criteria contained in the Applicant's Handbook (SFWMD 2021).

Loxahatchee River

As discussed in **Chapter 3**, 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 any MFL and implementation strategy established, pursuant to Sections 373.042 and 373.0421, F.S. [Paragraph 40E-2.301(1)(i), F.A.C.]. Applications for water use are reviewed based on the recovery or prevention strategy approved at the time of permit application review.

Rule 40E-8.021, F.A.C., identifies two categories of impact criteria: direct withdrawals and indirect withdrawals from the MFL water body. Each category is considered in the review of a permit application. Direct withdrawals are those from surface water facilities physically located within the boundaries of an MFL surface water body or groundwater withdrawals that cause a water table drawdown greater than 0.1 foot 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 groundwater from or is tributary to an MFL water body. The Applicant's Handbook (SFWMD 2021) describes evaluation criteria for permit renewals and new or modified permits for water bodies subject to an MFL recovery or prevention strategy.

## Water Reservations

Regional water supply plans must list the water resource development projects that support water supply development for all existing and future reasonable-beneficial uses and natural systems as identified in water reservations (Section 373.709, F.S.). Water reservations in the SFWMD are defined and adopted by rule in Chapter 40E-10, F.A.C. A water reservation sets aside a volume of water for the protection of fish and wildlife or public health and safety. Water reservations are developed based on existing water availability or in consideration of future water supplies made available by water resource development projects. Reserved volumes of water are unavailable for allocation to consumptive uses (Section 373.223, F.S.). Water reservations do not 1) establish operating regimes, 2) drought-proof natural systems, 3) ensure wildlife proliferation, 4) prevent the use of unreserved water or water allocated in consumptive use permits, or 5) improve water quality. Additionally, water reservations may be components of MFL recovery or prevention strategies and be adopted to protect water for Comprehensive Everglades Restoration Plan (CERP) projects prior to their construction (see *Water Reservations and RAAs for CERP Projects* section).

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 public interest. The District's Governing Board has the authority to make this determination. Reasonable assurances are provided for existing legal users, as cited in Section 373.1501(5)(d), 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.*

Fakahatchee Estuary

Chapter 40E-10, F.A.C., defines the quantity, location, and timing of waters reserved from allocation, pursuant to Section 373.223(4), F.S. As of 2021, seven water reservations have been adopted for water bodies within the District (**Figure 4-3**). Additional information about each water reservation is provided in the most recent applicable regional water supply plan update.

- Caloosahatchee River C-43 West Basin Storage Reservoir
- Everglades Agricultural Area Reservoir
- Fakahatchee Estuary
- Kissimmee River and Chain of Lakes
- North Fork of the St. Lucie River
- Nearshore Central Biscayne Bay
- Picayune Strand

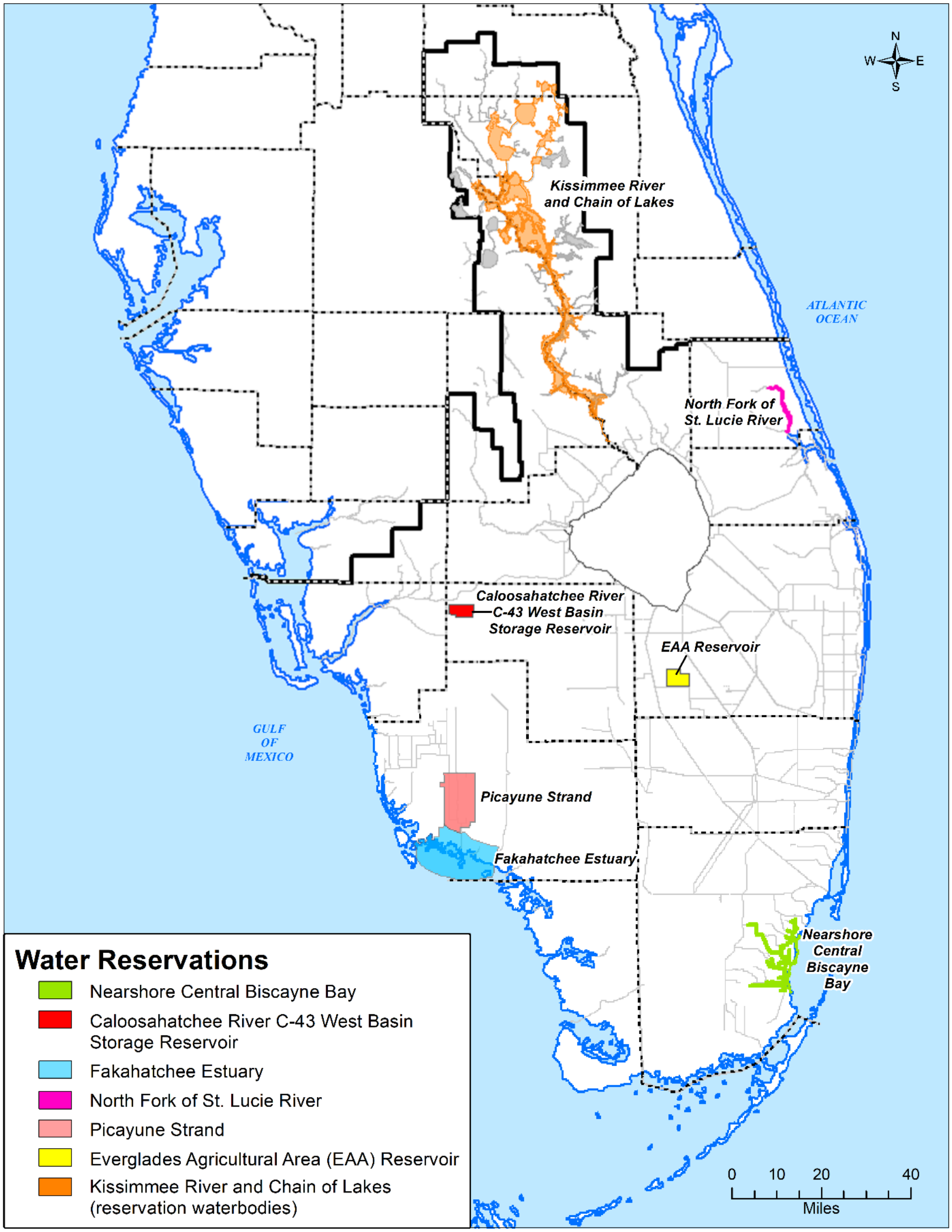



Figure 4-3. Water reservation water bodies within the South Florida Water Management District.

## Restricted Allocation Areas

RAAs are defined geographic areas where utilization of specific water supply sources (e.g., lakes, rivers, wetlands, canals, aquifers) is restricted due to concerns regarding water availability. RAAs are adopted for a variety of reasons, including 1) where there is insufficient water to meet the projected needs of a region, 2) to protect water for natural systems and future restoration projects (e.g., CERP), or 3) as part of MFL recovery or prevention strategies. RAAs are listed in Section 3.2.1 of the Applicant's Handbook (SFWMD 2021), which is incorporated by reference in Rule 40E-2.091, F.A.C. Water allocations beyond the criteria listed in the Applicant's Handbook are restricted or prohibited.

As of 2021, six RAAs have been adopted for the following geographic areas within the District (**Figure 4-4**). Additional information about each water reservation is provided in the most recent applicable regional water supply plan update.

- C-23, C-24, and C-25 Canal System
- Floridan Aquifer Wells in Martin and St. Lucie Counties
- L-1, L-2, and L-3 Canal System
- Lake Istokpoga/Indian Prairie Canal System
- Lake Okeechobee Service Area
- Lower East Coast Everglades Water Bodies and Northern Palm Beach County/Loxahatchee River Watershed Water Bodies (Lower East Coast Regional Water Availability)

Cypress Trees at Lake Istokpoga

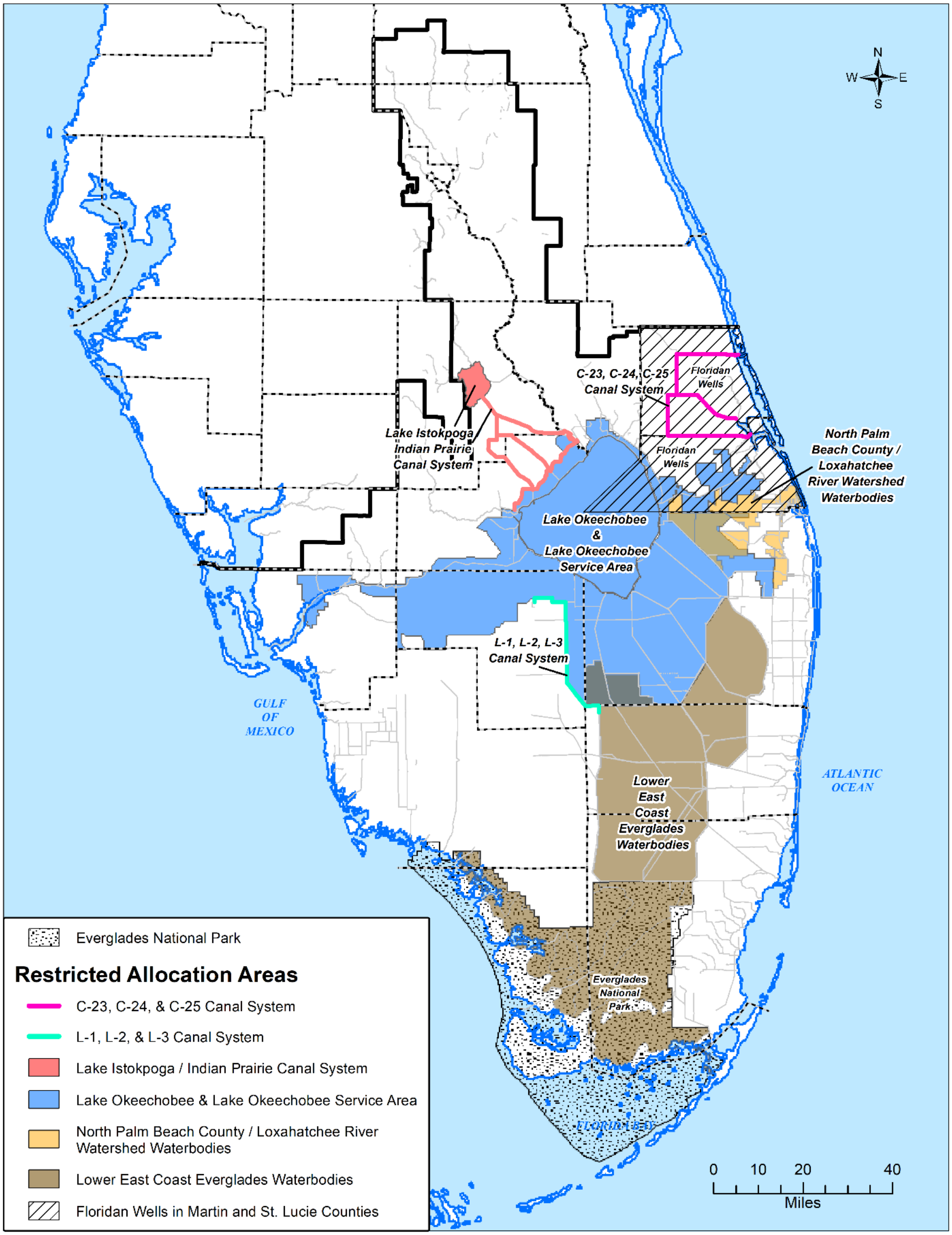


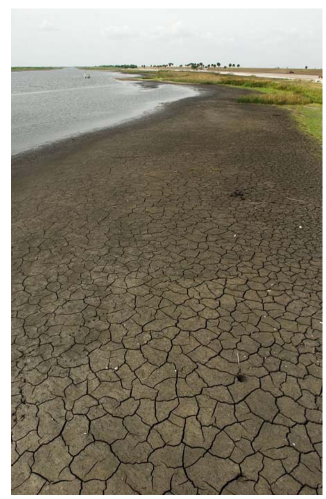

Figure 4-4. Restricted allocation areas within the South Florida Water Management District.

## Water Reservations and RAAs for CERP Projects

The Water Resources Development Act of 2000 and Section 373.470(3)(c), F.S., require the SFWMD to allocate or reserve the increase in water supplies resulting from a CERP project before executing a cost-share agreement with the United States Army Corps of Engineers (USACE) to construct the project. The SFWMD fulfills this requirement by adopting water reservation and/or RAA rules. The USACE then verifies that the federal requirements are met. Together, these measures protect water resources across substantial portions of the District. Any water made available by a CERP project beyond that needed for the natural system may be certified by the District's Governing Board as available and allocated to consumptive uses to meet the CERP goal of water made available for other water-related uses.

## Water Shortage Rules

Water shortages are declared by the District's Governing Board to prevent serious harm from occurring to water resources, including related natural systems (Sections 373.175 and 373.246, F.S.). Serious harm is defined as the long-term loss of water resource functions resulting from a change in surface water or groundwater hydrology [Subsection 40E-8.021(30), F.A.C.] (**Figure 4-1**).



