

**Document to Support a  
Water Reservation Rule for the  
CERP Caloosahatchee River (C-43)  
West Basin Storage Reservoir Project**

**August 2014**





## Executive Summary

This document summarizes information to support a water reservation rule for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project (C-43 Reservoir). The South Florida Water Management District (SFWMD) proposes to reserve from allocation, all water stored within and transferred from the C-43 Reservoir to the Caloosahatchee River for the protection of fish and wildlife located downstream of the S-79 Structure (Franklin Lock and Dam). For the purpose of this document and the water reservation rule, the term “Caloosahatchee River” means the surface waters that flow through the S-79 Structure, combined with tributary contributions below the S-79 Structure that collectively flow southwest to San Carlos Bay as defined in Section 40E-8.021 Florida Administrative Code (F.A.C.). The area between the S-79 Structure and Shell Point can contain freshwater, marine water or brackish water (a combination of fresh and marine waters) and is referred to as Caloosahatchee River, river, or estuary in this document. The channelized area between the S-77 and S-79 structures is referred to as the C-43 Canal.

The purpose of the C-43 Reservoir is to help promote a more balanced and healthy salinity regime for the Caloosahatchee River by providing more consistent flows during periods of low flow, typically occurring in the dry season, and reducing great influxes of fresh water from high flow discharges, typically occurring in the wet season. When complete, the reservoir, which will be located in the West Caloosahatchee Basin upstream of the S-79 Structure, will capture and store a portion of the watershed runoff and regulatory releases from Lake Okeechobee, and release the water to the Caloosahatchee River as needed.

A water reservation rule sets aside water for the protection of fish and wildlife or public health and safety and protects it from allocation to consumptive uses. A water reservation rule is required by the Water Resources Development Act of 2000 since the C-43 Reservoir is a component of the Comprehensive Everglades Restoration Plan (CERP). Once in effect, the SFWMD’s water use permitting program uses the reservation rule to prevent water use permit allocations of the reserved water.

The Caloosahatchee River ecosystem is a highly productive estuary where the influx of nutrient-rich freshwater runoff mixes with salt water from the Gulf of Mexico. The estuary is an important nursery ground for many species, including some commercially and recreationally important or endangered fish and shellfish. Alterations to the watershed upstream and downstream of the S-79 Structure have resulted in wide variations in freshwater inflows to the estuary on both an annual and inter-annual basis. The extreme fluctuations in freshwater inflows affect water quality including salinity, which impacts estuarine fish and wildlife health and productivity. Protection of estuarine species including habitat-forming organisms (submerged aquatic vegetation and oysters), requires a less extreme range of flows through the S-79 Structure.

The information used to establish the water reservation is largely based on existing evaluations contained in the *Caloosahatchee River (C-43) West Basin Storage Reservoir Project Final Integrated Implementation Report and Environmental Impact Statement* (PIR) (USACE and SFWMD 2010)<sup>1</sup> with consideration of additional information compiled since the PIR was finalized. The information and data collected in this document include summaries of: historical alterations that occurred within the Caloosahatchee Watershed, salinity monitoring data, research conducted on several important species within the estuary, and an analysis of the effects of a revised Lake Okeechobee regulation schedule. In conjunction with the PIR, the information presented herein provides the basis for protecting fresh water for the natural system.

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<sup>1</sup> Available online at [http://www.evergladesplan.org/pm/projects/docs\\_04\\_c43\\_pir\\_final.aspx](http://www.evergladesplan.org/pm/projects/docs_04_c43_pir_final.aspx).

The PIR, using a 41 year period of record (1965 through 2005), concluded that all of the surface water from the reservoir should be reserved for the natural system. Updated assessments presented in this document, using a 36-year period of record (1965 through 2000), were compared to the modeling results from the PIR for the same 36-year period of record and confirmed this conclusion. Based on monitoring data, the volume of water released at the S-79 Structure that may be required to ameliorate the effects of saltwater intrusion varies from year to year. As a result, surface water releases from the C-43 Reservoir will also vary from year to year and will vary with different lake regulation schedules. Therefore, the SFWMD proposes to reserve all surface water stored in and released from the C-43 Reservoir for the protection of fish and wildlife in the Caloosahatchee River.

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## Section 1. Introduction

### 1.1 Purpose and Scope of the Document

This document summarizes information to support a rule to reserve water for fish and wildlife in the Caloosahatchee River. Specifically, fresh water will be provided by the Caloosahatchee River (C-43) West Basin Storage Reservoir Project (C-43 Reservoir) as described in the *Caloosahatchee River (C-43) West Basin Storage Reservoir Project Final Integrated Project Implementation Report and Final Environmental Impact Statement (PIR)* (USACE and SFWMD 2010). A water reservation rule is a legal mechanism that sets aside water for the protection of fish and wildlife or public health and safety and protects that volume of water from allocation for consumptive uses. A water reservation consists of a quantification of the water to be protected, which may include a seasonal or geographical component. State rules allow for reservations to be adopted prospectively for water anticipated to be made available from a project yet to be constructed.

The relationships and evaluations in the PIR form the basis of a water reservation rule for the Caloosahatchee River. The PIR established relationships among freshwater flows discharged from Lake Okeechobee and the watershed, salinity, and downstream estuarine ecologic responses. The key information contained in this document is based on the PIR and provides:

- A basis for the water reservation rule
- A description of the Caloosahatchee River, the watershed, and the C-43 Reservoir
- An overview of ecosystem and improvements expected after construction of the reservoir as identified in the PIR
- Identification of water to be reserved by rule

The South Florida Water Management District (SFWMD) is undertaking rule development to reserve water for the Caloosahatchee River. For the purpose of this document and the water reservation rule, the term “Caloosahatchee River” means the surface waters that flow through the S-79 Structure, combined with tributary contributions below the S-79 Structure that collectively flow southwest to San Carlos Bay as defined in subsection 40E-8.021(2) F.A.C. The area between the S-79 Structure and Shell Point can contain freshwater, marine water or brackish water (a combination of fresh and marine waters) and is referred to as Caloosahatchee River, river, or estuary in this document. The channelized area between the S-77 and S-79 structures is referred to as the C-43 Canal.

The reservation rule will fulfill legal requirements for constructing the C-43 Reservoir. Section 601(h)(4) of the Water Resource Development Act of 2000 (WRDA 2000; US Congress 2000) and the Programmatic Regulations for Implementation of the Comprehensive Everglades Restoration Plan (33 C.F.R. § 385.26-27) set implementation requirements for Comprehensive Everglades Restoration Plan (CERP) projects. These federal requirements ensure that each CERP project provides the intended benefits for the natural system by protecting water for the natural system through the SFWMD’s reservation or allocation authority. The SFWMD has elected to use its reservation authority pursuant to subsection 373.223(4), Florida Statutes (F.S.) to protect water made available by the C-43 Reservoir.

The reservation rule and accompanying water use criteria will require permit applicants to provide reasonable assurances that their proposed use of water will not withdraw water that is reserved for the protection of fish and wildlife. The scope of this reservation rulemaking is the protection of water stored in and discharged from the C-43 Reservoir from allocation to consumptive use withdrawals. The geographic scope of the analysis performed in the PIR and this document includes the Caloosahatchee watershed and surface water discharges from Lake Okeechobee to the Caloosahatchee River through the S-79 Structure.

Although, there are many different CERP components outlined in the Restudy, the scope of this document and rulemaking initiative is limited to the Caloosahatchee River (C-43) West Basin Storage Reservoir project as outlined in Section 9.1.3 of USACE and SFWMD (1999). Part 1 of the CERP Master Program Management Plan (August 2000): The Caloosahatchee River (C-43) West Basin Storage Reservoir Project. This reservoir project is component of a larger strategy to provide a basin-wide approach to restoration for the Caloosahatchee Basin. A subsequent study will be conducted to address water supply needs and water quality issues of the upper Caloosahatchee River basin (watershed) and restoration needs and demands not met by the Caloosahatchee River (C-43) West Basin Storage Reservoir project in the lower portion of the basin.

## **1.2 Project Purpose**

Currently, freshwater flows to the Caloosahatchee River fluctuate widely, producing a salinity regime that often impacts the health and productivity of fish and wildlife found in the estuary (USACE and SFWMD 2010). Salinity levels are typically either too low during the wet season (due to high inflows from watershed runoff and/or Lake Okeechobee discharges) or too high during the dry season (due to insufficient freshwater inflows). Extreme and extended high and low salinity levels can trigger die-offs of submerged aquatic vegetation (SAV) and oysters, species that are indicators of the estuary's overall health (USACE and SFWMD 2010).

