March 2012

Enterprise Assessment for the Reduction of Nutrient Pollution in South Florida Waters

Final Report

Prepared for

The Everglades Foundation
18001 Old Cutler Road, Suite 625
Palmetto Bay, FL 33157

Prepared by

RTI International
3040 Cornwallis Road
Research Triangle Park, NC 27709

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Prepared by

George Van Houtven
Ken Reckhow
Ross Loomis
James Cunningham
Sara Casey
RTI International
3040 Cornwallis Road
Research Triangle Park, NC 27709

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EXECUTIVE SUMMARY

For over a century, surface waters in South Florida, and particularly the vast subtropical wetlands that make up the Everglades, have faced multiple pressures from human activities. These pressures include extensive drainage and channelization projects that have significantly altered the physical landscape and the timing, volume, and direction of water flows. They also include widespread agricultural, residential, and commercial development.

One of the main concerns for water quality has been excess inflows of nutrients (i.e., nitrogen and phosphorus) to surface waters as a result of these activities. Excess nutrients in surface water contribute to algal blooms, oxygen depletion, and other forms of ecological degradation.

As these impacts have become increasingly well recognized and understood, the State of Florida, in partnership with the federal and local governments and the South Florida Water Management District (SFWMD), has initiated several efforts to reduce nutrient loadings, restore wetland ecosystems, and improve water quality in South Florida. For example, 45,000 acres south of Lake Okeechobee have been converted to wetlands designed to treat excess phosphorus in waters bound for the Everglades. Domestic wastewater treatment facilities must meet federal and state standards limiting nutrients in their outflows, and these facilities are increasingly adopting technologies to reuse and recycle wastewater. Florida has also implemented a Best Management Practice (BMP) program to control surface runoff from farms, and it requires new urban and suburban developments to apply BMPs to reduce urban stormwater runoff.

These efforts have all contributed to improving water quality in South Florida, but they also have a price tag. The magnitude of current costs (and the prospect of higher future costs to meet stricter water quality standards) raises several issues and concerns.

- How large are the costs of existing nutrient control efforts in South Florida and how much are they reducing nutrient loads to surface waters?
- Who bears the cost of these nutrient control measures and how have they been shared across different sectors?
- How does the distribution and burden of costs compare with the contributions to nutrient loads in South Florida?

The purpose of this study is to address these questions.

ES.1 Scope of Analyses

This study evaluates these questions for activities related to reducing two primary nutrients, nitrogen and phosphorus, within the boundaries of the SFWMD. To conduct our analysis, the study area was subdivided into six major subbasins and three minor subbasins (see Figure 2-1 on page 2-2). Moreover, within each subbasin, we grouped costs and nutrient sources and reduction activities into the following four major categories, with the first two being primarily urban and the second two primarily agricultural:

- *Domestic Wastewater Treatment Facilities (WWTFs).* These facilities, which receive wastewater from residential, commercial, and industrial sources, are required to treat the wastewater to meet state and federal standards. Our analysis focused on the largest facilities within the SFWMD, which account for almost 90% of total domestic wastewater treatment capacity in the area. One benefit, though not the sole purpose, of these facilities is controlling nutrients. Rather than partitioning the costs of these efforts among the various purposes and given the paucity of information, we included the entire costs of treatment and disposal at these facilities in nutrient control.

- *Urban Stormwater BMPs*. In developed areas subject to Environmental Resource Permits from the State of Florida, developers are required to implement stormwater controls. As with the WWTFs, nutrient control is just one of the main benefits provided by these BMPs; however, the entire costs of these efforts are charged to nutrient control rather than attempting to partition them among the full range of possible benefits.

- *Agricultural BMPs.* Agricultural areas implement BMPs, and one of the major benefits of these BMPs is controlling nutrients. As with the urban BMPs, the entire costs of these efforts are charged to nutrient control. The report breaks these down further into crop type and BMP type.

- *Public Works Projects.* The federal and state governments have constructed several projects that reduce nutrients in discharges emptying into natural areas; the major examples are the Stormwater Treatment Areas (STAs) constructed in the Everglades Agricultural Area (EAA).

The analyses also investigate the primary funding sources for these nutrient control activities. The report provides specifics, but for the summaries, funding sources are identified as follows.

- *Federal Funds.* This category includes funds provided by federal agencies, including the U.S. Departments of Agriculture, Interior, Defense, and the U.S. Environmental Protection Agency.

- *State Funds.* This funding category includes funding provided by the Florida Legislature to state agencies, such as the Florida Department of Agriculture and Consumer Services or the Department of Environmental Protection.

- *Ad Valorem Taxes:* These funds are generated through property taxes levied by the SFWMD on all residential, commercial, and agricultural properties.

- *Agricultural Privilege Taxes.* These are funds collected by the SFWMD through a targeted levy on agricultural lands and used primarily to support construction and operation of the STAs.

- *Local Funds:* This category includes fees and taxes levied by local taxing districts such as counties and municipalities.

- *Private-Sector Sources:* Private-sector funding includes spending or fee payments by private-sector entities for nutrient reduction activities. Examples include user fees for wastewater treatment, costs borne by developers to meet stormwater BMPs, or costs borne by private agricultural interests to implement agricultural BMPs. In the report, these funding sources are specifically identified as appropriate.

ES.2 Estimated Size and Costs of Nutrient Load Reductions

The study estimates nutrient loads, removal rates, and costs for the domestic WWTFs, urban and agricultural BMPs, and for public works projects such as STAs for all of the subbasins in the SFWMD.

Before nutrient removal occurs, in the broadest terms, urban sources account for approximately 70 to 75% of both the nitrogen and phosphorus generated in South Florida, while agriculture produces about 20 to 25% of the total (see Figure ES-1).

In terms of nutrient removal, as shown in Figure ES-2, the urban WWTFs are responsible by far for most of the nutrient reductions, accounting for more than 90% of the 36,200 metric tons (MT) of nitrogen and 6,600 MT of phosphorus removed each year, followed by agricultural BMPs, which account for roughly 6% of the total removal. In comparing removal efficiencies, urban areas remove around 80% of the nitrogen and phosphorus they produce, while 26% or less of agricultural nutrients are removed.

Total nutrient control costs from these activities are estimated to be $866 million per year. Figure ES-3 shows how these costs are distributed across the main categories. Nutrient removals from urban sources account for over 80% of the total, whereas removals from the agricultural sector account for roughly 17%.

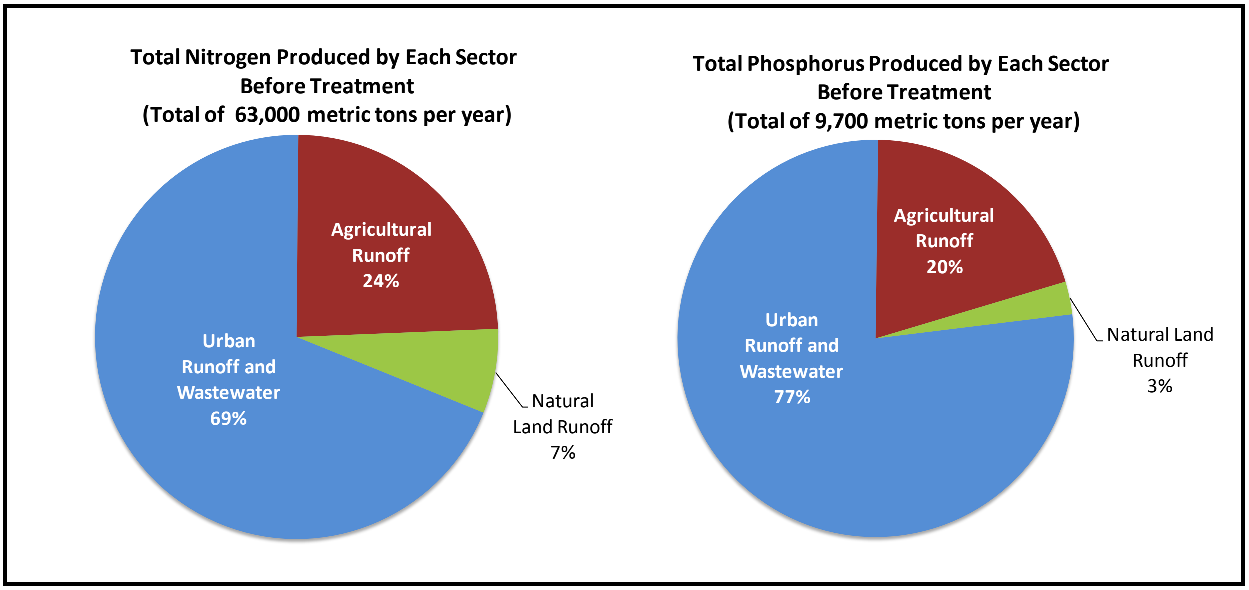


Figure ES-1. Total Quantities of Nitrogen and Phosphorus Produced by Each Sector before Treatment by WWTFs, BMPs, or Public Works Projects

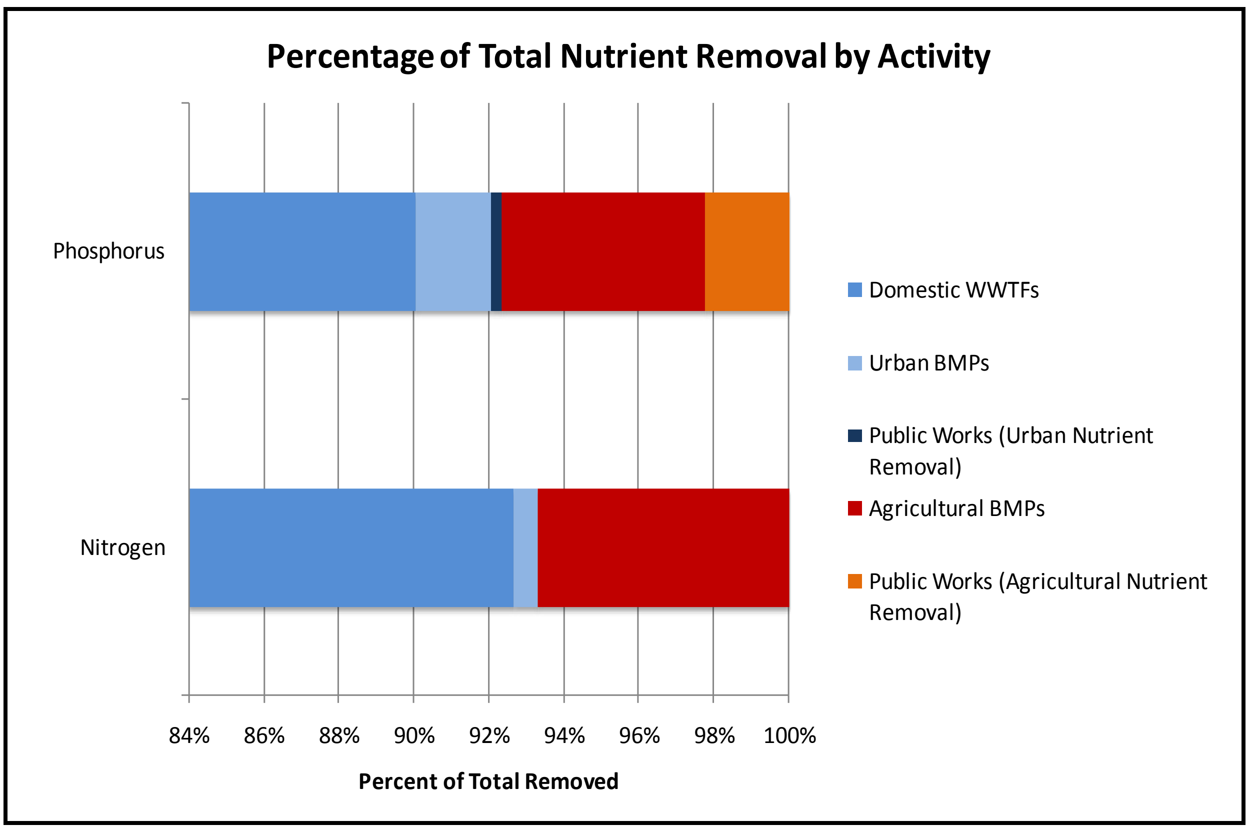


Figure ES-2. Domestic WWTFs Account for by Far the Largest Percentage of Total Nutrient Removal, Followed by Agricultural BMPs, Public Works Projects, and Urban Stormwater BMPs (note: percentage removal in diagram begins at 84%)

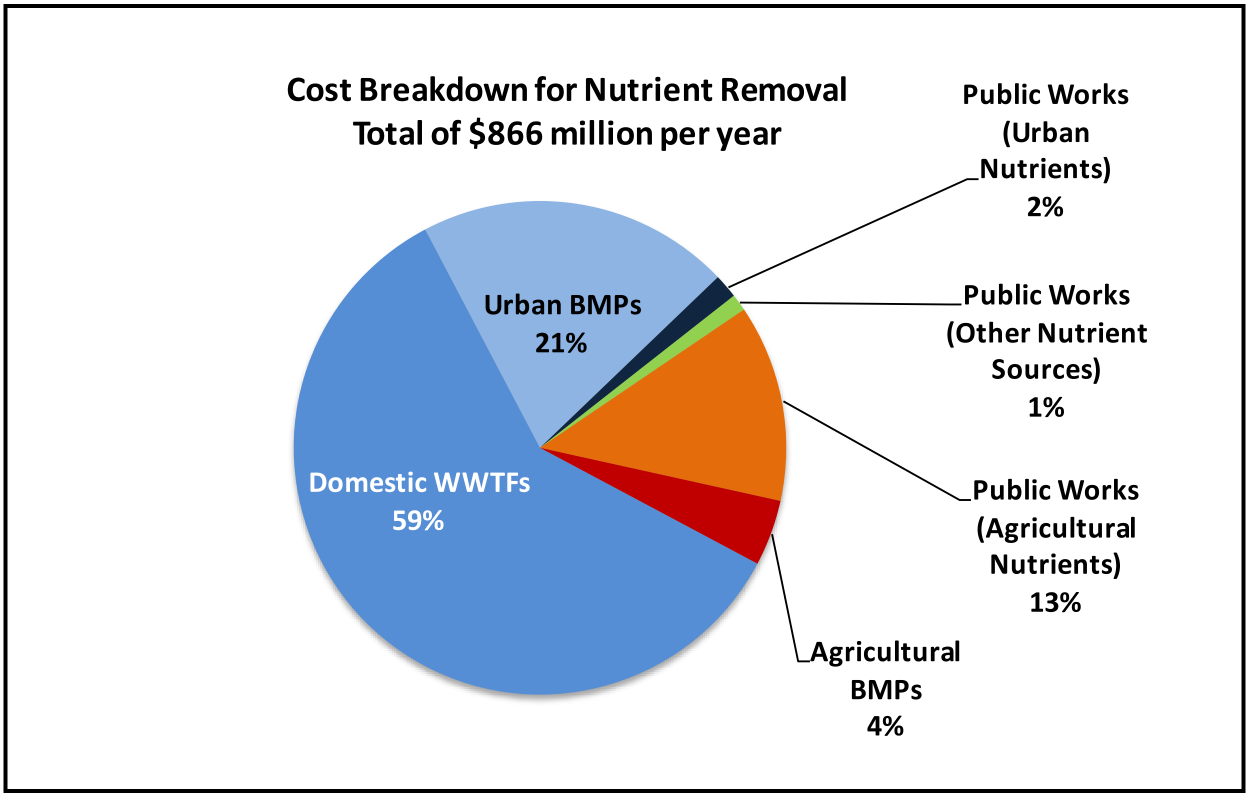


Figure ES-3. Cost Breakdown for the $866 Million Annual Expenditure. The largest costs are related to domestic WWTFs, urban stormwater BMPs, and public works projects such as STAs.

ES.3 Who Bears the Cost of Nutrient Controls?

Figure ES-4 shows the major funding sources for all of the estimated nutrient removal efforts in South Florida. Over 75% of the costs are paid through private residential and commercial sources, largely through wastewater treatment user fees to residences and businesses and through the costs of urban stormwater BMPs borne by commercial and residential developers and their customers. Governmental sources and ad valorem tax revenues account for about 18% of the funding, with the remaining 5% coming from agriculture, either in the form of private investment in BMPs (4%) or from the agricultural privilege tax, a levy used to pay for the STAs.

Figure ES-5 compares the funding distribution in the urban and agricultural sectors. Approximately 95% of the costs of urban nutrient removal are paid for by private residential and commercial sources. In the agricultural sector, about 27% of the costs of nutrient removal are borne by agricultural funding sources, with the remaining 73% derived from governmental sources. The largest public contributions for agricultural controls come from the ad valorem

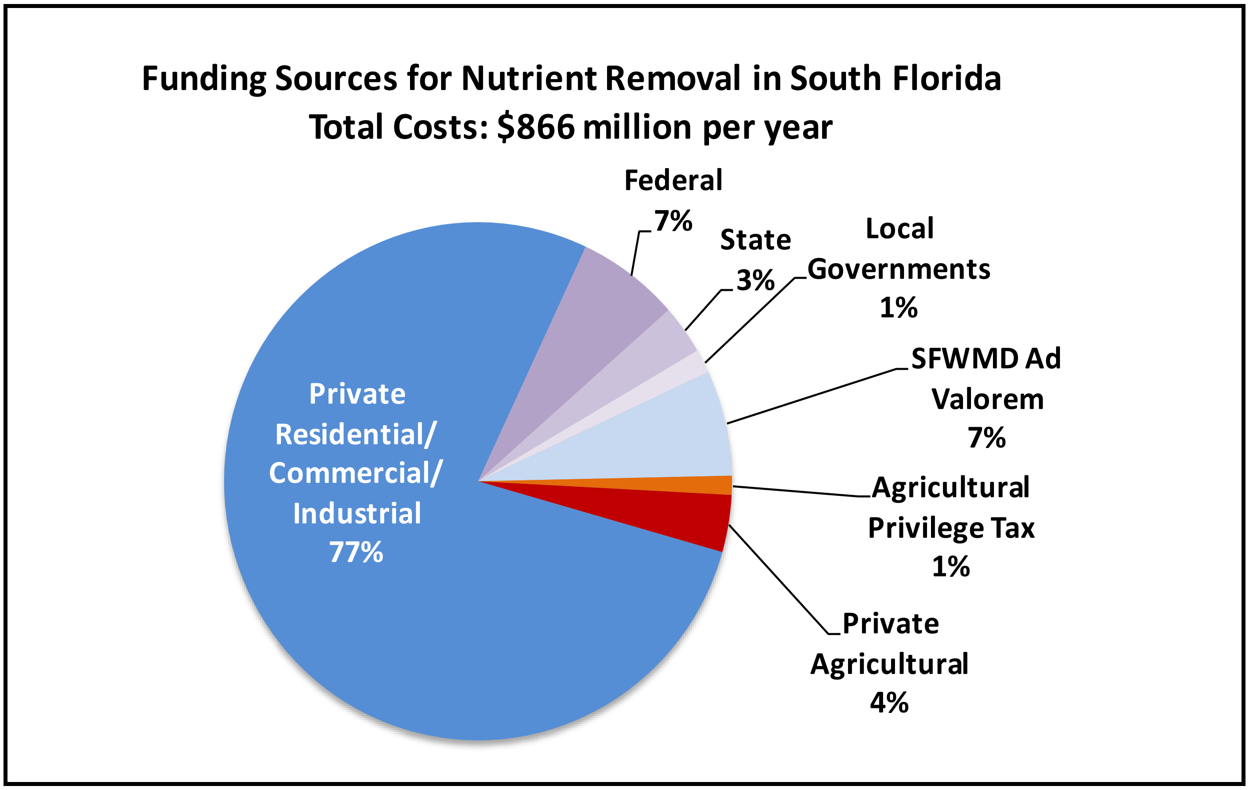


Figure ES-4. Almost 20% of the $866 Million in Annual Costs Are Paid for by Public-Sector Funding

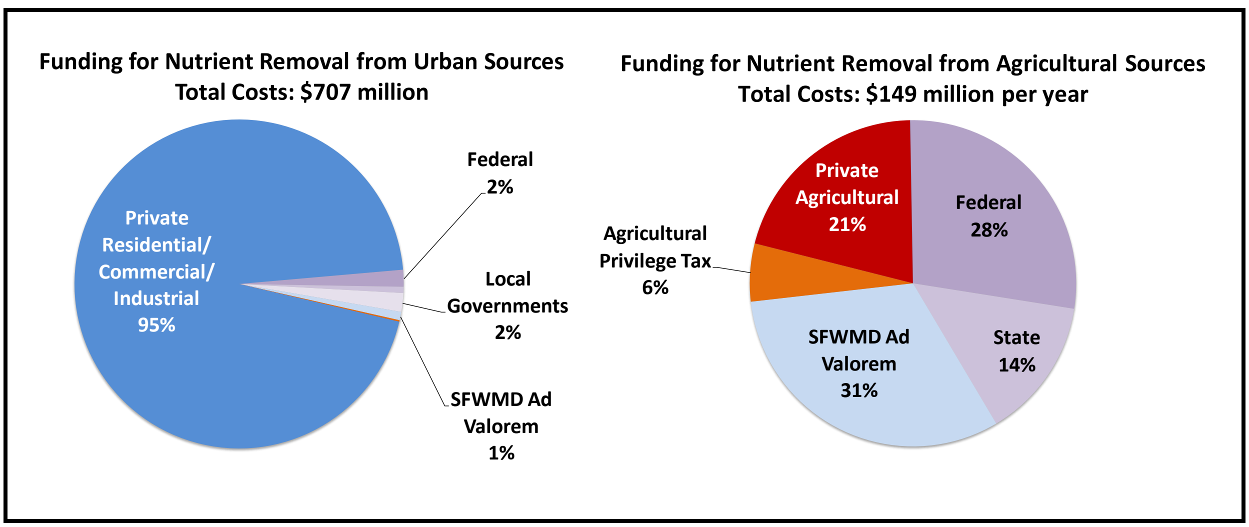


Figure ES-5. A Comparison of Funding Sources for Urban and Agricultural Nutrient Removal

property tax levied on all properties in the SFWMD (31%) and from the federal government (28%).

ES.4 Comparing the Distribution of Nutrient Loadings with the Distribution of Funding

At the broadest, level, Figures ES-1 and ES-4 compare nutrient loadings with funding for urban and agricultural nutrients. Roughly speaking, urban areas generate about 70% of the nutrients and contribute about 80% of the total funds for nutrient removal, while agriculture produces about 20% to 25% of the total nutrients while paying about 5% of the total costs. When examined by sector in Figure ES-5, the urban sector funds over 95% of the total cost to remove nutrients it generates, whereas agricultural entities fund about 26% of the costs to remove nutrients generated from their activities, and governmental sources cover the remainder.

Although this summary gives a broad overview, the report contains much greater specificity and detail that can used to address a broad range of questions. However, if the reader wishes to pursue specific questions on detailed topics, the report contains information by subbasin, nutrient removal project, and land use. For example, Section 6 contains specific information related to the public works projects, in particular the Everglades Construction Project (ECP) STAs in the EAA. Figure ES-6 summarizes findings from Section 6. In excess of 80% of the nutrient loadings are derived from agricultural sources, whereas 13% of the total funding is derived from primarily agricultural sources. The majority of funding (52%) is obtained from an ad valorem tax on property owners in the SFWMD.

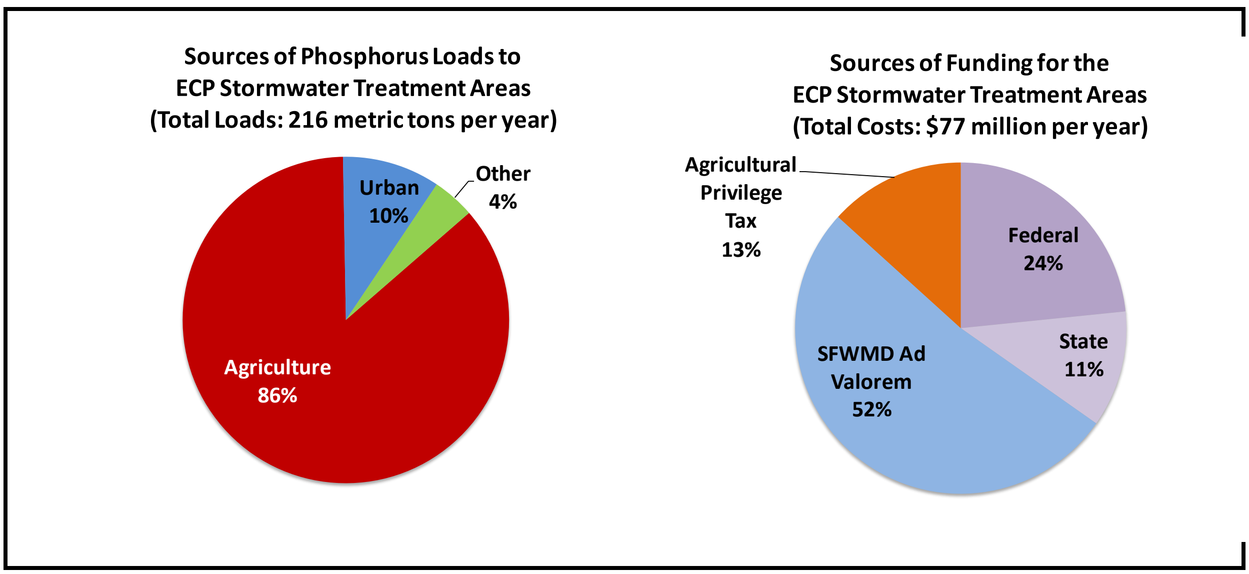
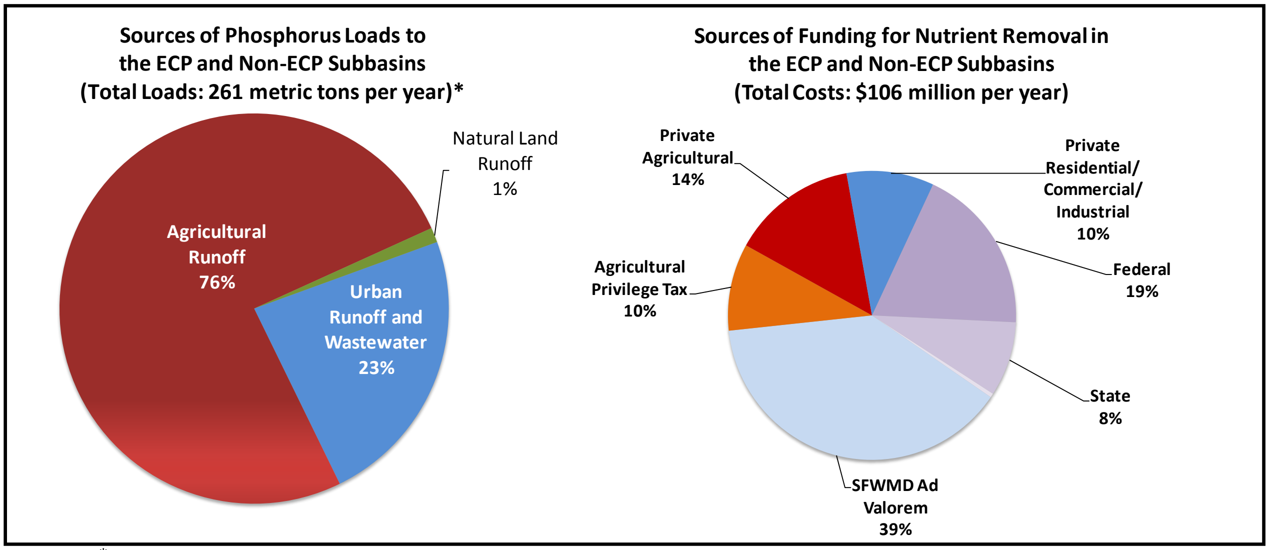


Figure ES-6. A Comparison of Nutrient Sources and Funding Sources for the ECP STAs

Figure ES-7 provides a similar summary for the ECP and non-ECP subbasins combined. The non-ECP subbasins are the ones that have discharge points into the Everglades Protection Area (EPA) without first being treated by STAs. Over 75% of the phosphorus loadings are derived from agricultural sources, whereas 24% of the total funding is derived from primarily agricultural sources. The majority of funding (39%) is obtained from an ad valorem tax on property owners in the SFWMD.



*deducts phosphorus removals from the STAs and the Western C-11 Project

Figure ES-7. A Comparison of Nutrient Sources and Funding Sources for the ECP and Non-ECP Subbasins Combined

SECTION 1
INTRODUCTION

For over a century, surface waters in South Florida, and particularly the vast subtropical wetlands that make up the Everglades, have faced multiple pressures from human activities. These pressures include extensive drainage and channelization projects that have significantly altered the physical landscape and the timing, volume, and direction of water flows. They also include widespread agricultural, residential, and commercial development. One of the main concerns for water quality has been excess inflows of nutrients (i.e., nitrogen and phosphorus) to surface waters as a result of these activities. Excess nutrients in surface water contribute to algal blooms, oxygen depletion, and other forms of ecological degradation.