Drought Conditions

The water shortage plans described in Chapters 40E-21 and 40E-22, F.A.C., are applied to manage water use when insufficient groundwater or surface water is available to meet user needs or when conditions require temporary water use reduction. Chapter 40E-22, F.A.C., contains regional water shortage plans and restrictions related to specific water bodies. The water shortage plans 1) ensure 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; 2) provide advance knowledge of the means by which water apportionments and reductions will be made during times of shortage; and 3) promote greater security for water use permittees.

# SUMMARY

Projects and programs to protect and restore natural resources are essential to ensuring 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.

NAVIGATE

Detailed information about MFLs is available on the SFWMD website at http://www.sfwmd.gov/mfls.

Detailed information about water reservations is available on the SFWMD website at http://www.sfwmd.gov/reservations.

Detailed information about RAAs is contained in the Applicant's Handbook (SFWMD 2021).

MFL, water reservation, and RAA status updates are provided annually in Chapter 3 of the *South Florida Environmental Report – Volume II*, available at http://www.sfwmd.gov/sfer. Additional updates can be found in the most recent applicable regional water supply plan update.

# REFERENCES


SFWMD. 2010. *Final Adaptive Protocols for Lake Okeechobee Operations*. South Florida Water Management District, West Palm Beach, FL.

SFWMD. 2021. *Applicant's Handbook for Water Use Permit Applications within the South Florida Water Management District*. South Florida Water Management District, West Palm Beach, FL. March 2021. Available at: https://www.sfwmd.gov/doing-business-with-us/permits/water-use-permits.

# 5

# Ecosystem Restoration and Water Resource Development

When discussing natural systems or ecosystem programs and projects, protection and restoration activities often are 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 discusses ecosystem restoration and water resource development projects that occur throughout the South Florida Water Management District (SFWMD or District) and often cross planning area boundaries. General resource protection criteria are addressed in **Chapter 4**, and specific resource protection projects are described in the applicable regional water supply plans.



## ECOSYSTEM RESTORATION

Changes in South Florida's hydrology and habitats over the past century have caused degradation of a vital subtropical wetland system. Because of development and drainage in the Greater Everglades, the right quantity and quality of water is not always available during dry periods for both the environment and the human population. Conversely, in wet times, a lack of storage capacity, natural or man-made, often causes damaging flooding in the Everglades and coastal estuaries.

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. Restoration scientists, planners, and engineers plan to recover many of the original characteristics of the Everglades that would allow the Everglades to function as a cohesive ecosystem. Such characteristics 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.

There are several separate restoration efforts under way throughout the District. Some projects are related under the umbrella of a larger restoration program (e.g., the South Florida Ecosystem Restoration Program). Projects in the Everglades require involvement from federal and state partners such as the United States Army Corps of Engineers (USACE), Florida Department of Environmental Protection (FDEP), and 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.

Everglades

Recognizing its ecological importance, the Everglades system is the focus of one of the largest ecological restoration projects in the world, the South Florida Ecosystem Restoration Program. The status of projects related to the South Florida Ecosystem Restoration Program is updated annually and published in the Integrated Delivery Schedule, available on the USACE website (https://www.saj.usace.army.mil/Missions/Environmental/Ecosystem-Restoration/Integrated-Delivery-Schedule/). The Integrated Delivery Schedule summarizes upcoming schedules and costs for project activities related to the current and planned Comprehensive Everglades Restoration Plan (CERP) components as well as non-CERP and foundation projects associated with the Central and Southern Florida Flood Control Project (C&SF Project). Many of these projects are discussed in the SFWMD's regional water supply plan updates.

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

## Comprehensive Everglades Restoration Plan

A major component of the South Florida Ecosystem Restoration Program (https://www.evergladesrestoration.gov/), CERP is the driving force behind many restoration projects in the District today. The project area spans more than 18,000 square miles and is designed to improve the health of more than 3,750 square miles (2.4 million acres) of South Florida ecosystems (USACE 2020). CERP was built on previously authorized non-CERP hydrologic restoration projects and foundational projects, which were assumed to be complete during the planning process and therefore able to serve as a foundation for CERP implementation, such as:

- Modified Water Deliveries to Everglades National Park
- Kissimmee River Restoration
- C-111 South Dade Project
- Tamiami Trail Next Steps
- Southern Corkscrew Regional Ecosystem Watershed

Corkscrew Regional Ecosystem Watershed

The status and details of these projects, as well as other CERP projects, are provided in the applicable regional water supply plans, which are updated every 5 years, and in the *South Florida Environmental Report*, which is updated annually.

Authorized by Congress in the Water Resources Development Act of 2000, CERP 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 SFWMD's boundary while providing for other water-related needs in the region. The USACE is the lead federal agency and the SFWMD is the lead state agency for this multidecadal effort. The USACE and SFWMD jointly implement CERP with a 50-50 cost share plan that includes the planning, design, and construction of projects.

CERP is composed of a series of projects designed to 1) capture, store, and redistribute fresh water, and 2) restore the Everglades ecosystem by improving the quality, quantity, timing, and distribution of water flows (**Figure 5-1**). Together, the various components of CERP will benefit the ecological function of the South Florida ecosystem, while improving regional water quality conditions, deliveries to coastal estuaries, urban and agricultural water supply, and existing levels of flood protection.

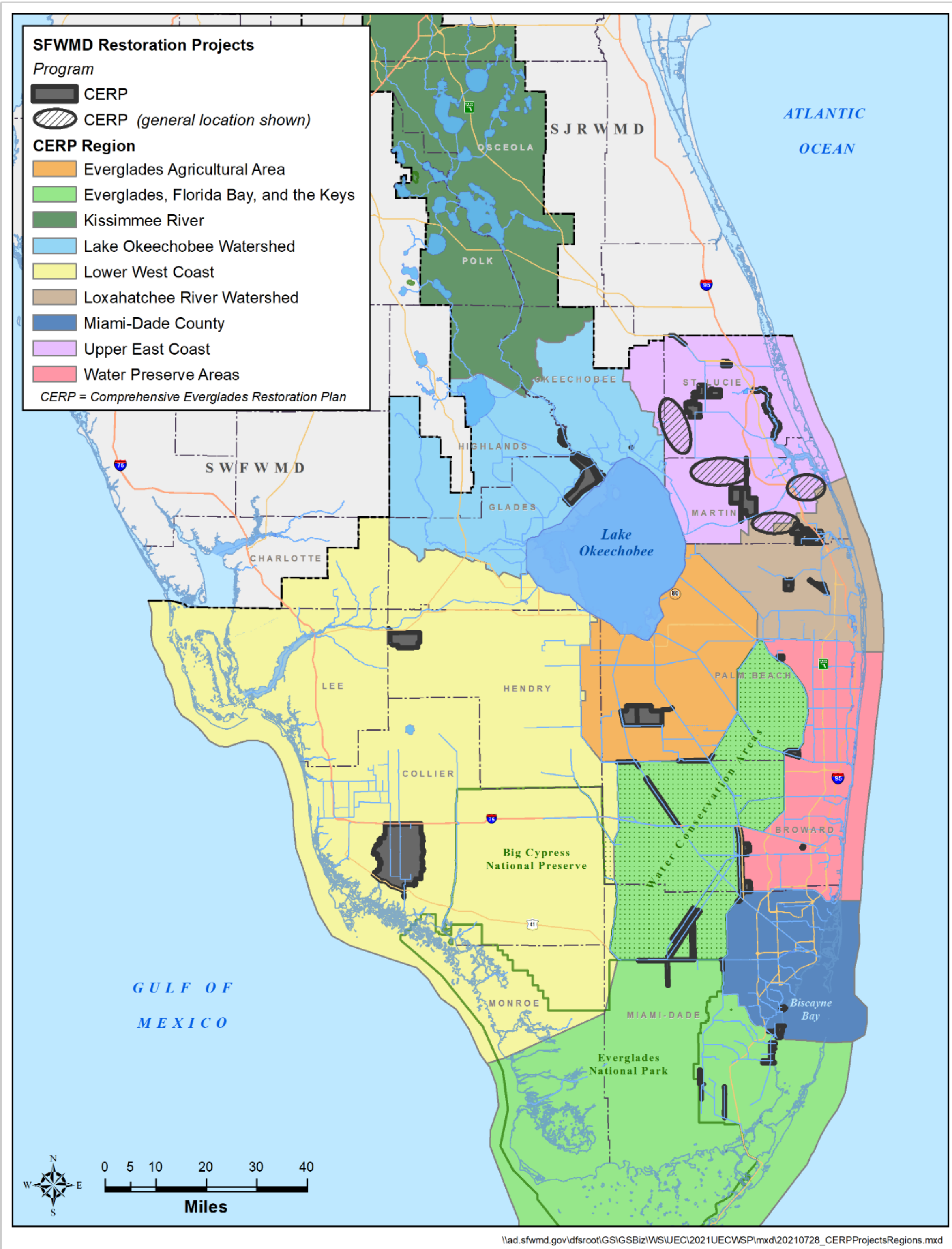



Figure 5-1. Comprehensive Everglades Restoration Plan (CERP) regions and projects.

## Northern Everglades and Estuaries Protection Program

Underscoring the state's commitment to ecosystem restoration, the Florida legislature expanded the Lake Okeechobee Protection Act in 2007 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), focuses on the water storage and water treatment needed to 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 Lake Okeechobee and downstream coastal estuaries. NEEPP requires the SFWMD, in collaboration with the FDEP and FDACS as coordinating agencies and in cooperation with local governments, to develop and implement protection plans for three northern watersheds: Lake Okeechobee, St. Lucie River, and Caloosahatchee River. While Northern Everglades projects have been conceptually identified in these protection plans, specific projects and activities are included in annual work plans and updates in the *South Florida Environmental Report – Volume I*, available at http://www.sfwmd.gov/sfer. Information about NEEPP is available from http://www.sfwmd.gov/northerneverglades.

# DISTRICTWIDE WATER RESOURCE DEVELOPMENT PROJECTS

Water resource development is defined in Section 373.019(24), Florida Statutes (F.S.), as:

> *…the formulation and implementation of regional water resource management strategies, including the collection and evaluation of surface water and groundwater data; structural and non-structural programs to protect and manage water resources; development of regional water resource implementation programs; construction, operation, and maintenance of major public works facilities to provide for flood, surface, and underground water storage and groundwater recharge augmentation; and related technical assistance to local governments and to government-owned and privately-owned water utilities.*

Water resource development projects encompassing more than one planning area generally are considered Districtwide projects. The estimated costs and time frames for completion of Districtwide water resource development projects are summarized in Chapter 5A of the annual *South Florida Environmental Report – Volume II*. The following categories are types of Districtwide water resource development projects:

- Minimum flow and minimum water level (MFL), water reservation, and restricted allocation area (RAA) rule activities
- Comprehensive Water Conservation Program
- Alternative water supply
- Drilling and testing
- Groundwater assessment
- Groundwater, surface water, and wetland monitoring
- Hydrologic modeling

## MFL, Water Reservation, and RAA Rule Activities

MFLs, water reservations, and RAA rules as well as other water resource protection measures have been developed to ensure the sustainability of water resources within the SFWMD. For information on MFLs, water reservations, and RAAs, see **Chapter 4**.

## Comprehensive Water Conservation Program

The long-standing conservation goal of the SFWMD is to prevent and reduce wasteful, uneconomical, impractical, or unreasonable use of water resources. This is addressed through planning, regulation, public education, and demand reduction through conservation technology, best management practices, and water-saving funding programs. The Comprehensive Water Conservation Program is a series of implementation strategies designed to create an enduring conservation ethic and permanent reduction in water use. The program is discussed further in **Chapter 2**.

## Alternative Water Supply

Alternative water supply (AWS) projects and source diversification are important supplements to traditional water sources in order to meet current and future water needs Districtwide. In 2016, the SFWMD combined funding programs for stormwater, AWS, and water conservation projects into one streamlined effort, the Cooperative Funding Program. AWS funding supports water users in development of reclaimed water projects, water reclamation facilities, brackish water wellfields, reverse osmosis treatment facilities, stormwater capture systems, and aquifer storage and recovery (ASR) well systems. A full description of AWS-related projects and associated funding is contained in the SFWMD's Alternative Water Supply Annual Reports, prepared pursuant to Section 373.707(7), F.S., and published in annual updates of the *South Florida Environmental Report*.

## Drilling and Testing

The SFWMD installs and continually tests groundwater monitor wells of various depths throughout the District to track aquifer water levels and water quality. Data from these wells enhance the SFWMD's knowledge of South Florida hydrogeology, improve the accuracy of regional groundwater models, and support decision-making regarding approval of water use permits.