The C-43 Reservoir will store watershed runoff and Lake Okeechobee discharges to ensure a more balanced, consistent flow of fresh water to the estuary. The project consists of an aboveground reservoir with a capacity of 170,000 acre-feet (ac-ft) located on the south side of the C-43 Canal and west of the Ortona Lock (S-78 Structure). The reservoir will be operated to capture a portion of peak flows during the wet season (consisting of watershed runoff and regulatory releases from Lake Okeechobee) and release this captured water to prevent harmful salinity increases in the Caloosahatchee River during the dry season. Reducing some high damaging discharges in the wet season and enhancing flows in the dry season will moderate changes in salinity that are detrimental to fish and wildlife located downstream of the S-79 Structure.

## **1.3 Identification of Water Reservation Water Body**

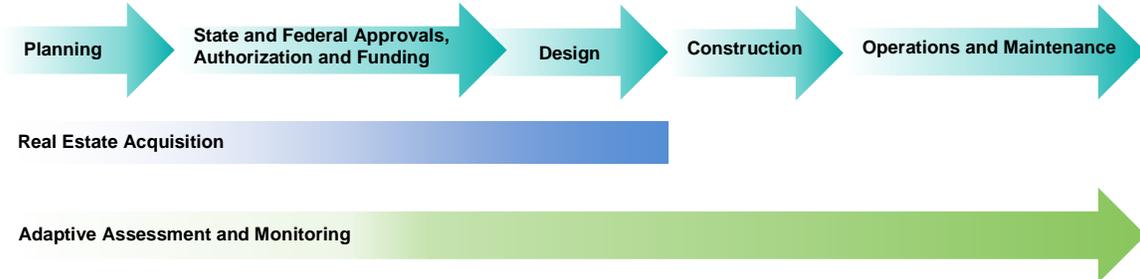
All waters stored within and released from the C-43 Reservoir are the subject of the proposed water reservation. These waters are to be protected from allocation for the purposes of protecting fish and wildlife within the Caloosahatchee River as defined in subsection 40E-8.021(2) F.A.C. including the associated estuarine resources contained therein.

## **1.4 Comprehensive Everglades Restoration Plan**

The C-43 Reservoir is one of many CERP projects. CERP provides a framework and guide to restore, protect, and preserve the water resources of central and southern Florida, including the Everglades. CERP covers 16 counties over an 18,000-square-mile area and modifies Central & Southern Florida (C&SF) project features (USACE and SFWMD 1999). CERP includes more than 60 elements and will take more than 30 years to construct.

The SFWMD is the state-designated local sponsor of the C-43 Reservoir with the U.S. Army Corps of Engineers (USACE) as the federal sponsor. The execution of the Record of Decision in April 2011 completed the planning phase of the C-43 Reservoir and enables its submittal to Congress for authorization and appropriation of funds (see [Figure 1-1](#)). The USACE anticipates project authorization to occur in 2014 with the appropriation of funding to follow at a later date. Once Congressional funding has been appropriated, a timetable for the completion of the reservoir will be developed. Construction is expected to take three to four years. Once Congress acts, the USACE and SFWMD will enter a Project

Partnership Agreement that outlines the cost-share arrangements to initiate construction. A prospective water reservation is needed since the reservation rule to support the C-43 Reservoir must be adopted and verified prior to execution of the Project Partnership Agreement consistent with WRDA 2000 (US Congress 2000).



**Figure 1-1.** Schematic of the CERP project development process.



## Section 2. Water Reservation Rules

The SFWMD is undertaking this water reservation as required by commitments made for CERP. For this water reservation, the water to be protected is the water made available for the natural system once the C-43 Reservoir is constructed and there is formal determination by the Governing Board that the reservoir is operational. The water reservation must be in effect prior to project construction in order for the SFWMD, as local sponsor for the C-43 Reservoir, to receive its 50 percent federal cost share for the project.

### 2.1 Legal Basis of the Water Reservation

As stated in Section 1.1, a water reservation is a legal mechanism to set aside water from consumptive use for the protection of fish and wildlife or public health and safety.

Subsection 373.223(4), F.S. states:

The governing board or the department, by regulation, may reserve from use by permit applicants, water in such locations and quantities, and for such seasons of the year, as in its judgment may be required for the protection of fish and wildlife or the public health and safety. Such reservations shall be subject to periodic review and revision in the light of changed conditions. However, all presently existing legal uses of water shall be protected so long as such use is not contrary to the public interest.

Protection of fish and wildlife means “ensuring the health and sustainability of fish and wildlife communities through natural cycles of drought, flood, and population variation”. *Assoc. of Florida Cmty. Developers, et al. v. Dep’t of Envtl. Prot., et al.*, DOAH Case No. 04-0880RP, Div. of Admin. Hrg., Final Order Feb. 24, 2006. Existing legal uses of water are protected so long as such uses are not contrary to the public interest. An existing legal use is a water use that is authorized under a SFWMD water use permit or is existing and exempt from permit requirements.

It is also important to understand what a water reservation does not do. While Part II of Chapter 373, F.S., authorizes water management districts to establish reservations, it does not authorize a water management district to establish criteria for operations of a CERP project. The SFWMD’s authority to act as local sponsor of a CERP project is found in Part I of Section 373.1501, F.S. Programmatic Regulations in 33 C.F.R. §385.28 require operating plans for CERP projects to be consistent with an established water reservation or allocation. While the CERP project operational criteria and the water reservation are related, they derive from distinct federal and state authorities.

#### 2.1.1 Prospective Water Reservation

Subsection 62-40.474(3), F.A.C. states that reservations may be adopted prospectively for water quantities anticipated to be made available at a future date. Surface water from the C-43 Reservoir will not be made available for the Caloosahatchee River until the reservoir is constructed and operational. Therefore, this will be a prospective water reservation rule.

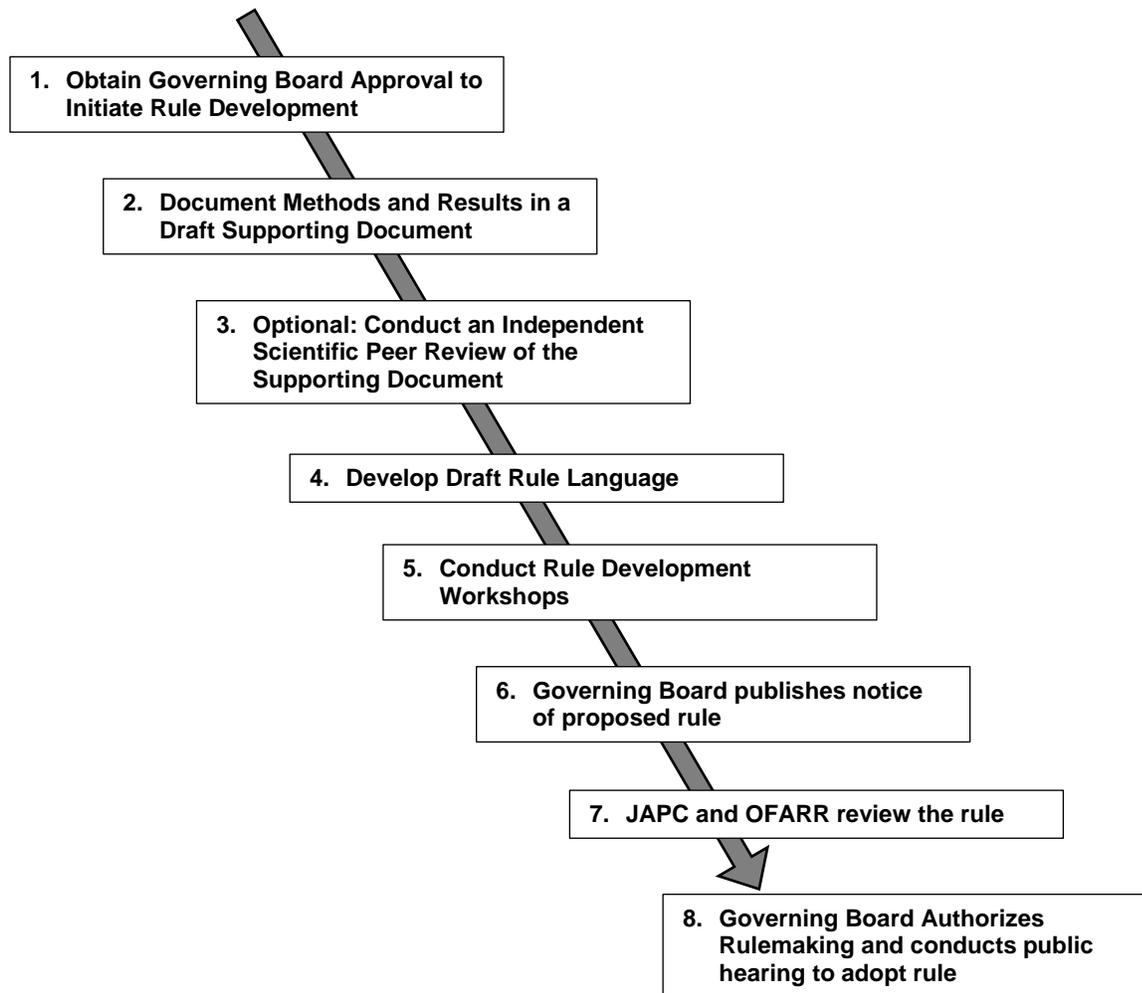
### 2.2 Water Reservation Rule Development Process