As these impacts have become increasingly well recognized and understood, several efforts have been initiated to reduce nutrient loadings, restore wetland ecosystems, and improve water quality in South Florida. The Everglades Forever Act (EFA) of 1994 required tight limits on phosphorus for waters entering federal lands in the Everglades area, and 45,000 acres of land south of Lake Okeechobee have been converted to wetlands designed to treat excess phosphorus. Through partnerships with the federal government and the South Florida Water Management District (SFWMD), such as the Comprehensive Everglades Restoration Plan (CERP), several ecosystem restoration and related projects are being conducted to further reduce nutrient loads. In addition, domestic wastewater treatment facilities (WWTFs) must meet federal and state standards limiting nutrients in their outflows, and these facilities are increasing adopting technologies to reuse and recycle wastewater. The SFWMD has also implemented a Best Management Practice (BMP) program to control surface runoff from farms, and it requires new urban and suburban developments to also apply BMPs to reduce urban stormwater runoff.

These efforts have all contributed to improving water quality in South Florida, but they also have a price tag. The magnitude of current costs (and the prospect of higher future costs to meet stricter water quality standards) raises several issues and concerns.

- How large are the costs of existing nutrient control efforts in South Florida and how much are they reducing nutrient loads to surface waters?
- Who bears the cost of these nutrient control measures and how have they been shared across different sectors?
- How does the distribution and burden of costs compare with the contributions to nutrient loads in South Florida?

The purpose of this study is to address these questions. Below we begin by describing the methodological framework and approach we used in our analysis. The details of this analysis and our findings are then described in the subsequent sections of the report.

1.1 Overview of the Report and Analytical Approach

In Section 2, we begin by defining the geographic boundaries of the study area and the main surface waterbodies and hydrologic features of South Florida. To organize the analysis, we divided the region into seven distinct subbasins with distinct flow characteristics and with different connections to the Everglades and Lake Okeechobee. We then reviewed and categorized the main sources of nutrient loads in these areas, and we summarized the main programs and initiatives that have been implemented to reduce these loadings.

Based on our review of these sources and programs and our evaluation of publicly available information, we organized our analysis to focus on the following four main areas:

- domestic WWTFs and the methods used at these facilities to treat, dispose of, and reuse wastewaters containing nutrients (Section 3)
- runoff from agricultural areas and the BMPs used to control nutrient loads to surface water (Section 4)
- runoff from urban areas and the urban stormwater BMPs used to control their nutrient loads (Section 5)
- public works projects that have been implemented to further treat and remove nutrient loads, primarily to Lake Okeechobee and the Everglades (Section 6)

To conduct our analysis we relied on a wide range of publicly available data sources, studies, reports, and models that are described in each section of this report.

Our analysis focuses specifically on nutrient controls that are currently in place in South Florida. Because it provides the last full year of available data, we used the year 2010 to represent current conditions.

For each sector (including different subcategories of sources) and subbasin, we used the available information to estimate the following:

- **Annual "pretreatment" nutrient loadings**. These loadings represent our estimates of the amount (in metric tons [MT] per year) of nitrogen and phosphorus that *would be* currently discharged to surface waters *if the current controls for the sector were not in place*. This "counterfactual" scenario cannot be directly observed; therefore, we estimated these loadings as described in each section of the report.

- **Annual nutrient load reductions**. These load reductions are based on estimates of the "removal efficiencies" (i.e., percentage reduction in nutrient loads relative to pretreatment levels) for the control methods used in each sector.

- **Current annual nutrient loadings**. These "posttreatment" loadings represent current average annual conditions with controls for each sector in place. They are equal to the difference between the pretreatment and load reduction estimates for each source category.

- **Annual costs of nutrient load reductions**. These costs represent our estimates of the average annual cost burden associated with the control methods used in each sector. The "one-time" capital and implementation costs that have been incurred to install these controls were all annualized using a 4% discount rate and a 20-year lifetime. To these annualized costs, we added estimates of the average annual operation and maintenance (O&M) costs for each control type. To adjust for inflation, we converted all dollar values from previous years to 2010 dollars using the gross domestic product (GDP) price deflator.

- **Funding sources for control costs**. In many instances, the costs of the controls are borne and paid for by the nutrient sources themselves (e.g., residential ratepayers for wastewater utility services); however, a number of public (federal, state, and local) cost-share and subsidy programs and public works projects also play an important role. These public sources of funding are themselves supported by a combination of general and dedicated revenue sources. Using the various data sources and methods described in Sections 3 through 6, we allocated annual costs of load reductions to their respective public and private sources of funds.

In Section 7 of this report, we review and summarize our findings. In particular, we describe how the estimated nutrient loadings and load reductions are distributed across the main nutrient source sectors and control categories. We then describe how the total annual costs of nutrient controls are distributed across sectors and public/private sources of funding, and we compare these distributions with the distribution of loadings.

SECTION 2
OVERVIEW OF SURFACE WATERS, NUTRIENT SOURCES, AND EXISTING CONTROL EFFORTS IN SOUTH FLORIDA

In this section, we provide an overview of the South Florida study area and the main characteristics of its surface water flows. In particular, to organize our analysis, we divided the region into seven distinct subbasins (Figure 2-1). We then defined the main source categories of nutrient loads to surface waters in the region, and we summarized the main control efforts that are currently in place to reduce these loads. In Sections 3 through 6, we use this categorization to investigate the costs, funding, and load reductions achieved by different programs.

2.1 Surface Waters and Water Flows in South Florida

Figure 2-1 provides an overview of the South Florida study area and its hydrology. The colored areas, which together represent the study area, correspond closely with the boundaries of the SFWMD; however, they are specifically defined by the ecological boundaries of watersheds that drain to Lake Okeechobee, the Everglades, and the estuaries and other coastal systems in South Florida.

The Northern Lake Okeechobee subbasin includes the main portions of the Lake Okeechobee drainage area (as defined, for example, in the Lake Okeechobee Protection Plan [SFWMD, 2011a]), which extends from urban areas just south of Orlando to the agricultural areas around the lake (SFWMD, 2011c) (Figure 2-2). It includes the Upper Kissimmee Chain of Lakes, the Kissimmee River, Taylor Creek/Nubbin Slough, Lake Istokpoga, Indian Prairie, and Fisheating Creek.

Adjacent areas to the east, south, and west can drain into the Lake, but they primarily drain away from the Lake. The Caloosahatchee subbasin mainly drains west into the Gulf of Mexico via the Caloosahatchee Estuary (Figure 2-3). The St. Lucie subbasin mainly drains east into the St. Lucie Estuary and Indian River Lagoon (Figure 2-4). Both of these watersheds are marked by inland agricultural land use and a more urban coastal land use (SFWMD, 2005b). The Lake Okeechobee, Caloosahatchee, and St. Lucie subbasins are collectively referred to as the Northern Everglades.

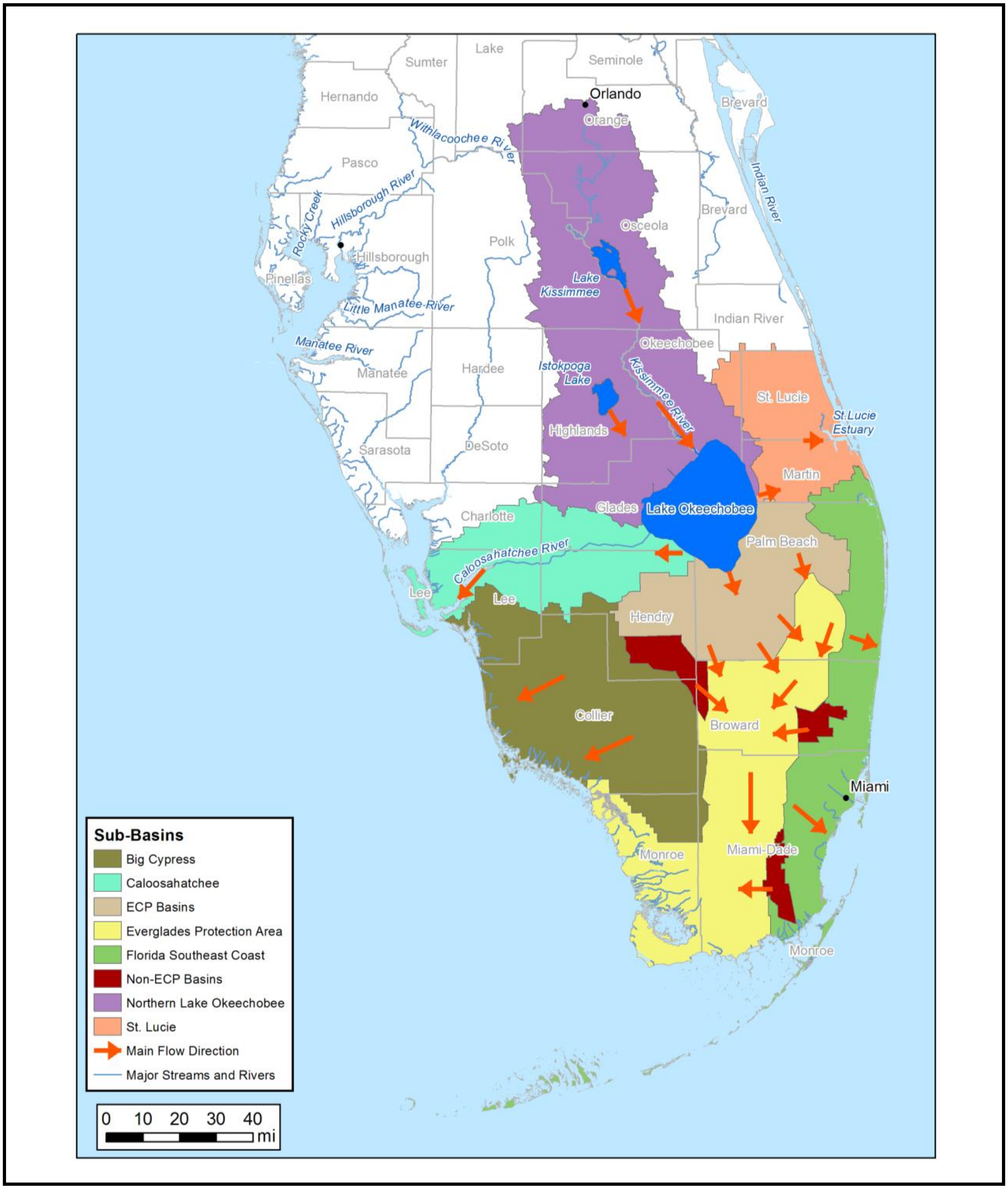


Figure 2-1. Drainage Subbasins in South Florida

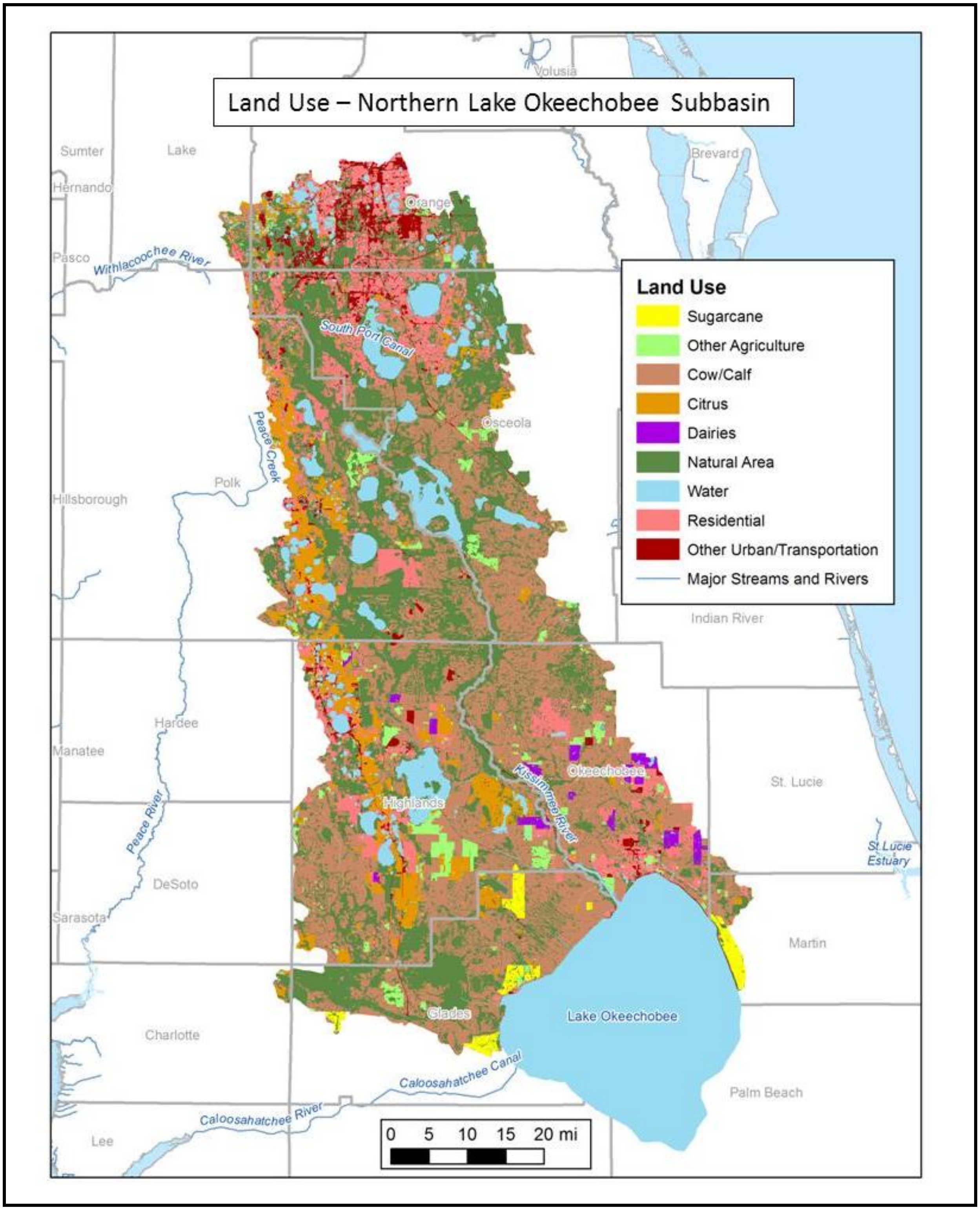


Figure 2-2. Land Use in the Northern Lake Okeechobee Subbasin

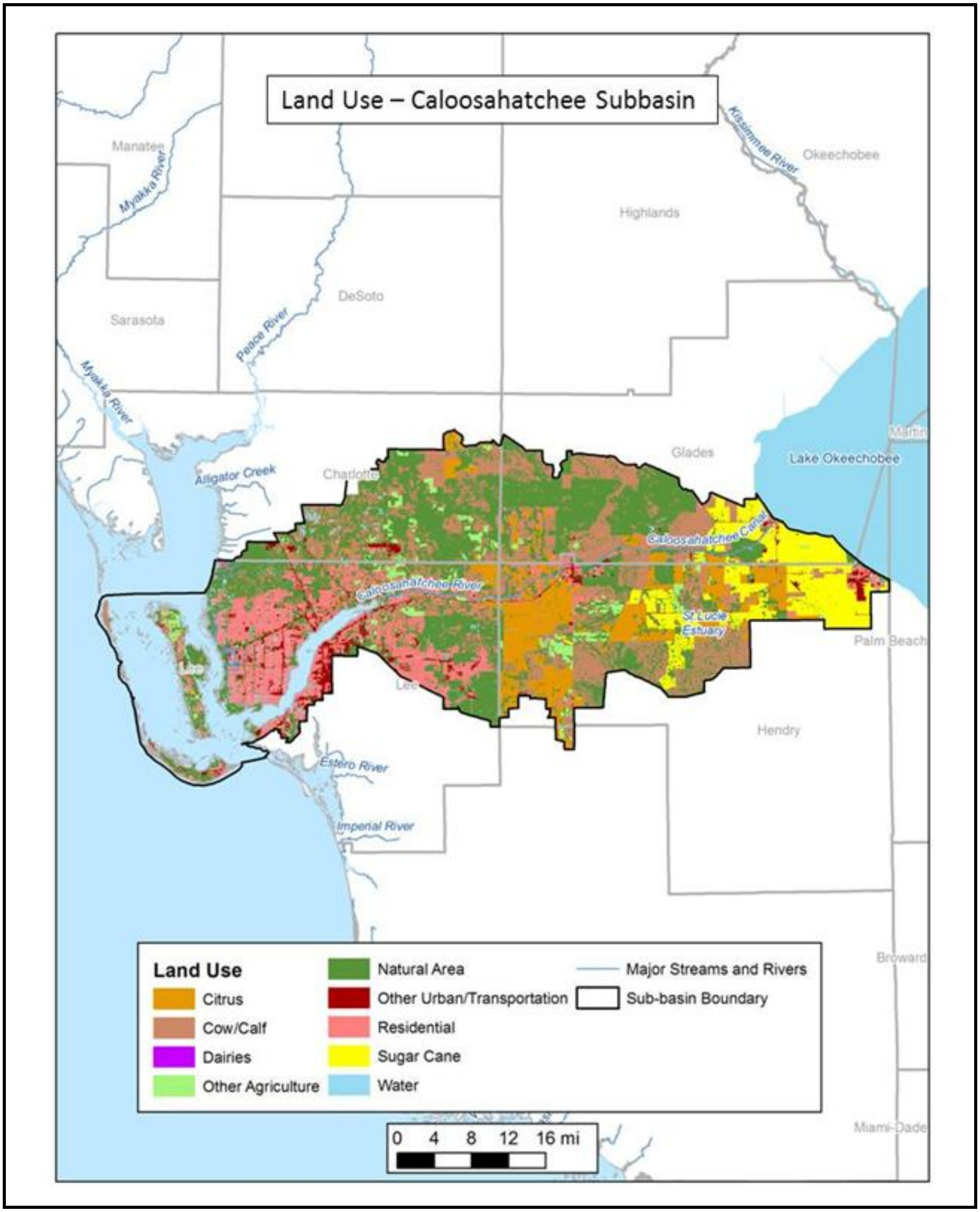


Figure 2-3. Land Use in the Caloosahatchee Subbasin

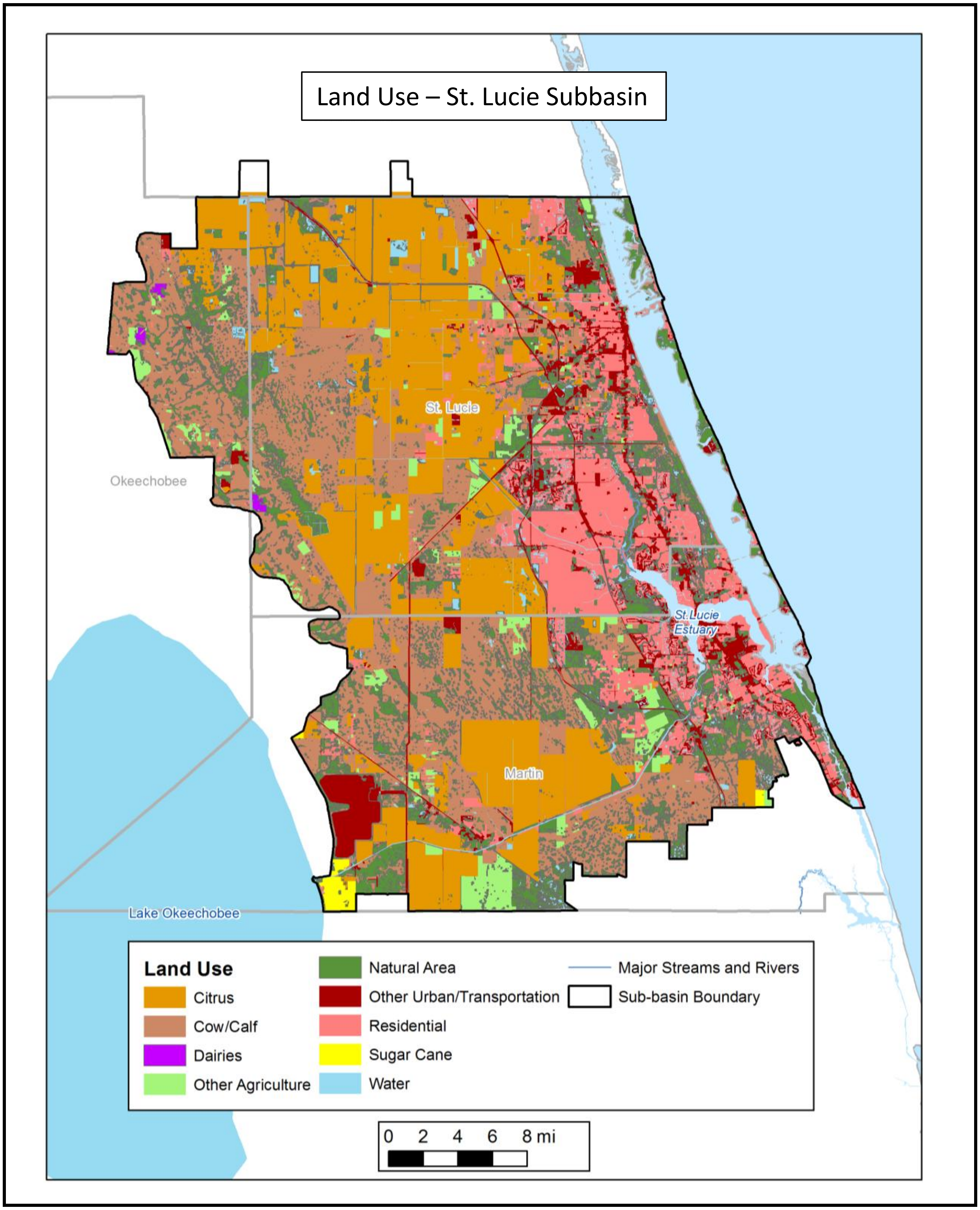


Figure 2-4. Land Use in the St. Lucie Subbasin

To the south of Lake Okeechobee, effluent from several basins can flow into areas of the Everglades Protection Area (EPA). Effluent from the Everglades Agricultural Area (EAA), C-139, L-8, and C-51W basins[1] is treated prior to being released into the EPA by stormwater treatment areas (STAs) created by the Everglades Construction Project (ECP) authorized by the Everglades Forever Act (EFA) of 1994. These basins are collectively referred to as ECP basins (Figure 2-5). Other basins have discharge points into the EPA without first being treated by STAs. These basins are referred to as the non-ECP basins (Figure 2-6).

To the east and west of the EPA are basins that drain to South Florida's coastal waters. To the west, the Big Cypress basin, which includes the Big Cypress National Preserve adjacent to the EPA, eventually drains to the Gulf of Mexico (Figure 2-7). We grouped the area east of the EPA as Florida's Southeast Coast. Surface water from this densely populated area drains into the Atlantic Ocean (Figure 2-8).

2.2 Nutrient Sources and Controls in South Florida

2.2.1 Point Sources

Nutrients can enter surface waters in South Florida from two types of sources: point and nonpoint. When pollution can be traced to a single identifiable location, such as a pipe, it is classified as point source pollution. Because outflow is traceable and known, regulations and controls can be more simply established for point source nutrient loads than nutrient loads delivered diffusely from multiple users across a broader area. To manage point source controls, the Florida Department of Environmental Protection (FDEP) was authorized to administer the National Pollutant Discharge Elimination Systems (NPDES) program through Section 402 of the Clean Water Act (CWA). Through this program the FDEP regulates 669 permitted domestic wastewater facilities and 110 municipal separate storm sewer systems (MS4s) in South Florida.

Domestic WWTFs are an important factor when looking at nutrient reduction because of their high levels of flow. In South Florida, the 669 domestic WWTFs have a combined total daily flow of 1,207 million gallons per day (MGD). Figure 2-9 shows the geographic distribution of these facilities. Ten facilities in South Florida are equipped with advanced wastewater treatment (AWT) systems, which are specifically designed to remove nutrients. The Florida effluent concentration requirements for AWT facilities are 3 mg/L of total nitrogen and 1 mg/L of total phosphorus (section 403.086(4), Florida Statutes). The remaining domestic WWTFs in South

[1] The alpha-numeric naming of different watersheds within South Florida results from the numeric naming of canals and water structures.