Floridan Aquifer Well Drilling

## Groundwater Assessment

Groundwater assessment includes results of drilling and aquifer testing programs as well as development of hydrostratigraphic maps and saltwater interface maps (for the coastal water supply planning areas).

### *Saltwater Interface Mapping*

The SFWMD periodically develops maps documenting the inland extent of saltwater intrusion to understand the potential effects on wellfields and coastal aquifers in all coastal counties except Miami-Dade County. Salinity data from monitor wells are compiled from multiple sources (e.g., United States Geological Survey [USGS], SFWMD, water use permittees) to estimate the farthest inland extent of the saltwater interface, as defined by the 250 milligrams per liter (mg/L) chloride concentration in groundwater. The SFWMD has developed maps for 2009, 2014, and 2019, with plans to update the maps every 5 years. This approach tracks the saltwater interface position over time, can be used to identify areas of concern that may require additional monitoring, and may suggest the need for changes in wellfield operations. In a separate effort, Miami-Dade County contracts with the USGS to develop saltwater intrusion maps, as defined by the 1,000 mg/L chloride concentration. An interactive salinity analysis map viewer managed by the USGS is available at https://fl.water.usgs.gov/mapper/. The SFWMD's 2009, 2014, and 2019 saltwater interface maps are available on the SFWMD's website at https://www.sfwmd.gov/documents-by-tag/saltwaterinterface.

The saltwater interface is regionally dynamic, with inland movement in some areas and seaward movement in other areas. Local-scale investigation of the interface position could be warranted in some areas, depending on the network of monitor wells available, the proximity of saltwater sources to wellfield locations, and withdrawal rates.

## Groundwater, Surface Water, and Wetland Monitoring

Information regarding groundwater and surface water levels is essential to manage and protect South Florida's water resources. Real-time data combined with historical information about water levels, weather, rainfall, and water quality changes inform water resource decisions.

Water level and water quality monitoring provides critical information for developing groundwater models, assessing groundwater conditions, and managing groundwater resources. The SFWMD maintains extensive groundwater monitoring networks and partners with the USGS to provide additional support for ongoing monitoring. Data are archived in DBHYDRO—the SFWMD's corporate environmental database—which contains hydrologic, meteorologic, hydrogeologic, and water quality data. Data are available through www.sfwmd.gov/dbhydro. The USGS monitors, archives, and publishes data annually.

Districtwide groundwater monitoring activities include the following:

- **USGS water level monitoring –** An ongoing effort by the USGS with funding support from the SFWMD to collect groundwater level monitoring data. The project includes well and recorder maintenance as well as archiving data in a USGS database for sites throughout the SFWMD. Real-time and periodic data can be accessed through a map interface (https://groundwaterwatch.usgs.gov/StateMap.asp?sa=FL&sc=12).

- **SFWMD water level monitoring –** An ongoing effort by the SFWMD to monitor groundwater levels throughout the District. As of 2019, Districtwide monitoring includes 604 active SFWMD groundwater stations for the surficial, intermediate, and Floridan aquifer systems as well as an additional 298 USGS groundwater stations. Data are collected, analyzed, validated, and archived in DBHYDRO.
- **Hydrogeologic database improvements** – SFWMD staff are uploading backlogged data and conducting miscellaneous database corrections. In addition to continued uploading of geophysical data and documents to DBHYDRO, borehole video logs for many Floridan aquifer system (FAS) monitor, injection, and ASR wells are available in each well station's multimedia.
- **FAS well installation, testing, and maintenance** – The SFWMD monitors water levels and water quality at 102 FAS well sites in the SFWMD, as of 2019. Well maintenance is conducted as needed. Data are collected, analyzed, validated, and archived in DBHYDRO.
- **Water use permitting water level and water quality monitoring** – Some SFWMD water use permittees submit water level and/or water quality data from selected surficial aquifer system and FAS monitor and production wells to the SFWMD. The data are available for each permit on the SFWMD website.
- **MFL-required monitoring** – In support of adopted MFL recovery and prevention strategies, the SFWMD monitors changes in surface water and groundwater levels, flows, and specific MFL-related constituents; the location of the saltwater interface; and the floral and faunal populations.
- **Monthly water level measurements –** Continued water level monitoring, including data collection, analysis, and validation, at select sites to supplement the existing groundwater level monitoring networks.

## Hydrologic Modeling

Regional surface water and groundwater flow models simulate the rate and direction of water movement through the SFWMD's water resources system and subsurface. The models include the major components of the hydrologic cycle and are used to understand the effects of current and future water management operations and water supply use under varied climatic and hydrologic conditions. For surface water modeling, the Regional Simulation Model uses climate records and technical details about regional canals, water control structures, local topography, and storage reservoirs to simulate the complex systems in South Florida. The SFWMD has applied the Regional Simulation Model to several Everglades restoration projects as well as the Kissimmee-Okeechobee-Everglades system and the Big Cypress pre-drainage watershed. For groundwater modeling, the SFWMD has developed several subregional models that collectively cover the entire District (**Figure 5-2**). These groundwater models simulate groundwater flow, and sometimes water quality, within the surficial, intermediate, and Floridan aquifer systems based on current and future withdrawal scenarios. More details about each model, including simulations using updated demands, are provided in the applicable water supply plan updates and model documentation reports.

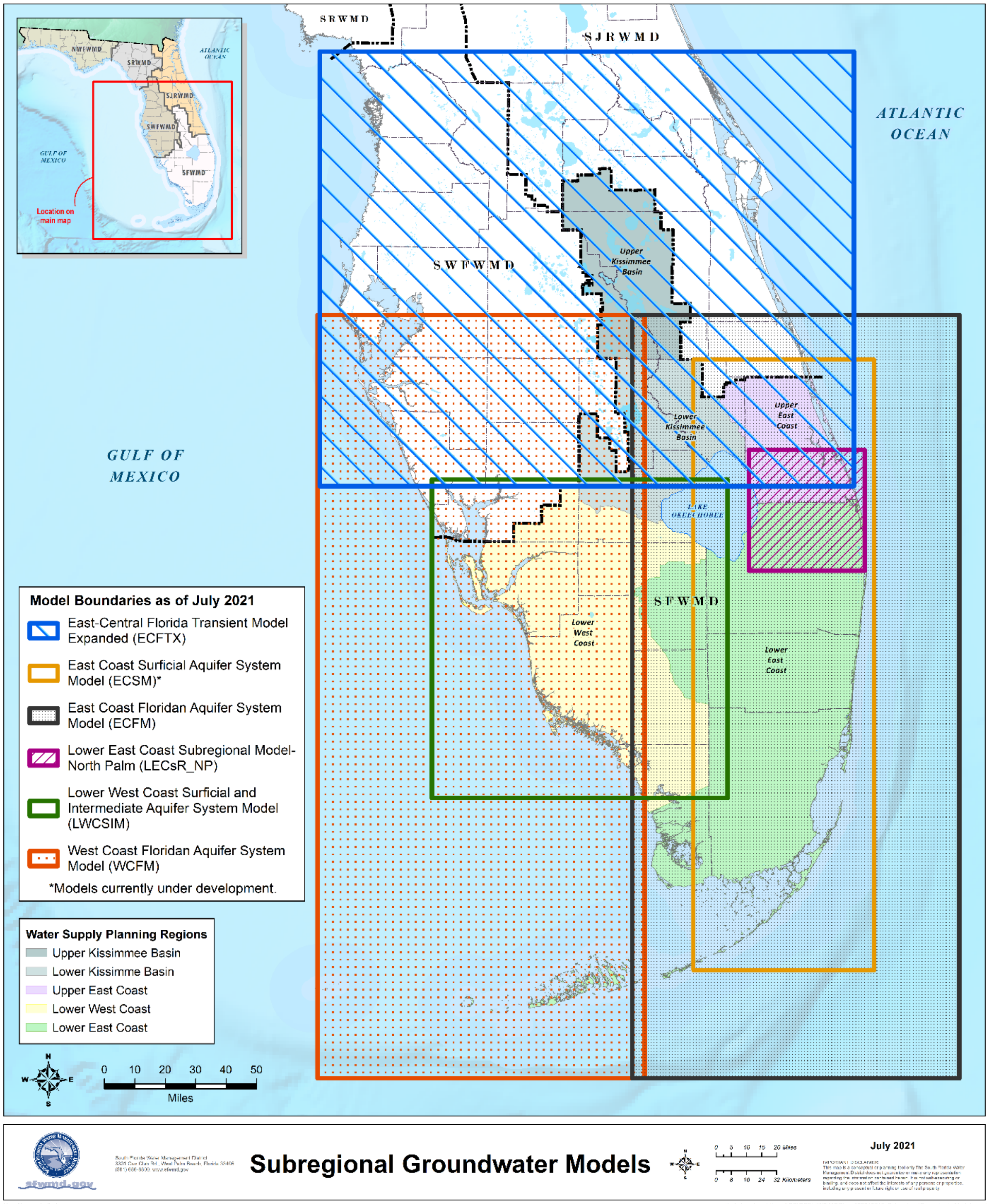



Figure 5-2. Subregional groundwater model boundaries within the South Florida Water Management District.

# SUMMARY

Ecosystem restoration and water resource development are important parts of the SFWMD's work. In partnership with the USACE, the SFWMD is designing and implementing multiple components of the South Florida Ecosystem Restoration Program, including CERP projects. CERP and other ecosystem restoration project activities will restore, protect, and preserve water resources throughout central and southern Florida. Complementing these efforts are Districtwide water resource development projects, which are critical to understanding the quantity and quality of South Florida's water resources.

# REFERENCES

USACE. 2020. *Integrated Delivery Schedule (IDS) Update 2020 – Task Force Final*. United States Army Corps of Engineers, Jacksonville, FL. September 2020.

Kissimmee River

# 6

# Water Source Options and Treatment

***Note: The text contained in this chapter has not been altered from the 2016 Water Supply Plan Support Document, except for minor editorial adjustments as needed. A new water supply cost estimation study is under way and scheduled for completion in spring 2023. This chapter will be updated once new cost data are finalized and available.***

This chapter discusses water source options and water treatment processes for public water supply (PWS), along with related costs. The source of water generally will determine the type of treatment needed to produce potable water that meets the standards of the Safe Drinking Water Act. Surface water has more suspended solids and bacteria than is found in groundwater. Additionally, the water quality and temperature of surface water has seasonal variability. Generally, groundwater has more constant water temperature and water quality.

## WATER SOURCE OPTIONS

**TOPICS**

- Groundwater
- Surface Water
- Seawater
- Reclaimed Water
- Storage Solutions
- Interconnects

Within the South Florida Water Management District (SFWMD or District), groundwater is the primary source of water for PWS utilities. Some groundwater is fresh and requires minimal treatment while other water is brackish and requires substantial treatment to meet drinking water standards. The water supply sources available to PWS utilities and other users include the following:

- **Groundwater** – Water beneath the surface of the ground, primarily withdrawn from three south Florida aquifer systems: the surficial aquifer system (SAS), intermediate aquifer system, and Floridan aquifer system (FAS).
- **Surface Water** – Water from lakes, rivers, and canals is used occasionally by PWS utilities and extensively by agricultural permittees.
- **Seawater** – In south Florida, the sources of seawater are the Atlantic Ocean and Gulf of Mexico.
- **Reclaimed Water** – Water that is reused after receiving at least secondary treatment and basic disinfection, flowing out of a domestic wastewater treatment facility.

Additional options for PWS utilities include storage solutions such as Aquifer Storage and Recovery (ASR), regional and local retention, and reservoirs. Utility interconnects, a physical connection between the distribution systems of two PWS utilities, are used as a means to address a temporary shortfall or for long-term water supply.

The chemical constituents or quality of the water dictates the treatment technologies and processes, and thus cost, necessary to meet water quality standards.

The scope of this Support Document does not include a comprehensive discussion of process technologies and components. Readers should use the information as a starting point for understanding some of the fundamental considerations and costs of incorporating new water supplies and treatment capabilities within specific localities. Unless otherwise noted, the cost information presented in this chapter cites the CDM, Inc. report, *Water Supply Cost Estimation Study* (Cost Study) (CDM 2007a).

## Cost Study

The Cost Study and addendum (CDM 2007a,b) provide engineering cost data as well as cost estimation relationships and curves to evaluate various water treatment technologies used for PWS in the District's water supply planning areas. Costs are planning-level estimates. The report also 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.

Water Treatment Plant in Collier County

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

However, 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 because of the fixed capital cost of a deep injection well for concentrate disposal in this capacity range. The labor component of the O&M cost becomes much more important 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. The costs are regarded as accurate within +50 percent or -30 percent and are presented in August 2006 dollars. After the release of the Cost Study, construction costs of water infrastructure rose substantially, then a reversal in pricing trends occurred. In 2010, it was determined that the August 2006 dollar estimates were still valid for use to portray market conditions.