General rulemaking requirements and procedures are described in Chapter 120, F.S. Consistent with statute and SFWMD policy, **Figure 2-1** summarizes the general steps in the rule development process. In 2009, the Governing Board authorized the publication of a Notice of Rule Development for the water reservation to support the C-43 Reservoir, fulfilling the first step. This document fulfills the second step and summarizes data and information that supports a rule to reserve water for the benefit of fish and

wildlife in the Caloosahatchee River. Independent scientific peer review of this document is not anticipated nor mandated by state statute or rule (*See* 62-40.474, F.A.C.). However, the USACE Agency Technical Review/External Peer Review of the Caloosahatchee River (C-43) West Basin Storage Reservoir document was carried out through collaboration with the USACE Planning Centers of Expertise in compliance with Engineer Circular 1105-2-408, *Peer Review of Decision Documents*, dated May 31, 2005.

Using this supporting document, the SFWMD has developed proposed rule language and conducted three rule development workshops, ensuring a public process for stakeholders and interested persons. Interested parties have provided comments on the proposed draft rule language, including suggestions for alternative rule language. SFWMD staff has received the Governing Board's authorization to publish a Notice of Proposed Rule. The Notice of Proposed Rule identified the public hearing date and provides stakeholders with the opportunity to provide written comments, alternative rule language, or a lowered cost regulatory alternative for consideration by the Governing Board. The SFWMD forwarded a copy of the Notice of Proposed Rule, including the rule text, to the Florida Department of Environmental Protection, Joint Administrative Procedures Committee (JAPC) and Office of Fiscal Accountability and Regulatory Reform (OFARR) on February 17, 2014. With the acceptance of JAPC and OFARR, the Governing Board will then consider adopting the proposed rule at a noticed public hearing. The adopted rule will be filed with the Florida Department of State 14 days after the public hearing and the rule becomes effective 20 days later.

## Key Steps in Rule Development Process



**Figure 2-1.** Steps in the water reservation rule development process.



## Section 3. Caloosahatchee River Watershed and Project Features

### 3.1 Caloosahatchee River Watershed

The Caloosahatchee River, C-43 Canal, and the associated watershed, are located on the lower west coast of Florida ([Figure 3-1](#)). The Caloosahatchee River receives surface water from Lake Okeechobee, runoff from five basins, which is defined as the Caloosahatchee Watershed (S-4, East Caloosahatchee, West Caloosahatchee, Tidal Caloosahatchee, and Coastal), and base groundwater flow from the Surficial Aquifer System. Other surface water bodies in the watershed include lakes, rivers, and canals, which provide limited storage and allow conveyance of surface water. The C-43 Canal runs 40 miles (70 km) from Lake Okeechobee at Moore Haven (S-77 Structure) to the Franklin Lock and Dam (S-79 Structure) at Olga. The major tributaries of the Caloosahatchee River are the Orange River and Telegraph Swamp, which drain into the river downstream of the S-79 Structure. The Caloosahatchee Watershed consists of approximately 1,090,380 acres (4412 km<sup>2</sup>) in parts of Lee, Glades, Charlotte, Collier, and Hendry counties. Lake Hicpochee is the largest lake in the area and is bisected by the C-43 Canal just west of Lake Okeechobee.



**Figure 3-1.** Caloosahatchee River, C-43 Canal, and watershed showing major basins, water management structures, and location of the C-43 Reservoir.

Separating fresh and brackish water, the S-79 Structure demarcates the head of the Caloosahatchee River. From the S-79 Structure, the estuary extends 26 miles (42 km) downstream to Shell Point, where it empties into San Carlos Bay in the southern portion of the greater Charlotte Harbor system. The width of the estuary is irregular, ranging from 525 ft. (160 m) in the upper portion to 8200 ft. (2500 m) near its mouth. The narrow section between the S-79 Structure and Beautiful Island has a mean depth of about 20 ft. (6 m), while the area downstream has an average depth of 4 ft. (1.5 m) (Scarlotos 1988). The surface area of the estuary is about 16,000 acres (65 km<sup>2</sup>). Surface water leaving the estuary at Shell Point enters San Carlos Bay. Most of this water takes a southerly route, flowing to the Gulf of Mexico under the Sanibel Causeway (Goodwin 1996). When freshwater inflows are high, tidal action pushes some of this

water back up into Matlacha Pass and Pine Island Sound. Additionally, some water exits to the south and flows into Estero Bay through Matanzas Pass.

### 3.1.1 Land Use in Caloosahatchee Watershed

Various land uses in a watershed dictate water demands and runoff volumes to surface water. For the Caloosahatchee Watershed as a whole, agricultural categories comprise the primary land-use type, with 44 percent of the total area. Natural land uses occupy the next largest group, at 30 percent, followed by urban at 14 percent and open water at 12 percent ([Table 3-1](#)).

Within the S-4 Basin, 82 percent of the area is agricultural land use, and is almost entirely sugar cane. Within the East Caloosahatchee Basin, 75 percent of land use is agricultural, with most of the remainder being natural areas. Similarly, within the West Caloosahatchee Basin, 61 percent of land use is agricultural, with most of the remainder natural. Within the Tidal Caloosahatchee, 37 percent of land use is natural, with urban and agricultural land uses comprising 31 percent and 23 percent, respectively. Within the Coastal Basin, 44 percent of the land use coverage is open water, followed by natural at 31 percent, urban at 17 percent, and agriculture at 8 percent.

**Table 3-1.** Land use by basin, in acres for the Caloosahatchee Watershed (Balci and Bertolotti 2012).

Land Use Categories (Grouped)	Basin				Coastal	Total	Percent of Total
	S-4	East Caloosahatchee	West Caloosahatchee	Tidal Caloosahatchee			
<b>Urban</b>	4,825	5,802	19,709	82,507	39,476	152,319	14.0%
<b>Agriculture</b>	34,527	153,342	212,130	60,865	18,399	479,262	44.0%
<b>Natural Areas</b>	2,136	42,825	114,621	98,594	70,191	328,367	30.1%
<b>Open Water</b>	658	2,125	3,654	22,741	101,256	130,432	12.0%
<b>Total</b>	<b>42,146</b>	<b>204,093</b>	<b>350,114</b>	<b>264,705</b>	<b>229,322</b>	<b>1,090,380</b>	<b>100.0%</b>

### 3.1.2 Alterations to the Caloosahatchee River

The present day Caloosahatchee River and C-43 Canal have been highly altered from their natural states by human intervention and engineering. Historically, the present day C-43 Canal was a sinuous river, originating near Lake Flirt, approximately 2 miles (3.2 km) east of La Belle at Ft. Thompson ([Figure 3-2](#)). Beginning in the 1880s, the river channel was straightened, deepened, and connected to Lake Okeechobee. This resulted in a loss of 76 river bends and 8.2 miles (13.2 km) of river length (Antonini et al. 2002).

In 1930, the first federal effort at flood control in Florida occurred with the passage of the River and Harbor Act of July 3, 1930, which authorized improvement of the Caloosahatchee River and canal. Based on this authorization, the river was improved by 1937 to provide a navigable channel at least 6 ft. (2 m) deep and 80 ft. (24 m) wide, with locks and water control structures at Ortona and Moore Haven. Under authority of the Rivers and Harbor Act of March 2, 1945, the river was improved for navigation purposes to include a channel 8 ft. (2.5 m) deep and 90 ft. (27 m) wide. The canal also is part of the Okeechobee Waterway, which allows boat traffic to navigate across Florida between Ft. Myers and Stuart.