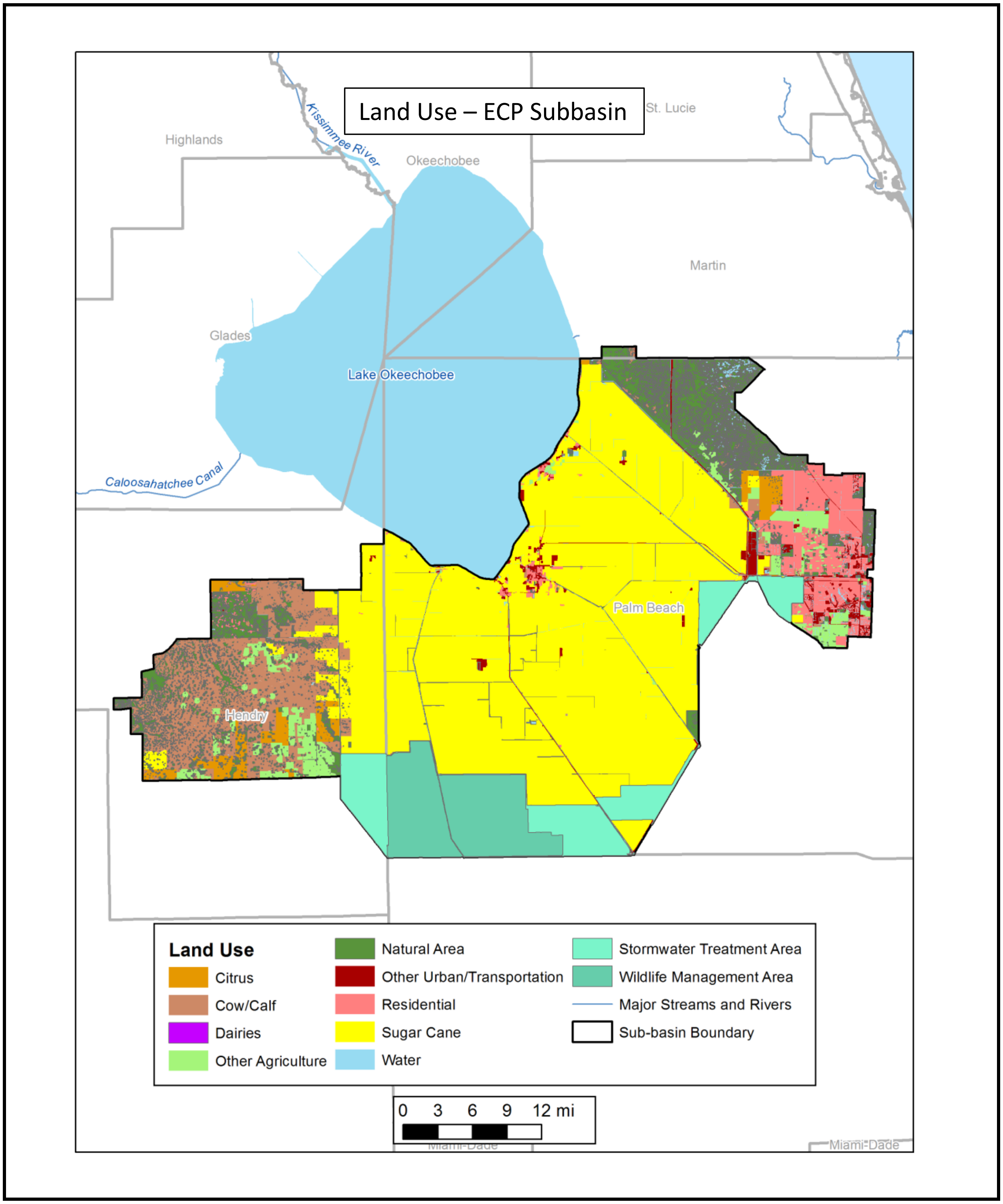


Figure 2-5. Land Use in the Everglades Construction Project Subbasins

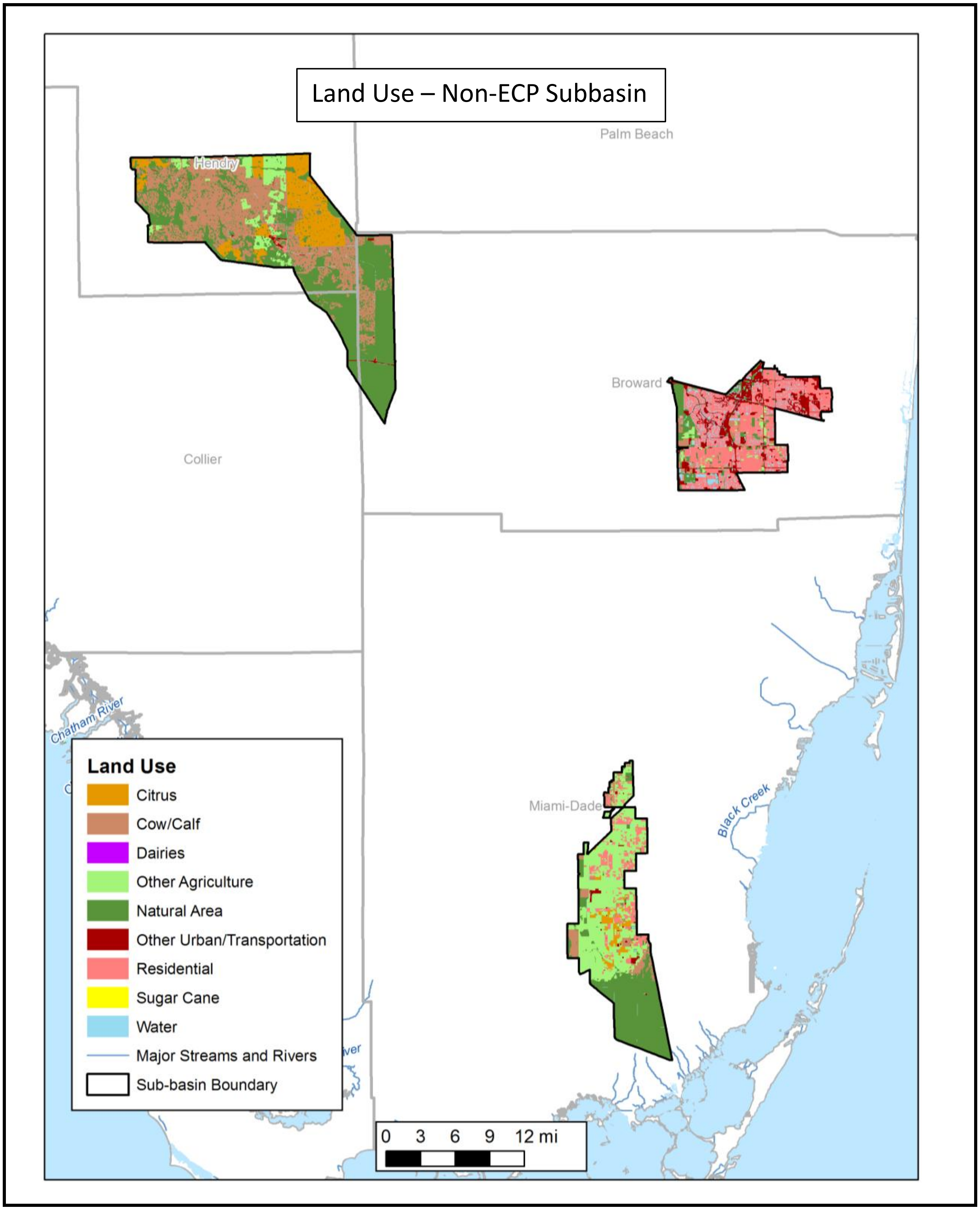


Figure 2-6. Land Use in the Non-Everglades Construction Project Subbasins

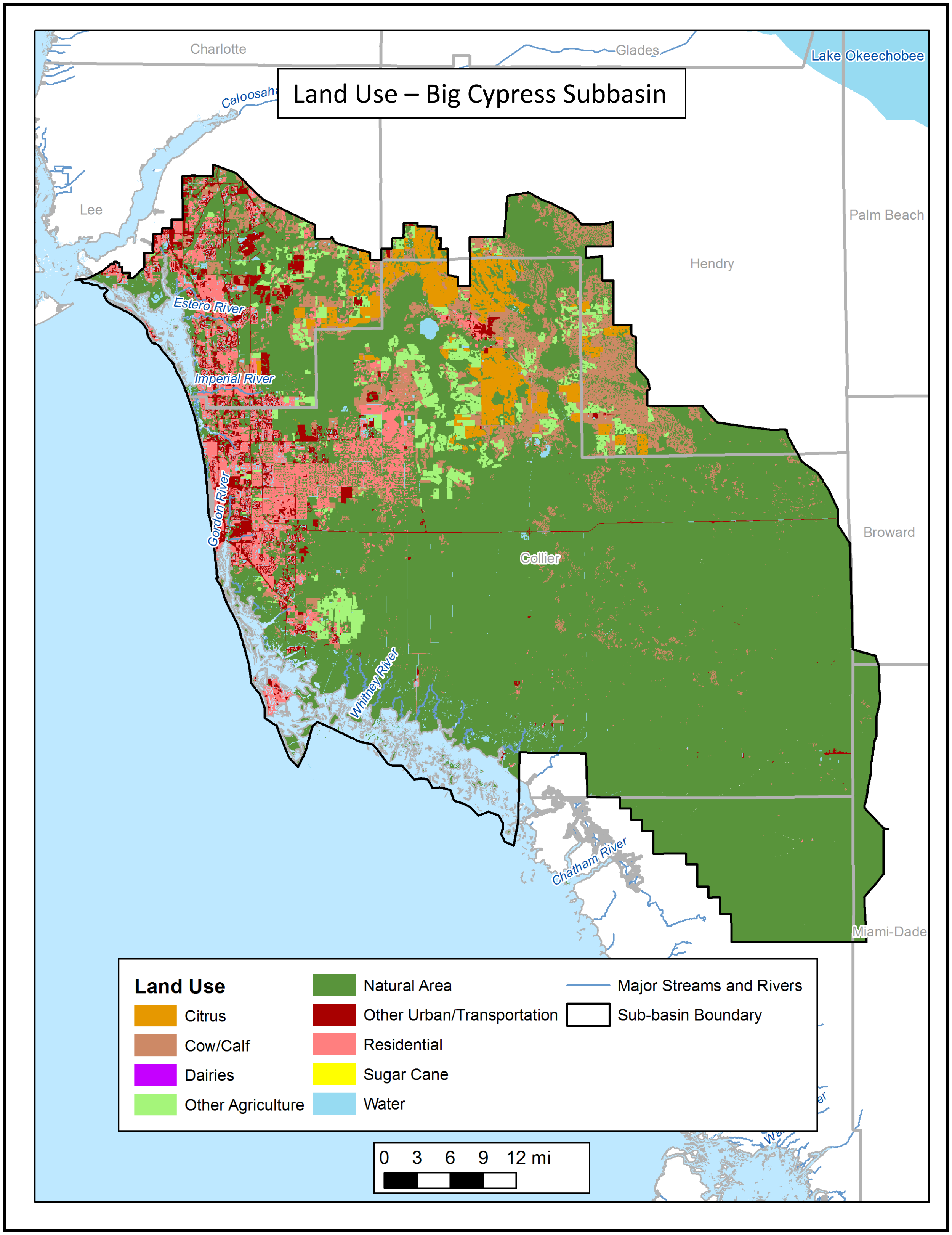


Figure 2-7. Land Use in the Big Cypress Subbasin

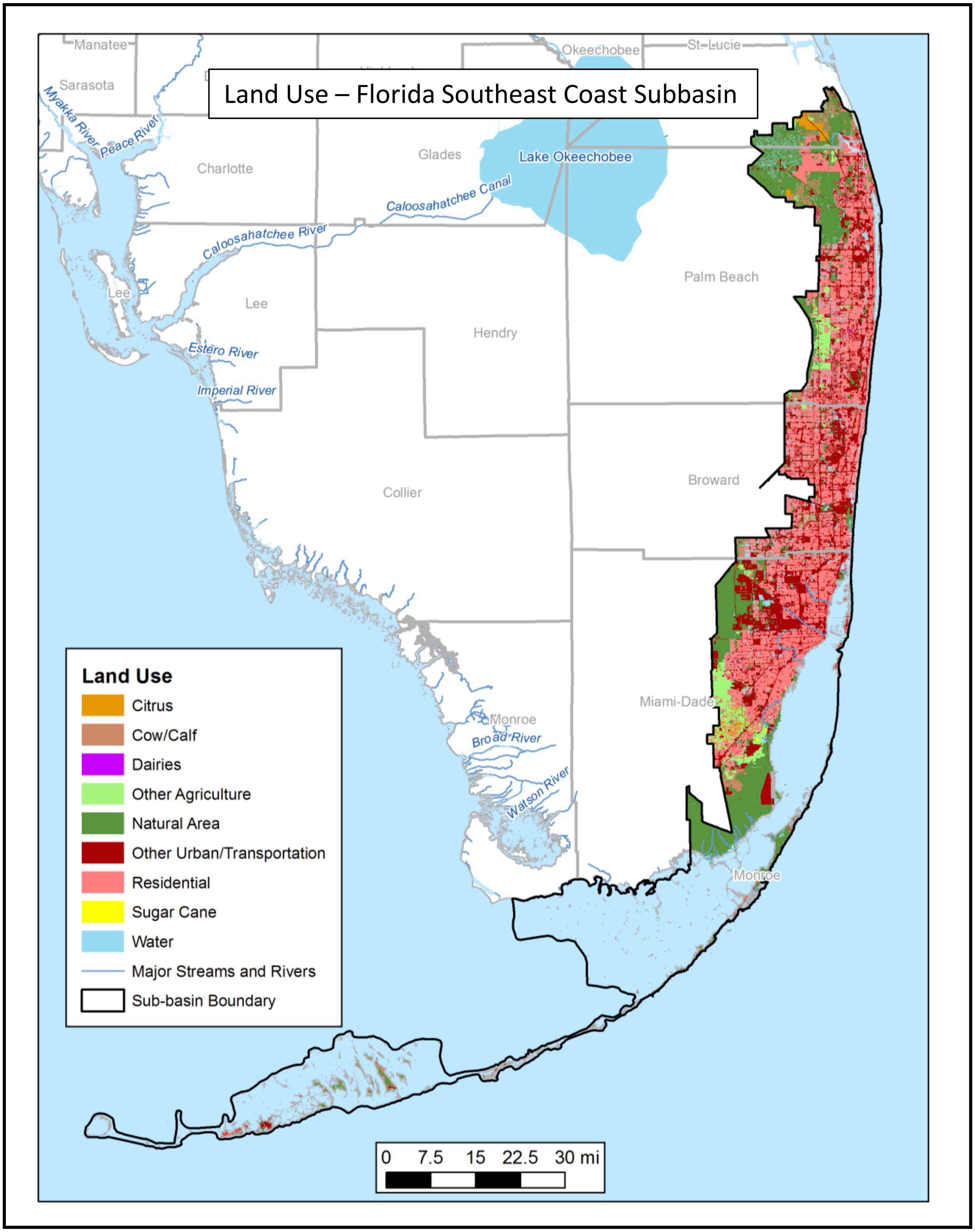


Figure 2-8. Land Use in the Southeast Coast Subbasin

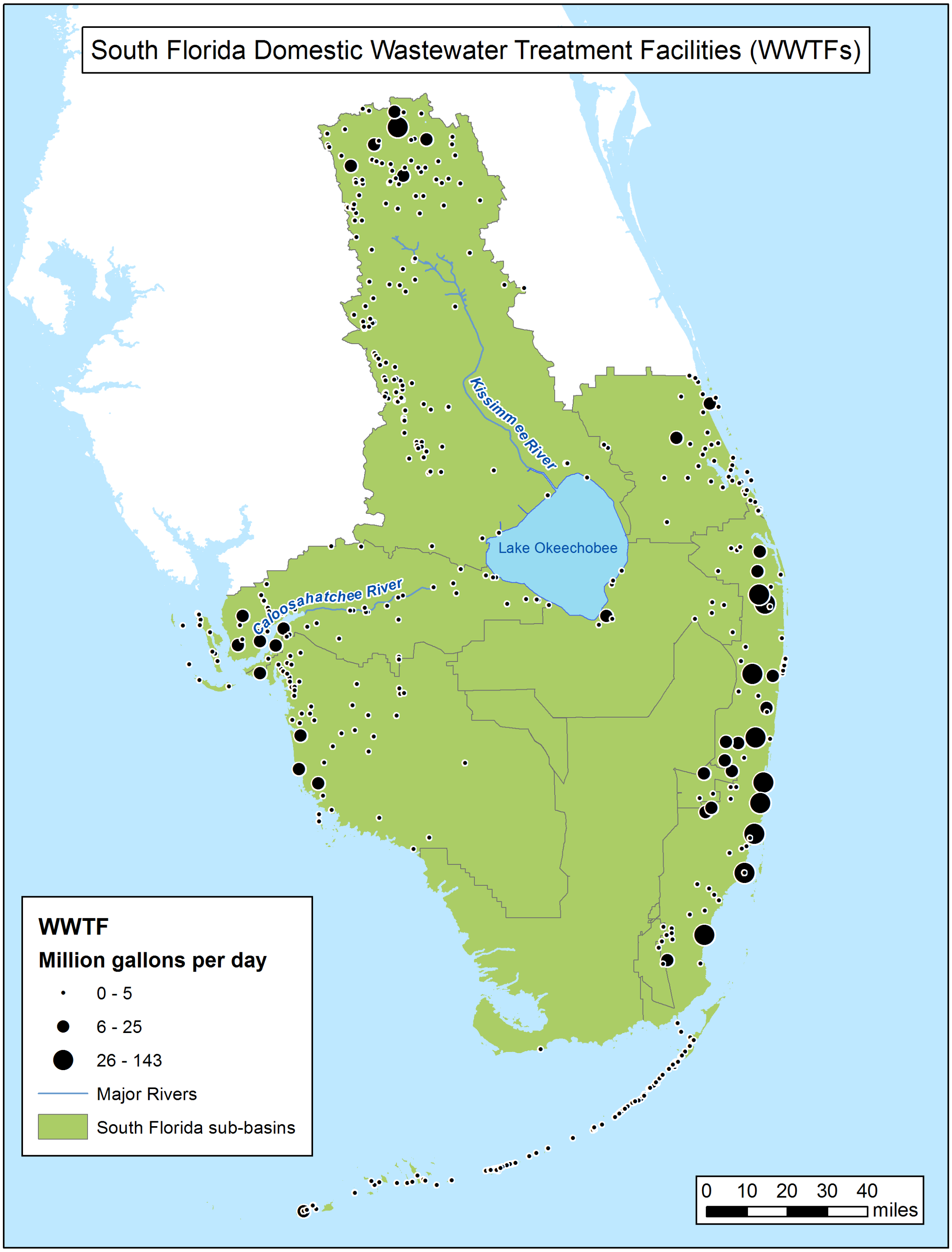


Figure 2-9. Location of Domestic WWTFs in South Florida by Size Category

Florida undergo primary and secondary treatment, which removes pathogens, suspended solids, and organic compounds to protect human health and aquatic life. Secondary treatment does provide incidental, yet significant, reduction in total nitrogen and total phosphorus. Many domestic WWTFs in South Florida are reducing nutrient loads by offering their reclaimed water for reuse purposes or injecting treated effluent into deep wells instead of discharging to local surface waters.

In addition, FDEP has issued NPDES permits with nitrogen and/or phosphorus limits to 45 other facilities that they classify as "industrial" WWTFs . These facilities are not included in our study because of a number of factors. Twenty-six of these facilities are concentrated animal feed operations (CAFOs) whose nutrient load is captured by land use data described in the agricultural section of this study. The remaining industrial WWTFs are relatively small low-flow operations and are not expected to be significant nutrient contributors. It is also difficult to determine to what extent these industrial wastewater treatment processes are intended to reduce total nitrogen and total phosphorus concentrations.

2.3 Nonpoint Sources

The major source of nonpoint nutrient loads in South Florida is runoff from agricultural and urban lands.

2.3.1 Agricultural Runoff

To address nitrogen and phosphorus loads from agricultural runoff, the Florida Department of Agricultural and Consumer Services (FDACS) oversees implementation of approved BMPs on agricultural lands in the Northern Everglades. This program is implemented under the Northern Everglades and Estuaries Protection Program (NEEPP) pursuant to Chapter 373.4595 of the Florida Statutes (F.S.), and it aims to reduce concentrations of total phosphorus going into Lake Okeechobee. FDACS encourages enrollment in the BMP program through incentive programs, such as cost-share programs, and the presumption of state water quality standards compliance for enrolled operations. The types of agricultural lands on which FDACS administers BMPs include citrus farms; CAFOs; beef cattle operations; containerized nurseries; and sod, vegetable, and agronomic crop production. As of December 2010, 1.3 million acres (77%) of agricultural land in the Lake Okeechobee watershed were enrolled in a BMP program. By 2015, FDACS anticipates that all agricultural lands in Lake Okeechobee will be enrolled in the program and implementing BMPs (SFWMD, 2011a). In addition to the NEEPP, FDACS has implemented other state-wide and region-specific BMP requirements for agriculture.

The federal government also provides cost-share funding for agricultural BMPs, primarily through the U.S. Department of Agriculture (USDA) Natural Resource Conservation Service's (NRCS's) Environmental Quality Incentive Program (EQIP) program. This program provides funding to farmers throughout South Florida, including within the EAA. USDA also funds wetland conservation and restoration projects through the Wetland Reserve Program (WRP), which serves to improve hydrological function and water quality in South Florida.

The SFWMD is responsible for permitting water use in agricultural production. The Everglades Program (Chapter 40-E-63, F.A.C.), administered by SFWMD's Everglades Regulation Division, requires that the EAA must collectively achieve a 25% reduction in phosphorus relative to a modeled baseline, and the C-139 basin must maintain phosphorus levels at a modeled baseline. This program issues Everglades Works of the District Permits to agricultural operations, requiring BMP implementation. SFWMD also administers the Lake Okeechobee Works of the District Rule Permit Program (Chapter 40E-61, F.A.C.), which requires a BMP and discharge monitoring plan for any entity in the Lake Okeechobee watershed.

FDEP also regulates the level of treatment required for biosolids prior to their application to agricultural land (Chapter 62-640, F.A.C.). Recent changes to these statewide rules require stricter accountability and management practices, which are expected to increase the costs of biosolids application and further limit their use. The costs and impacts of these rule changes are not included in this analysis, due to the very recent nature of the changes and uncertainty about their impacts.

2.3.2 Urban Stormwater Runoff

Urban stormwater runoff is another significant source of nutrient loading to South Florida surface waters, especially from Florida's heavily populated Southeast Coast. Increased development covers the land with impervious surfaces that cause stormwater to be channeled directly into sewer systems while carrying pollutants, instead of percolating through the ground. Florida was the first state in the United States to establish a statewide stormwater program for new developments. In 1982, Florida created a technology-based program that used BMPs to reach performance standards and reduce nutrient loads to nearby surface waters (Chapter 17-25, F.A.C.). These rules require a new development to use an approved erosion and sediment control method during construction and to have a stormwater management plan for postconstruction that integrates a number of different BMPs. Most new developments are required to obtain an Environmental Resource Permit (ERP) through Chapters 373 and 403, F.S. to minimize wetland impacts, reduce stormwater quantity, and improve stormwater quality. There are two different types of BMPs: structural and nonstructural. Structural refers to constructed stormwater management techniques like retention/infiltration areas, wet detention ponds, constructed wetlands, bio-retention areas, buffer strips, and swales. Nonstructural BMPs encourage low-impact development by managing land use, preserving wetlands/floodplains, and minimizing impervious surfaces. Florida's stormwater program also requires older stormwater systems, built before the 1982 legislation, to meet stormwater pollutant load reduction goals through retrofitting.

South Florida's stormwater program is operated jointly by the FDEP, SFWMD, and local governments. The FDEP is the lead agency and is responsible for coordinating the statewide stormwater program and is in charge of implementing certain parts of the program. The SFWMD acts as the chief administrator. The District and FDEP are responsible for permitting ERPs, establishing load reduction goals, and overseeing watershed management plans. Local governments must create land use plans and stormwater master plans and ensure that all local stormwater systems are functional and maintained (FDEP, 2011b).

In addition, to further reduce nutrient loads from urban areas, the state adopted the Urban Turf Fertilizer Rule in 2007. The rule limits the allowable amount of nitrogen and phosphorus contained in lawn fertilizers. Because of data limitations, the costs and impacts of this rule are not included in our analysis.

2.4 Public Works Projects

In recent years, the U.S. Congress and Florida legislature have passed legislation authorizing federal and state agencies to implement several large public works projects, which are aimed at improving and restoring the Everglades ecosystem. The largest and most notable Everglades legislation, the CERP, was authorized by the U.S. Congress in the Water Resources Development Act (WRDA) of 2000 (SFWMD, 2011b). The project has over 60 elements, will take over 30 years to complete, and will cost an estimated $11.7 billion. CERP projects are cosponsored by the SFWMD and the U.S. Army Corps of Engineers (USACE). The goals of CERP are to restore the natural flow of water to the Everglades, improve water quality, and repair struggling ecosystems.

CERP will implement at least eight projects that are focused on water quality improvement; however, these projects are still under construction and many will not be completed for several years. Therefore, the CERP projects are not featured in this study because they have not yet resulted in nutrient reductions. However, once completed, these CERP projects are anticipated to bring significant water quality improvements and nutrient reductions to the Everglades.

CERP-related “Critical Projects” that have been completed focus on improving water quality and have associated phosphorus reductions. These projects are the Lake Okeechobee Water Retention/Phosphorus Removal and the Western C-11 Basin Water Quality Improvement Project. These two projects are included in this study.

In addition, other major public works projects have been enacted and are currently reducing nutrient loads to the Everglades. In particular, six large-scale STAs have been constructed in the ECP subbasin since the project began in 1993. These STAs treat water coming primarily from the EAA and retain phosphorus, preventing it from entering the Everglades. Further phosphorus reductions are expected once the Compartment B and C additions to these STAs are completed.

Currently, six Hybrid Wetland Treatment Technology (HWTT) projects in the Lake Okeechobee Watershed are cofunded by FDACS and the District. These projects combine the retention qualities of wetlands and the removal power of chemical coagulants.

The final project included in this study is the Kissimmee River Restoration (KRR) project. The KRR project’s primary purpose is to restore the natural flow of the river, which was channelized in the 1960s. The restoration project began in 1994, and three of four main project phases have been completed and are contributing to nutrient reductions in South Florida. The KRR project is operated and constructed under a partnership between USACE, the State of Florida, and the SFWMD.

SECTION 3
DOMESTIC WASTEWATER TREATMENT FACILITIES

According to FDEP records, South Florida has 669 permitted domestic WWTFs. In total, these facilities treat an average of 821 MGD of wastewater from residential, commercial, and industrial sources. That is equivalent to roughly 105 gallons per day for each South Florida resident. The total permitted capacity at these facilities is 1,207 MGD; however, a relatively small number of large facilities (i.e., 42 facilities with design capacity of 5 MGD or more) account for nearly 90% of this total capacity.

Table 3-1 lists and describes the largest permitted domestic WWTFs currently located in South Florida. Not surprisingly, most of these facilities and the largest treatment capacity are located in the most heavily populated counties of the Southeast Coastal area.

The primary objectives of wastewater treatment are to remove physical, chemical, and biological contaminants from wastewater flows so that the water can be returned to the environment without causing harm to humans or ecosystems.

All facilities in Florida are required to provide (1) "secondary" treatment of wastewater, which removes suspended solids and organic compounds that are mainly harmful to aquatic life, and (2) disinfection to remove pathogens, which are harmful to human health. As part of the secondary treatment process, all of these facilities also remove significant amounts (roughly 50%) of nutrients—nitrogen and phosphorus—from their wastewater flows.

As shown in Table 3-1, a relatively small number of domestic WWTFs in South Florida (10 facilities) also provide AWT. The main objective of AWT is to remove additional nutrients—roughly another 40% of the inflow concentration—from the wastewater stream.

Once the wastewater is treated to remove nutrients and other pollutants, the facilities use different types and combinations of methods to dispose of and/or reuse the wastewater. These methods include reuse, ocean outfall, deep well injection, and surface water discharge for their effluent disposals. Reuse of reclaimed water has become increasingly popular in South Florida. In addition to reducing stresses on water supplies, particularly during periods of drought, reuse also helps reduce nutrient loads to surface waters. Table 3-1 shows that 32 out of the 45 large facilities engage in some type of water reuse. Reused water is used in South Florida predominantly for irrigation of public access areas, golf courses, and agricultural lands

Table 3-1. Large Domestic WWTFs in South Florida[a]

Treatment Facility	County	MGD Design Capacity	MGD Wastewater Flow	Reuse/Disposal Method Primary	Reuse/Disposal Method Secondary
Facilities with AWT					
City of Naples WWTP I	Collier	10.0	6.6	Reuse	Surface water
Fort Myers South AWWTP	Lee	12.0	9.4	Surface water	
Fort Myers Central AWWTF	Lee	11.0	5.4	Surface water	Reuse
Lee County Utilities—Fiesta Village	Lee	5.0	3.3	Surface water	Reuse
Waterway Estates Advanced WWTP	Lee	1.3	0.9	Surface water	
Richard A. Heyman WWTP—Key West	Monroe	10.0	4.4	Deep well	
Okeechobee Utility Authority	Okeechobee	1.2	0.8	Reuse	
Reedy Creek Improvement District	Orange	15.0	12.1	Reuse	
TWA/Camelot S/D WWTF	Osceola	5.0	3.3	Reuse	
East Central Regional WWTP[b]	Palm Beach	10.0	6.4	Deep well	Reuse
Facilities with Secondary Treatment					
Broward County North Regional WWTP	Broward	84.0	71.0	Deep well	Ocean outfall
Fort Lauderdale—G T Lohmeyer WWTP	Broward	55.7	37.6	Deep well	
Hollywood Southern Regional WWTF	Broward	55.5	45.9	Deep well	Ocean outfall
Sunrise No. 3 WWTP (Sawgrass)	Broward	20.0	18.3	Deep well	
Plantation Regional WWTP	Broward	18.9	13.8	Deep well	Reuse
Miramar, City of WWTF	Broward	10.1	7.6	Deep well	Reuse
Margate, City of West WWTP	Broward	10.1	7.2	Deep well	
Sunrise No. 1 WWTP (Springtree)	Broward	10.0	7.2	Deep well	
Pembroke Pines, City of WWTP	Broward	9.5	7.1	Deep well	
Coral Springs Improvement District WWTF	Broward	5.7	5.1	Deep well	
Collier County North Regional WRF	Collier	26.0	9.5	Reuse	Deep well
Collier County South Regional WRF	Collier	16.0	7.3	Reuse	Deep well
Cape Coral North WRF	Lee	10.0	7.2	Reuse	Surface water
City of Cape Coral, Everest WRF	Lee	8.5	6.5	Reuse	Surface water
Southwest WRF	Lee	6.6	6.2	Reuse	Surface water
Fort Myers Beach STP	Lee	6.0	3.6	Reuse	Deep well
Martin County Tropical Farms WWTF	Martin	5.0	3.5	Deep well	Reuse
Miami-Dade Central District WWTF	Miami-Dade	143.0	101.0	Ocean outfall	Reuse
Miami-Dade North District WWTP	Miami-Dade	112.5	87.2	Ocean outfall	Deep well
Miami-Dade South District WWTF	Miami-Dade	112.5	93.2	Deep well	Reuse
South Central Regional WWTP	Miami-Dade	24.0	16.8	Deep well	Reuse
Homestead, City of WWTP	Miami-Dade	6.0	5.3	Reuse	
OCUD/South WRF	Orange	43.0	29.0	Reuse	
Orlando—Conserv II WRF	Orange	25.0	12.7	Reuse	
Orlando—Conserv I WWTF	Orange	7.5	4.6	Reuse	

(continued)

Table 3-1. Large Domestic WWTFs in South Florida[a] (continued)

Treatment Facility	County	MGD Design Capacity	MGD Wastewater Flow	Reuse/Disposal Method Primary	Reuse/Disposal Method Secondary
TWA—South Bermuda	Osceola	13.0	9.3	Reuse	
TWA—Sandhill Road WWTF	Osceola	6.0	3.3	Reuse	
East Central Regional WWTP[b]	Palm Beach	54.0	34.6	Deep well	Reuse
Palm Beach Co. Southern Regional WWTP	Palm Beach	35.0	22.9	Reuse	Deep well
Boca Raton, City of WWTP	Palm Beach	27.5	19.2	Ocean outfall	Reuse
Seacoast Utilities PGAWWTP	Palm Beach	12.0	7.5	Reuse	Deep well
Loxahatchee Env. Control Dist. WWTP	Palm Beach	11.0	6.7	Reuse	Deep well
Belle Glade WWTP	Palm Beach	6.5	4.0	Deep well	
Fort Pierce Utility Authority—WWTF	St. Lucie	10.0	4.7	Deep well	Reuse
Port St. Lucie Utilities Glades WWTF	St. Lucie	6.0	3.7	Reuse	Deep well

[a] For AWT facilities, includes facilities with design capacity greater than 1 MGD. For secondary, includes facilities with design capacity greater than 5 MGD.

[b] This facility includes a 10 MGD component with AWT and secondary treatment component; therefore, it is listed twice.