The Cost Study cites energy costs of $0.10 per kilowatt-hour (kWh) based on review of planning-level power costs for water utilities in Palm Beach and Collier counties. Information from several PWS utilities in 2015 indicates that for planning purposes, when considering plants that operate facilities, wells, and other pumps, the rate of $0.09/kWh appears 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.
- **Non-Construction 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 non-construction costs.
- **O&M Costs –** 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 Supply Systems

Groundwater supply systems are composed of wellfields and related features such as pipelines and pumps. The production of each well is limited by several factors, including the rate of water movement in the aquifers, rate of recharge, aquifer storage capacity, potential environmental impacts, proximity to sources of contamination, proximity to existing legal users, and the potential for saltwater intrusion. A combination of these factors determines the number, depth, diameter, and distribution of wells that can be constructed at a specific site. These factors also affect the rate at which the wells can be pumped.

The cost of well construction is a function of diameter, depth, and underlying sediments. The costs include drilling, construction, and casing to professional standards, geophysical logging, aquifer testing as appropriate, and the final wellhead. Many utilities have found that a test well was helpful to understand the hydrogeology of the site and design the wellfield and wells.

Equipment costs to operate the wellfield include pumps, piping, valves, fittings, meters, well house, and electrical controls. Costs to construct groundwater wells and send the water to a water treatment plant represent only one component in the water withdrawal process.

## Surface Water Supply Systems

The costs associated with surface water withdrawal are for pumps to obtain the water from the source at a steady rate and for piping to transmit the water to the water treatment plant. **Table 6-1** provides estimates of costs to install water-pumping facilities designed to divert surface water.

Table 6-1. Pump installation and operating costs[a] (From: CDM 2007a).

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

[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.

## Seawater Supply Systems

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 configurations have reduced the cost of production of desalinated seawater.

Seawater contains approximately 3.5 percent or 35,000 parts per million (ppm) of dissolved salts, most of which is sodium chloride (NaCl), with lesser amounts of sulfates, magnesium, potassium, and calcium. Therefore, removal of salts is required before potable or irrigation uses are feasible. The salt removal is accomplished with desalination treatment technology such as distillation, reverse osmosis (RO), or electrodialysis reversal. Some utilities with seawater desalination plants have found that a pilot test facility is helpful to understand the water that will be processed by the plant to more effectively design the full desalination plant.

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 (e.g., sharing facility components). Cost savings also are associated with using the existing intake and discharge structures of the power plant to provide raw water to the desalination facility and 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 6-2** shows a brackish surface or seawater desalination facility co-located with a power plant listing cost-saving features, including savings from economy of scale. 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.

Table 6-2. Estimated project costs for developing a co-located brackish surface water or seawater treatment facility (From: Metcalf & Eddy 2006).

| Candidate Site | Facility Capacity (MGD) | Water Quality (TDS) (ppm) | Total Construction Costs (millions) | Capital $/Gallon of Capacity | Total Annual O&M Costs (millions) | Equivalent Annual Costs ($/1,000 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 |

ppm = parts per million; TDS = total dissolved solids.

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; equipment, electrical, and instrumentation costs were added when appropriate. After 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.
- 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 were considered budget-level costs (in 2010) with an accuracy of +30 percent to -15 percent, and reflect capital amortized at 7 percent for 20 years.


St. Lucie West Wastewater Treatment Facility

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

For example, the 25 MGD Tampa Bay, Florida 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 was completed in late 2015 (Carlsbad Desalination Project 2015). Water from the plant is expected to cost $1,849 to $2,064 per acre-foot ($5.67 to $6.33 per 1,000 gallons), depending on how much is purchased (San Diego County Water Authority 2012).

## Reclaimed Water

The costs associated with the production of reclaimed water includes the treatment of the water as well as transmission lines, storage facilities, and a backup disposal system. 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. More information about existing wastewater treatment facilities, including water reuse data, is provided in the appendices of each regional water supply plan update.

## Storage

The cost of storage will vary based on the storage option and the volume of water to be stored. The three major types of potential storage options are aquifer storage and recovery, regional and local retention, and reservoirs.

### Aquifer Storage and Recovery

ASR systems are composed of injection and monitor wells, a water treatment facility, and related features such as pipelines and pumps. The volume of water that may be injected into an ASR well is limited by several factors, including aquifer storage capacity, water quality in the aquifer, and water availability. A combination of these factors determines the number of wells that can be constructed at a specific ASR site.

Treatment costs for meeting federal water quality regulations are the main driver for treatment associated with ASR systems, particularly regarding disinfection technology. Disinfection is required to inactivate biologic pathogens that may enter the aquifer through an ASR well. Therefore, the source of the water also affects the treatment and monitoring. Arsenic 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.


Hillsboro Canal ASR Pilot Project

Estimated costs for an ASR system depend on many factors, including hydrogeologic conditions, number of wells, well depths, flow rates, water treatment process, required number of monitor wells, and other required features. **Table 6-3** provides estimated costs for a 2 MGD potable water ASR system and a 5 MGD surface water ASR system.

Table 6-3. ASR cost estimates (From: CDM 2007a).

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

The potable water cost information assumes that the 2 MGD potable ASR system 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 generally are lower. The 5 MGD surface water ASR system cost information assumes 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 with higher costs.

## Regional and Local Retention

Projects in this category capture and store excess surface water, and include reservoirs, retention of water in secondary canals, and use of excess surface water to supplement irrigation quality reclaimed water. Regional and local retention costs vary because they are project and site specific. Because the costs vary greatly based on the type and location of the projects, only cost information for reservoirs is included in this section.

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

**Table 6-4** 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 substantially for construction of higher levees but may be partially offset by reduced land requirements. Related costs not included in the surface water storage option are costs for inflow and outflow transmission infrastructure as well as costs for water treatment facilities, if any (depending on the end user).

Table 6-4. Surface water storage costs (From: U.S. Army Corps of Engineers [USACE] and SFWMD 2005*; CDM 2007a).

| 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 |

*All costs were obtained from CDM (2007a) except for Land costs, which were obtained from USACE and SFWMD (2005).

### *Utility Interconnections*

The costs associated with PWS interconnects depend on the size, distance, and potential engineering challenges. Typically, an interconnect system includes booster pump stations, transmission mains, valves, jack and bores, encasements, and tunneling. Costs are site-specific.

# WATER QUALITY AND TREATMENT

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

The first portion of **Chapter 3** introduced the first phase of the water delivery and treatment process – withdrawal from the water source – along with related costs. This section reviews water treatment quality considerations, and the technologies and processes used to treat water supplies from each water source.

## Water Quality Standards

Water for potable (suitable for drinking) and nonpotable water uses have different water quality requirements and treatability constraints. Potable water has very specific quality standards to protect human health while water quality limits for nonpotable uses vary and are dictated by the intended use of the water.

### *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 MCL. Secondary drinking water standards, commonly referred to as aesthetic standards, are 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*

Nonpotable water uses include golf course, landscape, agricultural, and recreational irrigation as well as some industrial and commercial uses, and the water quality standards for each type of use may vary. For example, high iron content usually is not a factor in water used for flood irrigation of food crops but requires removal for irrigation of ornamental crops. Excessive iron must be removed for use in microirrigation systems, which become clogged by iron precipitates.

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. In addition, water constituents harmful to irrigation system infrastructure or equipment (e.g., 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

## Potable Water Treatment Processes

The technologies and processes employed to produce potable water that meets drinking water standards are presented in the following sections of this chapter. Chlorination, lime softening, and membrane processes are processes currently employed by PWS water treatment facilities within the District's jurisdiction. The type of treatment needed depends on the quality and type of the source water. Higher levels of treatment are needed to meet increasingly stringent drinking water quality standards. Water treatment also is 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) Regional PWS, municipal, or privately owned facilities
2) Small developer/homeowner association or utility-owned PWS treatment facilities
3) Self-supplied domestic wells serving individual residences

It is common for smaller interim facilities to be constructed until regional potable water becomes available. The smaller water treatment facility typically is abandoned upon connection to the regional water system. A brief description of the various water treatment methods is followed by cost information for the most common types of new water treatment facilities built within the SFWMD.


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. Lime softening is an inexpensive treatment process commonly used in water treatment facilities throughout Florida to reduce hardness. When these facilities need to be replaced, however, utilities are switching to membrane treatment technology processes. 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 byproducts precursors. These processes can provide softening as well. The most commonly used membrane processes to treat drinking water are ultrafiltration (UF), microfiltration (MF), nanofiltration (NF), and 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 technology depends on source water quality and characteristics as well as the desired treated water quality. 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 appropriate 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 setup as shown in **Table 6-5**.

Table 6-5. General water treatment technology process recover rates.

| Process | Recovery Rate (%) | Comments |
|---|---|---|
| RO seawater | 30 – 50 | |
| RO brackish | 70 – 90 | Depends on the source water's TDS level |
| NF | 80 – 95 | Can remove turbidity, microorganisms, disinfection byproduct 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 |
| Lime softening | 95 – 99 | Effective at reducing water hardness for some source water but is relatively ineffective at controlling contaminants |

MF = microfiltration; NF = nanofiltration; RO = reverse osmosis; TDS = total dissolved solids; UF = ultrafiltration.

Source water requires some pre-treatment to remove particulates, suspended sediments, and volatile substances. Pre-treatment includes aeration, coagulation, flocculation, and filtration. The type of pre-treatment will vary based on the source water.

## Aeration Process Units

In the aeration process, air is brought into contact with water 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, oxidize organic matter.
- Remove substances that may interfere with or add to the cost of subsequent water treatment (e.g., the removal of carbon dioxide from water before lime softening).
- Add oxygen to water, primarily for oxidation of iron and manganese, so the elements may be removed by further treatment.
- Remove radon gas or 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, which usually is 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 water. Air is compressed and then released at the bottom of the water 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 vertically arranged trays. Water is introduced at the top of a series of trays and aeration of the water takes place as the water cascades from one tray to the other.

## Coagulation, Flocculation, and Sedimentation Process Units

Coagulation, flocculation, and sedimentation remove suspended material and color, and may be used as a pre-treatment 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 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 like a conventional flocculation sedimentation design, except that 130- to 150-micrometer sand (microsand) is added to the water during the flocculation process to enhance coagulation and settling. The microsand adds surface area in the coagulation process, which substantially 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 the following:

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

## Filtration Process Units

Filtration process units remove particulate matter from the water supply. Filtration involves passing 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 with particle sizes of approximately 1 millimeter (mm). The filters are operated at flow velocities of approximately 15 to 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 2 feet and operates at flow rates of 0.3 to 1.0 feet per hour. The vital process in slow sand filtration is the formation of a biologically active layer, called the Schmutzdecke, in the top 20 mm of the sand bed. This layer provides an effective surface filtration of very small particles, including bacteria, parasites, and viruses. Any particles that pass through the Schmutzdecke may be retained in the remaining depth of the sand bed by the same mechanisms that exist in rapid filtration.

- **Activated Carbon Filtration** – Active carbon filters remove organic compounds that impart taste and odor to the water. However, these filters may also reduce the number of microbial organisms, including viruses and parasites. Carbon filtering uses activated carbon to remove contaminants and impurities using chemical adsorption. The carbon filter is designed to provide a large surface area that allows 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*.

## Ultrafiltration and Microfiltration Processes

UF and MF are low-pressure water treatment technology processes. UF removes nonionic matter, higher molecular weight substances, and colloids (extremely fine-sized suspended materials that will not settle out of the water column). MF 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, *Cryptosporidium*, and *Giardia* cysts. Due to the larger pore size of the membranes used for MF, the process is not as effective as UF for removing viruses.

## Nanofiltration Process

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

NF membranes generally are effective for removing particles 10 to 100 micrometers in size, making them well suited for removing high molecular weight molecules (e.g., dissolved organics such as disinfectant/disinfection byproduct [DBP] precursors) and hardness ions. NF membranes commonly are applied for softening, which is sometimes referred to as membrane softening. One advantage of membrane softening technology is its effectiveness at removing organics that function as total trihalomethane (TTHM) and other DBP precursors. In recent years, utilities have been replacing aging lime softening facilities with NF processes to accommodate current and projected regulatory standards.

## Desalination/Reverse Osmosis Process

Desalination processes treat saline water to remove or reduce chlorides and dissolved solids, resulting in the production of fresh water suitable for human consumption or irrigation. South Florida utilities use several types of membrane processes for producing potable water from brackish sources.

There are several desalination processes that do not use membranes and are not used in south Florida. Electrodialysis and electrodialysis reversal generally are not considered efficient or cost-effective for organic removal (American Water Works Association [AWWA] 1988). Distillation treatment processes are based on evaporation.

Reverse Osmosis Treatment Facility

RO 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.

RO 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.

As of June 2014, there are 36 brackish and two seawater desalination PWS facilities operating within the SFWMD, with two brackish water facilities under construction. The existing facilities have the capacity to produce 269 MGD. The two new facilities will increase the overall production capacity by 18.9 MGD, bringing the Districtwide total capacity to 288 MGD.