In 1957, the USACE prepared *The Report on C&S Fla. Project, Part IV, Supplement 6--General Design Memorandum, Caloosahatchee River and Control Structures (Canal 43 and Lock and Spillway Structures 77, 78, and 79)* (GDM) that focused specifically on the drainage, water control, and navigation needs of the Caloosahatchee Watershed. The recommended plan as specified in the 1957 document provided for improvement of the C-43 Canal, construction modification of two existing structures in the main canal (S-77 and S-78), and a new structure located in Ft. Myers (S-79) for water control and regulation (USACE 1957).

The purposes and objectives for these additional improvements as envisioned in the GDM was to (1) provide additional capacity for removal of runoff from the Caloosahatchee Watershed, (2) provide water control for the area adjacent to the C-43 Canal to prevent excessive depletion of groundwater during normal or dry periods, (3) provide regulatory discharge capacity for Lake Okeechobee, (4) provide adequate spillway capacity so that existing navigation locks would not have to be used for flood or regulatory releases, and (5) prevent saltwater encroachment and maintain freshwater supplies in the lower reaches of C-43 Canal. Overall, the economic analysis of the proposed improvements established that they created two types of benefits: reduction of flood damage and subsequent increased flood protection, and improvement in fresh water supply to allow an increase in agricultural land use while providing additional water supply for urban areas.

The specific purpose of the S-79 Structure set forth in the GDM was to provide salinity and water control in lands adjacent to the C-43 Canal that are dependent upon it to recharge groundwater levels and serve as water supply. During the wet season, the S-79 Structure was designed to be a spillway structure to pass permissible regulatory releases from Lake Okeechobee, which at the time were between 4200 to 9300 cubic feet per second (cfs). During the dry season, the S-79 Structure was designed to address the lack of freshwater supply for irrigation in the lower river basin. Under conditions existing at the time, freshwater supply was depleted by uncontrolled downstream discharges to such an extent that the water table near the river was as much as 10 ft. (3 m) below ground (a depth of 2 or 3 feet [1 m] was considered optimum). Construction of the S-79 Structure was designed to (1) eliminate undesirable salinity upstream of the structure, (2) prevent the rapid depletion of water supplies, and (3) raise the prevailing dry-weather water table levels.

The U.S. Fish and Wildlife Service (USFWS) analyzed the environmental impacts of the proposed improvements on the Caloosahatchee River. At the time, the USFWS concluded that existing fisheries of the river and estuary were of relatively low quality and value due to adverse effects on the natural environment caused by past construction works such as the prior history of channelization. In addition, past regulatory discharges through the C-43 Canal had adverse effects on the sport and commercial fisheries of the estuary. The USFWS report concluded that these conditions were likely to persist and may be worsened by the deepening of the channel and the installation of the S-79 Structure, primarily in that the effects may be extended over a greater area, including inshore waters (USFWS 1957).

No additional capital project components have been made to the C-43 Canal, water control structures or watershed to improve estuary salinity regime since completion of the S-79 Structure in 1966.

A network of secondary and tertiary canals exists in the Caloosahatchee Watershed that is hydrologically connected to the C-43 Canal and Caloosahatchee River. These canals convey water for both drainage and irrigation to accommodate citrus groves, sugar cane, cattle grazing, urban development, and other uses. As a result, the river and canal now serve many functions, including irrigation water, drainage, and navigation, as well as conveyance of watershed runoff and regulatory releases of water from Lake Okeechobee to tide.



**Figure 3-2.** Caloosahatchee River showing water control structures, connection to Lake Okeechobee, and historical headwaters at Lake Flirt and Lake Bonnet.

The Caloosahatchee Estuary has also been significantly altered (Chamberlain and Doering 1998a). Early descriptions of the estuary characterize it as barely navigable due to extensive shoals and oyster bars (Sackett 1888). A navigation channel was dredged and a causeway was built across the mouth of San Carlos Bay in the 1960s, which altered the natural configuration and flow of water within the estuary. Historic oyster bars upstream of Shell Point were mined and removed to be used in the construction of roads. Seven automobile bridges and one railroad bridge now connect the north and south shores of the estuary.

As might be expected for a watershed characterized by extensive drainage features (see Hopkinson and Vallino 1995), runoff is more variable with higher wet season discharges and lower dry season discharges leading to lasting ecological consequences. Conveyance of storm water to the estuary is highly variable and seasonally affects salinity levels. Large volumes of fresh water during the wet season can flush most of the salt water from the estuary. By contrast, dry season inflow at the S-79 Structure can stop entirely, sometimes allowing the head of the estuary to reach a practical salinity of 20<sup>2</sup> (Chamberlain and Doering 1998a, 1998b). Wide salinity fluctuations throughout the estuary cause mortality of flora and fauna at both ends of the salinity gradient (Doering et al., 2002).

<sup>2</sup> Common practice no longer uses units for measurements of salinity. These results were previously reported as parts per thousand (ppt) or practical salinity units (psu).

The construction of the Sanibel Causeway, which crosses the mouth of San Carlos Bay at Punta Rassa, may have influenced the seaward end of the system. The U.S. Fish and Wildlife Service (1960) predicted that this barrier would restrict the exchange of fresh water with salt water from the Gulf of Mexico, causing the retention of fresh water and a decrease in salinity in southern Charlotte Harbor. Reductions in salinity were expected to adversely affect a flourishing bay scallop fishery, which collapsed after the construction of the causeway was completed in 1963. Twenty years later, the Florida Department of Natural Resources reported a significant decline in seagrass coverage in deeper areas and attributed this, in part, to an increased amount of colored fresh water due to the exchange restriction (Harris et al. 1983).

### **3.2 Freshwater Inflows to the Caloosahatchee Estuary**

The two major sources of surface water inflows to the estuary are the C-43 Canal, which discharges at the S-79 Structure, and the Tidal Caloosahatchee Basin surrounding the estuary to the west and downstream of S-79 ([Figure 3-1](#)).

Historically, inflows from the Tidal Caloosahatchee Basin (TCB) to the estuary are not well known but this is changing as collection of 5 years of flow data from selected creeks has recently been completed. Despite limited data, modeling efforts have estimated annual Tidal Caloosahatchee Basin inflows. A linear reservoir model estimated daily flows from the Tidal Caloosahatchee Basin over 1966–2005 (Y. Wan, SFWMD, personal communication). Annual flows averaged 344 Kac-ft/yr (thousand acre-feet per year), ranging from a low of 157 Kac-ft in 1990 to a high of 788 Kac-ft in 1995. The median daily flow from the Tidal Caloosahatchee Basin was 270 cfs, 157 cfs during the dry season and 497 cfs during the wet season.

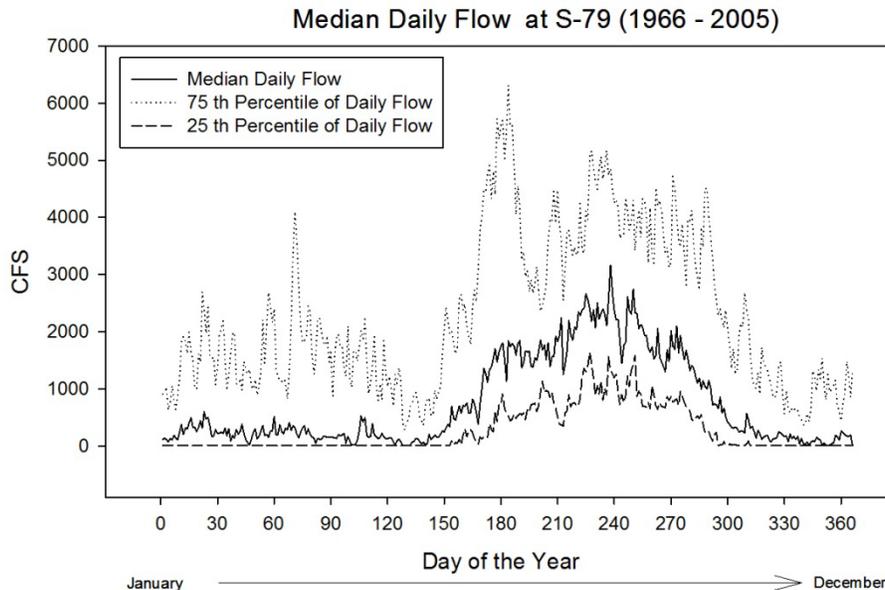
The relative contribution of freshwater flows to the downstream estuary from TCB and the S-79 Structure varies from year to year and during the wet and dry seasons. On average, the contribution of flows from the TCB to the downstream estuary accounts for about 20 percent of the total freshwater inflows on an annual basis, 23 percent during the wet season and 16 percent during the dry season. The lower percentage for the dry season than the wet season reflects the unproportional regulatory releases from Lake Okeechobee. Overall, the contribution of freshwater flows to the estuary from the Tidal Caloosahatchee Basin can be relatively significant in some years.