(FDEP, 2011a). Deep well injection is the second most common form of effluent disposal in South Florida with 26 of the 45 large facilities discharging their reclaimed water in this manner. Table 3-1 also shows that only 8 of the 45 large facilities discharge to local surface waters, while 5 facilities in Florida’s Southeast Coast still rely, at least in part, on discharging to an ocean outfall. Twenty-nine percent of total effluent in South Florida is discharged to an ocean outfall.

3.1 Pretreatment Nutrient Loads

Pretreatment nutrient loads for WWTFs are measured as the yearly amount of nitrogen and phosphorus contained in the wastewater entering the facilities. For this analysis, these “baseline” loads are also interpreted as the annual amount of nutrients that *would have been* directly discharged to South Florida surface waters if (1) WWTFs did *not* remove nutrients as part of their treatment processes and (2) they did *not* reuse or dispose of wastewater in other ways.

To estimate these annual nutrient inflows to the domestic WWTFs, we relied on three primary sources of information: (1) direct contacts and interviews with officials at a subset of the WWTFs, (2) published data on influent levels at selected plants (Koopman et al., 2006), and (3) estimates of national average nitrogen and phosphorus influent concentrations. Based on information provided by 8 South Florida facilities,[1] measured influent concentrations of nitrogen range from 20 to 44 mg/L, with an average of 37.8 mg/L. For phosphorus, they range between 2.6 and 8.2 mg/L, with a flow-weighted average of 5.9 mg/L (based on 13 facility reports).[2] These values correspond closely with other estimates of typical raw nutrient concentrations in wastewater estimates of 31.6 mg/L for total nitrogen (Tchobanoglous, Burton, & Stensel, 2003) and 6 mg/L for total phosphorus (U.S. Environmental Protection Agency [USEPA], 2007). To estimate influent concentrations at facilities for which we did not have site-specific data, we applied the average concentration values we obtained from the other South Florida facilities. To convert the nutrient concentration estimates into annual load estimates, we multiplied them by the average annual wastewater flow through each facility (FDEP, 2010) and converted them to annual loads expressed as metric tons per year. The resulting pretreatment load estimates are reported in Table 3-2. In total, for the 45 large WWTFs listed in Table 3-1, we estimate annual inflows of phosphorus equal to 6,387 MT/yr and of nitrogen equal to 38,774 MT/yr.

Table 3-2. Annual Nutrient Loads, Reductions, and Costs for Large Domestic WWTFs in South Florida

Subbasin	Number of Facilities	Pretreatment Nutrient Loads (MT/yr)		Nutrient Load Reductions (MT/yr)		Annual Cost of Wastewater Treatment and Disposal ($ mil/yr)
		N	P	N	P	
Big Cypress	4	880	223	877	222	24.6
Caloosahatchee	7	2,040	319	1,952	304	29.6
Everglades Construction Project Basins	1	210	33	210	33	4.2
Florida Southeast Coast	22	31,233	5,105	26,073	4,639	372.4
Northern Lake Okeechobee	8	3,789	610	3,789	610	71.5
St. Lucie	3	622	97	622	97	12.8
Total	**45**	**38,774**	**6,387**	**33,534**	**5,905**	**515.0**

[1] Reedy Creek Improvement District, City of Naples, Collier County North Regional, Collier County South Regional, Loxahatchee Environmental Control District, Fort Myers South, Fort Myers Central, and Fort Lauderdale: G T Lohmeyer reported influent concentration data during interviews.

[2] Reedy Creek Improvement District, City of Naples, Collier County North Regional, Loxahatchee Environmental Control District, Fort Myers South, Fort Myers Central, and Fort Lauderdale: G T Lohmeyer reported influent concentration data during interviews. Influent data for South Central Regional, City of Boca Raton, Broward County North Regional, Miami-Dade Central District, Hollywood Southern Regional, and Miami-Dade North District WWTP were gathered from the Koopman et al. (2006) study.

As previously stated, these large facilities account for roughly 90% of the total domestic wastewater treatment capacity in South Florida. Assuming that the remaining smaller facilities have the same ratio of nutrient inflows to design capacity, these results imply that the total nutrient inflows to all domestic WWTFs in South Florida are 43,082 MT/yr of nitrogen and 7,097 MT/yr of phosphorus.

Table 3-2 also shows how the pretreatment loads are distributed across the six South Florida basins. As expected, a majority (80%) of the total pretreatment loads are associated with facilities in the most heavily populated Southeast Coast Basin.

3.2 Nutrient Load Reductions

Load reductions are measured as the difference between the amount of nutrients entering the facilities (i.e., the pretreatment loads) and the amount of nutrients discharged to South Florida surface waters. This difference in nutrient levels is attributable to two main factors: (1) the treatment processes used at the facilities and (2) the disposal methods used.

3.2.1 Wastewater Treatment

To estimate nutrient removals at the wastewater facilities, we again relied on a combination of data received through interviews with facility operators and from other publicly available data sources.

For facilities using **secondary treatment** and for whom we acquired site-specific information, measured *effluent* (i.e., post treatment) concentrations of nitrogen ranged from 3.3 to 21.9 mg/L, with a flow-weighted average of 16.4 mg/L. For phosphorus, the posttreatment concentrations ranged between 0.7 and 3 mg/L, with a flow-weighted average of 1.5 mg/L. These values correspond closely with the national average estimates of 15.3 mg/L for total nitrogen (Tchobanoglous, Burton, & Stensel, 2003) and 3 mg/L for total phosphorus (USEPA, 2007). These posttreatment concentrations imply a 57% reduction in nitrogen levels and a 75% reduction in phosphorus levels associated with secondary treatment.

For facilities using AWT, Florida standards (section 403.086(4), Florida Statutes) require that treated wastewater contain no more than 3 mg/L of nitrogen and 1 mg/L of phosphorus. We acquired site-specific information for two AWT facilities that reported effluent concentrations averaging 1.1 mg/L of nitrogen and 0.16 mg/L for phosphorus, which are significantly below the standard. For the other facilities, we assumed that nitrogen and phosphorus levels would be consistent with other data collected from AWT facilities across the state: 2 mg/L of nitrogen and 0.5 mg/L of phosphorus (Steinbrecher & Reardon 2011). Relative to the pretreatment levels, these posttreatment concentrations imply a 96% reduction in nitrogen levels and a 92% reduction in phosphorus levels associated with advanced treatment.

3.2.2 Disposal/Reuse of Treated Wastewater

As shown in Table 3-1, South Florida WWTFs use different combinations of four main approaches for disposing of treated wastewater—surface water discharge, ocean outfall, deep well injection, and reuse.

For this analysis, we treated ocean outfall discharges as a form of surface water discharge and included them in our estimates of nutrient loads to South Florida surface waters. For effluents discharged directly to the ocean or other surface waters, we assumed no additional reductions in nitrogen and phosphorus loads beyond the AWT or secondary treatment reductions. We estimate that 21% of wastewater flows treated in large South Florida WWTFs are disposed of in this manner, 92% of which is disposed of through ocean outfall.

In contrast, we assumed that no surface water discharges would result from disposal using deep well injection or from water reuse. In other words, for wastewater flows directed to deep well injection or reuse, we applied a 100% reduction factor to the pretreatment loads of nitrogen and phosphorus.

3.2.3 Annual Load Reduction Estimates

Table 3-2 reports the resulting estimates of nutrient load reductions. In total, for all 45 of the large South Florida domestic WWTFs, we estimate annual load reductions equal to 33,523 MT/yr for nitrogen and 5,905 MT/yr for phosphorus. These reductions represent 86% and 92%, respectively, of the pretreatment nitrogen and phosphorus loads.

Table 3-2 also shows how the load reductions are distributed across the six South Florida basins. As expected, the largest portion of these reductions (78%) occurs in the Southeast Coast basin.

3.3 Annual Costs of Nutrient Reductions

Each type of wastewater treatment, disposal, and reuse method described above requires both capital and O&M expenditures. To the extent that we were able to acquire site-specific capital and O&M data from facility operators or from publicly available data, we used these data to estimate the annual costs. Otherwise, we used the following methods to estimate these costs. All capital costs were annualized using a 4% real interest rate and a 20-year lifetime. All costs were converted to 2010 dollars using a GDP deflator.

3.3.1 AWT Costs

Two main sources of information were used to estimate unit capital and O&M costs for AWT. The first source is a recent report by USEPA (2010), which estimates average costs for installing and operating a biological nutrient removal (BNR) system, based on an application of the CapdetWorks wastewater cost estimating software. For a 10 MGD facility, USEPA reports an average capital cost of $1.3 million per MGD capacity and an average O&M cost of $0.385 per 1,000 gallons per day. The second source is a study sponsored by the Florida Water Environment Association Utility Council (2010), which was developed in response to the USEPA study. Based on an assessment of 50 different BNR projects, they estimated an average capital cost of $8.2 million per MGD capacity and an average O&M cost of $1 per 1,000 gallons per day. For our analysis, we used an average of the two studies (i.e., a capital cost of $4.75 million per MGD capacity and an average O&M cost of $0.69 per 1,000 gallons of wastewater flow per day).

3.3.2 Secondary Treatment Costs

To estimate the average capital and O&M costs associated with a secondary treatment facility, we used CapdetWorks to derive the following two relationships:

$$C = 7.7594 * Q^{0.8346}$$

$$OM = 0.2376 * F^{0.8202}$$

where C represents total capital costs, OM represents annual O&M costs (including operation, maintenance, materials, chemicals, and energy), Q represents the design capacity, and F represents annual average daily wastewater flow in MGD. For details on the derivation of these cost equations, see Appendix A.

3.3.3 Deep Well Injection Costs

The cost estimates for deep well injection were derived using cost equations developed for six South Florida facilities (Koopman et al., 2006).[3] The cost equations have the following form:

[3] The purpose of the Koopman et al. (2006) study was to examine the economic feasibility of converting six facilities— South Central Regional, City of Boca Raton, Broward County North Regional, Miami-Dade Central District, Hollywood Southern Regional, and Miami-Dade North District WWTP —from ocean outfall to other types of disposal, including deep well injection.

$$TC = b*W^{0.7}$$

where TC represents the total annual costs (in 2006 dollars), including both capital and O&M costs, b is an estimated coefficient that varies between 0.2465 and 0.39454 across the six plants, and W represents the annual average deep well injection flow. For our analysis, we used an average of the six coefficients and adjusted to account for the difference in discount rate assumptions (Koopman et al. use a 7% rate) by setting b equal to 0.242.

3.3.4 Reuse Costs and Revenues

The cost estimates for reuse were derived using the following unit-cost assumptions. The average capital cost associated with pumping and storing water for reuse is assumed to be $0.68 per MGD of reuse capacity, and the average capital cost associated with transmitting water is $2.45 per MGD for reuse capacity. Both of these estimates are based on the average cost estimates derived for the City of Cape Coral's wastewater system (Duncan & Associates, 2006). The average O&M costs are assumed to be $0.21 per 1,000 gallons, based on estimates reported in Koopman et al. (2006).

The costs of reuse are also at least partially offset by revenues generated from water reuse activities. Water utilities use different methods to recoup costs; however, according to the FDEP (2011a) study of water reuse in Florida, for programs that use a per-gallon charge, the median rates range between $0.32 per 1,000 gallons for nonresidential customers and $0.66 per 1,000 gallons for residential customers. For our analysis, we used an average of these two values and assumed the WWTFs recover $0.49 per 1,000 gallons of reuse water flow.

3.3.5 Annual Cost Estimates

Table 3-2 reports the resulting total annual cost estimates for nutrient load reductions at South Florida domestic WWTFs. In total, for all 45 of the large South Florida domestic WWTFs, we estimate costs for treatment, disposal, and reuse (net of reuse revenues) of wastewater equal to $515 million per year. ***It must be emphasized that these costs are not incurred exclusively to reduce nutrients.*** Although each treatment, disposal, and reuse step included in the cost analysis results in reduced loads of nutrients to South Florida surface waters, these processes also protect human health and the environment by removing several other physical, chemical, and biological contaminants from returned wastewater flows and by reusing reclaimed water.

Table 3-2 also shows how the annual cost estimates for WWTFs are distributed across the six South Florida basins. The Southeast Coast basin accounts for a majority of the costs (72%), followed by the Northern Lake Okeechobee basin (14%).

3.4 Funding Sources for Nutrient Reductions

The main sources of funds to pay for wastewater treatment in South Florida are the utility ratepayers themselves, which can be generally categorized as either residential or commercial/industrial customers. Based on interviews with several facilities, residential customers most often account for between 70% and 90% of the utilities' customer base. For our analysis, we have, therefore, assumed that 80% of costs funded through utility rates are borne by residential customers and the remaining 20% is from the commercial/industrial sector.

We estimate that a relatively small percentage of the annual WWTF costs are paid for by public-sector funds. Because of the large capital investments required by WWTFs, loan funds are essential to finance these investments, but these borrowed funds must most often be repaid with ratepayer revenues. Over the last 20 years, one of the main sources of financing has been the Clean Water State Revolving Fund (SRF) loan program, which provides low-interest loans to design, construct, or upgrade WWTFs.[4] Because the low interest rates are, in effect, subsidized through federal and state taxpayer revenues, they pay for a portion of the annualized capital costs of the facilities. According to data from the SRF, between 1991 and 2010, the program has provided a total of $65.3 million (in 2010 dollars) in loans for advanced treatment, secondary treatment, and water reuse at South Florida WWTFs. To estimate the annual value of the interest rate discount provided by this program, we assumed that the program pays for half of the 4% rate (i.e., 2 percentage points) we have used to annualize the WWTF capital costs. In 2010, this implies support by the program equal to $8.1 million. According to SRF data, over the last 20 years, the State of Florida has contributed roughly 18% of the capital funds used to finance Florida's SRF; therefore, we attribute $1.5 million of the support to the state and the remainder to the federal government.

Based on these findings and assumptions, Figure 3-1 shows the estimated distribution of funding for the $515 million in annual costs for the large WWTFs. Residential and commercial/industrial customers pay an estimated 78.7% and 19.7%, respectively, and the federal and state funds account for the remaining 1.3% and 0.3%, respectively.

[4] Although grant funding for WWTFs is available through, for example, Florida's Small Community Wastewater Facilities Grants and Disadvantaged Community Grants, these sources of funding support smaller facilities and have accounted for a very small percentage of the total WWTF capital costs in South Florida.

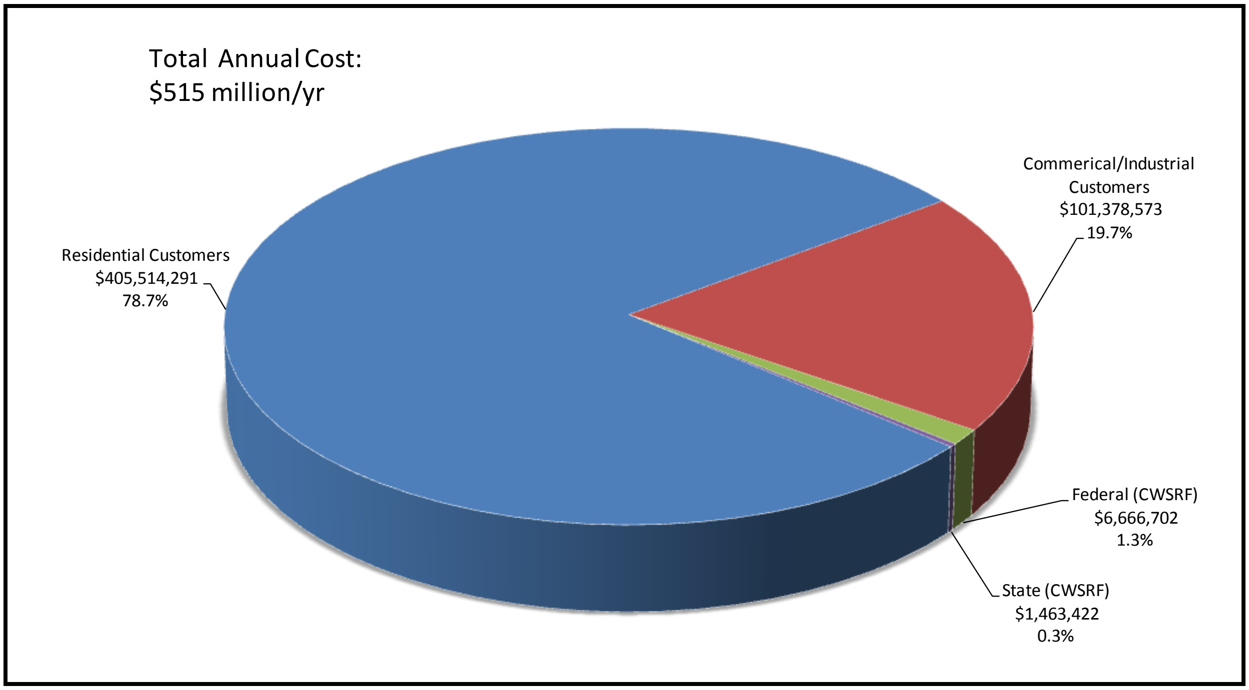


Figure 3-1. Estimated Distribution of Annual WWTF Costs by Funding Source

3.5 Caveats and Uncertainties

To estimate the nutrient loadings, control costs and funding sources for WWTFs in South Florida, we combined data and results from a number of different sources. As described above, to make the analysis tractable, we have also made a number of simplifying assumptions. Consequently, the results must be interpreted in light of the following key caveats and uncertainties.

- The analysis does not include nutrient loading or cost estimates for several hundred smaller (less than 5 MGD) WWTFs. This omission excludes a large number of facilities; however, they account for less than 12% of the total wastewater capacity in South Florida and, therefore, most likely less than 12% of the nutrient loadings as well. Because of economies of scale in wastewater treatment, the costs associated with these facilities may represent somewhat more than the 12% of the total costs.

- The pretreatment and load reduction estimates for most facilities are based on average influent and effluent concentration (mg/L) estimates from a relatively small number of facilities in South Florida; however, they are similar in magnitude to other reported estimates for the United States.

- For the most part, the treatment and disposal cost estimates are based on simple model *predictions* of the average capital and O&M costs, based on design capacity and standardized plant configurations. In practice, the costs for individual plants are certain to vary from these estimates; however, some of the under- or overestimation of costs for the individual 45 facilities should cancel out in the aggregate cost estimates for all facilities combined.

- Because of data limitations, the capital and O&M cost estimates do not account for the age of the treatment capacity installed at the facilities. In particular, these estimates are likely to overestimate the annual capital costs for facility capacity that is more than 20 years old; however, they are also likely to underestimate the higher O&M costs that are required for older facilities.

- As previously noted, it is important to emphasize that many of the estimated treatment, disposal, and reuse costs included in our aggregate estimate of $515 million per year are not incurred exclusively (or even primarily) to reduce nutrients. In fact, only the AWT facilities are *specifically* designed to reduce nutrient levels in wastewater. For secondary treatment and disposal processes, the nutrient reductions are often significant, but they may be a secondary objective. Because of the joint production of other treatment, disposal, and reuse objectives, it is not possible to meaningfully separate out nutrient-specific costs.

- For our analysis, we assumed that water reuse results in no surface water discharges of nutrients *from WWTFs*. That is, the WWTF nutrient removal rate is assumed to be 100% for water reuse. In practice, reused water is often used to irrigate lands, in which case a portion of the nutrients may end up in surface runoff to water. To the extent that this runoff is not accounted for in the nonpoint source runoff estimates described in the following chapters, then we have overestimated the total reductions in nutrient loadings. Similarly, we have not included in our WWTF loading estimates nutrient loads resulting from land application of biosolids.[5]

[5] The costs associated with recent changes in Florida's biosolids application rules have also not been included in the analysis. However, these rules have only been in effect since August 2010, and information on their cost implications is limited.

SECTION 4
AGRICULTURAL STORMWATER RUNOFF AND CONTROLS

Agriculture is an important component the noncoastal areas of South Florida's economy and heritage. Florida accounts for 70% of national citrus production and 50% of sugarcane production, two crops grown predominantly within the study region. Cattle ranching in Florida began prior to 1700, and Florida currently ranks 10th in the nation in beef cattle production. The EAA, which encompassed 27% of the historic Everglades, was created as part of the Central and Southern Florida (C&SF) Project of 1948. In 2007, Palm Beach County, which contains the EAA, sold $973 million of agricultural products, the most of any county in Florida (FDACS, 2011a).

From the conversion of historic wetlands to agricultural use, long-term cattle ranching north of Lake Okeechobee, and manure and fertilizer application to other agricultural lands, agriculture is a significant source of the excess nutrients to the Everglades, Lake Okeechobee, and estuaries in South Florida. As discussed in Section 1, Florida has taken several steps to address and better manage nutrients originating from agricultural sources in South Florida.

In this section, we estimate the pretreatment nutrient contribution of agricultural activities to surface waters and the reduction of these loads due to currently implemented BMPs. We also estimate the cost of the BMPs and the sources of funding received to implement BMPs on agricultural land.

4.1 Annual Pretreatment Nutrient Loads

As a point of reference, we begin by estimating the yearly amount of nitrogen and phosphorus that *would be* directly discharged to South Florida surface waters through agricultural runoff if current agricultural control measures were not in place. These estimates are based on an estimate of (1) the number of acres in different agricultural land use categories in South Florida and (2) estimates of average "baseline" loadings (pounds per acre per year) for each agricultural category. The following sections discuss how we estimated baseline loadings for each basin.

4.1.1 Northern Everglades

The Northern Everglades include the Northern Lake Okeechobee, St. Lucie, and Caloosahatchee subbasins. Each of the three watersheds within the Northern Everglades has unique nutrient loading estimates by land use. For the St. Lucie and Caloosahatchee, we applied per-acre loading estimates developed to support the 2012 update of their protection plans (Soil and Water Engineering Technology, Inc. [SWET], 2011) to acres by land use from the 2004–2005 SFWMD land use data (SFWMD, 2005b). We applied two types of adjustments to these data.

The first adjustment adapted the per-acre loading rates to account for the agricultural BMPs that are included in the SFWMD's baseline estimates. According to the 2009 St. Lucie and Caloosahatchee Protection Plans (SFWMD, 2009c, 2009d), the baseline loadings for row crops, citrus groves, and nurseries account for previously implemented BMPs. To estimate pretreatment loading rates (i.e., with no BMPs), we adjusted the current loading rates to account for the percentage of land assumed to have previously implemented BMPs and the associated nutrient reductions.[1]

The second adjustment required adjusting the baseline land use acreage to reflect the agricultural BMP data provided by FDACS Office of Agricultural Water Policy (OAWP) (FDACS, 2011b). Where the BMP data indicated that a particular land use exists, but the 2004 to 2005 land use data did not contain that land use category, we overlaid the two GIS layers to estimate how the land use is characterized in the 2004 to 2005 data for that BMP. Where appropriate, either the BMP acres or the 2004 to 2005 land use acres were adjusted to best estimate the nutrient reductions of agricultural BMPs.

Agricultural land makes up 56% of the area within the St. Lucie watershed, with the majority split between cow/calf operations (26%) and citrus groves (26%) (Table 4-1). Agricultural land, as a whole, contributes approximately 73% of total nitrogen and 77% of total phosphorus loadings to surface waters in the watershed. Within the Caloosahatchee, agricultural land accounts for 40% of the area. Cow/calf operations are present in 20% of the area, while citrus groves and sugarcane make up 9% and 8%, respectively. Agriculture within the Caloosahatchee is estimated to contribute 63% of nitrogen and 63% of phosphorus loadings to surface waters.

For the Northern Lake Okeechobee watershed, we used inputs to the Lake Okeechobee Watershed Assessment Model (WAM) to develop loading estimates (SFWMD, 2011c). We applied these loading estimates to land use data from the Lake Okeechobee WAM, as opposed to

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[1] For each land use category and basin, we used the following adjustment:

$$PL = \frac{PC}{1-(p*r)}$$

where *PL* is the *pretreatment* per-acre load rate (lbs/acre/yr), *PC* is the *current* per-acre load rate, *p* is the percentage of the acres in the land use category with BMPs applied in the baseline, and *r* is the removal efficiency (%) for the land use's BMP.

Table 4-1. Annual Pretreatment Loads from Agricultural Runoff in the Northern Everglades

Subbasin Agricultural Land Cover Category	Percentage of Acres in Agricultural Land Cover Category	Number of Acres in Agricultural Land Cover Category	Pretreatment Average Nutrient Loads (lbs/acre/yr)		Pretreatment Total Nutrient Loads (MT/yr)	
			N	P	N	P
St. Lucie						
Cow/Calf	26%	190,300	6.90	1.50	595	130
Citrus	26%	187,304	7.10	1.95	603	166
Sugar Cane	0%	2,749	6.24	0.63	8	1
Row Crops	2%	14,238	12.79	4.92	83	32
Field Crops	0%	2,803	5.17	2.96	7	4
Dairies	1%	6,599	12.46	5.81	37	17
Sod Farms	0%	624	7.02	2.52	2	1
Tree Nurseries	0%	2,036	12.48	4.36	12	4
Horse Farms	0%	784	12.48	1.82	4	1
Other Agriculture	0%	1,207	9.80	2.06	5	1
All Agriculture	**56%**	**408,644**	**7.32**	**1.92**	**1,356**	**355**
Caloosahatchee						
Cow/Calf	20%	218,164	8.21	1.10	812	108
Citrus	9%	96,683	9.10	0.81	399	35
Sugarcane	8%	87,302	8.21	0.47	325	19
Row Crops	1%	11,048	17.82	3.41	89	17
Field Crops	1%	5,934	6.80	3.50	18	9
Dairies	0%	2,140	12.26	5.51	12	5
Sod Farms	0%	2,100	9.24	2.39	9	2
Tree Nurseries	0%	1,831	15.48	4.69	13	4
Horse Farms	0%	202	16.43	2.15	2	0
Other Agriculture	1%	5,513	8.08	1.57	20	4
All Agriculture	**40%**	**430,917**	**8.69**	**1.05**	**1,699**	**205**

(continued)

Table 4-1. Annual Pretreatment Loads from Agricultural Runoff in the Northern Everglades (continued)

Subbasin Agricultural Land Cover Category	Percentage of Acres in Agricultural Land Cover Category	Number of Acres in Agricultural Land Cover Category	Pretreatment Average Nutrient Loads (lbs/acre/yr)		Pretreatment Total Nutrient Loads (MT/yr)	
			N	P	N	P
Northern Lake Okeechobee						
Cow/Calf	34%	894,688	12.69	1.01	5,152	410
Citrus	6%	171,507	19.68	0.42	1,531	33
Sugar Cane	1%	29,017	3.55	0.42	47	5
Row Crops	1%	17,360	64.87	2.42	511	19
Field Crops	0%	2,606	17.42	4.00	21	5
Dairies	1%	20,268	12.11	5.41	111	50
Sod Farms	1%	29,757	35.49	5.39	479	73
Tree Nurseries	0%	9,105	26.42	5.28	109	22
Horse Farms	0%	1,123	0.81	0.21	0	0
Other Agriculture	0%	12,273	2.71	0.37	15	2
All Agriculture	**45%**	**1,187,703**	**14.80**	**1.15**	**7,976**	**618**
TOTAL	**45%**	**2,027,265**	**12.00**	**1.28**	**11,031**	**1,178**

the 2004 to 2005 SFWMD land use data used in the other basins. Consistent with how the Lake Okeechobee WAM is used to estimate nutrient reductions in the Lake Okeechobee Protection Plan, no BMPs were assumed to be implemented in the baseline loading estimates, so we made no adjustments to these pretreatment agricultural loads.

The Northern Lake Okeechobee watershed, including the area above Lake Kissimmee and Lake Istokpoga, is 45% agricultural. Almost 900,000 acres, or 34%, of the Northern Lake Okeechobee watershed are in cow/calf operations and another 6% in citrus groves. Agriculture contributes an estimated 75% of nitrogen and 73% of phosphorus loadings to surface waters. Cow/calf operations contribute the most nutrients to surface water (48% nitrogen, 48% phosphorus). Although they account for only 2% of the land area, sod farms and dairies contribute an estimated 14% of phosphorus loadings to surface waters.

4.1.2 Southern Everglades Source Basins

Although monitored data exist regarding the contribution of most ECP and non-ECP basins to the EPA, because of the lack of attribution to land use and the divergence of some loads to tide, we relied on per-acre loadings by land use to estimate the baseline loadings. For both nutrients in the non-EAA basins and nitrogen in the EAA, we estimated loading rates by averaging the pretreatment loading rates for the different land uses from the St. Lucie and Caloosahatchee watersheds. For phosphorus in the EAA, to estimate BMP loading reductions consistent with those reported annually in the *South Florida Environmental Report* (SFER) (SFWMD, 2011b), we adjusted these per-acre loading rates by a factor of 1.7 so that the estimated pretreatment loading rates equal the average modeled phosphorus loadings from 2001to 2010.