## 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, TTHM precursors, and others (Hamann et al. 1990). Chloride levels of raw water sources expected to serve lime softening facilities should be below the chloride MCLs to avoid possible exceedance of the standard in the treated water. Additionally, lime softening facilities with raw water sources and nitrate concentrations exceeding the MCL probably will 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.

## *Water Treatment Technology Costs*

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 were considered valid in 2010. 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 non-construction costs. Probable capital costs include raw water supply, pre- 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, O&M, permitting, design- and engineering-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 generally are not phased; most costs are upfront and not incremental.
- Costs for raw water transmission mains usually are included in well construction costs.
- Well construction and O&M costs are difficult to estimate due to the variation in costs by planning region; in well types depending on aquifer source (differences in size, depth, and wellhead equipment requirements); and in economy of scale (cost per well usually is reduced in multi-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.

### Ultrafiltration and Microfiltration Water Treatment Cost

This cost estimate for UF and MF water treatment processes includes components for a completed functioning facility: raw water supply, pre- and post-treatment, typical UF or MF process component, finished water stabilization, intermediate (in-plant) storage, transfer pumping, backup 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 6-6**.

Table 6-6. Estimated costs associated with ultrafiltration and microfiltration treatment technology (From: CDM 2007a).

| Facility Capacity (MGD) | Construction Cost | Capital Cost | Equivalent Annual Capital Cost | Annual O&M Cost | Total Annual Production Cost | Cost (per 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 |

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-micrometer 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, residuals thickener, and centrifuge.
- 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, or pilings.
    - 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/kWh.
    - 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.

## Nanofiltration Water Treatment Cost

**Table 6-7** presents probable costs 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.

Table 6-7. Estimated costs associated with nanofiltration treatment technology (From: CDM 2007a).

| Facility Capacity (MGD) | Construction Cost | Capital Cost | Equivalent Annual Capital Cost | Annual O&M Cost | Total Annual Production Cost | Cost (per 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 |

Considerations:

- Shallow water aquifers are assumed to supply the raw water for the NF treatment facility.
- 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.
- Pre-treatment includes raw water acidification, antiscalant feed, and micrometer 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) feed system for pH adjustment, and application of a corrosion inhibitor.
- Pre- and post-treatment chemical systems include bulk storage tanks and containment basins, day tanks, metering pumps, chemical piping, and chemical injection quills or diffusers.

## Brackish Groundwater RO Water Treatment Cost

The pre-treatment, 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.

Considerations:

- The raw water supply for the brackish groundwater RO treatment technology is assumed to be from 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 are shown in **Table 6-8**. The estimates 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 6-8. Estimated costs associated with brackish groundwater reverse osmosis treatment technology (From: CDM 2007a).

| Facility Capacity (MGD) | Construction Cost | Capital Cost | Equivalent Annual Capital Cost | Annual O&M Cost | Total Annual Production Cost | Cost (per 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 |

Estimated costs are planning-level cost estimates made without detailed engineering design and a margin of error from +50 percent to -30 percent.

### Brackish Surface Water RO Water Treatment Cost

The pre-treatment, process, and post-treatment components provided are essentially the same as the groundwater NF systems, with the exception of an additional pre-treatment step of media filters required upstream due to higher levels of suspended particulate contaminants present in a surface water supply.

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 6-9** 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 6-9. Estimated costs associated with brackish surface water reverse osmosis treatment technology (From: CDM 2007a).

| Facility Capacity (MGD) | Construction Cost | Capital Cost | Equivalent Annual Capital Cost | Annual O&M Cost | Total Annual Production Cost | Cost (per 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 |

Estimated costs are planning-level cost estimates made without detailed engineering design and a margin of error from +50 percent to -30 percent.

### Seawater RO Water Treatment Cost – Surface Intake Co-Located with a Power Plant

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

Considerations:

- 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 are shown in **Table 6-10**. The estimates 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 6-10. Estimated costs associated with seawater reverse osmosis treatment technology (From: CDM 2007a).

| Facility Capacity (MGD) | Construction Cost | Capital Cost | Equivalent Annual Capital Cost | Annual O&M Cost | Total Annual Production Cost | Cost (per 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 |

Estimated costs are planning-level cost estimates made without detailed engineering design and 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 pre-treatment 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; pre-treatment 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 6-11**. The estimates 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 6-11. Estimated costs associated with nanofiltration process addition (From: CDM 2007a).

| Facility Capacity (MGD) | Construction Cost | Capital Cost | Equivalent Annual Capital Cost | Annual O&M Cost | Total Annual Production Cost | Cost (per 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 |

### Brackish Water RO 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 an 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; pre-treatment chemicals (acid and antiscalant); membrane units (membrane pressure vessels, frames, and piping); piping inside the membrane building, cleaning system, instruments, and controls; and electrical equipment.

**Table 6-12** 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 6-12. Estimated costs associated with brackish water reverse osmosis process addition (From: CDM 2007a).

| Facility Capacity (MGD) | Construction Cost | Capital Cost | Equivalent Annual Capital Cost | Annual O&M Cost | Total Annual Production Cost | Cost (per 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 |

## *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.

PWS facilities are required to provide adequate disinfection of finished/treated water and 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. O&M 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 6-13**.

Table 6-13. Estimated costs for chlorination disinfection by on-site generation of sodium hypochlorite (From CDM 2007a).

| Facility Capacity (MGD) | Construction Cost | Capital Cost | Equivalent Annual Capital Cost | Annual O&M Cost | Total Annual Production Cost | Cost (per 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 |

## 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. UV 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 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. CDM (2007a) developed the O&M costs (except for replacement parts and materials) using standard unit costs for power and labor. **Table 6-14** presents probable costs for UV disinfection.

Table 6-14. Estimated costs for ultraviolet light disinfection (From: CDM 2007a).

| Facility Capacity (MGD) | Construction Cost | Capital Cost | Equivalent Annual Capital Cost | Annual O&M Cost | Total Annual Production Cost | Cost (per 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 |

## 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) compared to the longer disinfection time required by chlorine. Ozonation is an effective way to alleviate most of PWS taste and odor issues (AWWA 2003).

Ozonation is widely used in western Europe. However, in the U.S., use of ozonation is 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 greater amount of electricity needed for water treatment. Another disadvantage of ozonation 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. However, 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). **Table 6-15** shows probable costs for ozonation disinfection.

Table 6-15. Estimated costs of ozonation (From: CDM 2007a).

| Facility Capacity (MGD) | Construction Cost | Capital Cost | Equivalent Annual Capital Cost | Annual O&M Cost | Total Annual Production Cost | Cost (per 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 |

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 using standard unit costs for power, liquid oxygen, and labor.
- The USEPA cost tables assumed:
  - A design dose of 4.5 milligrams per liter (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 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 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.

### *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 pre-stressed 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 million gallon storage tank is provided. Probable costs for the finished water storage component are shown in **Table 6-16**.

Table 6-16. Estimated costs for finished water storage (From: CDM 2007a).

| Facility Capacity (MGD) | Construction Cost | Capital Cost | Equivalent Annual Capital Cost | Total Annual Production Cost | Cost (per 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 |

#### 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 6-17** presents probable costs for the high service pumping component. The cost estimates do not include distribution system piping and finished water storage component costs.

Table 6-17. Estimated costs for high service pumping (From: CDM 2007a).

| Facility Capacity (MGD) | Construction Cost | Capital Cost | Equivalent Annual Capital Cost | Annual O&M Cost | Total Annual Production Cost | Cost (per 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 |

## Wastewater Treatment Technologies

Wastewater treatment in the SFWMD is provided by regional, municipal, or privately owned wastewater treatment facilities, small developer/homeowners association or utility-owned wastewater treatment facilities, and septic tanks for some single family homes. Wastewater treatment in the SFWMD is regulated by the Florida Department of Environmental Protection (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

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

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 2013b).

The *2013 Reuse Inventory* (FDEP 2014) indicates 112 wastewater facilities located within the SFWMD reused approximately 271 MGD of reclaimed water for beneficial purposes. Disposal of the remaining 575 MGD of treated wastewater was by deep well injection and discharge to the ocean. More information about existing wastewater treatment facilities, including water reuse data, is provided in the appendices of each regional water supply plan update.

## *Advanced Secondary Treatment*

Advanced secondary treatment typically refers to the addition of filtration and high-level disinfection to a standard secondary treatment facility. Treatment facilities that use reclaimed water for public access irrigation (the most common end use) must provide 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.

### Granular Media Filters Followed by Ultraviolet Disinfection

Filtration is a component of advanced secondary wastewater treatment, which provides a reclaimed water quality that can be 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 6-18**. The construction costs include all equipment, material, and installation; 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. The cost includes equipment, concrete, and installation.
- UV construction cost is based on an in-vessel medium pressure system.
- The facility infrastructure includes a building to house process equipment.

Table 6-18. Estimated costs for granular media filters followed by ultraviolet disinfection (From: CDM 2007a).

| Facility Capacity (MGD) | Construction Cost | Capital Cost | Equivalent Annual Capital Cost | Annual O&M Cost | Total Annual Production Cost | Cost (per 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 |

## *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. AWT 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 6-19** 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 6-19. Estimated costs for advanced wastewater treatment – five-stage Bardenpho process (From: CDM 2007a).

| Facility Capacity (MGD) | Construction Cost | Capital Cost | Equivalent Annual Capital Cost | Annual O&M Cost | Total Annual Production Cost | Cost (per 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 |

### 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 membranesand eliminates the need for clarification and tertiary filtration. The membranes typically are 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 6-20** shows the costs for the membrane bioreactor process.

Table 6-20. Estimated costs for advanced wastewater treatment – membrane bioreactor process (From: CDM 2007a).

| Facility Capacity (MGD) | Construction Cost | Capital Cost | Equivalent Annual Capital Cost | Annual O&M Cost | Total Annual Production Cost | Cost (per 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 |

## 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. The construction costs for the MF and RO process include pre-treatment facilities, an MF system, and an RO system. **Table 6-21** presents the costs for the MF and RO process. The following assumptions are used to develop cost estimates for the MF and RO option:

- Pre-treatment construction cost includes estimates for rotary drum 2-mm fine screens.
- MF system cost is based on a submerged MF system and includes equipment, concrete, and installation.
- RO system cost includes membranes, a break tank, an 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 6-21. Estimated costs for advanced wastewater treatment – microfiltration/reverse osmosis (From: CDM 2007a).

| Facility Capacity (MGD) | Construction Cost | Capital Cost | Equivalent Annual Capital Cost | Annual O&M Cost | Total Annual Production Cost | Cost (per 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 |

# 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 on the contaminant (i.e., any physical, chemical, biological, or radiological substance or matter in water) [Section 403.852(9), F.S.].

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 SAS, while saltwater intrusion presents a potential threat to aquifers. Once a contaminant enters an aquifer, it can 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 PWS wells and wellfields from activities that present a possible contamination threat is preferable. Many counties have enacted ordinances for well protection.

### *Saltwater Intrusion*

Saltwater intrusion is the movement of saline water into freshwater aquifers and can occur laterally or vertically. The intrusion of saline water could occur in most coastal aquifers hydraulically connected to seawater. Within the SFWMD, 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 could be contaminated by saline water. Relict seawater (connate water with high salinity) is found in some areas of the District in deeper portions of the SAS. As the freshwater aquifer is pumped, upconing of saline water may occur, which could degrade water supplies. PWS 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 FAS wells within the District. The causes of contamination vary. Several artesian wells were drilled into the FAS for agricultural water supply and oil exploration from the 1930s through the 1950s. The wells were constructed with casings that extend to approximately 200 feet or less below land surface (bls). This construction method exposed shallower freshwater zones to invasion by more saline FAS water.

Over time, the steel casings of some properly constructed wells have corroded, allowing interaquifer exchange. 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 FAS water is used as a supplemental source for agriculture during periods of water shortage, brackish water can infiltrate the SAS.

The Water Quality Assurance Act passed in 1981 requires FAS wells to be equipped with a valve capable of controlling 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 PWS 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; for example, 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 (2009) 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)*.

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 substantial 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 (2002) 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*, 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 threat to groundwater resources. Many of Florida's older landfills and dumps were used with little or no control 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 that 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 depends on several factors that dictate the extent and character of the resulting groundwater impacts, including the following:

- Landfill size and age
- Types and quantities of wastes produced in the area
- Local hydrogeology
- Landfill design and filling 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 high health and environmental risks. 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 and 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.

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# Appendix: Conservation Glossary

This appendix contains a glossary of conservation measures and practices, as discussed in **Chapter 2**. This information was initially developed by the Central Florida Water Initiative (CFWI) Conservation sub-team. The measures and practices herein have been edited, as needed, for this *Support Document for the 2021-2024 Water Supply Plan Updates*.

INFO ⓘ

**Water User Groups**

AG – Agriculture

CII – Commercial/Industrial/Institutional

L/R – Landscape/Recreational

PG – Power Generation

PS – Public Supply*

RES – Residential*

*Note: PS measures and practices apply specifically to the utility and not the end user(s). The RES group includes all residential end users regardless of water source (i.e., PS utility-supplied water or private well).