#### **3.2.1 Flows Over the S-79 Structure**

Discharge at the S-79 Structure varies by day, month, and year, and is largely driven by variations in rainfall and regulatory releases from Lake Okeechobee to manage lake water levels and provide water supplies. The fluctuations in Lake Okeechobee regulatory releases occur because lake water levels can change drastically from year to year due to the variable rainfall input from the lake's northern watersheds (SFWMD, et al. 2009). Annual flows averaged 1,321 Kac-ft/yr, ranging from a low of 216 Kac-ft in 1972 to a high of 3,877 Kac-ft in 2005 (based on measured flow data from 1966 through 2005).

Flow records from the period 1966 through 2005 indicate that there is considerable seasonal variation in median daily flows at the S-79 Structure ([Figure 3-3](#)). The median daily flow of 1260 cfs during the wet season was about seven times greater than the median dry season flow of 183 cfs. During June and September, the wettest months of the wet season, 25 percent of the flows measured on a particular day of the year may exceed 3700 cfs. During the dry season, 25 percent of the flows measured on a particular day can be less than 10 cfs.

These same records can also be used to illustrate annual variability represented by the inter-quartile range<sup>3</sup>. During the wet season the inter-quartile range was 2894 cfs or 230 percent of the median flow. Similarly, the median dry season inter-quartile range was 1240 cfs or 679 percent of the median flow.



**Figure 3-3.** Median daily discharge (cfs) at the S-79 Structure for 1966 through 2005. Also shown are the 25th and 75th percentiles.

### 3.2.2 Salinity Downstream of the S-79 Structure

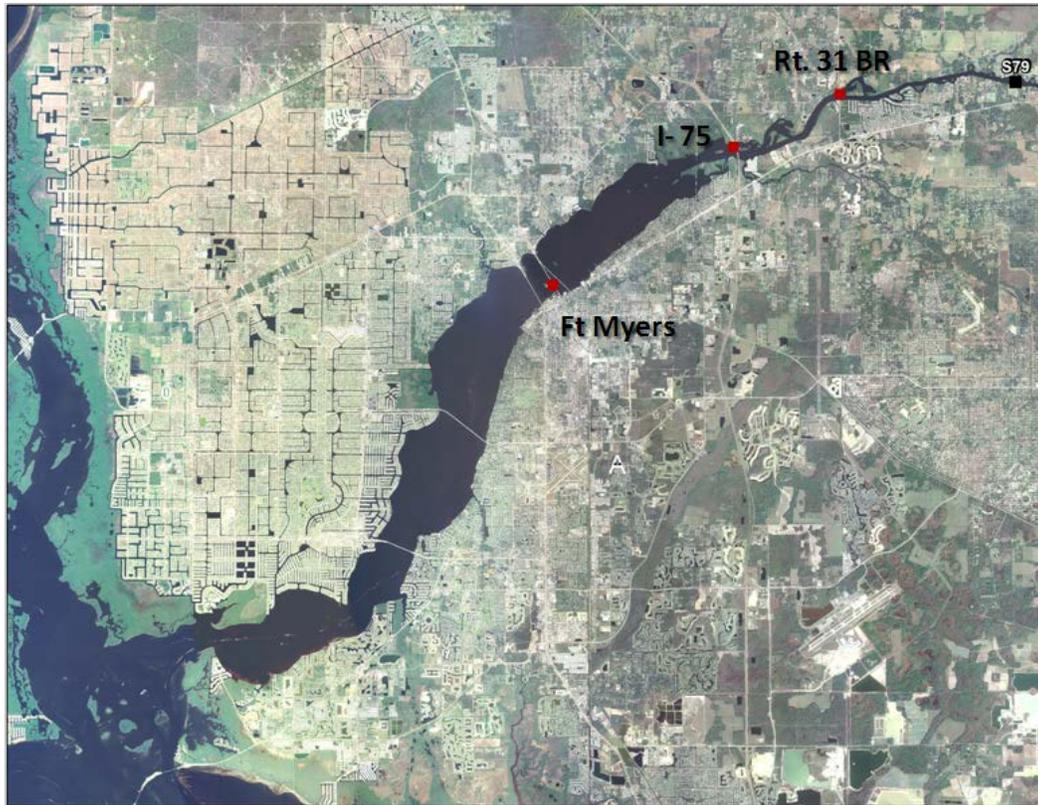
Salinity downstream of the S-79 Structure is largely a function of freshwater inflow (e.g., Bierman 1993) and has been measured at several monitoring stations since 1992 ([Figure 3-4](#)). Variations in salinity in the estuary reflect the high variability in freshwater inflow at the S-79 Structure and from the Tidal Caloosahatchee Basin ([Figure 3-1](#)). **Figures 3-5 through 3-8** show examples of variability in the portions of the estuary just downstream of the S-79 Structure, the Route 31 Bridge, the Interstate 75 Bridge, and Fort Myers Yacht Basin for varying periods of record. These data reflect both past and current lake operations; current operations include low-level lake releases to the estuary and adaptive protocols. Additional details regarding the current lake regulation schedule are included in **Section 3.4**.

Median daily salinity data gathered just downstream of the S-79 Structure over the period 1992–2011 ([Figure 3-5](#)) indicate that the estuarine salinity gradient is truncated during the dry season of most years and the extent of this truncation varies from year to year. Salinity data indicate at the end of the dry season in May (Day 150), there is at least a 10 percent chance that practical salinity will exceed 18 at the S-79 Structure indicating that 90 percent of the time oligohaline and/or mesohaline<sup>4</sup> conditions occur within portions of the estuary. This same pattern occurs further downstream at the Route 31 Bridge ([Figure 3-6](#)). Although the period of record is far shorter, the same pattern of salinity intrusion can be seen at the I-75 Bridge ([Figure 3-7](#)).

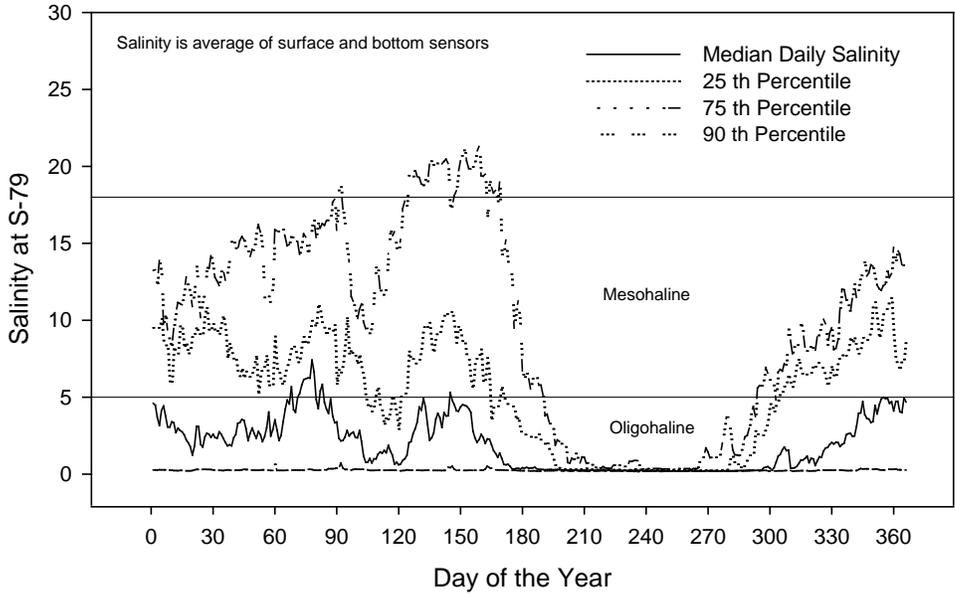
<sup>3</sup> Inter-quartile range represents the difference between the 75<sup>th</sup> and 25<sup>th</sup> percentile.

<sup>4</sup> The Venice System for Classification of Marine Waters defines estuarine conditions by salinity as oligohaline:  $\pm 0.5\text{--}\pm 5$ , mesohaline:  $\pm 5\text{--}\pm 18$ , and polyhaline:  $\pm 18\text{--}\pm 30$  (Anonymous 1958).