Agricultural land use makes up 69% of land use in the Southern Everglades source basins (77% of ECP and 44% of non-ECP basins) and accounts for 83% of nitrogen and 84% of phosphorus loadings to surface water. Sugarcane in the EAA is present on 45% of land in these basins (66% of ECP basins) and accounts for an estimated 51% of nitrogen and 30% of phosphorus loadings to surface water (Table 4-2).

Table 4-2. Annual Pretreatment Loads from Agricultural Runoff in the Southern Everglades Source Basins

Agricultural Land Cover Category	Percentage of Acres in Agricultural Land Cover Category	Number of Acres in Agricultural Land Cover Category	Pretreatment Average Nutrient Loads (lbs/acre/yr)		Pretreatment Total Nutrient Loads (MT/yr)	
			N	P	N	P
Cow/Calf	13%	147,153	7.95	1.39	531	93
Citrus	4%	44,014	8.10	1.38	162	28
Sugarcane	45%	499,961	7.23	1.10	1,638	249
Row Crops	3%	32,091	15.30	4.18	223	61
Field Crops	1%	10,704	5.99	3.23	29	16
Dairies	0%	0	—	—	0	0
Sod Farms	0%	0	—	—	0	0
Tree Nurseries	1%	10,881	13.98	4.79	69	24
Horse Farms	0%	4,157	14.46	1.99	27	4
Other Agriculture	1%	10,349	7.21	1.53	34	7
Total	**69%**	**759,310**	**7.88**	**1.39**	**2,713**	**480**

4.1.3 Southern Coastal Basins

No reliable estimates exist for nutrient loading by land use in the Big Cypress and Southeast Coast watersheds. For the Big Cypress watershed, we relied on the pretreatment loading rates developed for the Caloosahatchee. Pretreatment loading rates from the St. Lucie watershed were applied to the Southeast Coast watershed.

The majority of the Big Cypress watershed, which includes the Big Cypress National Preserve, is in a natural land use (77%). Agricultural land use covers 14% of the watershed, contributing 40% of nitrogen and 55% of phosphorus loadings to surface waters. Cow/calf operations and row crops are the primary contributors of nutrient loadings with 30% of nitrogen and 45% of phosphorus loadings in the watershed (Table 4-3).

The Southeast Coast watershed has fewer than 100,000 acres (6%) in agricultural uses. These agricultural areas contribute an estimated 12% of nitrogen and 17% of phosphorus loadings to surface waters (Table 4-3).

Table 4-3. Annual Pretreatment Loads from Agricultural Runoff in the Southern Coastal Basins

Subbasin Agricultural Land Cover Category	Percentage of Acres in Agricultural Land Cover Category	Number of Acres in Agricultural Land Cover Category	Pretreatment Average Nutrient Loads (lbs/acre/yr)		Pretreatment Total Nutrient Loads (MT/yr)	
			N	P	N	P
Big Cypress						
Cow/Calf	7%	134,233	7.64	1.00	465	61
Citrus	3%	58,977	9.10	0.81	243	22
Sugarcane	0%	0	8.21	0.47	0	0
Row Crops	3%	50,765	17.82	3.41	410	79
Field Crops	0%	1,460	6.80	3.50	5	2
Dairies	0%	0	—	—	0	0
Sod Farms	0%	38	9.24	2.39	0	0
Tree Nurseries	0%	2,008	15.48	4.69	14	4
Horse Farms	0%	111	16.43	2.15	1	0
Other Agriculture	0%	5,314	7.83	1.12	19	3
All Agriculture	**14%**	**252,906**	**10.09**	**1.49**	**1,157**	**171**

(continued)

Table 4-3. Annual Pretreatment Loads from Agricultural Runoff in the Southern Coastal Basins (continued)

Subbasin Agricultural Land Cover Category	Percentage of Acres in Agricultural Land Cover Category	Number of Acres in Agricultural Land Cover Category	Pretreatment Average Nutrient Loads (lbs/acre/yr)		Pretreatment Total Nutrient Loads (MT/yr)	
Florida Southeast Coast						
Cow/Calf	2%	34,614	4.74	0.81	74	13
Citrus	1%	9,618	7.10	1.95	31	9
Sugarcane	0%	221	6.24	0.63	1	0
Row Crops	1%	17,507	12.79	4.92	102	39
Field Crops	1%	13,436	5.17	2.96	32	18
Dairies	0%	110	15.60	9.38	1	0
Sod Farms	0%	371	7.02	2.52	1	0
Tree Nurseries	1%	18,568	12.48	4.36	105	37
Horse Farms	0%	1,379	12.48	1.82	8	1
Other Agriculture	0%	3,025	8.32	2.34	11	3
All Agriculture	**6%**	**98,850**	**8.15**	**2.68**	**365**	**120**
Total	**10%**	**351,756**	**9.54**	**1.82**	**1,523**	**291**

4.2 Annual Nutrient Reductions

Many actions can be taken to reduce nutrient loadings from agricultural lands, from reducing fertilizer application to adding structures that retain water on site longer. These actions are collectively referred to as BMPs.

Several statutes require implementation of agricultural BMPs in Florida. The EFA and Long-Term Plan required implementing comprehensive BMPs in the EAA that achieve at least a 25% phosphorus reduction relative to a predicted baseline and increasing BMP implementation in the C-139 basin if they fail to meet a predicted baseline. The NEEPP requires implementation of BMPs within the Caloosahatchee, St. Lucie, and Northern Lake Okeechobee watersheds. FDACS has a number of rules requiring BMPs on different agricultural land uses either statewide or at the relevant regional level (Table 4-4).

Table 4-4. FDACS Rules for Agricultural BMPs Applicable in South Florida

BMP Program	Rule	Area(s) of Application	Year Adopted
Ridge Citrus	5E-1	Lake Wales Citrus Ridge area; areas with well-drained soils	2003
Indian River Citrus	5M-2	All or part of Volusia, Brevard, Indian River, St. Lucie, Martin, Okeechobee, and Palm Beach counties	2002
Lake Okeechobee Watershed	5M-3	Lake Okeechobee Watershed	2003
Container Nursery	5M-6	Statewide applicability	2006
Gulf Citrus	5M-7	All or parts of Hendry, Glades, Lee, Collier, and Charlotte counties	2006
Vegetable/Agronomic Crops	5M-8	Statewide applicability	2006
Sod Farms	5M-9	Statewide applicability	2008
Land Application of Manure	5M-10	Caloosahatchee and St. Lucie rivers watersheds	2009
Cow/Calf Operations	5M-11	Statewide applicability	2009
Conservation Plans	5M-12	Statewide—specified operations	2010
Specialty Fruit and Nut Crops	5M-13	Statewide—blueberries, pecans, etc	2011
Equine/Horse Farms	5M-14	Statewide—commercial equine operations	Under development
Silviculture	5I-6	Statewide applicability	2004
Aquaculture	5L-3	Statewide applicability	2000

4.2.1 Northern Everglades

To estimate nutrient reductions in the Northern Everglades watersheds, we relied on BMP cost and effectiveness estimates developed for the Caloosahatchee and St. Lucie Protection Plans (SWET, 2008) (Table 4-5). Farmers were assumed to be able to implement lower cost BMPs without funding from state or federal programs, while more expensive, structural BMPs were often assumed to require cost-share funding to implement.

Table 4-5. Cost and Effectiveness of Agricultural BMPs

Land Use		Owner-Applied BMPs			Owner-Applied and Cost-Shared BMPs		
		Initial Cost/Acre	% N Reduction	% P Reduction	Initial Cost/Acre	% N Reduction	% P Reduction
Cow/ Calf	Improved Pasture	$11.23	17	11	$50.54	27	30
	Unimproved Pasture	$2.25	11	7	$13.48	19	20
	Rangeland/ Woodland Pasture	$2.25	4	4	$13.48	10	10
Citrus		$5.62	10	12	$82.23	15	17
Sugarcane		$2.25	10	10	$112.31	33	33
Row Crop		$11.23	30	30	$224.62	60	60
Field Crop		$11.23	15	15	$51.05	40	40
Sod/Turf Farm		$2.25	20	20	$112.31	47	47
Dairies		$2.25	20	9	$1,066.96	60	37
Tree Nurseries		$11.23	25	32	$224.62	50	67
Horse Farms		$11.23	30	20	$50.54	52	42

The number of acres with agricultural BMPs currently implemented was estimated using FDACS OAWP enrollment data (Figure 4-1). As described in Section 4.1, we adjusted either the BMP acres or land use acres when discrepancies emerged between the BMP data and the land use data. In addition, some BMPs are categorized in the FDACs data as applied to “mixed use” land use. When data allowed, we reclassified the “mixed use” BMPs into specific land use BMPs by overlaying the BMP and land use data. We did not estimate nutrient reductions on lands implementing conservation plans.

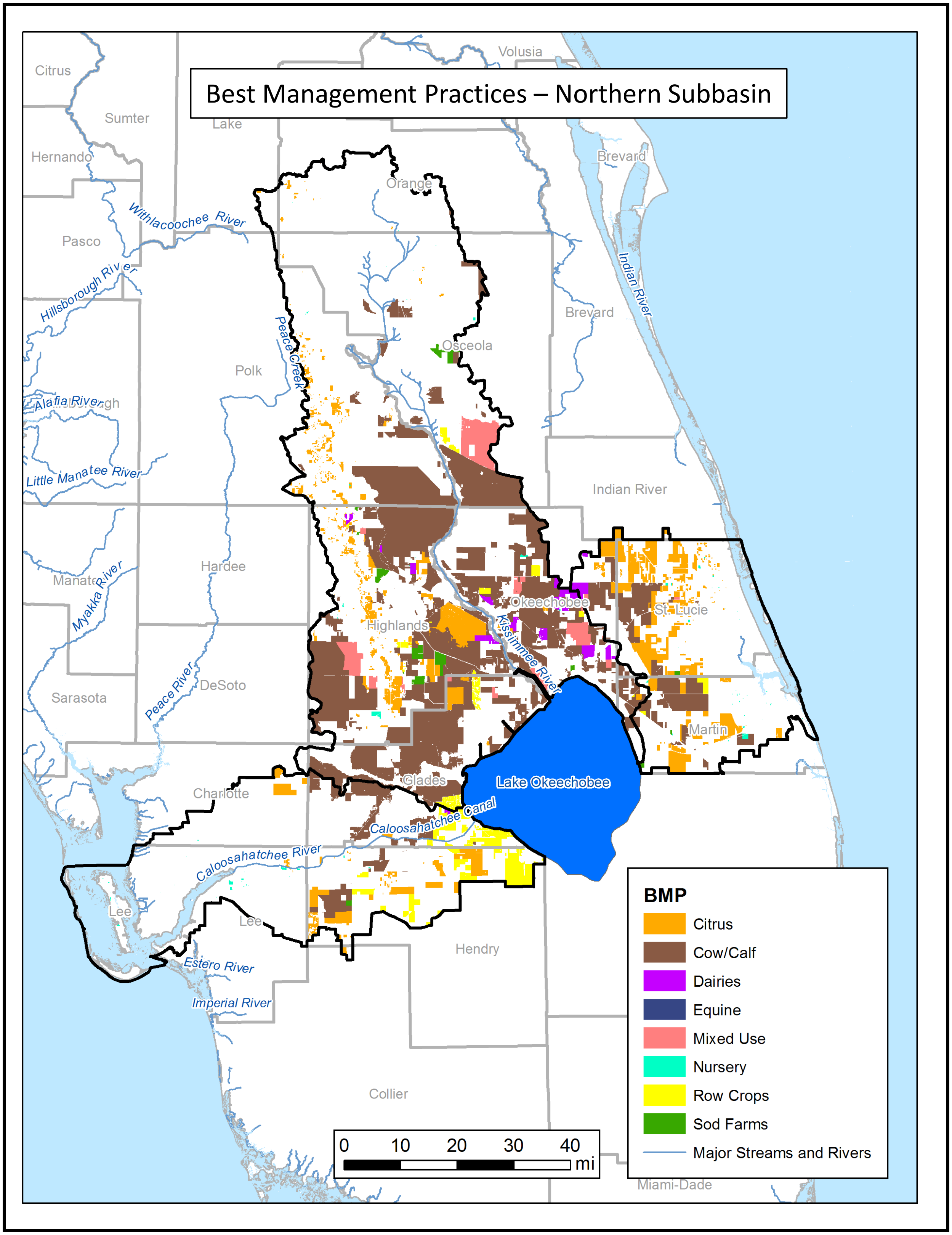

Figure 4-1. Northern Everglades Enrollment in FDACS BMP Programs

To estimate nutrient reductions associated with BMPs, we first estimated the percentage of BMP acres with owner-applied BMPs or a combination of owner-applied and cost-shared BMPs, because they have different reduction efficiencies. We estimated the fraction of these acres implementing cost-shared BMPs using FDACS OAWP data (FDACS, 2011d) on participation by dairy and other agricultural land uses (Table 4-6). Based on these data, we estimated that 90% of the dairies and 67% of other agricultural land with BMPs are implementing both cost-shared and owner-applied BMPs.

Table 4-6. Cost-Shared BMP Acres and Funding in the Northern Everglades

Value	Dairies	Other
Total BMP Acres	27,408	1,222,470
Cost-Shared BMP Acres	24,804	815,521
% Cost-Shared BMPs	**90%**	**67%**
Total Implementation Cost (Million $)	$26	$48
Total Cost-Share Funding (Million $)	$23	$44
% Implementation Cost Funded	**89%**	**92%**

In the Caloosahatchee watershed, 143,000 acres of agricultural BMPs reduce an estimated 142 MT of nitrogen and 18 MT of phosphorus to surface waters. The 55,000 acres of BMPs on cow/calf operations are expected to have the largest impact, reducing 54 MT of nitrogen and 8 MT of phosphorus (Table 4-7).

Table 4-7. Agricultural BMPs in the Caloosahatchee Watershed

	BMP Acres		Reduction (MT/yr)		Cost	
Category	**Total**	**% BMP**	**N**	**P**	**Initial**	**Annualized**
Cow/Calf	54,559	25%	53.9	7.8	$1,624,261	$444,368
Citrus	29,429	30%	16.2	1.7	$1,673,559	$457,855
Sugarcane	50,774	58%	47.9	2.7	$3,763,056	$1,029,504
Row Crops	3,447	31%	13.9	2.7	$518,574	$141,872
Field Crops	60	1%	0.1	0.0	$2,211	$605
Dairies	1,345	63%	4.2	1.2	$1,272,115	$348,027
Sod Farms	2,100	100%	3.3	0.9	$155,640	$42,580
Tree Nurseries	895	49%	2.6	1.1	$134,664	$36,842
Horse Farms	0	0%	0.0	0.0	$0	$0
Total	**142,609**	**33%**	**142**	**18**	**$9,144,081**	**$2,501,654**

In the St. Lucie watershed, 194,000 acres of agricultural BMPs are estimated to reduce surface water loadings of phosphorus by 38 MT and nitrogen by 137 MT. Citrus groves and cow/calf operations are estimated to account for 72% of the phosphorus reductions and 77% of nitrogen reductions (Table 4-8).

Table 4-8. Agricultural BMPs in the St. Lucie Watershed

	BMP Acres		Reduction (MT/yr)		Cost	
Category	Total	% BMP	N	P	Initial	Annualized
Cow/Calf	89,055	47%	66.3	14.6	$2,666,441	$729,490
Citrus	93,299	50%	40.1	12.6	$5,305,688	$1,451,539
Sugarcane	0	0%	0.0	0.0	$0	$0
Row Crops	2,410	17%	7.0	2.7	$362,561	$99,190
Field Crops	0	0%	0.0	0.0	$0	$0
Dairies	5,946	90%	18.9	5.4	$5,624,191	$1,538,676
Sod Farms	512	82%	0.6	0.2	$37,921	$10,374
Tree Nurseries	1,939	95%	4.6	2.1	$291,740	$79,815
Horse Farms	5	1%	0.0	0.0	$229	$63
Total	**193,166**	**47%**	**137**	**38**	**$14,288,770**	**$3,909,147**

The over 926,000 acres of BMPs in the Northern Lake Okeechobee watershed are estimated to reduce nitrogen loadings to surface water from agriculture by 18% and phosphorus loadings by 21%. The 764,000 acres of BMPs on cow/calf operations are assumed to generate 71% of the nitrogen and 66% of the phosphorus reductions (Table 4-9).

4.2.2 Southern Everglades Source Basins

Within the EAA, we estimated nitrogen reductions by assuming that all agricultural acres have owner-applied and cost-shared BMPs applied. To be consistent with the phosphorus reductions reported in the SFER, we used the average difference between the modeled baseline and actual phosphorus reductions from 2001 to 2010 to estimate phosphorus reductions due to BMP implementation.

For the C-139 basin, the current BMP program has not shown consistent reductions below the modeled baseline over time. Therefore, we estimated both nitrogen and phosphorus reductions using the BMP effectiveness estimates shown in Table 4-5. We assumed that all

Table 4-9. Agricultural BMPs in the Northern Lake Okeechobee Watershed

	BMP Acres		Reduction (MT/yr)		Cost	
Category	**Total**	**% BMP**	**N**	**P**	**Initial**	**Annualized**
Cow/Calf	764,314	85%	1,022.7	85.1	$21,532,727	$5,890,961
Citrus	92,297	54%	109.9	2.7	$5,248,672	$1,435,941
Sugarcane	9,170	32%	3.7	0.4	$679,665	$185,944
Row Crops	9,013	52%	132.6	5.0	$1,355,848	$370,935
Field Crops	174	7%	0.4	0.1	$6,453	$1,766
Dairies	20,118	99%	62.1	16.9	$19,029,604	$5,206,152
Sod Farms	15,288	51%	93.5	14.2	$1,133,027	$309,975
Tree Nurseries	1,962	22%	14.2	4.7	$295,126	$80,741
Horse Farms	70	6%	0.0	0.0	$3,209	$878
Total	**912,406**	**77%**	**1,439**	**129**	**$49,284,332**	**$13,483,294**

agricultural acres have implemented the owner-applied BMPs, while only those BMPs funded under the C-139 and Western Basins BMP Grant Program (SFWMD, 2005a) have implemented both owner-applied and cost-shared BMPs.

For agricultural BMPs within the other ECP basins and non-ECP basins, we relied on BMP enrollment data provided by OAWP (Figure 4-2) (FDACS, 2011c). To calculate nutrient reductions, we assumed the same cost-share percentage in these basins as in the Northern Everglades.

Nutrient reductions in the Southern Everglades Source Control Basins are primarily attributable to the nearly 500,000 acres of sugarcane BMPs, with 82% of the nitrogen and 82% of the phosphorus reductions, which come almost entirely from the EAA. These BMPs are estimated to remove 24% of nitrogen and 33% of phosphorus loadings agriculture (Table 4-10).

4.2.3 Southern Coastal Basins

We estimated the number of agricultural acres with BMPs applied in the Southern Coastal Basins using BMP enrollment data provided by FDACS OAWP (FDACS, 2011c). To estimate nutrient load reductions, we assumed the percentage of cost-shared BMPs is the same in these basins as in the Northern Everglades.

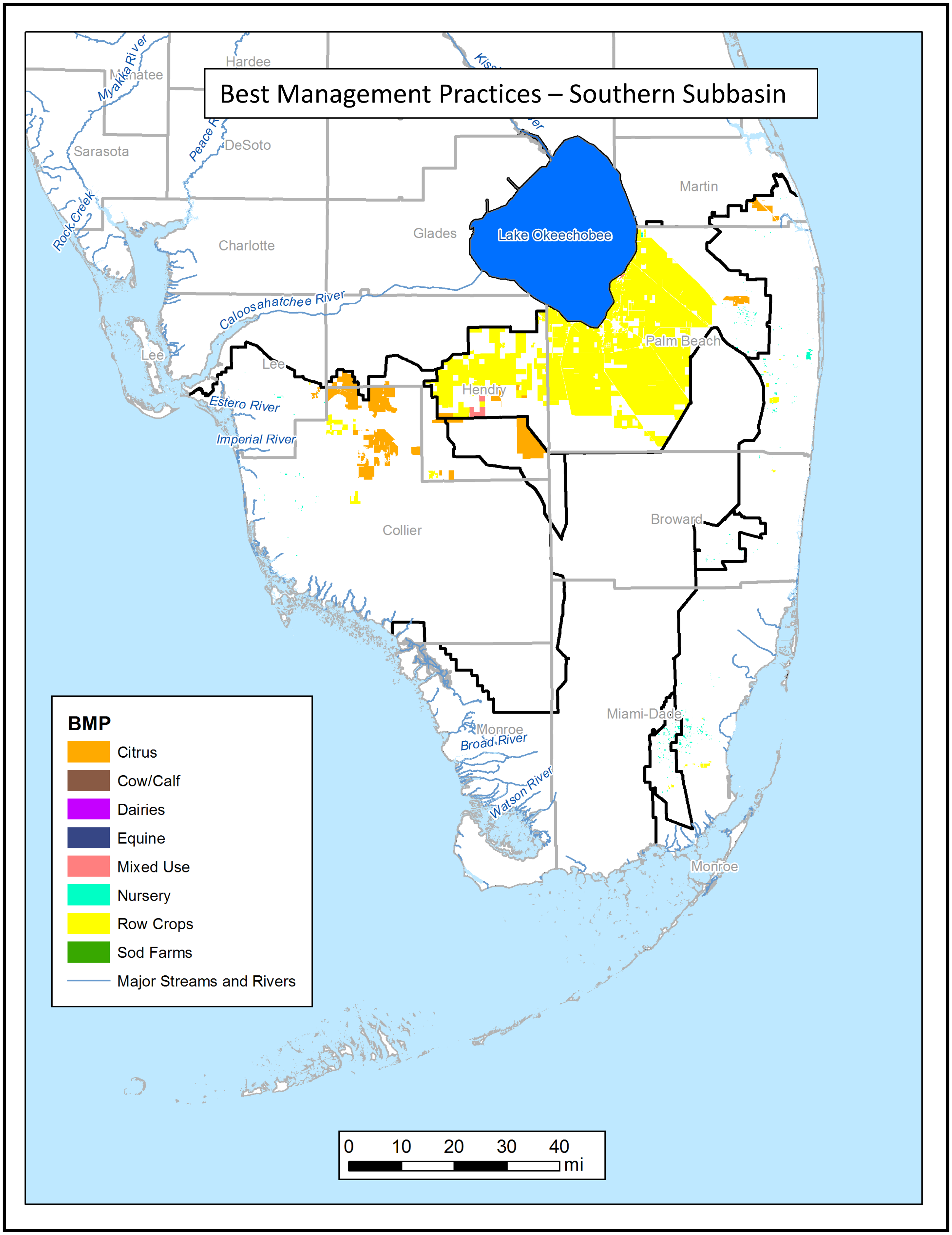

Figure 4-2. South Florida Enrollment in FDACS BMP Programs

Table 4-10. Agricultural BMPs in the Southern Everglades Source Basins

	BMP Acres		Reduction (MT/yr)		Cost	
Category	**Total**	**% BMP**	**N**	**P**	**Initial**	**Annualized**
Cow/Calf	87,016	59%	65.0	11.4	$1,867,964	$511,041
Citrus	27,456	62%	13.2	2.6	$1,435,135	$392,627
Sugarcane	497,483	100%	528.1	129.6	$53,311,409	$14,585,028
Row Crops	15,096	47%	32.7	9.2	$299,142	$81,840
Field Crops	969	9%	0.4	0.2	$10,659	$2,916
Dairies	0	—	0.0	0.0	$0	$0
Sod Farms	0	—	0.0	0.0	$0	$0
Tree Nurseries	3,059	28%	8.5	5.8	$519,663	$142,170
Horse Farms	0	0%	0.0	0.0	$0	$0
Total	**631,078**	**83%**	**648**	**159**	**$57,443,972**	**$15,715,622**

BMP enrollment data for the Big Cypress and Southeast coast only include citrus groves, row crops, and tree nurseries. In the Big Cypress Basin, 60% of citrus groves have BMPs applied, which reduces 19.5 MT of nitrogen and 2 MT of phosphorus (Table 4-11). Approximately 9% of agricultural acres in the Southeast Coast are enrolled in BMP programs, generating reductions of 16 MT of nitrogen and 6 MT of phosphorus (Table 4-12).

Table 4-11. Agricultural BMPs in the Big Cypress Basins

	BMP Acres		Reduction (MT/yr)		Cost	
Category	**Total**	**% BMP**	**N**	**P**	**Initial**	**Annualized**
Cow/Calf	0	0%	0.0	0.0	$0	$0
Citrus	35,357	60%	19.5	2.0	$2,010,684	$550,087
Sugarcane	0	0%	0.0	0.0	$0	$0
Row Crops	4,546	9%	18.4	3.5	$683,876	$187,096
Field Crops	0	0%	0.0	0.0	$0	$0
Dairies	0	-	0.0	0.0	$0	$0
Sod Farms	0	0%	0.0	0.0	$0	$0
Tree Nurseries	560	28%	1.6	0.7	$84,191	$23,033
Horse Farms	0	0%	0.0	0.0	$0	$0
Total	**40,463**	**16%**	**39**	**6**	**$2,778,751**	**$760,216**

Table 4-12. Agricultural BMPs in the Southeast Coast Basin

Category	BMP Acres		Reduction (MT/yr)		Cost	
	Total	**% BMP**	**N**	**P**	**Initial**	**Annualized**
Cow/Calf	0	0%	0.0	0.0	$0	$0
Citrus	4,092	43%	1.8	0.6	$232,696	$63,661
Sugarcane	0	0%	0.0	0.0	$0	$0
Row Crops	2,623	15%	7.6	2.9	$394,527	$107,935
Field Crops	0	0%	0.0	0.0	$0	$0
Dairies	0	0%	0.0	0.0	$0	$0
Sod Farms	0	0%	0.0	0.0	$0	$0
Tree Nurseries	2,620	14%	6.2	2.9	$394,137	$107,829
Horse Farms	0	0%	0.0	0.0	$0	$0
Total	**9,335**	**9%**	**16**	**6**	**$1,021,361**	**$279,426**

4.3 Annual Cost of Nutrient Reductions

To estimate the cost of agricultural nutrient reductions, we relied on per-acre BMP cost estimates developed to support the Caloosahatchee and St. Lucie Protection Plans (Table 4-5) (SWET, 2008). Consistent with the protection plans methodology, we estimated the annualized cost of the BMPs, assuming annual O&M is 20% of the initial cost and the initial cost is amortized over a 20-year lifetime using a 4% real interest rate.

We estimate that all agricultural BMPs in South Florida have cost $137 million to implement, with an annualized cost of $37.4 million (Table 4-13). Twenty million is spent annually on agricultural BMPs in the Northern Everglades watersheds, with 56% of the cost applied to cow/calf operations and dairies in the Northern Lake Okeechobee watershed. BMPs implemented in the ECP basins are estimated to cost than $16 million annually, with 94% of the cost attributable to BMPs for sugarcane production.

4.4 Annual Funding of Agricultural Nutrient Reductions

Funding for the implementation of agricultural BMPs is available from a variety of programs. USDA's NRCS provides cost-share funding for BMPs through the EQIP. The percentage of the BMP implementation cost funded by EQIP depends on the type of farm and environmental improvement expected. Currently in south Florida, EQIP funds 75% of the implementation cost of BMPs related to water quality and water quantity (USDA NRCS, personal communication). Farms are contracted to receive EQIP funding through a competitive

Table 4-13. Agricultural BMPs in South Florida

	BMP Acres		Reduction (MT/yr)		Cost	
Category	**Total**	**% BMP**	**N**	**P**	**Initial**	**Annualized**
Cow/Calf	994,944	61%	1,207.8	118.9	$28,273,272	$7,735,051
Citrus	281,930	50%	200.5	22.1	$16,240,676	$4,443,153
Sugarcane	557,428	90%	579.8	132.8	$58,967,719	$16,132,492
Row Crops	37,136	26%	212.3	26.0	$3,690,481	$1,009,648
Field Crops	1,203	3%	0.9	0.3	$19,730	$5,398
Dairies	27,408	94%	85.2	23.5	$26,470,691	$7,241,898
Sod Farms	17,899	54%	97.5	15.3	$1,354,463	$370,556
Tree Nurseries	11,035	25%	37.8	17.2	$1,755,655	$480,315
Horse Farms	75	1%	0.0	0.0	$3,510	$960
Total	**1,929,057**	**61%**	**2,422**	**356**	**$136,776,198**	**$37,419,472**

process. In addition to EQIP, FDACS has its own program to provide cost share for BMP implementation. Farms may receive funding for BMP implementation from both NRCS and FDACS. We include both sources of funding in our analysis, as well as funding from SFWMD as part of the C-139 and Western Basins BMP Grant Program (SFWMD, 2005a, 2007b). USDA NRCS began providing $1.3 million in annual funding to agricultural BMPs in the EAA in 1995, originally planning to fund $13 million through 2005 (South Florida Ecosystem Restoration Task Force, 1999). After 1999, the South Florida Ecosystem Restoration Task Force no longer reported funding from EAA BMPs as a separate category, so we rely on the $13 million planned funding reported in 1999 as the total funding estimate. In the C-139 basin, we assumed that the estimated BMPs implemented received funding solely through the C-139 and Western Basins BMP Grant Program.