# CONSERVATION MEASURES (HARDWARE)

## Indoor

**Clothes washer high-efficiency replacement (RES, CII)** – Replacement of conventional clothes washers with water-efficient models (ENERGY STAR qualified). High-efficiency models often feature innovative tub designs and high-speed spin cycles and typically are more energy efficient than conventional models.

**Combination oven high-efficiency replacement (CII)** – Replacement of conventional combination ovens in commercial kitchens with water-efficient models. A combination oven can function as a steam cooker or a conventional (hot air) oven. Conventional models consume up to 40 gallons of water per hour. Boilerless models and some new boiler-type models can save more than 100,000 gallons of water per year compared with traditional models. High-efficiency models are programmable, with low-energy idle settings.

**Dishwasher high-efficiency replacement (RES, CII) –** Replacement of standard dishwashers with water-efficient models (ENERGY STAR qualified). High-efficiency dishwashers include several innovations, such as "soil" sensors, high-efficiency jets, and dish rack designs that reduce energy and water consumption and improve performance.

**Faucet aerator high-efficiency replacement (RES, CII)** – Replacing existing faucet aerators with United States Environmental Protection Agency (USEPA) WaterSense-labeled, high-efficiency kitchen and bathroom faucet aerators.

**Faucet installation, metered-flow (CII) –** Use of faucets that have a specified flow rate and duration setting (in seconds) typically triggered by a sensor. The typical rate is 0.25 gallons per cycle. Water savings are obtained by allowing only a preset volume of water to flow for each cycle rather than allowing the user to manually control the faucets operation (or walk away leaving a faucet running while not in use).

**Heating, ventilation, and air conditioning (HVAC) efficiency improvements (CII) –** Increasing HVAC cooling tower water use efficiency through the use of conductivity meters (to determine when to bleed off water), drift eliminators (to reduce water drifting away from towers), makeup and blowdown submeters (to calculate cycles of concentrations), and/or possibly pre-treatment devices and chemicals.

**Hot water use (efficient) (RES, CII) –** Use of close proximity "instant hot" heaters or electric showers that instantly heat water as it passes through the unit. Water savings are obtained by avoiding the purging of cold water first as the hot water moves from the water heater or boiler source through the system to the point of use.

**Ice making machines high-efficiency replacement (CII) –** Replacing conventional ice machines with water-efficient models (ENERGY STAR qualified). Efficient models use approximately 23% less water than standard models.

**Metering and submetering (indoor) (CII, PG) –** Installation of water meters and/or submeters at pumping facilities, at critical locations throughout a manufacturing system, or on other high-volume, water-using equipment. Information collected from meters can help detect leaks and calculate and maintain system efficiencies.

**Pre-rinse spray valve high-efficiency replacement (CII) –** Replacing conventional pre-rinse spray valves with more efficient models, such as USEPA WaterSense-labeled equivalent products. These devices are used primarily in restaurants and bars but are also found in commercial office buildings and institutions that have cafeterias. Other possible applications include food processing/washing stations.

**Showerhead high-efficiency replacement (RES, CII) –** Replacing conventional showerheads with more efficient models, such as USEPA WaterSense-labeled equivalent products.

**Steam cooker replacement, high-efficiency (CII) –** Replacing conventional commercial kitchen steamers with water-efficient models (ENERGY STAR qualified). On average, ENERGY STAR qualified steam cookers use 3 gallons of water per hour versus approximately 40 gallons of water per hour for standard steam cooker models.

**Toilet, flapperless use (RES, CII)** – Using toilets designed to hold flush water in a pan within the tank, thus not requiring any flapper and avoiding potential losses from this leak source. Kits may be available to convert conventional tanks to flapperless.

**Toilet, redesigned flapper use (RES, CII)** – Using toilet flappers designed for longer life. Standard rubber flappers deteriorate over time due to toilet bowl cleaners placed in the toilet tank or chemicals used by utilities. Use of a long-life flapper decreases the frequency of leaking tank toilets due to flapper deterioration.

**Toilet fill cycle diverters (RES, CII) –** Using a diverter to redirect water that would typically drain down the overflow tube back into the toilet tank during the fill cycle. The diverter increases efficiency by conserving up to 50% of the fill cycle water, which would otherwise flow down the drain.

**Toilet high-efficiency replacement (RES, CII) –** Replacing conventional toilets (using more than 1.6 gallons per flush) with more efficient models, such as USEPA WaterSense-labeled equivalent products.

**Toilet replacement, dual flush (RES, CII) –** Replacement of a standard tank toilet with more efficient models, such as USEPA WaterSense-labeled, dual-flush toilets, which feature two buttons or handles to flush with different volumes of water. The smaller volume (typically 0.8 to 1.1 gallons) is designed for liquid waste, and the larger volume (typically 1.28 to 1.6 gallons) is designed for solid waste.

**Urinal replacement high-efficiency (CII) –** Replacing conventional urinals with more efficient models, such as USEPA WaterSense-labeled equivalent products.

**Urinal replacement, waterless (CII) –** Replacing conventional urinals with more efficient models, such as USEPA WaterSense-labeled equivalent products. This practice could be applied to new CII facilities but may have limited application. This device is recommended primarily in new construction as there are challenges to successful implementation in existing buildings. In all applications, special maintenance is required.

## Indoor/Outdoor

**Air-cooled devices (CII)** – Replacing water-cooled devices with air-cooled devices and equipment at CII facilities. Examples of equipment that can use air cooling include air compressors, vacuum pumps, ice machines, refrigeration condensers, hydraulic equipment, and X-ray processing equipment.

**Automatic shutoff valve use (CII) –** Employing the use of water valves that automatically shut off water flow to water-using equipment or shut off the equipment altogether when a user-determined water level, volume, or time interval is reached. Water savings are increased compared with manually operating valves primarily due to operator inconsistencies (e.g., letting water flow too long).

## Outdoor

**Auto pump start/stop (AG) –** These devices automatically start and stop irrigation pump engines. The grower controls the pumps remotely or by using other sensor data such as air temperature, rain, or soil moisture. Water is conserved by allowing growers or farm managers who are responsible for multiple pumps (often more than 10 pumps) to start and stop pumps based on crop needs instead of when time allows them to visit each pump station.

**Automated valves (AG, L/R) –** Using irrigation system valves, which can be operated remotely or automatically shut off when a sensor indicates a certain water level, soil moisture level, irrigation volume, or time interval is reached. Water savings are realized over manually operated valves primarily due to operator inconsistencies (e.g., letting water flow too long).

**Car wash equipment, low flow/recirculating (CII) –** Using either a portable, high-pressure, low-flow device to replace the use of a hose for car washing or using a recirculating system that captures, treats, and reuses wash and rinse water at commercial car wash facilities.

**Fully enclosed seepage irrigation system conversion (AG) –** The replacement of open or semi-closed seepage irrigation systems with more efficient, fully enclosed seepage systems. Fully enclosed seepage irrigation systems increase irrigation efficiency by reducing losses due to evaporation and runoff from open or semi-closed seepage irrigation systems.

**Gated and flexible pipe for field water distribution systems (AG) –** The use of gated and flexible irrigation piping in an agricultural operation. This measure is applicable to agricultural producers who plant row crops and is used to convey irrigation water to furrow- or border-irrigated fields. Gated and flexible pipe reduces seepage losses associated with open-channel distribution and increases efficiency and uniformity of delivery to the furrows (e.g., by reducing deep percolation of irrigation water near the head of the field). Cost effectiveness varies based on site-specific seepage rates in open channels and field layout (i.e., furrow spacing). Furrow dikes typically are used in arid and semi-arid regions, so applicability in Florida is limited.

**Irrigation efficiency nozzle and head use (AG, RES, CII, L/R) –** Increasing irrigation efficiency by switching irrigation hardware to more efficient nozzles and heads. Efficiency can be achieved through increased distribution uniformity and less drift loss.

**Irrigation retrofit/replacement with a more efficient irrigation system or system components (AG, RES, CII, L/R)** – Replacing an existing irrigation system or component with a more efficient system or component. Some examples are listed herein as individual measures.

**Isolation valve use (AG, L/R) –** Installation of valves that separate main irrigation lines and major laterals from the water supply source. These valves isolate all or part of the system for repairs, maintenance, or winter shutdown. These devices can save water as they allow for the repair of a portion of the system without running the entire system.

**Line flushing, automatic devices (PS) –** Flushing water lines is a routine practice of utilities to meet and maintain water quality requirements within distribution lines. An automatic device can achieve and maintain the desired water quality levels in a water distribution system by releasing prescribed volumes of water, at a regulated frequency or (when smart technology is incorporated) per automatic on-site water quality sampling. These devices typically are more efficient than manually opening a fire hydrant.

**Line flushing, looping (PS) –** Line looping is a design approach for water supply conduit infrastructure that involves the installation of new piping to connect existing dead-end lines to existing sections of piping with higher demands (usually the main trunk line). By installing flow-regulating valves and diverting additional flows through the local area where the dead-end line was located, the need for flushing often can be reduced or eliminated.

**Line flushing, unidirectional (PS) –** Unidirectional line flushing is a routine practice of utilities to meet and maintain water quality requirements and to scour biofoul and sediments from distribution lines. Distribution lines are flushed at high velocity in a pattern whereby only previously scoured pipes (clean) precede the next section of pipe targeted for cleaning. This method of flushing has been shown to scour distribution lines using less water than other methods.

**Linear move sprinkler irrigation system conversion (AG) –** Increasing irrigation efficiency by installing a more efficient, linear-move sprinkler irrigation system in place of a less efficient irrigation system.

**Lining of irrigation canals and on-farm irrigation ditches (AG) –** Lining of open conveyance canals and on-farm ditches with impervious material to decrease conveyance losses from seepage.

**Low-pressure, center-pivot sprinkler irrigation system conversion (AG) –** Replacing an irrigation system with more efficient, low-pressure, center-pivot sprinklers. These systems increase irrigation efficiency by reducing losses due to evaporation and runoff compared to high-pressure, center-pivot systems or seepage irrigation systems.

**Metering and submetering water (outdoor) (AG, CII, L/R) –** Installation of water meters in pumping facilities and at critical locations throughout an irrigation system. Irrigation meters typically register flow rate and total volume. Information collected from meters can help detect leaks and calculate irrigation efficiencies.

**Micro-irrigation use (drip/bubbler/micro-spray) conversion (AG, RES, CII, L/R) –** Increasing irrigation efficiency by switching irrigation methods to low-flow hardware in landscape beds. Most types of micro-irrigation deliver water below the plant canopy and directly to the root ball, resulting in higher application efficiencies than sprinklers. Micro-irrigation emitters apply less than 30 gallons per hour.

**Multi-stage greenhouse control systems (AG) –** In Florida, greenhouses commonly are cooled using fog or fan and pad evaporative systems. As temperatures rise, multi-stage controllers can separately open greenhouse vents, then run cooling fans and delay turning on the fog or wetting system for the evaporative cooling pads until needed. These controllers operate in the reverse direction as temperatures drop. These adjustments in water use can reduce the amount of water lost to evaporation.

**On-farm irrigation ditch replacement with pipelines (AG) –** Replacement of on-farm conveyance ditches with pipelines to decrease conveyance losses from seepage by replacement of open channels with pipelines. This is applicable to irrigated farms that use an open ditch to convey irrigation water, and as an alternative to lining the ditch. It is limited by ditch capacity (typically limited to ditches with less than 5 cubic feet per second capacity) and cost. Cost effectiveness varies based on site-specific seepage rates in open channels and required pipe size based on capacity.

**Rain sensor shutoff device (AG, RES, CII, L/R, PG) –** Using a device that interrupts the operation of an automatic irrigation system during and shortly after significant rainfall events. Water is conserved by preventing the application of irrigation water when it is not necessary. Functioning automatic shutoff devices are required by state statute on all irrigation systems regardless of the year built.

**Shade control structures (AG) –** Installation of structures to provide shade and temperature control from direct sunlight, reducing evapotranspiration (ET) and soil drying, which reduces irrigation needs. Shade structures provide other advantages for crops such as bird protection, hail protection, and some wind protection. Because shade structures can reduce air mixing during cold radiation events, temperatures inside often are colder than outside, so supplemental heating may be needed.

**Smart irrigation controllers (AG, RES, CII, L/R) –** Smart (or advanced) irrigation controllers are those that monitor and use information about site conditions (e.g., soil moisture, rain, wind, slope, soil, plant type) and apply the amount of water necessary to meet plant needs based on those factors and plant species (www.irrigation.org). There are generally two types of smart controllers: climatologically based controllers (also known as weather- or ET-based controllers) and soil moisture sensor-based controllers. Water is conserved by automatically controlling the system based on crop water needs.