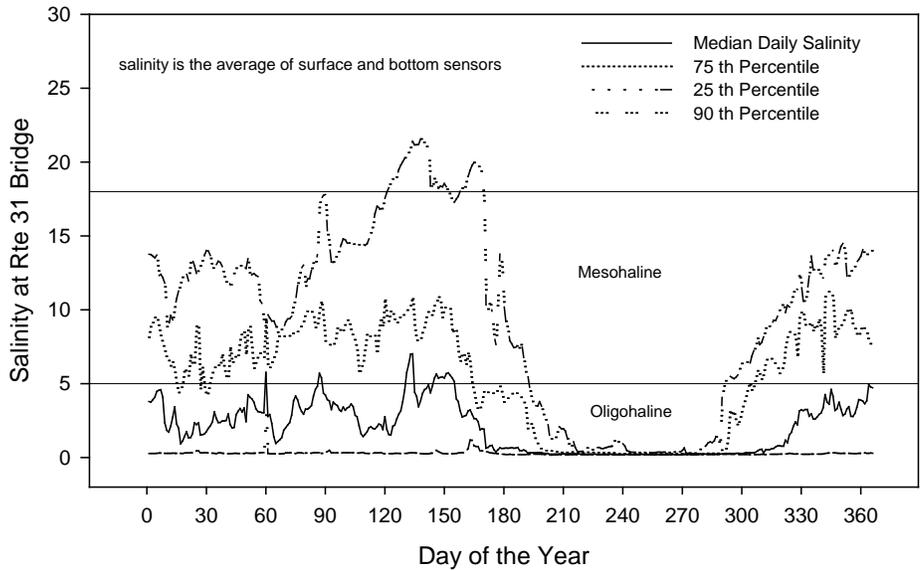
**Figures 3-5 through 3-8** illustrate a seasonal migration of salt water up the river from Fort Myers to the S-79 Structure during the dry season. The volume of low salinity water decreases as saltwater intrusion proceeds upstream. By the end of the dry season in April and May, there is at least a 25 percent chance that the oligohaline zone and at least a 10 percent chance that the mesohaline zone will be absent from the estuary.



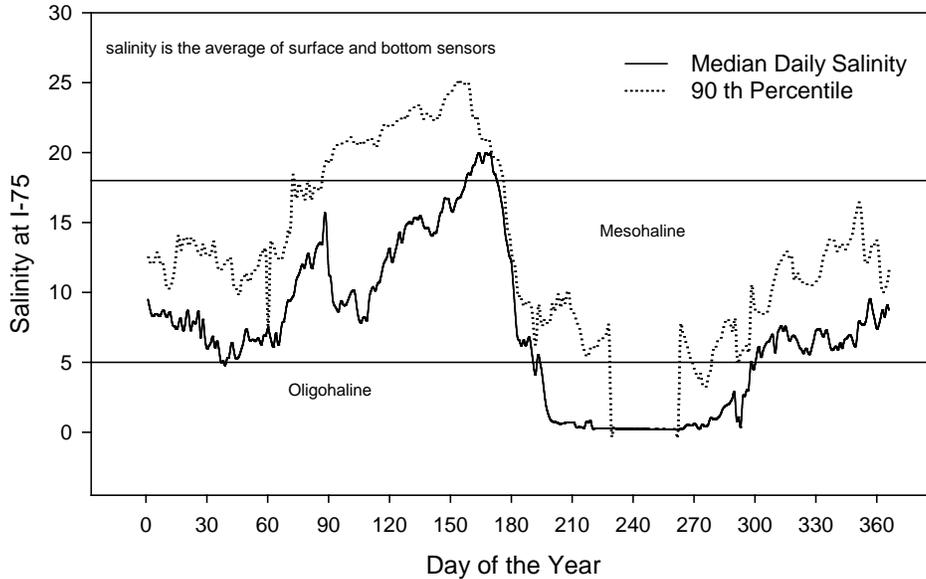
**Figure 3-4.** Location of continuous salinity monitoring stations. Locations shown are the S-79 Structure, Rt. 31 Bridge, I-75 Bridge, and the Fort Myers Yacht Basin.



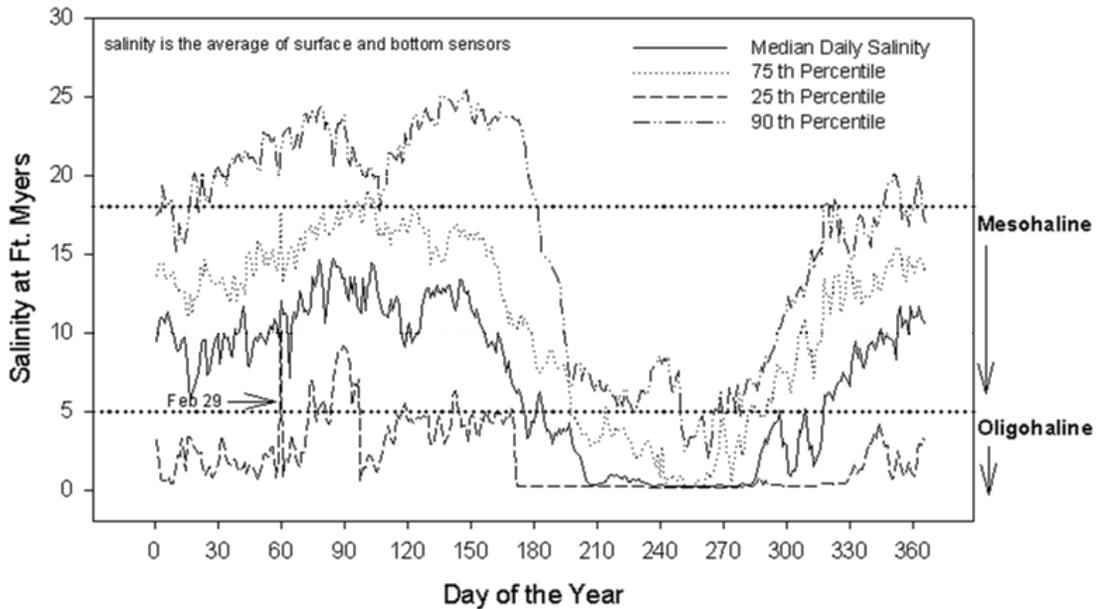
**Figure 3-5.** Median daily salinity just downstream of the S-79 Structure for 1992–2011. Also shown are the 25<sup>th</sup>, 75<sup>th</sup>, and 90<sup>th</sup> percentiles. Upper limits of the oligohaline (5) and mesohaline zones (18) are shown for reference.



**Figure 3-6.** Median daily salinity at the Route 31 Bridge for 1992–2011. Also shown are the 25<sup>th</sup>, 75<sup>th</sup>, and 90<sup>th</sup> percentiles. Upper limits of the oligohaline (5) and mesohaline zones (18) are shown for reference. Salinity is measured at two depths and values from the two depths were averaged to produce one salinity value for each day in the period of record.



**Figure 3-7.** Median daily salinity at I-75 Bridge for October 2006–March 2012. Also shown is the 90<sup>th</sup> percentile. Upper limits of the oligohaline (5) and mesohaline zones (18) are shown for reference. Salinity is measured at two depths and values from the two depths were averaged to produce one salinity value for each day in the period of record.