For the Northern Everglades, we applied funding data provided by FDACS to estimate the percentage of cost-share funding received by agricultural BMPs (Table 4-6). Based on these data, we estimate that 89% of the initial cost of dairy BMPs and 92% of the initial cost of all other agricultural BMPs are covered by a combination of state and federal funding. For the other basins we lacked geographic-specific funding estimates; therefore, we assumed the same cost-share percentage (92% of initial cost) as for the "Other Agriculture" category in the Northern Everglades (Table 4-14). When data for the distribution of funding between government entities were not available, we distributed funding based on the relative remaining funding provided by the different sources to South Florida agricultural BMPs (South Florida Ecosystem Restoration Task Force, 2009).

Based on these data and assumptions, we estimate that government agencies have contributed about 64% ($87 million) of the initial cost of agricultural BMP implementation in south Florida. Annual O&M costs, which are assumed to be 20% of these initial costs, are borne only by the farmers. In total, we estimate that government agencies subsidize $6.4 million, or 17%, of the $37.4 million annual cost of agricultural BMP implementation (Table 4-14). The federal government is estimated to contribute 53% of this funding, with 45% coming from the state. Through the C-139 and Western Basins BMP Grant program, ad valorem taxes and agricultural privilege taxes are estimated to contribute the remaining 1.5% and 0.4% of the funding respectively.

Table 4-14. Estimated Funding of Agricultural BMPs in South Florida (Million $)

		Cost-Share Funding				Portion Subsidized	
Basin/Source	**Initial Cost**	**Total**	**NRCS**	**FDACS**	**SFWMD**	**Initial Cost**	**Annual Cost**
EAA	$54.27	$12.58	$12.58	$0.00	$0.00	23%	6.23%
C-139	$2.62	$1.75	$0.26	$0.09	$1.40	67%	17.95%
Northern Everglades							
Dairies	$26.47	$23.47	$10.84	$12.63	$0.00	89%	23.84%
Other Agriculture	$47.77	$43.98	$20.31	$23.67	$0.00	92%	24.76%
Other Basins	$5.65	$5.20	$2.12	$2.47	$0.62	92%	24.76%
Estimated Total	**$136.78**	**$86.97**	**$46.10**	**$38.86**	**$2.01**	**64%**	**17.10%**

4.5 Caveats and Uncertainties

The nutrient loading, cost, and funding estimates reported above for agriculture are all approximations based on available data. The following caveats and uncertainties must be considered when interpreting these estimates.

- The estimates of per-acre loadings, nutrient removal efficiencies, and per-acre BMP costs used in our analysis are average estimates reported in SWET (2008, 2011) and SFWMD (2011c) for the Caloosahatchee, St. Lucie, and Northern Everglades basins. Therefore, they may be either overestimates or underestimates for the specific sites and BMPs included in our analysis. In addition, because of a lack of similar data for the other basins, we transferred these unit values to the other areas of South Florida, which adds to the uncertainty in our estimates.

- To match phosphorus reductions due to BMPs within the EAA, we adjusted the per-acre loading rates to match the modeled baseline. Because this modeled baseline represents loadings downstream of farms, it is an underestimate of the phosphorus loading to surface waters within the EAA.

- Our estimates of loadings rely on land use datasets used by SFWMD. These datasets may contain some level of error in classifying land use. In addition, land use changes over time, so there may be some difference between the land use at the time the data were collected and current conditions.

- To estimate the current level of BMP implementation, we relied on FDACS OAWP parcel-level enrollment data. Some farmers enrolled with FDACS may not have their data incorporated spatially into OAWP's dataset. Other farmers may have implemented BMPs, potentially with federal cost-share funding, and not yet enrolled with FDACS.

- Funding data are available at aggregate levels and not at the finer scale of analysis within this study. Assumptions based on the distribution of this aggregated data are necessary to allocate estimated funding across government sources. These assumptions result in an underestimate of reported NRCS and FDACS funding for agricultural BMPs in South Florida (South Florida Ecosystem Restoration Task Force, 2009).

- The Florida Ranchland Environmental Services Project (FRESP) and USDA's WRP fund water retention projects that also reduce nutrient loadings to surface waters. Other regulatory programs, such as FDEP's biosolids rule, have impacts on nutrient loadings. Because of data limitations, we did not incorporate estimates for these programs.

SECTION 5
URBAN STORMWATER RUNOFF AND CONTROLS

Like many other parts of the country, South Florida has experienced rapid urbanization over the last several decades. One of the unfortunate results of this urban development is that, because of construction of roads, parking lots, and other structures, surface areas become increasingly impervious, and, particularly after storm events, rainwater is less likely to infiltrate into the ground. Stormwater increasingly flows over land and drains directly into surface waters, carrying with it nutrients and other pollutants.

As discussed in Section 1, Florida has taken several steps to address and better manage urban stormwater runoff across the state. In this section, we analyze nutrient loads and controls for urban stormwater runoff using the following steps. First, we estimate the annual *pretreatment* nutrient loads, which are the loads that would have occurred if existing urban stormwater BMPs were not in place. Second, we estimate the *reductions* in annual nutrient loads that are currently being achieved through the implementation of existing practices. Third, we estimate the annual costs associated with implementing existing stormwater runoff control measures. Finally, we describe how the burden of these costs has been distributed across the affected sectors.

5.1 Annual Pretreatment Nutrient Loads from Urban Runoff

Since implementation of the State Stormwater Rule in 1982, new development or redevelopment activities in Florida have been required to implement BMPs for controlling stormwater discharges. Since 1993, these requirements have been implemented through the state's ERP program. In addition, Florida requires that loadings from older stormwater management systems be reduced to ensure that the beneficial uses of waters are supported. Retrofitting older systems is sometimes needed, for example, to meet the stormwater pollutant load reduction goals associated with Florida's total maximum daily load (TMDL) program. These retrofit projects must also receive permits through the ERP program.

For urban runoff, "pretreatment" loads represent conditions *without* the currently required urban runoff controls. To estimate pretreatment nutrient loads to South Florida surface waters, we used a three-step process.

First, we estimated the number of acres in 11 different urban land use categories for each basin.[1] Table 5-1 summarizes these estimates, with the urban land uses grouped into four categories. The Southeast Coast basin has the highest percentage of urban acres (38%) followed by the St. Lucie basin (18%). Overall, 17% of the South Florida acreage is classified under one of the urban land uses.

Second, we estimated average per-acre load estimates for each land use category. These per-acre estimates represent annual nutrient loading rates from urban lands *without* BMPs. To generate these estimates, we adapted estimates of *current* per-acre load estimates for the Northern Lake Okeechobee basin (SFWMD, 2011c) and for the St. Lucie and Caloosahatchee basins (SWET, 2011). Because these per-acre load estimates represent current conditions (i.e., *with* BMPs on land developed under the ERP program), they underestimate the average loadings that would have occurred from these sites *without* the BMPs. Therefore, we adjusted the current per-acre load rates upward, accounting for the percentage of urban land with ERP-related BMPs in place.[2] Our estimation of ERP acreage is described below in Section 5.2. Absent data on loading rates for the other basins, we transferred estimates from the northern basins. In particular, we assumed that (1) the pretreatment loading rates from the St. Lucie basin are applicable in the Southeast Coast basin, (2) the rates from the Caloosahatchee basin are applicable in the Big Cypress Basin, and (3) an average of the St. Lucie and Caloosahatchee rates is applicable in the ECP and non-ECP basins.

Third, to estimate total annual pretreatment loads in each basin, we multiplied the acreage in each urban land use category (Step 1 results) by the per-acre pretreatment load estimates (Step 2 results). The results are reported in Table 5-1. The Southeast Coast is the basin with the highest estimated pretreatment nutrient loadings (2,200 MT/yr of nitrogen and 600 MT/yr of phosphorus), followed by the Northern Lake Okeechobee basin. The total estimated pretreatment loads in South Florida are 4,735 MT/yr of nitrogen and 1,070 MT/yr of phosphorus, with roughly two-thirds of these loads associated with the residential land use category.

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[1] Categories include low, medium, and high density residential, commercial and services, industrial, extractive, institutional, recreational, transportation, communication, and utilities (SWET, 2008).

[2] For each land use category and basin, we used the following adjustment:

$$PL = \frac{PC}{1-(p*r)}$$

where *PL* is the *pretreatment* per-acre load rate (lbs/acre/yr), *PC* is the *current* per-acre load rate, *p* is the percentage of the acres in the land use category that are under the ERP program, and *r* is the removal efficiency (%) for the land use's BMP.

Table 5-1. Annual Pretreatment Nutrient Loads from Urban Runoff

Subbasin Urban Land Use Category	Percentage of Acres in Urban Land Use Category	Number of Acres in Urban Land Use Category	Per-Acre Pre-treatment Nutrient Loads (lbs/acre/yr)		Total Pre-treatment Nutrient Loads (MT/yr)	
			N	P	N	P
Big Cypress	**9%**	**166,238**	**8.55**	**1.76**	**644**	**133**
Residential	6%	108,491	8.23	1.75	405	86
Other urban (mixed comm, ind, inst, and recr)	2%	43,879	8.70	1.47	173	29
Institutional	0%	3,440	8.24	4.48	13	7
Transportation corridors	1%	10,427	11.26	2.22	53	11
Caloosahatchee	**14%**	**152,255**	**7.72**	**1.44**	**533**	**100**
Residential	11%	121,570	7.22	1.27	398	70
Other urban (mixed comm, ind, inst, and recr)	2%	22,067	9.61	1.70	96	17
Institutional	0%	3,676	8.24	4.48	14	7
Transportation corridors	0%	4,941	11.26	2.22	25	5
Southern Everglades Source Basins	**11%**	**118,043**	**6.94**	**1.53**	**372**	**82**
Residential	8%	88,204	6.46	1.30	258	52
Other urban (mixed comm, ind, inst, and recr)	2%	20,411	8.11	1.83	75	17
Institutional	0%	2,962	7.10	4.56	10	6
Transportation corridors	1%	6,466	9.81	2.55	29	7
Florida Southeast Coast	**38%**	**651,691**	**7.44**	**2.02**	**2,200**	**598**
Residential	23%	399,840	7.46	2.21	1,353	400
Other urban (mixed comm, ind, inst, and recr)	10%	175,307	7.41	1.46	589	116
Institutional	2%	29,689	5.96	3.17	80	43
Transportation corridors	3%	46,855	8.37	1.85	178	39
Northern Lake Okeechobee	**14%**	**363,172**	**3.62**	**0.37**	**596**	**61**
Residential	11%	283,454	3.56	0.19	458	24
Other urban (mixed comm, ind, inst, and recr)	2%	46,563	5.08	1.30	107	27
Institutional	0%	6,801	3.49	1.39	11	4
Transportation corridors	1%	26,354	1.73	0.37	21	4
St. Lucie	**18%**	**129,764**	**6.61**	**1.61**	**389**	**95**
Residential	12%	86,584	6.50	1.66	255	65
Other urban (mixed comm, ind, inst, and recr)	4%	30,862	6.51	1.22	91	17
Institutional	1%	3,662	5.96	3.17	10	5
Transportation corridors	1%	8,657	8.37	1.85	33	7
Total	**17%**	**1,581,162**	**6.60**	**1.49**	**4,735**	**1,068**

5.2 Nutrient Load Reductions from Urban Stormwater BMPs

To estimate the urban stormwater load *reductions* that are currently being achieved, we used data from the ERP program. The ERP program maintains a database of all permits reviewed and issued since 1995. This database includes information on the location and dates of the development activity, the main land use category of the permitted site, the number of acres served by the development activity, and the status of the permit. Information about the specific BMPs being proposed and approved for the sites is not recorded in the database, but the individual permit applications can be viewed online.

The database contains 9,750 ERP sites that have been issued new and completed permits since 1995.[3] For our analysis, we selected the 8,420 sites (86%) whose main land use description could be categorized into one the following four main urban land use categories:

1. residential
2. commercial/industrial/recreation
3. institutional
4. transportation corridors

These four categories were selected based on the availability of (1) data on land cover acreage for these categories and (2) estimates of average nutrient reductions and costs for BMPs applied in these areas. In addition, the categories can be roughly divided into private and public lands, with the first two categories (residential and commercial/industrial/recreation) primarily associated with privately owned lands and the others (institutional and transportation corridors) with publicly owned lands.

To estimate load reductions at these sites, we used the following steps. First, we specified the number of acres affected at each ERP site. Because the measure of "acres served" in the ERP data is only a rough estimate of the acres treated by the BMPs, and to avoid overestimation of the affected area, we set the maximum treated area at 500 acres. In other words, for the 139 sites reporting more than 500 acres served, we assumed that the number of acres treated by stormwater BMPs would be equal to 500 acres.

[3] Several sites are issued multiple "modified" permits; however, to avoid double counting controls we selected only "new" permits.

Second, for sites in each of the four land use categories, we assumed a standard set of stormwater BMPs, based on information reported in SWET (2008). As shown in Table 5-2, for the first three categories, we assumed a combination of dry retention and wet detention ponds, and for transportation corridors we assumed a combination of reduced nitrogen fertilization, water management, and limited wetland restoration/retention.

Table 5-2. Nutrient Removal Efficiencies and Unit Costs for Urban Stormwater BMPs

Urban Land Cover Category	BMP	Nutrient Removal Efficiency (% reduction)		Average Annual Costs per Treated Acre ($/acre/yr)
		N	P	
Residential	Dry retention/wet detention ponds	22.5[a]	65[a]	$670.4[b]
Commercial/industrial/ recreations	Dry retention/wet detention ponds	22.5[a]	65[a]	$670.4[b]
Institutional	Dry retention/wet detention ponds	22.5[a]	65[a]	$670.4[b]
Transportation corridors	Reduced nitrogen fertilization, water management, and limited wetland restoration/retention	43	33	$10.4

[a] Average of removal efficiencies (SWET, 2008) for dry retention and wet detention BMPs in medium-density residential areas and in "other urban" areas (mixed commercial, industrial, institutional, and recreation).

[b] Average of costs for dry retention and wet detention BMPs.

Third, we specified nitrogen and phosphorus removal efficiencies for each of the BMPs using estimates from SWET (2008). These removal efficiencies, which are expressed as the percentage reduction in nitrogen and phosphorus loads relative to baseline (pretreatment) levels, are also shown in Table 5-2.

Fourth, combining the results from the previous steps, we estimated the total load reductions from the ERP sites by multiplying (1) the number of affected acres in each land use category, (2) the per-acre pretreatment loads for each category (see Table 5-1), and (3) the BMP removal efficiencies for each category.

The results of applying these steps are reported in Table 5-3. The largest reductions in urban nutrient loadings are estimated for the Southeast Coast basin (86 MT/yr and 55 MT/yr of nitrogen and phosphorus, respectively) followed by the Big Cypress basin. For South Florida as a whole, we estimate 221 MT/yr and 131 MT/yr in reduced nitrogen and phosphorus loads, respectively.

Table 5-3. Annual Reduction in Nutrient Loads from Urban Runoff

Subbasin Urban Land Use Category	Annual Nutrient Load Reductions (MT/yr)	
	N	P
Big Cypress	**47**	**28**
Residential	28	17
Other urban (mixed comm, ind, inst, and recr)	12	6
Institutional	3	5
Transportation corridors	4	1
Caloosahatchee	**24**	**12**
Residential	13	7
Other urban (mixed comm, ind, inst, and recr)	5	2
Institutional	2	3
Transportation corridors	4	1
Southern Everglades Source Basins	**10**	**6**
Residential	4	2
Other urban (mixed comm, ind, inst, and recr)	2	2
Institutional	1	1
Transportation corridors	3	1
Florida Southeast Coast	**85**	**56**
Residential	41	35
Other urban (mixed comm, ind, inst, and recr)	17	9
Institutional	5	7
Transportation corridors	23	4
Northern Lake Okeechobee	**28**	**12**
Residential	14	2
Other urban (mixed comm, ind, inst, and recr)	10	7
Institutional	1	2
Transportation corridors	2	0
St. Lucie	**28**	**17**
Residential	17	12
Other urban (mixed comm, ind, inst, and recr)	5	3
Institutional	1	1
Transportation corridors	5	1
Total	**221**	**131**

5.3 Annual Costs of Nutrient Reductions

To estimate annual costs for urban stormwater BMPs at the ERP sites, we also used a two-step process. First, we first developed average per-acre cost estimates for each land use/BMP category. These estimates, which are reported in Table 5-2 with the removal efficiencies, are based on BMP cost estimates developed for the St. Lucie and Caloosahatchee basins (SWET, 2008). For residential and other urban areas, the reported average implementation cost for dry retention/swales is $6,400 per acre and for wet detention it is $8,000 per acre (in 2008 dollars). For transportation corridors, the BMP costs are $112 per acre. These estimates were derived assuming that the BMPs are for retrofit projects rather than for new construction. Because retrofit projects are typically much more costly and because almost all of the ERP sites are engaged in new construction, we adjusted the SWET cost estimates downward by a factor of 3.[4] The adjusted BMP implementation costs were converted to 2010 dollars and then annualized assuming a 4% discount rate and a 20-year lifetime. Consistent with the assumptions in the SWET report, we also assumed that annual O&M costs for the stormwater BMPs are equal to 20% of the implementation costs. Combining implementation and O&M costs, the average annual cost estimate for residential and other urban BMPs is $670 and for transportation corridors it is $10.

Second, for each ERP site, we multiplied its number of acres by the average per-acre cost of its assumed BMP. As we did for the nutrient reduction calculations, we set the maximum treated area at 500 acres.

Table 5-4 reports the estimated annual costs of urban stormwater nutrient controls by subbasin. The largest costs are for the Florida Southeast Coast basin ($56.2 million per year) followed by the Northern Lake Okeechobee basin ($41.8 million). In total, the annual costs for South Florida as a whole are estimated to be $178 million per year.

5.4 Funding Sources for Nutrient Reductions

Although a number of public programs are available to assist communities with the development and implementation of urban stormwater management programs, it appears that the level of public funding for existing urban BMPs represents a relatively small proportion of the total costs. Moreover, much of the funding is designed for retrofit projects, rather than for the

[4] According to Schueler et al. (2007), the ratio of retrofit to new construction costs of extended detention and wet pond stormwater BMPs ranged from 2 to 5.

new development or redevelopment projects that account for a large majority of the BMPs implemented under the ERP program.

Table 5-4. Annual Nutrient Loads, Reductions, and Costs for Urban Stormwater BMPs in South Florida

Subbasin	Pretreatment Nutrient Loads (MT/yr)		Nutrient Load Reductions (MT/yr)		Annual Cost of Urban Stormwater BMPs ($ mil/yr)
	N	P	N	P	
Big Cypress	644	133	47	28	33.4
Caloosahatchee	533	100	24	12	16.6
Southern Everglades Source Basins	372	82	10	6	6.7
Florida Southeast Coast	2,200	598	85	56	56.2
Northern Lake Okeechobee	596	61	28	12	41.8
St. Lucie	389	95	28	17	23.2
Total	**4,735**	**1,068**	**221**	**131**	**178.0**

For example, FDEP administers the TMDL Water Quality Restoration Grant Program, which uses documentary stamp funding to support projects designed to reduce urban stormwater pollutant loadings. It specifically funds retrofit projects for urban lands that were developed without stormwater treatment and that discharge to waterbodies that are on the state's list of impaired waters. FDEP requires that the project provide at least 50% of matching funds, with a minimum of 25% from local government. A listing of existing TMDL grants indicates that through 2009 the program funded over $100 million in projects across the state of Florida; however, roughly $20 million of this total was for eight projects in South Florida. Assuming that 40% of the cost of these eight projects was funded by the grant program, on an annualized basis (4% discount rate and 20-year lifetime), this funding translates to roughly $0.7 million per year.

The FDEP also administers grant money from the USEPA under Section 319(h) of the CWA. Under this program, the federal government provides as much as 60% funding for projects conducted within the state's nonpoint source priority watersheds. The program receives about $4 million per year from USEPA; however, most of the funded BMP projects are pilot projects with relatively small budgets (less than $1 million), and currently few of the projects are located in South Florida.

The SRF program also makes low interest loan funds available for stormwater projects; however, the implied annual cost share from this program for urban stormwater BMP projects is expected to be very small.

Given the limited extent of these public programs, we conclude that the overwhelming majority of the funding for nutrient controls through urban stormwater BMPs has been from the sectors implementing the BMPs. Given this finding, Figure 5-1 shows how the costs are distributed across the private and public sectors that are assumed to own and operate these lands. This distribution assigns all of the costs of BMPs on residential and commercial/industrial/recreational land to the corresponding private sectors. Together they account for over 92% of the total annual costs. The costs of BMPs on institutional land and transportation categories are all attributed to the public sector. For these categories, we have split out the cost estimates for ERP projects that are owned by easily identifiable federal and state government agencies (e.g., Florida Department of Transportation). Together, the public sector spending on urban stormwater controls accounts for the remaining 8% of total annual costs.

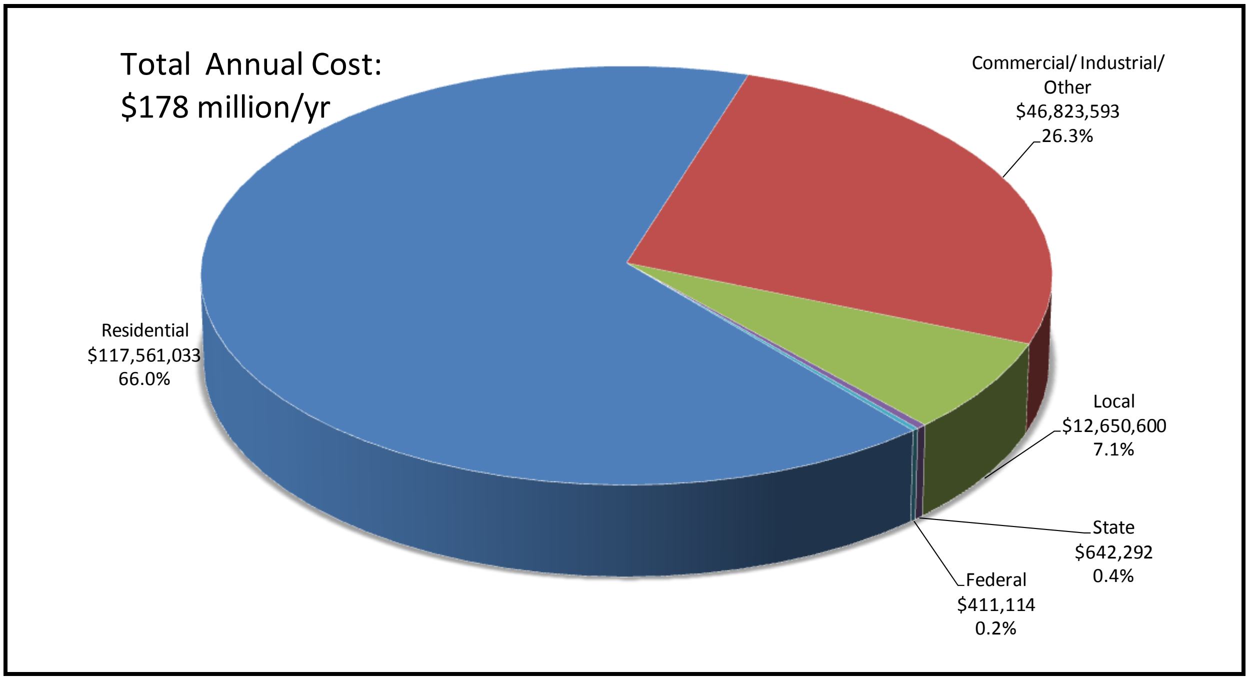

Figure 5-1. Distribution of Annual Nutrient Reduction Costs by Source of Funds

5.5 Caveats and Uncertainties

The nutrient loading, cost, and funding estimates reported above for urban stormwater are all approximations based on available data. The following caveats and uncertainties must be considered when interpreting these estimates.

- The ERP database provides a detailed inventory of stormwater permits issued since the mid-1990s; however, it has important limitations as a source of data for quantifying the implementation of urban stormwater BMPs. In particular, the database does not provide a unique identifier for each development activity requiring BMPs. By selecting only “new” permits, we have, in some cases, omitted new BMP activities, and in other cases we may have double counted activities. In addition, the database does not provide codified data identifying the type(s) of BMPs implemented at each ERP site; therefore, we have assumed a standard BMP, based on the main land use category identified for the permit. Finally, the field describing the number of acres “served” by the site may only provide a rough estimate of the number of acres being treated by BMPs.

- The estimates of per-acre loadings, nutrient removal efficiencies, and per-acre BMP costs used in our analysis are average estimates reported in SWET (2008, 2011) and SFWMD (2011c) for the Caloosahatchee, St. Lucie, and Northern Everglades basins. Therefore, they may be either overestimates or underestimates for the specific sites and BMPs included in our analysis. In addition, because of lack of similar data for the other basins, we transferred these unit values to the other areas of South Florida, which adds to the uncertainty in our estimates.

- To distinguish between private and public sector spending on urban stormwater BMPs, we assumed that ERP sites designated as “recreation” are on private land (e.g., golf courses) and those designated as “institutional” are on public land (e.g., public schools); however, this designation is not always correct.

- Because of data limitation, the analysis does not include the costs or nutrient reductions associated with Florida’s Urban Turf Fertilizer Rule, which restricts the amount of nutrients applied to lawns as fertilizer.

- The analysis does not include the costs or nutrient load reductions associated with controls on active construction sites. These controls are specifically designed to reduce sediment runoff from the sites during construction activity; however, in the process, they also provide some reductions in nutrient runoff.

SECTION 6
PUBLIC WORKS WATER QUALITY PROJECTS

In addition to the previously described programs for controlling nutrients from point sources and for implementing BMPs on agricultural and urban lands, the State of Florida, SFWMD, and the federal government have jointly initiated a wide range of ecosystem restoration projects in South Florida. Beginning in the 1990s, the main objectives of this public-sector partnership have been to improve the quality, quantity, and timing of water flows and to restore and preserve the natural habitats, particularly for the benefit of the Everglades. A key component of these efforts has been the CERP, which was formally launched in 2000 and includes over 60 projects to be implemented over roughly 40 years.

In this section, we focus on five main groups of public works projects that have been completed and are currently providing reductions in nutrient loads to South Florida surface waters[1]. The location of these projects is shown in Figure 6-1. The largest and most significant part of these efforts has been the construction and operation of six main STAs south of Lake Okeechobee; however, a number of other completed projects are also contributing to water quality improvements for the Everglades and other parts of the region.

In this section we describe the scope and costs of the five main groups of projects shown in Figure 6-1. We describe the sources of and annual reductions in nutrient loads associated with these projects, and we discuss how the funding for these projects has been distributed.

6.1 The ECP STAs

The ECP was mandated in 1994 by the EFA (Section 373.4592, Florida Statutes) and is the cornerstone project for Everglades restoration. The main component of this project has been the construction and operation of six large STAs, which together comprise roughly 45,000 acres of freshwater treatment wetlands. As shown in Figure 6-2, the STAs are all located south of Lake Okeechobee and the EAA. Using natural biological processes, they are primarily designed to remove excess levels of phosphorus in the waters flowing from Lake Okeechobee and the EAA to the EPA.

[1] One of the projects—Kissimmee River Restoration—is ongoing, but significant phases of the project have been completed.