There are three types of ET-based controllers:

1) Signal-based controllers receive weather and climate data from publicly available sources or a paid provider.
2) Historical ET-based controllers use a pre-programmed crop water use curve for different regions.
3) On-site, sensor-based controllers use real-time, on-site measurements of soil and weather conditions to calculate ET continuously and adjust the irrigation scheduling accordingly.

There are two types of soil moisture sensor-based controllers:

1) Bypass systems are most commonly used for small sites, including most residential lots. A soil moisture sensor-based system will irrigate according to soil moisture thresholds, set by the user, which should correspond to plant species needs, accounting for soil and other local climate conditions. This arrangement will bypass a scheduled irrigation event if soil moisture content is sufficient due to antecedent rainfall or irrigation.
2) On-demand soil moisture sensor controller systems are set to irrigate when soil moisture falls below a set threshold and terminate the irrigation event when the threshold has been met.

**Soil moisture sensor(s) (AG, RES, CII, L/R)** – These devices interrupt the operation of an irrigation system when the soil reaches field capacity or excess irrigation water is draining below the root zone of the crop. Water is conserved by preventing the application of water when it is not necessary. Soil moisture sensors can also indicate when the soil moisture drops too low and irrigation is required. In some cases, this measure has increased water use.

**Tensiometers in field or container blocks (AG)** – A tensiometer measures soil moisture or soil water content. By knowing the water content in the root zone, a grower can make an informed decision about when irrigation is necessary.

**Water control structures (AG) –** Use of a structure or series of structures in a water management system to convey water, control the direction or rate of flow, and/or maintain a desired water surface elevation. Typical water control structures consist of a combination of drops, chutes, turnouts, surface water inlets, pipe drop inlets, box inlets, head gates, flashboard risers, culverts, and pipes, all in varying sizes and shapes.

**Water table observation wells (AG) –** Use of water table monitor wells placed in agricultural fields to show the grower how high the water table is in the field. The depth to the water table indicates whether further irrigation is required and prevents irrigation when it is not needed. Depth readings can be taken manually or monitored remotely. This practice is limited to certain soil types, such as those with a spodic or clay horizon.

**Weather station with ET measurement (AG, CII, L/R) –** An irrigation controller or computerized system incorporates real-time weather data to automatically update scheduled irrigation events. This can include a rain sensor that interrupts the operation of an automatic irrigation system during and after rainfall events, or a temperature and relative humidity sensor that helps the grower decide when to turn the irrigation system on or off for frost or freeze protection. Some irrigation controllers do not automatically change scheduled irrigation events, but the data collected by the weather station can be used by the grower to limit irrigation to only the amount of water that was not supplied by rainfall.

**Wind blocks (AG) –** Planting of trees or bushes along the perimeter of a field to reduce and deflect winds, which reduces evaporation. Lower evaporation rates can translate to lower irrigation needs.

## Other

**Advanced metering infrastructure and advanced metering analytics (PS)** – Automatic meter reading refers to technology that automatically collects consumption data from water meters and transfers that data to a central database for billing, troubleshooting, and analyzing. Advanced metering infrastructure represents the networking technology of fixed network meter systems that go beyond automatic meter reading into remote utility management. In addition to saving labor costs, these technologies help water providers more accurately monitor water use and demand management program effectiveness, detect leaks, and account for revenue and non-revenue water. Advanced metering analytics is the use of computer technology to analyze water use and identify high water users, potential leaks, and use patterns.

**Treatment system efficiency increases (PS) –** A utility may be able to reduce water losses within the water treatment process and at the treatment plant via the following actions: metering unit processes, increasing water use efficiency of the treatment components, recirculating water where feasible, routinely checking for water leaks, and outfitting storage tanks and reservoirs with overflow check valves.

# CONSERVATION PRACTICES

## Indoor

**Dish and clothes washer practices (RES, CII)** – Eliminating the running of partial loads in favor of running only fully loaded appliances.

**Food preparation and washing (RES, CII)** – Decreasing the water used to rinse, wash, and prepare food.

**Garbage disposal efficient use (RES, CII)** – Decreasing the time and flow rate of disposal and food grinder water use. Regular maintenance and water use monitoring (to maintain efficiency settings) can reduce water use. Automatic shutoff (every 15 minutes) can help reduce loss as well. Using cold water only will reduce energy consumption. This practice may also include the scraping of food waste directly into the garbage and avoiding the use of a grinder or disposal altogether.

**HVAC cycles of concentration (CII)** – Various methods and technologies can increase the cycles of concentration in cooling tower operations. A cycle of concentration is related to how often fresh water can be pumped around the system before the water accumulates impurities and has to be bled off from the system or augmented with fresh water. The higher the cycles of concentration, the less makeup water is required, thereby maximize water efficiency.

**Indoor high-efficiency codes adoption (RES, CII)** – The adoption of codes requiring high-efficiency fixtures and devices in new construction and major renovations of existing structures. New appliances and fixtures typically reduce water use 20% (or more) compared to equivalent conventional models. Codes can be adopted in conjunction with high-efficiency irrigation and landscaping standards or separately. High-efficiency indoor water use codes can be adopted statewide, by local governments per ordinance, and by water management districts via rule. Some utilities may be able to require implementation of high-efficiency codes as a condition of service.

**Indoor residential water use assessment/audit (RES) –** Many utilities provide indoor water audits to customers upon request, or the audit may be initiated by the utility as a result of high water use on a customer's bill. The purpose of the audit is to assess the customer's water use to determine how much can be saved versus how much is being used and to educate and assist the customer in conserving water and reducing their water bill. Water conservation kits and conservation literature often are provided to the customer as part of the audit. Auditors typically check the water meter for movement in order to detect water leaks; check the faucets, shower heads, and hot water heaters for leaks; and check under cabinet sinks, the hot and cold water hoses on the customer's clothes washer, and the outside water spigots and hoses for leaks.

**Restriction of one-pass (once-through) equipment (CII)** – Precluding any processes or equipment that use water only once before discharge. Types of equipment that typically use one-pass cooling are ice machines, X-ray equipment, ice cream and yogurt machines, walk-in coolers, vacuum pumps, air compressors, condensers, hydraulic equipment, degreasers, CAT scanners, and some air conditioning equipment.

**Retrofit at resale requirement (RES, CII)** – Local ordinances or conditions of service that require the replacement of inefficient fixtures and/or appliances at the time of housing resale or major improvement (renovations).

**Steam boiler efficiency (CII)** – Increasing the operating efficiency of steam boiler equipment. This may entail improving water quality, increasing boiler cycles, and/or capturing and reusing boiler condensate for makeup water.

**Water use ethic (PS, AG, RES, CII, L/R, PG) –** Encapsulates all water-conserving behaviors that are voluntarily employed (e.g., fewer toilet flushes, shortened or limited faucet and shower use).

**Water use survey (RES)** – A questionnaire-based survey designed to gain an understanding of a user's or community's water use (e.g., volumes used for specific tasks, patterns/timing of use). The data acquired can be used by property owners and/or conservation professionals to better understand use patterns and to identify practices, measures, and/or design programs to increase water use efficiency.

## Indoor/Outdoor

**Facility water use assessment/audit (CII)** – A formal, comprehensive assessment or audit of all aspects of a CII facility's water use (indoors and outdoors). This self-audit process precedes the development of a water use efficiency improvement plan. The South Florida Water Management District (SFWMD) has developed a facility water use efficiency self-audit guidebook for commercial and institutional facilities (SFWMD Commercial Institutional Self-Audit Guidebook) that may also have some applicability to residential settings (See *Water Use Efficiency Improvement Plan Development* below).

**On-site generated gray water reuse (RES, CII)** – Capturing gray water from sinks and showers, treating it, and reusing it for some other purpose (typically toilet flushing).

**Process water control and recycling (CII)** – Capturing water from part of an industrial or commercial process for reuse in another on-site process.

## Outdoor

**Allow lawn to go dormant (RES, CII, L/R)** – Curtailing or discontinuing lawn irrigation during the winter months when grass is dormant.

**Brush control/management (AG) –** The removal and/or reduction of brush to reduce ET. It is typically applicable to non-irrigated land in areas with sufficient rainfall. Brush near a crop field competes with the crop for the available water, resulting in a need for increased irrigation.

**Contour farming (AG)** – Creating beds of consistent elevation on properties with sloped land reduces runoff and increases water infiltration, so less supplemental irrigation is required.

**Conversion of supplemental irrigated farmland to dry-land farmland (AG)** – Switching to a crop that does not require irrigation to supplement rainfall.

**Crop residue management and conservation tillage (AG)** – Soil tillage improves soil's ability to hold moisture, reduces the amount of runoff from the field, and reduces evaporation of water from the soil surface.

**Cyclic scheduled irrigation (AG, L/R)** – Irrigating over a short period of time until surface water pooling starts, then stopping irrigation to allow infiltration. This is applicable to nearly all direct application (i.e., surface) irrigation methods. Applying irrigation in short bursts rather than in longer cycles ensures effective infiltration with minimal runoff. This conserves water by reducing runoff, thereby increasing application efficiency. Cyclic irrigation can also be used to decrease water loss in container nurseries.

**Distribution system audits, leak detection, and repair (PS, CII, PG) –** A water distribution system audit primarily helps utilities understand the various components of their water balance and their non-revenue water sources and costs. Tools are available to help utility managers conduct this type of analysis. Acoustic equipment often is used to pinpoint leaks in the distribution system. A successful leak management strategy requires pressure management, active leakage control, pipeline and asset management, and rapid and quality repairs.

**Fertilization efficiency practices (AG, RES, CII, L/R)** – Optimizing fertilizer use (through application timing, volume, and watering methods) with the goal of protecting groundwater and surface water quality. Additionally, efficient fertilizer use can reduce the need to irrigate.

**Furrow dikes (AG) –** The addition of dikes in irrigation furrows to control distribution of surface water within a field, which reduces runoff and increases infiltration of rain or applied irrigation. Furrow dikes typically are used in arid and semi-arid regions, so applicability in Florida is limited.

**Green roofs (CII) –** The installation of a roof that is partially or completely covered with vegetation. A green roof absorbs rain (reducing stormwater runoff) and provides insulation to reduce heating, thus reducing indoor cooling loads. By reducing cooling loads, less water is consumed by cooling tower units.

**Group plants according to water needs (AG, RES, CII, L/R) –** The practice of grouping plants with similar water needs together (to be irrigated on the same irrigation zone). Water savings are realized by not overwatering plants with a lower irrigation need in order to meet the higher irrigation demands of plants in the same irrigation zone.

**Irrigation codes, adoption of higher efficiency (RES, CII, L/R) –** The adoption of codes with high-efficiency irrigation design standards for a region, county, municipality, or utility service area. The codes aim to reduce the volume of water used to meet plant needs (supplemental to rainfall) and to deliver water in application patterns that minimize waste. Examples include requiring water-efficient and/or pressure-regulating sprinkler heads, head-to-head coverage, the use of micro-irrigation (where applicable), and irrigation of plants with similar water needs separate from other plant types with different needs. Codes can be adopted in conjunction with high-efficiency landscaping and/or indoor standards or separately. High-efficiency irrigation water use codes can be adopted statewide, by local governments per ordinance, or by water management districts via rule. Some utilities may be able to require implementation of high-efficiency irrigation practices as a condition of service.

**Irrigation scheduling (AG, RES, CII, L/R) –** The development of an irrigation schedule to determine when and how much to irrigate based on the irrigation system type and efficiency, weather conditions, crop requirements, and soil characteristics. Local weather stations and soil moisture sensors can help adapt the schedule to the real-time site conditions. Water savings are obtained by not over-watering plants.

**Irrigation system audit/evaluation (AG, RES, CII, L/R)** – Evaluation of in-ground irrigation systems. Most audit evaluations include inspection of the irrigation equipment and controllers, performance of sprinkler precipitation tests, calculation of a site-specific water budget, and derivation of an irrigation schedule based on test and local weather data that serve as a precursor to a water-efficiency improvement program. The SFWMD has developed a full-facility water use efficiency self-audit guidebook for commercial and institutional facilities, which includes irrigation system evaluation procedures (SFWMD Commercial Institutional Self-Audit Guidebook). Many elements of this guidebook could also be used for residential systems.

**Landscape codes, adoption of water efficiency (RES, CII, L/R) –** The adoption of codes with high-efficiency landscape design standards for a region, county, municipality, or utility service area. The codes aim to reduce the volume of water used (supplemental to rainfall) to meet plant needs. Examples include using plants adapted to the local environment, limiting the use of plants with high-irrigation needs, and requiring some part of the landscape to remain unirrigated. These codes can be adopted in conjunction with high-efficiency irrigation and/or indoor standards or separately. High-efficiency landscape codes can be adopted statewide, by local governments per ordinance, or by water management districts via rule. Some utilities may be able to require implementation of high-efficiency practices as a condition of service.