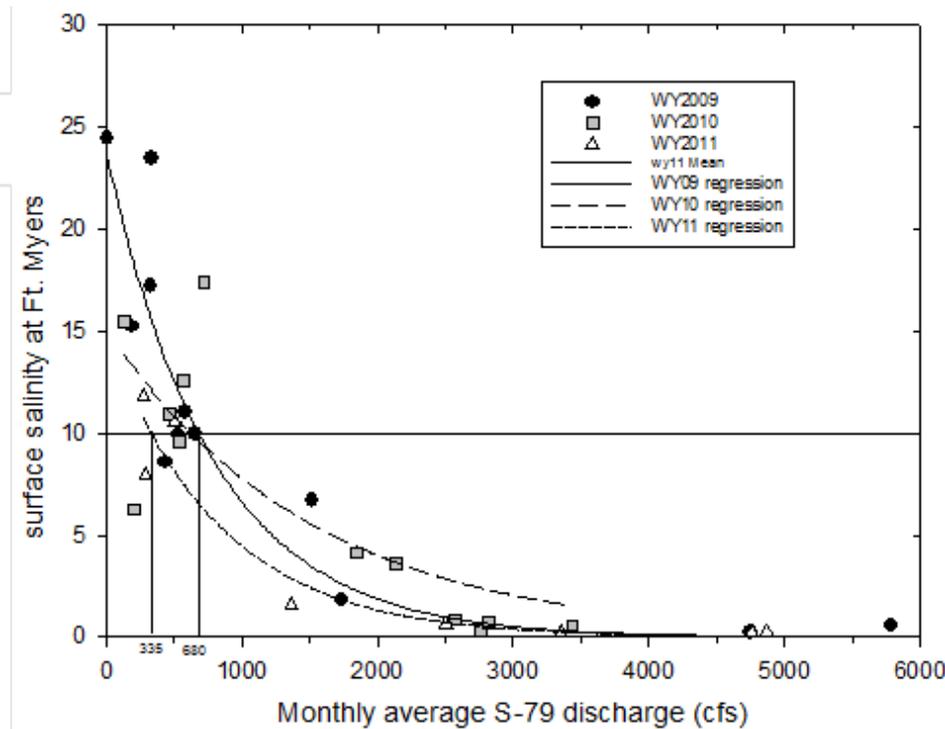


**Figure 3-8.** Median daily salinity at the Fort Myers Yacht Basin for 1992–2011. Also shown are the 25<sup>th</sup>, 75<sup>th</sup>, and 90<sup>th</sup> percentiles. Upper limits of the oligohaline (5) and mesohaline zones (18) are shown for reference. Salinity is measured at two depths and values from the two depths were averaged to produce one salinity value for each day in the period of record.

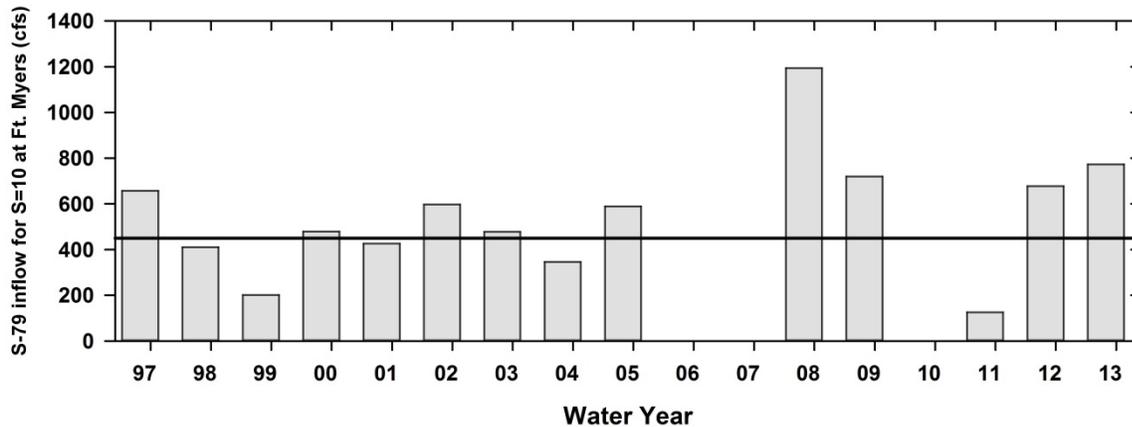
Salinity downstream of the S-79 Structure is dependent upon discharges from the S-79 Structure and other inflows, including those from the Tidal Caloosahatchee Basin. For this reason, the same discharge at the S-79 Structure will contribute to different salinities at a particular point in the river in different years. In other words, the amount of discharge required at the S-79 Structure to produce a particular salinity at a particular site in the river also varies depending upon the magnitude of other contributing inflows. This scenario is illustrated in **Figure 3-9** where 335 cfs of freshwater discharges at the S-79 Structure combined with downstream conditions, were sufficient to achieve a practical salinity of 10 at Ft. Myers in 2011, while 680 cfs achieved the same salinity at the same location in 2009.

Average monthly inflow at the S-79 Structure and salinity at Fort Myers were calculated from Water Years (WY is defined from May 1–April 30) 1993-2013 (C. Buzzelli, SFWMD, personal communication). The relationship between the two variables was used to estimate the inflow needed to obtain a salinity of 10 at Ft. Myers for each WY. The predicted amount of freshwater inflow that resulted in a salinity of 10 ranged from 125-1193 cfs (**Figure 3-10**). This value was below 450 cfs in WY1999 (201 cfs), WY2004 (346 cfs), and WY2011 (125 cfs) and was greatest in WY1997 (657 cfs), WY2008 (1193 cfs), WY2009 (719 cfs), WY2012 (677 cfs), and WY2013 (773 cfs). The amount of freshwater inflow at S-79 for a salinity of 10 at Fort Myers varies inter-annually. One potential reason for the variability in flow related to a salinity of 10 is tidal basin inflows that occur downstream of the S-79 Structure. Less inflow years generally follow a wet year, while higher inflow years occur when the preceding year was dry.

The PIR also described the variability of the volumes of water needed to achieve the desired dry season salinity targets associated with the protection of fish and wildlife. The PIR flow target identifies that approximately 70 percent of the flows at the S-79 Structure are needed to achieve the target (USACE and SFWMD, 2010). Under severe dry season conditions, flows of these magnitudes may be insufficient to achieve the target salinity in part due to the low volume of flow from the Tidal Caloosahatchee Basin.



**Figure 3-9.** Relationship between mean monthly surface salinity at Ft. Myers and monthly average discharge at the S-79 Structure in three different years. Vertical lines indicate the mean monthly flow required to achieve a salinity of 10 at Ft. Myers in 2009 and 2011.



**Figure 3-9.** Time series of the estimated freshwater inflow at S-79 required to maintain salinity = 10 at Ft. Myers (bars). The value could not be predicted for WY2006, 2007, and 2010. WY=water year (May 1 – April 30).

### 3.3 C-43 Reservoir Features and Operations

The C-43 Reservoir will be located in the West Caloosahatchee Basin in Hendry County, west of LaBelle and on the east side of the Townsend Canal ([Figure 3-1](#)). This aboveground facility will have a storage capacity of 170,000 ac-ft with an average depth of 17–19 feet at normal pool. The project footprint is 10,700 acres (42 km<sup>2</sup>). Its major features include a two-cell reservoir, soil-bentonite slurry walls (cut off walls) within and beneath the external embankments, an internal embankment separating the two cells, a pump station with a 1500 cfs capacity, and a perimeter canal. Other features include spillways with an emergency overflow, perimeter canal structures, and a pump station with a capacity of 195 cfs, internal control and discharge (outflow) control structures, and multiple culverts ([Figure 3-10](#)) (see USACE and SFWMD 2010 for more details).

The reservoir will be operated to improve conditions in the Caloosahatchee River by reducing flows through the S-79 Structure during wet periods and increasing the flows during dry periods. Operations will vary by the season, capacity in the reservoir, and salinity downstream of the S-79 Structure. Once the reservoir is constructed, a detailed operational plan will be established. After the initial filling of the reservoir and operational testing and verification is completed, the operational protocol will continue to be a function of conditions within the reservoir, at the S-79 Structure, and in the Caloosahatchee River. The reservoir will be filled with surface water from the C-43 Canal. Water will be pumped from the C-43 Canal via the Townsend Canal into Cell 1 of the reservoir. An internal cell balancing structure in the internal embankment will allow water to enter Cell 2. When higher flows are present in the regional system and there is capacity in the reservoir, the main pump station will pump water into the reservoir.

Discharges from the reservoir will typically occur when flows are needed to maintain a desirable salinity range in the estuary. Each cell of the reservoir is designed to discharge independently through separate structures. Cell 1 will discharge via the S-1 Structure into the Townsend Canal as shown in [Figure 3-10](#). Cell 2 will discharge via the S-8 Structure into the perimeter canal. These structures will be designed for incremental operation. Water may be released from both reservoir cells by outlet structures into the perimeter canal for delivery back to the C-43 Canal via the Townsend Canal and two other direct connections (Fort Simmons Branch and Banana Branch Canal). Additional details regarding the operational strategy can be found in Annex D of the PIR (USACE and SFWMD 2010).

Numeric model simulations, conducted at the time of PIR development for analyzing the effect of the proposed reservoir on flows at the S-79 Structure, were based on a 36-year period of record (1965 through 2000) and the Water Supply and Environment (WSE) regulation schedule for Lake Okeechobee, which was in effect at the time. Comparing model results from scenarios with and without the C-43 Reservoir shows the difference in flows at the S-79 Structure. During the wet season some of the damaging high flows will be reduced by storing water in the reservoir and then released during the dry season to improve the salinity regime downstream of S-79 Structure to benefit fish and wildlife. (Figure 3-11).