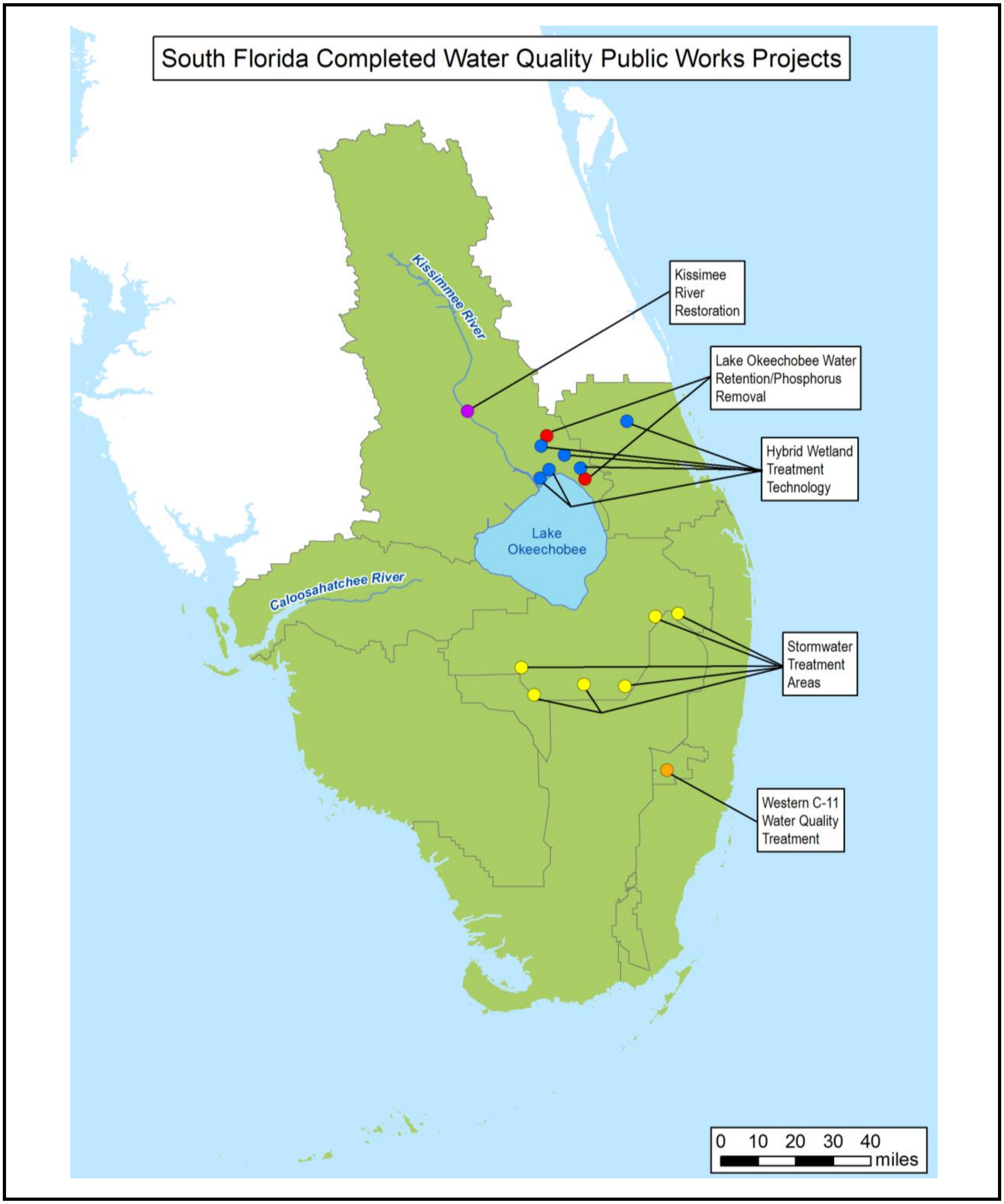

Figure 6-1. Completed Water Quality Public Works Projects

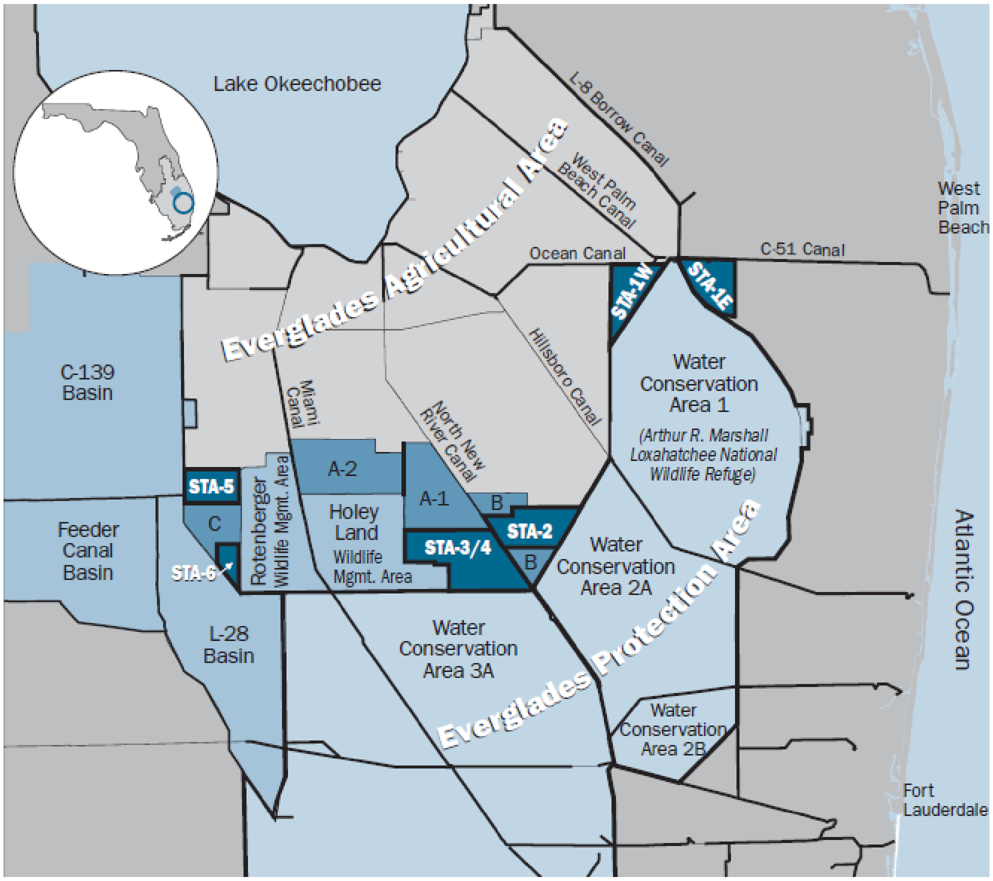

Figure 6-2. The ECP STAs

Source: http://my.sfwmd.gov/portal/page/portal/xrepository/sfwmd_repository_pdf/bts_sta.pdf

Construction of the six STAs began in 1997 and was completed in 2005. In addition, construction for two main expansions of the STAs is currently in progress and expected to be completed in 2012. These Compartment B & C expansions, which are also shown in Figure 6-2, will primarily supplement STA-2 and STA-6 by adding almost 12,000 additional acres of wetlands.

Based on monitoring data from 2004 to 2010, Table 6-1 reports the average annual pretreatment load of phosphorus for each STA (SFWMD, 2005c, 2006a, 2007b, 2008b, 2009e, 2010a, 2011b). The pretreatment load is equal to the inflow of total phosphorus to each STA. It represents the amount of phosphorus that would be discharged each year from the ECP basin into the EPA, if the STAs were not in place. The combined annual pretreatment load for the STAs is equal to 216 MT of phosphorus.

Table 6-1. Annual Nutrient Loads, Reductions, and Costs for the ECP STAs

ECP Basin STA	Pretreatment Phosphorus Loads (MT/yr)	Phosphorus Load Reductions (MT/yr)	Annual Project Cost ($ mil/yr)
STA 1 E	24.3	14.2	22.0
STA 1 W	52.5	26.9	11.6
STA 2	38.9	21.8	13.1
STA 3/4	64.2	57.8	20.0
STA 5	29.2	19.0	6.5
STA 6	6.6	4.5	3.8
Total	**215.7**	**144.2**	**77.0**

Loadings to the STAs originate in the ECP basins south of Lake Okeechobee, including the EAA, C-139, and portions of the C-51W and L-8 basins (northeast of the EAA) that are not delivered to tide. In addition, STAs receive flow-through loadings from Lake Okeechobee. Because the Lake has accumulated nutrients over many years, we characterize these flows as legacy loadings. To estimate the portions of phosphorus attributable to the different land uses and legacy loadings, we first estimated annual flow-through loads from Lake Okeechobee. Between WY2004 and WY2010 an estimated average of 18.11 MT of phosphorus delivered to STAs are attributable to Lake Okeechobee flow-through in the EAA (BPC, 2008; SFWMD, 2009e, 2010a, 2011b). Since comparable data does not exist for Lake Okeechobee flow-through from L-8 canal, we rely on the estimated average for WY1995-2004 of 9.45 MT (Burns & McDonnell, 2005). This flow-through from Lake Okeechobee is 13% of phosphorus loadings to STAs, which we attributed to land use based on the estimated pretreatment loading to surface waters in the Northern Lake Okeechobee subbasin, including agricultural, urban, and natural sources. We then attributed the remaining 87% of phosphorus loadings to land use based on the estimated pretreatment loadings to surface waters in all ECP basins (see Table 6-3 [later in this section] for details). For these estimates, we do not adjust for in-stream attenuation or estimate loadings delivered to tide by land use.

Table 6-1 also reports the load reduction achieved by each STA, which is equal to the annual amount of phosphorus retained by each wetland area. In combination, the STAs retain an average of 144 MT of phosphorus each year. In other words, the STAs, on average, retain and reduce phosphorus loads to the EPA by 67%.

To estimate the annual costs of the STAs we combined information on the total construction costs of the projects with average annual O&M costs from 2004 to 2010. In 2010 dollars, the total combined construction cost for the six STAs was $867 million (SFWMD, 2011d). Annualizing these costs (4% discount rate and 20-year lifetime), the combined annualized construction cost for the six STAs is $64 million per year. Based on expenditures listed in the SFWMD's yearly Comprehensive Annual Financial Reports from 2004 to 2010 (SFWMD, 2005d, 2006b, 2007c, 2008c, 2009f, 2010c, 2011g), the average annual O&M cost for the STAs has been $13 million per year. In the cost estimates reported in Table 6-1, these O&M costs have been divided equally across the six STAs. Combining the annualized construction and O&M costs, we estimate the annual costs of the ECP STAs to be $77 million per year.

As shown in Figure 6-3, funding for the STAs is split between the federal government through USACE, the State of Florida, and the SFWMD. The USACE contributed primarily to the project by assisting the construction of STA-1E at a cost of $199 million. Thus, the federal contribution to the STA project is 23%. The rest of the funding is divided among the State and the SFWMD, through its ad valorem and agricultural taxes. To calculate the remaining funding, we estimated percentages based on revenue data for the ad valorem taxes, agricultural taxes (from both the EAA and C-139 basins), and state contributions from the Everglades Financial Report for the year 2011 (SFWMD, 2011b). Over half of STA funding comes from SFWMD ad valorem taxes, while the State's contribution accounts for 12% of the STA funding. The SFWMD agricultural privilege tax accounts for 13% of the total STA yearly costs, with over 95% of those revenues coming from the EAA basin.

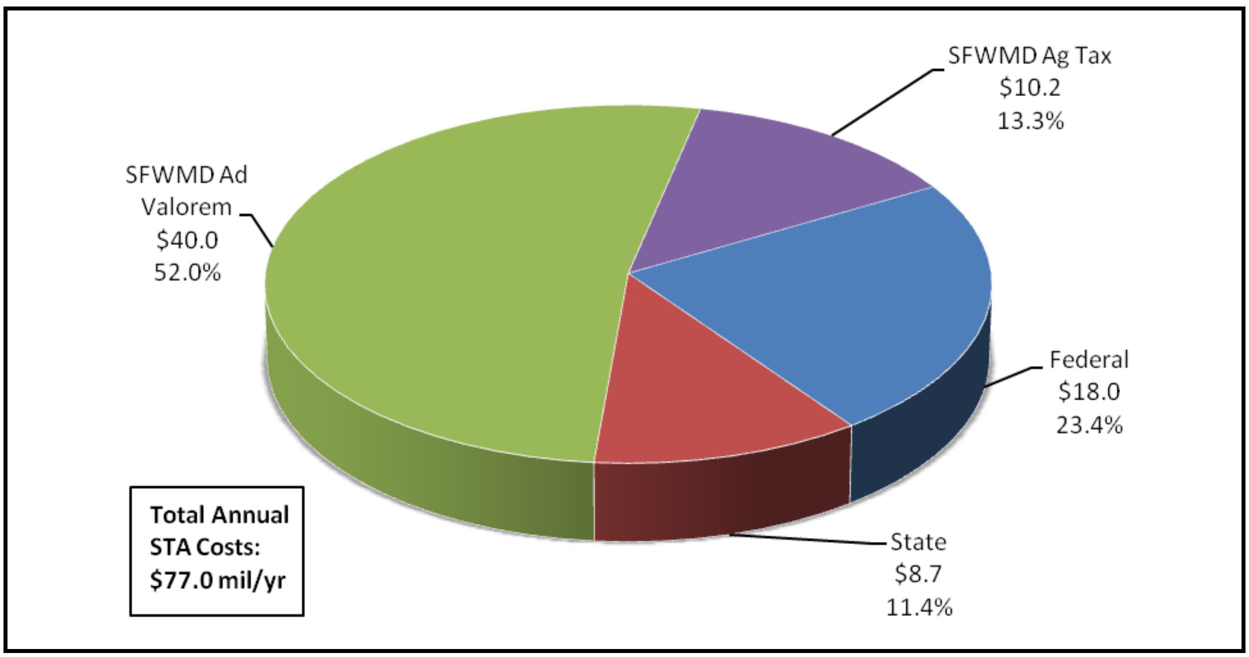

Figure 6-3. STA Funding by Source ($ mil/year, %)

6.2 The “Critical Projects”

Under the WRDA of 1997, the U.S. Congress authorized the Everglades and South Florida Ecosystem Restoration Critical Projects. These projects, which have been jointly funded by the USACE and SFWMD, include several initiatives to restore natural water flows and improve water quality in South Florida. Although these projects were not formally created as part of the CERP, they are interrelated with the CERP projects as efforts to restore the south Florida ecosystem.

6.2.1 The Lake Okeechobee Water Retention/Phosphorus Removal Critical Restoration Project

This project consists of two main components—the 190-acre **Taylor Creek STA** and the 780-acre **Nubbin Slough STA**—which are designed to store water runoff and reduce phosphorus discharges to Lake Okeechobee. They are located north of Lake Okeechobee, in the watersheds of the same name, which are shown in Figure 6-4. Like the ECP STAs, these smaller projects use constructed freshwater wetlands to achieve these objectives.

Figure 6-4. The Taylor Creek and Nubbin Slough Watersheds

Source: http://www.evergladesplan.org/images/taylor_72.jpg

As shown in Table 6-2, the pretreatment phosphorus loads (i.e., phosphorus inflow loads) to the two STAs are each between 5 and 6 MT per year (Miller & Barascout, 2003). In the Taylor Creek and Nubbin Slough watersheds in general, WAM estimates indicate that roughly 91% of phosphorus loads to surface waters are associated with agricultural sources, in particular cow/calf operations and dairies; therefore, the pretreatment loads to the STAs are also assumed to be predominantly from agricultural sources. According to the SFWMD's Lake Okeechobee Watershed Stormwater Treatment Areas Projects Report (SFWMD, 2009b), each of the two STAs remove between 2 and 3 MTs of phosphorus per year or roughly 45% of the inflow.

Table 6-2. Annual Phosphorus Loads, Reductions, and Costs for Other Public Projects

Project Name	Pretreatment Phosphorus Loads (MT/yr)	Phosphorus Load Reductions (MT/yr)	Annual Costs ($ mil/yr)
Critical Projects			
Lake Okeechobee Water Retention/Phosphorus Removal			
Taylor Creek STA	5.4	2.0	0.7
Nubbin Slough STA	5.6	3.0	1.9
Western C-11 Water Quality Treatment	6.4	1.5	1.6
Hybrid Wetland Treatment Technology (HWTT)	5.0	4.0	2.1
Kissimmee River Restoration (KRR)	108.2	20.6	51.7
Total	**130.8**	**31.1**	**58.1**

The construction costs for the Taylor Creek and Nubbin Slough STAs were $5 million and $20 million (in 2010 dollars), respectively, and the annual O&M costs are $0.3 million and $0.4 million (SFWMD, 2011e). Annualizing the construction costs and combining these elements, the annual costs for the two STAs are estimated to be $0.7 million and $1.9 million, respectively. Because these STAs were a part of a Critical Project from the WRDA of 1997, the project was eligible for a 50% funding match by the USACE. Therefore, funding for this critical project is a 50/50 split between the SFWMD ad valorem funds and the federal government (SFWMD, 2011b).

6.2.2 Western C-11 Water Quality Treatment

The C-11 West Basin is a predominantly urban 72-square mile drainage area in southwest Broward County (see Figure 6-5). Before 2003, seepage and stormwater runoff from the basin were back-pumped into the Everglades. The purpose of this project was to construct a spillway structure to separate clean seepage flows from stormwater flows and a pump station to pump clean flows into the Everglades Water Conservation Area 3A. The pump station was completed in 2003, and the spillway structure was completed in 2005.

During the period 1998 to 2002 (i.e., prior to completion of the project), annual phosphorus loads from the C-11 basin to the EPA averaged 6.4 MT per year. This value is interpreted and reported in Table 6-2 as the pretreatment load from the C-11 West Basin. During the period 2006 to 2008, after completion of the project, the average phosphorus load declined to roughly 3 MT per year (SFWMD, 2011b). Because part of this decline may be a result of other factors, we conservatively assumed that half of the observed reduction in phosphorus loads (1.5 MT) is attributable to the project (Table 6-2).

As shown in Table 6-3, the construction costs for the project were $18.5 million (in 2010 dollars) (USACE, 2011). On an annualized basis, this translates to $1.36 million per year. No data are available regarding O&M costs for this project; therefore, we assumed that they are the same percentage of total annual costs as for the ECP STAs (i.e., 25% of annualized construction costs). This provided an annual O&M cost of $0.35 million and a total annual cost of $1.6 million. As described above, the funding for the Western C-11 water quality improvements were spilt 50/50 between the SFWMD ad valorem funds and the USACE.

6.3 Other Projects

6.3.1 The Lake Okeechobee Watershed Hybrid Wetland Treatment Technology

This project involved several pilot applications of an HWTT (i.e., a combination of wetland and chemical treatment approaches) to achieve nutrient removals. In 2008, the method was applied at three 1- to 2-acre sites north of Lake Okeechobee and another in the St. Lucie watershed. In 2010, two additional HWTT facilities were completed in the Lake Okeechobee watershed (SFWMD, 2011f).

According to data from the SFWMD (2011f), the combined projects are reducing phosphorus concentrations by 80 to 90% and are reducing total phosphorus loads by 4 MT per year. These rates imply that without treatment the annual pretreatment loads from these sites would have been as much as 5 MT per year.

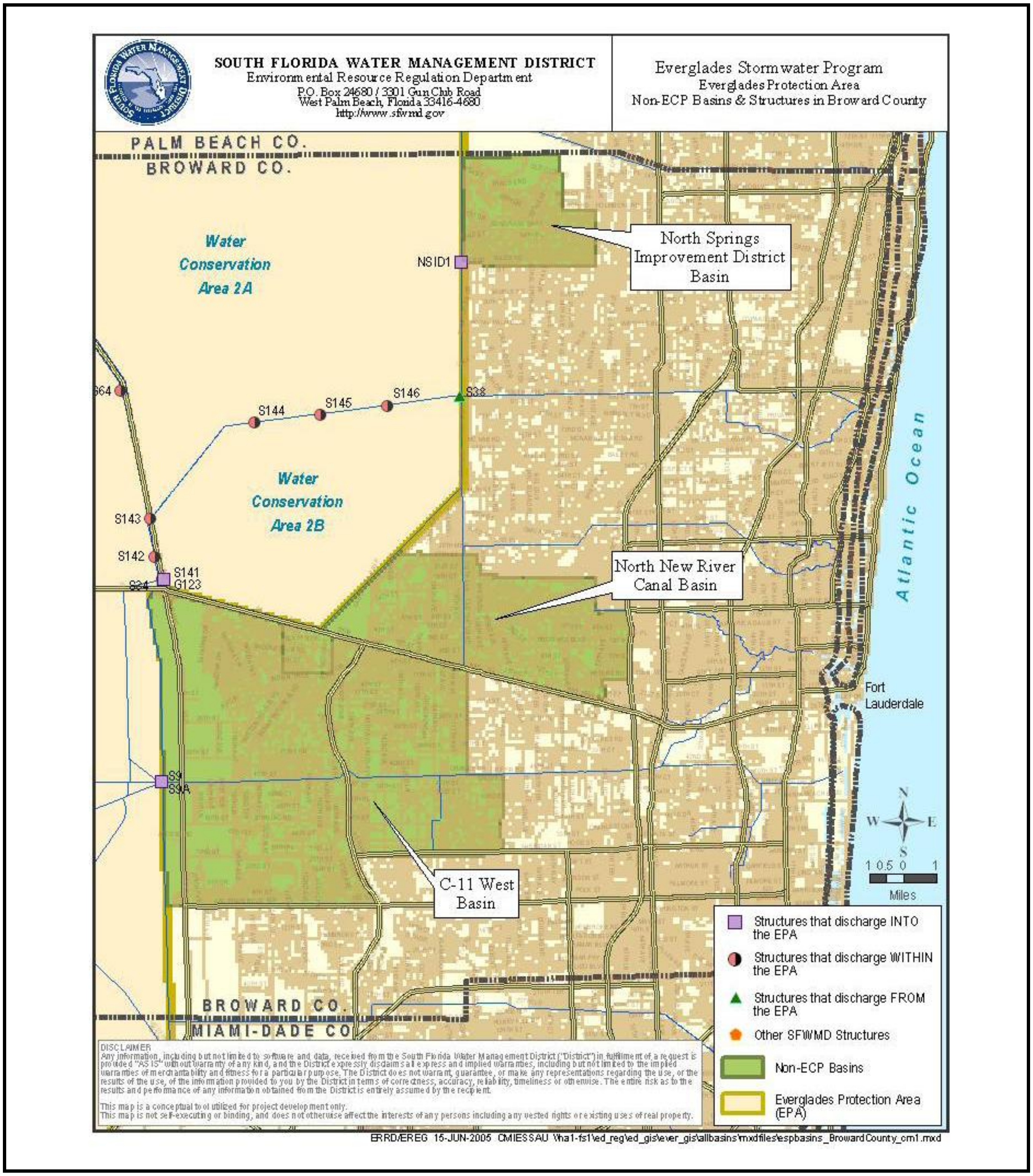

Figure 6-5. The C-11 West Basin Discharging to the EPA

Source: http://www.sfwmd.gov/portal/page/portal/xrepository/sfwmd_repository_pdf/c-11april_06_v2_wappendix.pdf

Table 6-3. Sources of Pretreatment Phosphorus Loads and Funding for the Completed Public Works Projects

	Pretreatment Loads (MT/yr) by Source Category			Annual Project Costs ($ mil/yr) by Funding Source			
Project Name	**Agriculture**	**Urban**	**Natural Lands**	**Federal**	**State**	**SFWMD Ad Valorem Property Tax**	**SFWMD Agricultural Privilege Tax**
ECP Basin STAs[a]	185.7	20.9	9.1	18.0	8.7	40	10.2
Lake Okeechobee Water Retention/Phosphorus Removal	9.9	0.4	0.6	1.3		1.3	
Western C-11 Water Quality Treatment	1.0	5.3	0.1	0.8		0.8	
Hybrid Wetland Treatment Technology (HWTT)	4.5	0.2	0.3		1.1	1.1	
Kissimmee River Restoration (KRR)	66.1	11.7	30.6	25.9	11.9	14.0	
Total	**267.3**	**38.5**	**40.7**	**46.0**	**21.7**	**57.2**	**10.2**
Percent	**77%**	**11%**	**12%**	**34%**	**16%**	**42%**	**8%**

[a] Estimated pretreatment loads for this project include 27.6 MT of Lake Okeechobee flow-through loads to the STAs.

The total construction costs of the HWTT projects were $6 million (in 2010 dollars) with annual O&M costs of $1.7 million. Once the construction costs are annualized and these elements are combined, the total cost of all six HWTT projects is $2.1 million a year. The HWTT projects are a joint venture between the SFWMD and FDACS, and the cost is shared 50/50 by the entities (Merriam, 2008).

6.3.2 Kissimmee River Restoration (KRR)

To protect the developing coastline of Florida after World War II, the USACE enacted numerous flood-control projects on South Florida’s waterbodies under the Central and Southern Florida (C&SF) Flood Control Project. One of these projects was the channelization of the Kissimmee River. The created channel eliminated the natural meanders of the river and dewatered the nearby wetlands. This project had many negative environmental impacts, including degrading water quality, increasing sedimentation, and diminishing fish and wildlife habitat. In the 1990s, the KRR Evaluation Program was enacted to return the river to hydrologic conditions similar to that of prechannelization.

The KRR involves four phases of recarving the natural river channel and backfilling the former canal. From 1999 to 2009, the first three phases were completed, and 14 miles of canals have been backfilled and 7,700 acres of wetlands have been gained. In 2014, when the final phase is expected to be complete, 40 miles of river channel will receive reestablished flow (SFWMD, 2011b).

Although improving water quality is only one of the intended results of the KRR project, the restoration of the Kissimmee River results in reduced phosphorus loading because water experiences a more natural and longer hydroperiod and must pass through a wetland ecosystem. The SFWMD estimates a 19% reduction, or 20.6 MT per year, in total phosphorus from this project (SFWMD, 2011a). This is the amount of total phosphorus that would enter Lake Okeechobee and the Everglades system if the river system had not undergone this restoration.

The KRR project is funded jointly between the SFWMD and the USACE. The District is primarily responsible for land acquisition and evaluation monitoring, while USACE is tasked with engineering and construction responsibilities. According to the South Florida Ecosystem Restoration Program Task Force's 2011 Cross-Cut Budget, the USACE has funded $293 million (in 2010 dollars) of the KRR project (South Florida Ecosystem Restoration Program, 2011), while the District has spent $410 million (in 2010 dollars) thus far on land acquisition (SFWMD, 2010a). This results in a total cost of $703 million as of 2011. At a 20-year lifetime and a 4% discount rate, the KRR total annual construction and land acquisition costs come to $51.7 million.[2]

It is important to remember when comparing the costs of the KRR project to other nutrient control efforts that reducing nutrient loads has not been the primary objective of this project. The project has many other intended benefits such as flood control, improved hydrology, and restored habitat for local species. Nevertheless, the project has resulted in significant nutrient load reductions, which are important to account for in our analysis.

Similar to other Everglades public works projects, the KRR project's funding is spilt 50/50 between the USACE and SFWMD. For this project, the District received funding from the State's Florida Forever Fund in addition to ad valorem taxes. The Florida Forever Fund is administered by FDEP to fund land acquisition needed for conservation and restoration projects. The Florida Forever Fund accounts for 55% of the SFWMD's contribution, while the remaining

[2] Data on the annual O&M costs of the KRR were not reported in the data sources we used for our analysis and are, therefore, not included in the estimates.

funding comes from ad valorem taxes (SFWMD, 2006c, 2007a, 2008a, 2009a, 2010b). This results in a total funding breakdown of 50% from USACE, 27% from the State of Florida, and 23% from SFWMD ad valorem taxes.

6.4 Caveats and Uncertainties

The estimated costs, funding, and load reductions associated with public works projects in South Florida must be interpreted with the following caveats and limitations in mind.

- The analysis only includes completed projects (in the case of the KRR, completion of the first three phases). Several other projects are also currently in development, including the expansions of the ECP STAs and several large-scale CERP projects. These projects are currently being funded (primarily through the USACE and SFWMD), and they are projected to provide substantial additional future reductions in nutrient loads. However, because data are limited on any *current* nutrient reductions associated with these other projects, we have not included them in our analysis.

- Based on data availability, all of the quantified nutrient reductions from the completed projects are expressed only in terms of phosphorus reductions. Generally speaking, excess phosphorus loadings are a much higher level of concern than nitrogen for the Everglades and Lake Okeechobee. Nevertheless, some amount of nitrogen reduction is certainly occurring with these projects, but data on these reductions are lacking.

- Our analysis does not include the recently completed Lake Trafford Restoration Critical Project in Collier County. This $21.4 million project, which has been funded primarily through SFWMD and USACE funds, has improved water quality in the lake by removing 6 million cubic yards of nutrient-laden muck from its bottom. However, because the project was not designed to reduce *external* loads of nutrients to the lake and we were not able to locate estimates of changes in internal nutrient loads from the lake bottom, it was not included in our estimates.

- As previously discussed, the KRR project was not designed for the specific purpose of reducing nutrient loads. It includes a much broader set of objectives, including establishing a more natural flow pattern and restoring the river’s ecosystem. Therefore, the cost estimates for the project as a whole overstate the costs for specifically achieving the reported nutrient reductions.

- Although the District estimates a 19% reduction in total phosphorus from the KRR project, current total phosphorus loads (while decreasing since 2005) have not returned to levels below the average baseline, water years (WY) 1974–1995 (SFWMD, 2011b). Total phosphorus reduction estimates are difficult to ascertain because loading data from before the river was channelized were not calculated, and further study of the KRR’s effect on total phosphorus loading is currently underway.

Because of these factors, the 19% total phosphorus reduction figure may be an overestimation.

SECTION 7
SUMMARY OF FINDINGS

This section combines and summarizes the results from the previous sections to address the following key questions posed at the beginning of the report:

- How large are the costs of existing nutrient control efforts in South Florida and how much are they reducing nutrient loads to surface waters?
- Who bears the cost of these nutrient control measures and how have they been shared across different sectors?
- How does the distribution and burden of costs compare with the contributions to nutrient loads in South Florida?