**Landscape efficiency audit (RES, CII, L/R)** – A formal audit of a landscape to evaluate elements that can improve water use efficiency. The audit typically includes an inspection of plants' compatibility with local climate and soil conditions, placement (with respect to shading and size at maturity), grouping (plants arranged with similar needs such as water and fertilizer), and management (including mulching, weeding, and pruning) The SFWMD Commercial Institutional Self-Audit Guidebook could also be referenced for residential landscapes.

**Laser land leveling (AG)** – A laser transmitter can produce a horizontal laser plane, grading a field to the conditions needed to conserve water on the site. This practice increases irrigation uniformity and decreases runoff.

**Licensed irrigation and design (professional, working with) (RES, CII, L/R)** – Contracting with an irrigation company licensed with a local government or the state. This ensures that projects are overseen by an individual who has demonstrated technical and financial competency and experience at the management level. Obtaining a state license is currently voluntary.

**Limiting high-volume irrigation areas (RES, CII, L/R)** – Decreasing or eliminating high-volume irrigation areas within a landscape such as sprinklers or emitters with flow rates of 30 gallons per hour or 0.5 gallons per minute or greater.

**Limiting irrigated areas (RES, CII, L/R)** – Decreasing or eliminating irrigation by adding or increasing areas landscaped with plants that do not need irrigation supplemental to the area's natural rainfall and can withstand periods of drought. In practice, this usually allows irrigation to establish plant material but not thereafter.

**Limiting use of turfgrass (RES, CII, L/R)** – The appropriate and prudent use of turfgrass where it serves an identified purpose. When integrated in the landscape with intention, turfgrass has many benefits such as erosion control, creating recreational areas, and stormwater runoff reduction. However, turfgrass often requires the greatest amount of irrigation supplemental to rainfall in a man-made landscape and is typically overused. This is congruent with the Florida-Friendly Landscaping program's principle of planting the right plant in the right place.

**Limiting turf traffic on golf courses (L/R)** – Limiting cart and pedestrian traffic to paths in order to minimize turf wear and limit soil compaction, thus reducing stress and water needs of the turf.

**Mowing height adjustment (RES, L/R)** – Using the correct mowing height for turfgrass to reduce water needs during the hot summer months. Increased mowing height allows grass roots to grow deeper, which allows them to survive longer without supplemental irrigation.

**Net irrigation requirement-based irrigation determination (AG, RES, CII, L/R)** – Calculating the specific water needs of an irrigated landscape based on plant material, soil type, irrigation system efficiency, and weather. The difference between the daily crop demand (ET) and the daily effective rainfall (amount of natural rainfall available to the plant's root zone, excluding deep percolation, runoff, and plant interception) will closely predict the daily net irrigation requirement. This practice involves a trained technician (irrigation manager or auditor) tracking a water balance estimate to give the grower a refined schedule of when to irrigate and how much water to apply.

**On-site rain harvesting and reuse (CII) –** The capture and storage of rainfall runoff in a barrel (small-scale) or cistern (large-scale). This water typically is used for irrigation but can be used for other purposes. While not conservation in a traditional sense (as no improvement in water use efficiency occurs as a direct result), this practice can reduce demand from potable or other supply sources.

**Routine system maintenance (AG, RES, CII, L/R)** – Inspecting irrigation system components for compromised integrity and ensuring any previously replaced emitters are compatible with the original irrigation system design. Pressure losses through leaks and inappropriately sized components can cause inefficiencies and non-uniform irrigation patterns throughout the production field.

**Sidewalk and driveway cleaning practices (RES, CII, L/R)** – Removing debris with a broom or leaf blower rather than with a hose to conserve water.

**Soil amendment use for water efficiency (AG, RES, CII, L/R)** – Amending the soil to improve its physical properties (e.g., water retention, permeability, water infiltration, drainage, aeration, structure). Improved soil conditions can decrease the frequency of required irrigation.

**Soil cultivation techniques (spiking, slicing, and core aerification) (AG, L/R)** – Spiking, slicing, and/or core aerification of the soil to improve permeability, water infiltration, drainage, aeration, and structure. Improved soil conditions can decrease the frequency of required irrigation.

**Surge flow irrigation use for field water distribution systems (AG) –** Intermittently applying water to furrows in seepage irrigation systems. This practice is applicable to agricultural producers who currently use gated or flexible pipe (see above) to distribute irrigation water to furrow irrigated fields and who have soil types that swell and reduce infiltration rates in response to irrigation. This practice increases efficiency and uniformity of delivery to the furrows (by reducing deep percolation of irrigation water near the head of the field) and reduces the potential for ponding and runoff. Water saved by switching to surge flow is estimated to be between 10% and 40%.

**Swimming pool and hot tub water use efficiency (RES, CII, L/R)** – Active practices such as routinely and consistently using pool covers, detecting and repairing leaks, and reducing drains and fills by increasing water quality.

**Turfgrass maintenance for water efficiency (RES, CII, L/R)** – Employing management techniques directed at increasing drought tolerance of turf. Techniques include proper mowing height, fertilizer application, thatching, aerating, seeding, and top dressing applications.

**Turfgrass, improved cultivar uses (RES, CII, L/R) –** The use of drought-tolerant turfgrass cultivars. Cultivars should be selected to accommodate the intended use pattern and survive in the local soil and climate conditions with minimal or no need for irrigation supplemental to rainfall.

**Volumetric measurement of irrigation water use (AG)** – Maintaining an accurate assessment of the irrigation water use. Helpful direct volumetric measuring devices include properly calibrated (propeller/magnetic flux/ultrasonic) flow meters and pipe pressure meters. Indirect measuring devices include energy use of the pump and duration of the irrigation event.

**Water use efficiency improvement plan development (AG, CII, L/R, PG)** – Intentionally developing a written water use plan focused on increased water use efficiency. The plan should outline a specific implementation roll-out and monitoring program. This typically is preceded by a comprehensive water use audit (or survey).

## Other

**Conservation analysis using a planning tool (PS) –** The use of predictive models, which can evaluate conservation measures and practices, to estimate the associated program costs, savings, impacts on revenues, and other financial considerations. These planning tools help utilities develop water conservation plans with a numerical goal for achievable water savings. Goals typically are expressed as gallons per capita per day or a specified volume reduction.

**Goal-based water conservation planning (PS)** – Creating a demand management plan tied to a measurable, numeric goal (gallons per capita per day or a volume) to be met within a specified time according to an implementation schedule. A well-designed plan identifies a variety of measures and practices that target specific user groups. The circumstances of the utility will determine which conservation practices and measures are economically feasible and desirable to implement. Water conservation planning tools are available to help utilities develop these plans.

**Improved billing and accounting software (PS) –** Improved billing and accounting software is used by utilities to decrease non-revenue water by identifying billing and data-handling errors and inconsistencies and by identifying meter inaccuracies. Many billing software packages have built-in analysis functions that can identify potential data-handling errors, by either meter readers or the utility's billing department, and report them for verification. In addition, billing software will report monthly estimated readings and zero reads, both of which may indicate a problem with a customer's meter. Site visits will help identify meters that need replacing.

**Other proven water conservation techniques and ideas (PS, AG, RES, CII, L/R, PG)** – Allows new water conservation and water savings techniques, measures, and ideas to be included for water conservation and/or savings. These measures should be proven to have a net water resource benefit and may include practices currently being researched, unknown, or not recognized.

**Rate structure (PS) –** The primary purpose of water pricing is to cover utility costs, but it can simultaneously be an effective means to promote water conservation through rate structure design. A conservation-based rate structure provides a financial incentive for end users to reduce wasteful water use. A rate structure that responsibly minimizes fixed charges, places more emphasis on volume-related charges, and has an inclining block rate structure will typically conserve more water than a flat or uniform rate structure that generates the same amount of revenue. Users faced with proper rate incentives will achieve water conservation by implementing conservation measures. Forecasting and rate models designed to analyze the effects of rate structures can be used to help utilities develop rates for their service area.

**Water budget development (AG, RES, CII, L/R)** – Evaluating natural rainfall and plant ET to determine the relationship between input and output of water to and from the site. The budget considers plant type, plant water needs, irrigation system design, and the water received by the crop's root zone via rainfall or irrigation during times of water deficit. Water budgets are associated with a specific amount of time (i.e., weekly) to schedule irrigation events and reduce or eliminate overwatering.

**Crop row covers/frost blankets (AG)** – Fabrics that cover crops during frost/freeze events help prevent damage to the plants. These products serve as weak insulators but reduce convectional heat loss, thereby creating a micro-climate around the plant that is warmer than outside the cover. This practice can reduce or eliminate the need to irrigate during frost/freeze events. Crop row covers/frost blankets can be used if there is a sufficient labor force available to deploy and anchor the covers before the freeze event.

**Selective inverted sink (AG)** – Use of an engine-driven propeller, placed parallel to the ground surface, to push cold air that accumulates in low areas where crops are grown upward, creating a suction effect that draws down warmer air during a radiation frost/freeze event. The use of inverted sinks can reduce the need to irrigate during certain frost/freeze events.

**Sprinkler heads and spacing retrofits (AG)** – Employing the use of irrigation systems that more efficiently apply water for frost/freeze protection. This can include changing the sprinkler spacing to improve uniformity or changing the sprinkler type to decrease the rewetting intervals. Decreasing the rewetting interval reduces application rates.

**Fog for cold protection in greenhouses/shade houses (AG)** – In greenhouses or polyethylene film-wrapped shade houses, using a low-volume fog system can effectively provide heat and reduce heat loss from the soil and plant surfaces when cold protection is required. The use of a low-volume system reduces the volume of water required for crop protection compared to a mist or sprinkler system.

**Wind machines (AG)** – The movement of air by an engine-driven wind machine mixes warmer air above a temperature inversion layer with cooler air at ground level during a radiation frost/freeze event. The use of wind machines may require selective inverted sinks (see above) and reduces the need to irrigate during certain frost/freeze events. Wind machines are only effective during radiation freezes (calm wind conditions), during which temperature inversions develop as cold air builds up near the ground (crop). Wind machines may eliminate the need to use water for cold protection during some radiation freezes, but water may still be needed when advective freezes occur.

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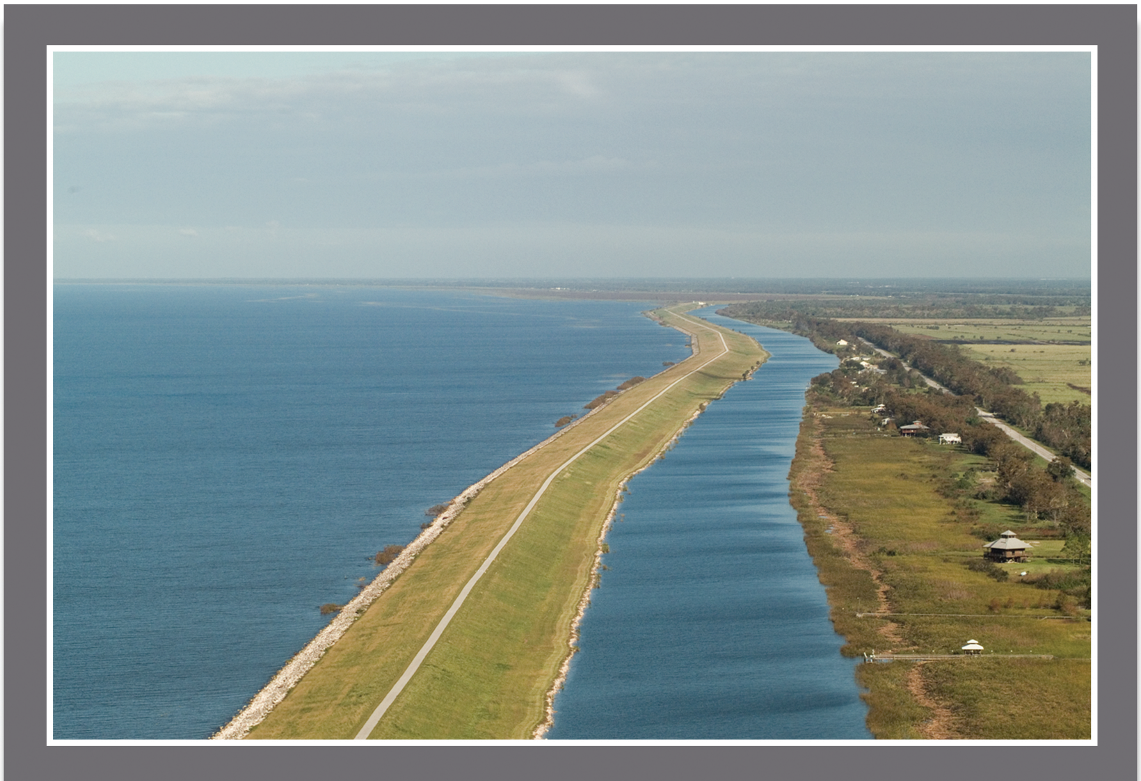

South Florida Water Management District is committed to managing and protecting our region's water resources

Meeting South Florida's water supply needs while safeguarding its natural systems requires innovative solutions, cohesive planning, and a shared vision.

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