Table 7-1 summarizes our estimates of the total nutrient loadings (pretreatment and current) coming from four main categories of sources—domestic WWTFs, agricultural runoff, urban runoff, and runoff from undeveloped (i.e., natural) land areas.[14]

7.1 Nutrient Loading Estimates

For **pretreatment loads**, we estimate that domestic WWTFs are the main source of both nutrients, accounting for over 60% of the total 63,000 MT/yr of nitrogen and 9,700 MT/yr of phosphorus. Agriculture accounts for the second largest portion (20 to 24%), followed by urban lands (8 to 11%).

For **current loads** (i.e., "posttreatment" loads), the ordering across categories is different, with agriculture accounting for the largest portion (almost 50%) of the total 26,900 MT/yr of nitrogen and 3,100 MT/yr of phosphorus. We estimate that WWTFs account for 20% and 16% of the nitrogen and phosphorus loads, respectively, compared with 17% and 30% for urban lands.

It is important to note that there is a distinct spatial distribution of these loads. Under current conditions, we estimate that the Florida Southeast Coast Basin, with roughly 70% of South Florida's population, accounts for 30% of the nitrogen and 37% of the annual phosphorus loads to surface water (including ocean outfalls).

[14] Loadings estimates from natural areas were not included in our previous sections because they are not the focus of nutrient control efforts in South Florida. For completeness (i.e., to account for all main sources of nutrients loads) we have included them in this summary discussion.

Table 7-1. Summary of Annual Loads, Reductions, and Costs by Nutrient Source and Control Category

	Nitrogen (MT/yr)			Phosphorus (MT/yr)			
Nutrient Source **Nutrient Control Category**	**Pretreatment Loads**	**Load Reductions**	**Current Loads**	**Pretreatment Loads**	**Load Reductions**	**Current Loads**	**Total Annual Cost ($ mil/yr)**
Wastewater (Residential, Commercial, Industrial, and Other)	38,774		5,240	6,387		482	515
Domestic WWTFs		33,534			5,905		
Agricultural Land	15,266		12,845	1,950		1,449	
Agricultural BMPs		2,422			356		37
Public Works Projects		—[a]			145		112
Urban Land (Residential, Commercial, Industrial, and Other)	4,735		4,514	1,068		920	
Urban Stormwater BMPs		221			131		178
Public Works Projects		—[a]			18		14
Natural Lands	4,255		4,255	258		246	
Public Works Projects		—[a]			12		10
Total	**63,031**	**36,176**	**26,854**	**9,663**	**6,568**	**3,095**	**866**

[a] Not quantified

7.2 Estimated Size and Costs of Nutrient Load Reductions

Table 7-1 also summarizes our estimates of (1) the annual nutrient load reductions associated with four main categories of controls—WWTFs, agricultural BMPs, urban BMPs, and public works projects (corresponding to Sections 3, 4, 5, and 6 of this report) and (2) the annual costs of these controls. In general, the public works projects treat nutrient loadings originating from multiple upstream sources; therefore, the nutrient reductions and costs of these projects are spread across the agricultural, urban, and natural land source categories in Table 7-1.

Of the four main control categories, WWTFs account for the largest reduction in nutrient loads. We estimate that they account for 93% of the total 36,200 MT/yr in nitrogen load reductions and 90% of the total 6,600 MT/yr in phosphorus load reductions. Agricultural BMPs account for 7% and 5%, respectively, and urban stormwater BMPs account for 1% and 2%, respectively, of these total annual nitrogen and phosphorus reductions. The public works projects account for almost 5% of the annual phosphorus load reductions.

In addition, Table 7-1 summarizes the estimated annual costs of these nutrient load reductions. For the four main nutrient control categories combined, we estimate annual costs of $866 million per year. Wastewater treatment, disposal, and reuse account for 60% of these costs, followed by urban stormwater BMPs, which account for 21%. The annual cost of the completed public works projects is estimated to be $135 million, which is approximately 16% of the total. We estimate that the agricultural BMPs account for 4% of the total annual costs.

7.3 Who Bears the Costs of the Nutrient Controls?

For each of the four nutrient control categories, Table 7-2 summarizes how the estimated costs of nutrient reductions are distributed across different sources of government funding and private-sector spending. As discussed in Section 3, the costs of wastewater treatment, disposal, and reuse are primarily borne by wastewater utility customers, with roughly an 80/20 split between residential and commercial/industrial sectors. A small portion of these costs (roughly 1%) is publicly funded.

For agricultural BMPs, we estimate that approximately 83% of the $37 million in annual costs is directly paid for by the agricultural sector. Through cost-share programs, the federal and state governments fund almost all of the remaining 17%.

Like wastewater treatment, we estimate that a large majority of the costs of urban stormwater BMPs are borne by sectors in which they are installed; therefore, 92% of the annual costs are paid for by urban residential, commercial, and industrial landowners. Urban stormwater

Table 7-2. Distribution of Annual Nutrient Control Costs by Funding Source ($ mil/year)[a]

	Government					**Private Sector**			
			SFWMD						
Nutrient Control Category	**Federal**	**State**	**Ad Valorem Tax**	**Ag. Privilege Tax**	**Local**	**Residential**	**Commercial, Industrial & Other**	**Agricultural**	**Total Annual Cost ($ mil/yr)**
Domestic WWTFs	7	1				406	101		515
	1%	*0.3%*				*79%*	*20%*		*100%*
Agricultural BMPs	3	3	0.03	0.1				31	37
	9%	*8%*	*0.1%*	*0.3%*				*83%*	*100%*
Urban Stormwater BMPs	0.4	1			13	117	47		178
	0.2%	*0.4%*			*7%*	*66%*	*26%*		*100%*
Public Works	46	22	57	10					135
	34%	*16%*	*42%*	*8%*					*100%*
Total	**56**	**27**	**57**	**10**	**13**	**523**	**148**	**31**	**866**
	7%	***3%***	***7%***	***1%***	***1%***	***60%***	***17%***	***4%***	***100%***

[a] Numbers in percentage terms represent the percentage of each row's total costs that are paid for by each funding source.

BMPs are also installed on public lands (e.g., public schools and roadways); therefore, we estimate that federal, state, and local institutions pay for roughly 8% of the total annual costs. Although federal and state grant funds are available to support urban stormwater BMP projects (in particular, retrofit projects), we estimate that these funds account for a very small portion of the total annual costs of urban stormwater controls.

Finally, we estimate that about half of the annual funding for the completed public works projects is provided by the SFWMD through a combination of ad valorem property tax revenues (42% of total annual projects costs) and agricultural privilege taxes (8% of total costs). The federal government, in particular the USACE, funds the second highest portion of the costs (34%) and state government revenues fund the remaining 16%.

The last lines of Table 7-2 show how the costs for the four areas combined are divided. Spending by the residential and commercial/industrial sectors accounts for approximately 80% of the total annual costs. Property owners in the SFWMD support another 7% of the costs through ad valorem tax payments. The agricultural sector pays for roughly 5% through a combination of direct spending on BMPs and agricultural privilege tax payments. federal, state, and local government revenues account for the remaining 10%.

7.4 Comparing the Distributions of Nutrient Loadings with the Distribution of Funding

To answer the last question—how does the distribution and burden of costs compare with the contributions to nutrient loads in South Florida?—Figures 7-1, 7-2, and 7-3 compare the distributions of annual pretreatment nitrogen loads and current nitrogen loads (across loading source categories) with the distribution of total annual control costs (across source funding source categories). Figures 7-4, 7-5, and 7-6 provide the same comparisons for phosphorus loads. Figure 7-6 contains the same information as Figure 7-3, because the costs and funding estimates do not vary according to the nutrient type (nitrogen or phosphorus). The information is repeated for comparison purposes.

As discussed above, the residential, commercial, industrial, and related private sectors account for approximately 69% of the pretreatment nitrogen loads through wastewater discharges and urban runoff.[1] Posttreatment, they account for a smaller portion (36%) of current

[1] In the figures, the relative contribution of the residential and the commercial/industrial sectors to wastewater loads is assumed to be 80% versus 20%, which is the same as the assumed distribution of spending for wastewater treatment, disposal, and reuse.

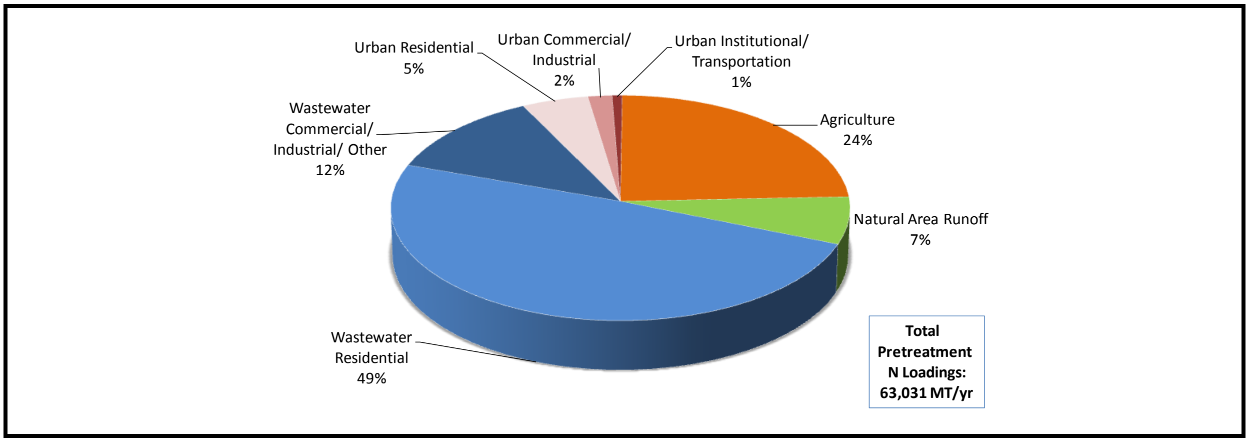

Figure 7-1. Distribution of Pretreatment Nitrogen Loads by Source Category

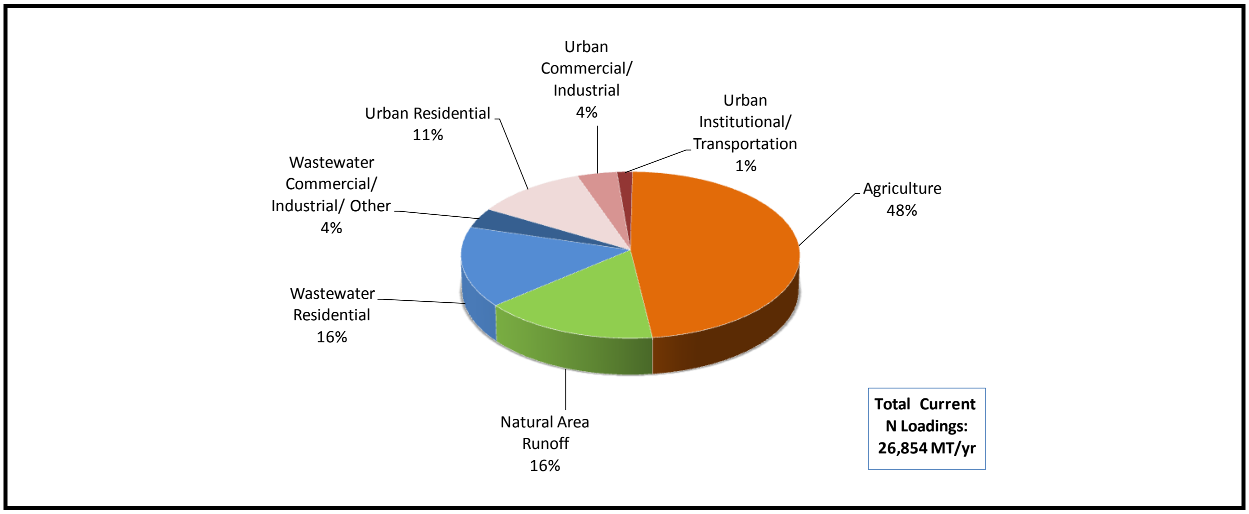

Figure 7-2. Distribution of Current Nitrogen Loads by Source Category

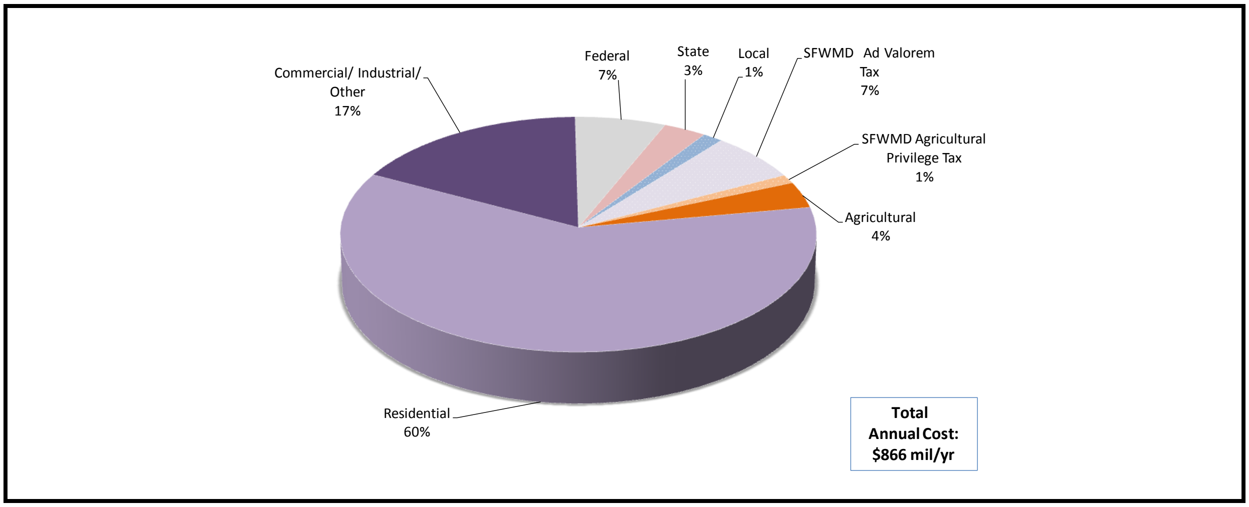

Figure 7-3. Distribution of Nutrient Reduction Costs by Source of Funds

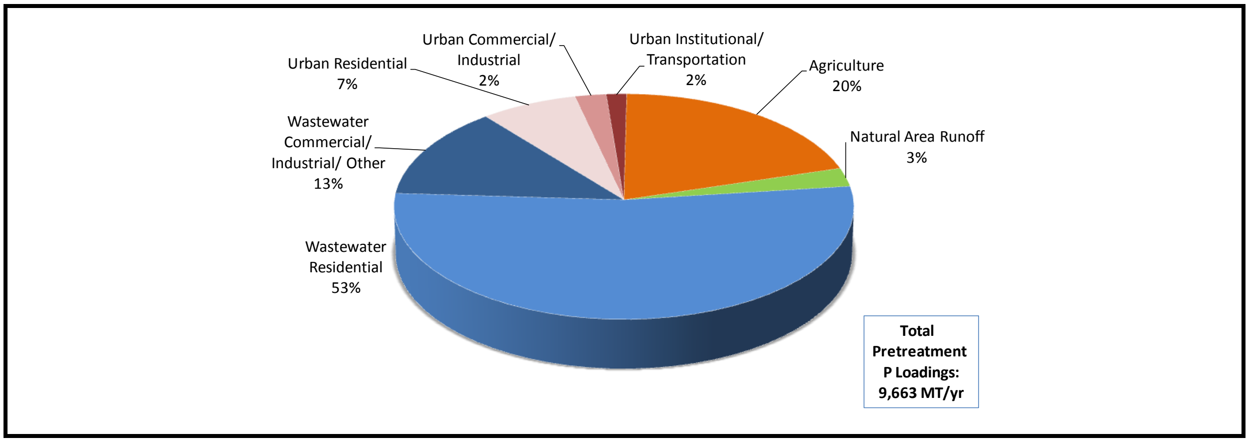

Figure 7-4. Distribution of Pretreatment Phosphorus Loads by Source Category

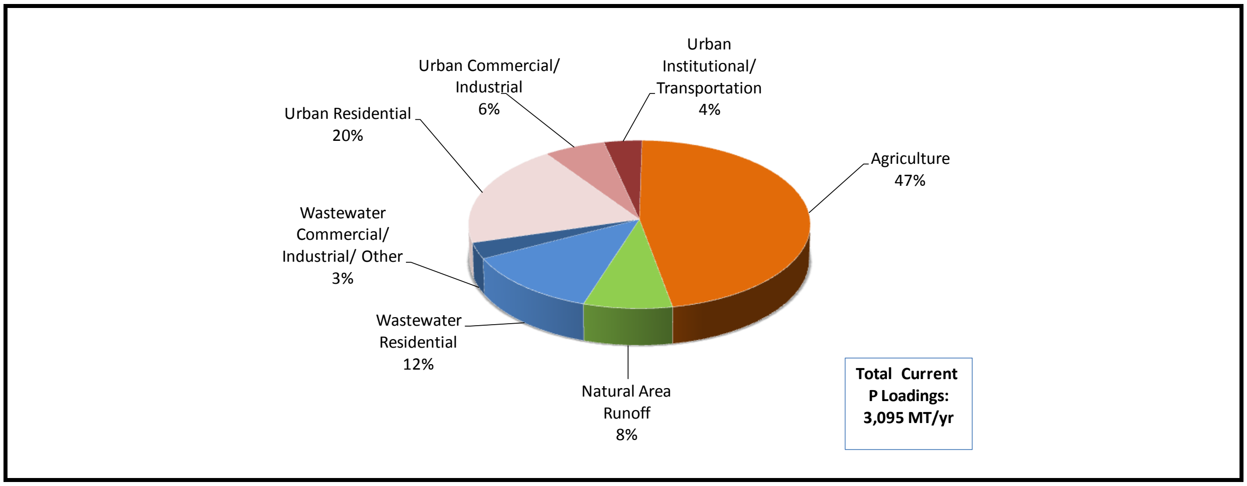

Figure 7-5. Distribution of Current Phosphorus Loads by Source Category

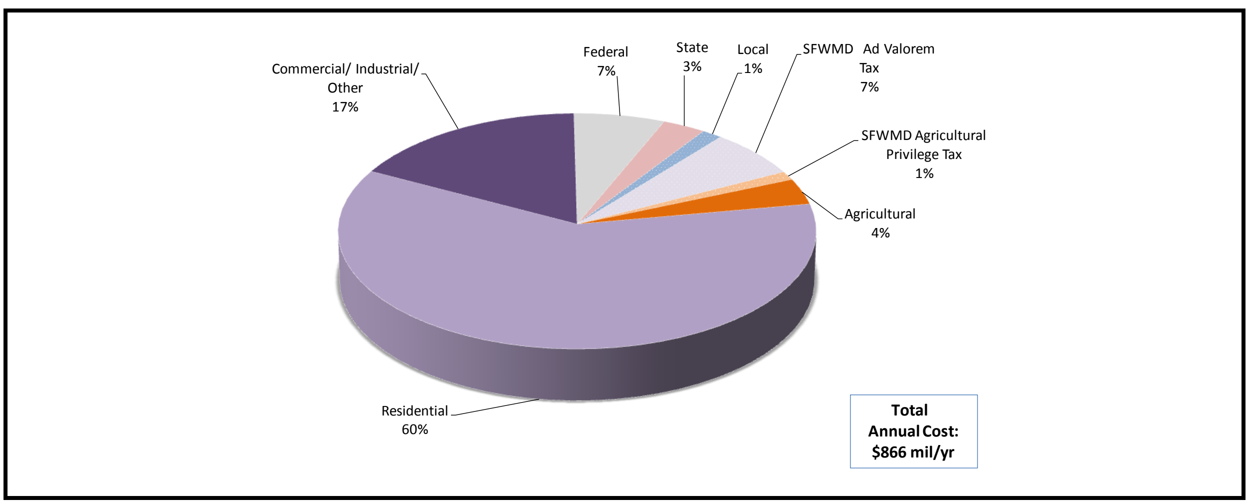

Figure 7-6. Distribution of Nutrient Reduction Costs by Source of Funds

annual nitrogen loads to South Florida surface waters. According to the results summarized in Figure 7-3, these sectors in the SFWMD also incur about 77% of the costs of nutrient controls, primarily through wastewater utility rates and spending on urban stormwater BMPs as part of development and redevelopment activities. They also are the largest contributors to SFWMD ad valorem property tax revenues, which cover another 7% of the total costs. In addition, they contribute a portion of the state, federal, and local tax revenues that are used to fund nutrient reduction activities in South Florida and that account for about 11% of total funding.

The agricultural sector in contrast contributes roughly 24% of the annual pretreatment nitrogen loads and almost 48% of the current annual loads to South Florida surface waters. According to the results summarized in Figure 7-3, the agricultural sector in the SFWMD incurs roughly 4% of the total costs of nutrient controls, primarily through BMP installation, operation, and maintenance. It also contributes another 1% through the SFWMD agricultural privilege tax. In addition, this sector contributes some percentage of the district's property tax revenues and the state, federal, and local tax revenues that are used to fund nutrient reduction activities in South Florida. The agricultural sector is the only sector with significant cost shares from public funds (17% of annual costs) for source controls. Agriculture also contributes a portion of the district's property tax revenues and the state, federal, and local tax revenues that are used to fund nutrient reduction activities in South Florida.

As shown in Figures 7-4, 7-5, and 7-6, the basic comparative results are very similar for phosphorus loadings. Compared with nitrogen loads, the residential, commercial, industrial, and related private sectors account for an even larger percentage of the pretreatment phosphorus loads (over 75%) through wastewater and urban runoff, whereas agriculture contributes a somewhat smaller percentage (20%). Posttreatment, agriculture's relative contribution to current annual phosphorus loads is similar to its nitrogen contribution (47%), whereas the residential, commercial, industrial, and related sectors' contribution is somewhat larger (45%). We estimate that the completed public works projects reduce 175 MT of phosphorus annually, 77% of which is estimated to originate from agricultural land (see Table 6-3). Property owners in South Florida fund 42% of the cost of these reductions through ad valorem taxes, federal and state funding contributes 50%, and the dedicated agricultural privilege tax supplies the remaining 8%.

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APPENDIX A
COST ESTIMATION METHODOLOGY FOR SECONDARY TREATMENT AT DOMESTIC WASTEWATER TREATMENT FACILITIES

To estimate capital and O&M costs associated with secondary wastewater treatment at domestic WWTFs in South Florida cost correlations were developed from a series of model facilities. The model facilities’ costs were developed using CapdetWorks v2.5d and updated to August 2010 dollars using the *Engineering New Record Construction Cost Index* (http://enr.construction.com/economics/default.asp). As shown in Table A-1, we used five model facilities with flow rates ranging from 5 to 145 MGD and consisting of the following unit processes:

- Bar screen (primary treatment)
- Activated sludge (secondary treatment)
- Secondary clarification (secondary treatment)
- UV disinfection
- Sludge thickening
- Anaerobic sludge digestion
- Belt filter press sludge dewatering
- Sludge hauling and landfilling

Default influent chemical characteristics and steady-state flow rates were assumed when developing the models. O&M cots were assumed to include operation, maintenance, materials, chemicals, and energy costs. The capital and O&M costs for each size facility were plotted versus flow rate and the data analyzed using Microsoft Excel. Presented in Figures A-1 and A-2 are the developed cost curves for the capital and O&M costs.

Table A-1. Summary of Cost Estimates for Five Model Facilities

Flow, MGD	Capital Costs, $MM	Total O&M Cost, $MM	$/1,000
5	29.8	0.917	0.50
40	168	4.55	0.31
75	283	8.04	0.29
110	395	11.42	0.28
145	495	14.73	0.28

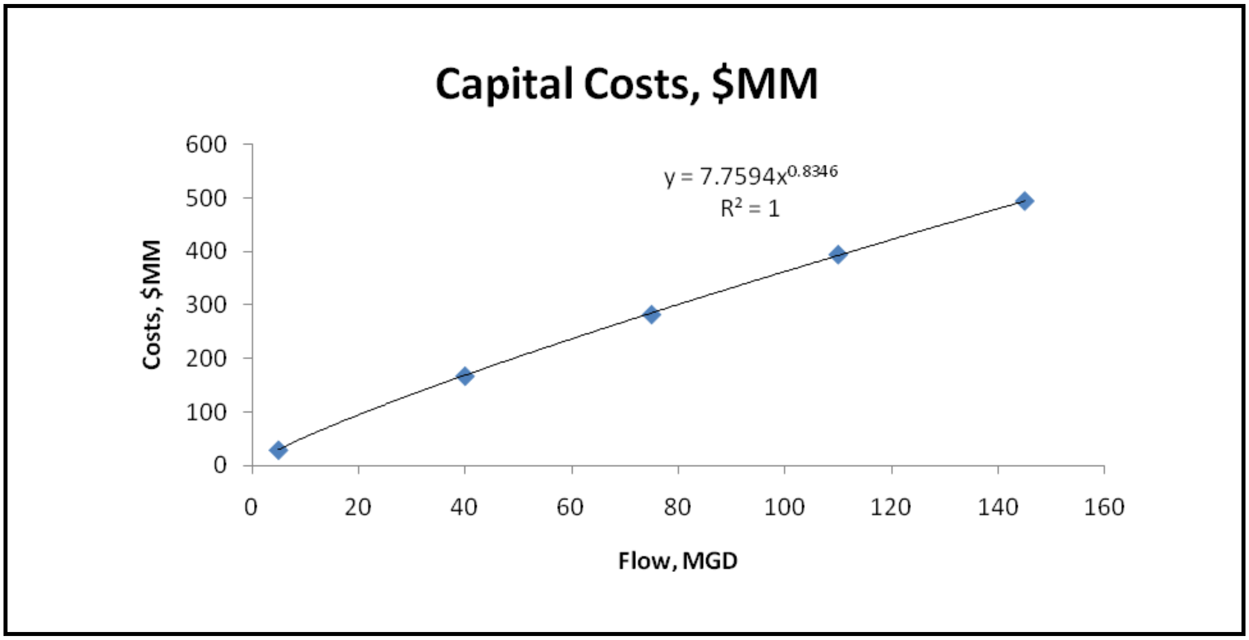

Figure A-1. Estimated Capital Cost Equation ($ mil.)

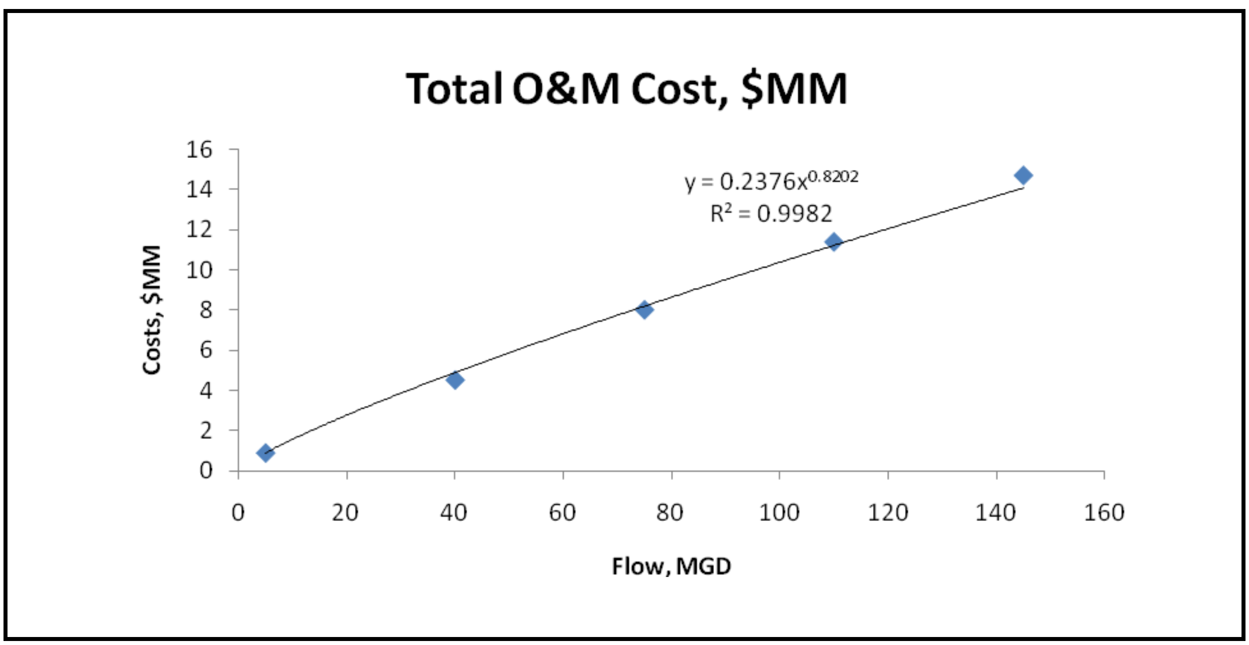

Figure A-2. Estimated O&M Cost Equation ($mil.)