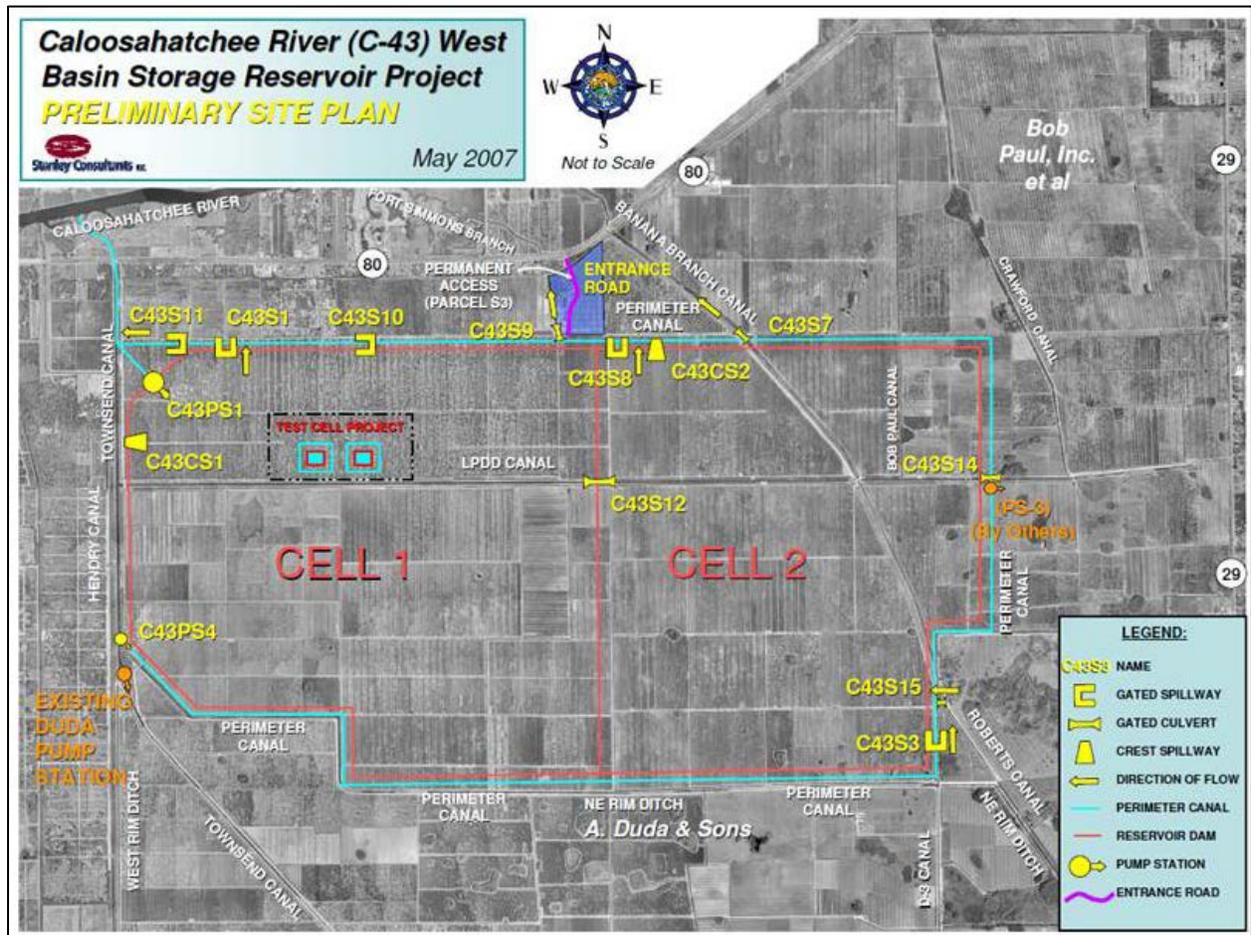
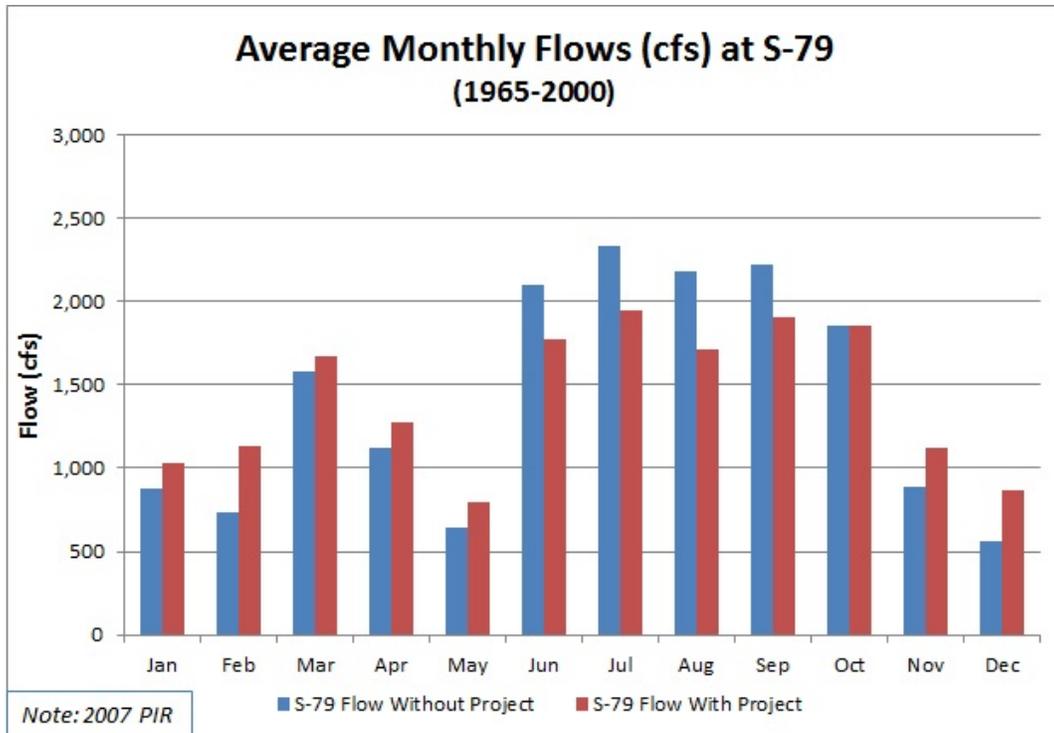


Figure 3-10. General features of the C-43 Reservoir.



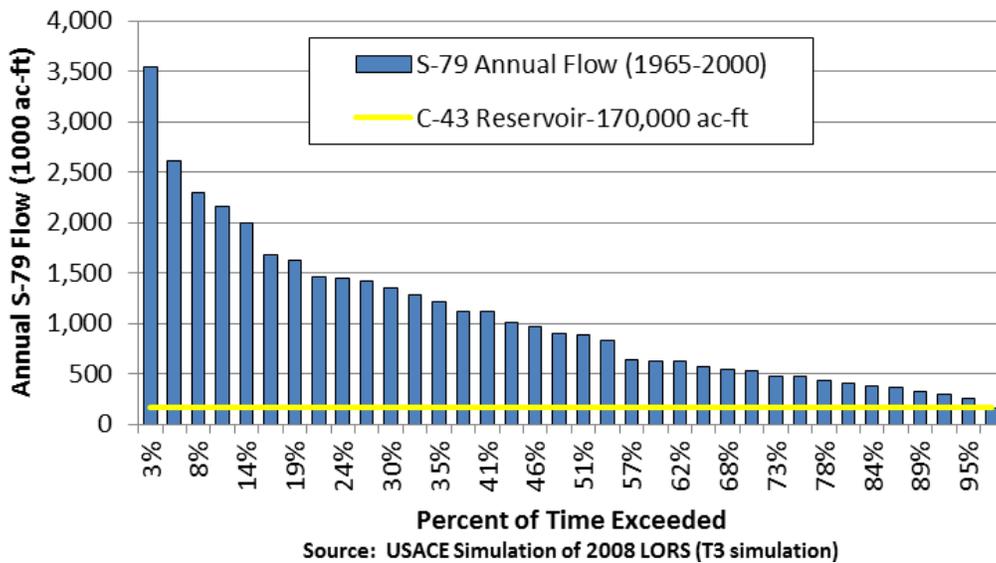
**Figure 3-11.** Average monthly flows (cfs) at the S-79 Structure with and without the C-43 Reservoir based on the WSE and a 36-year period of record (1965 through 2000).

### 3.4 Potential Effect of LORS 2008 on C-43 Reservoir Performance

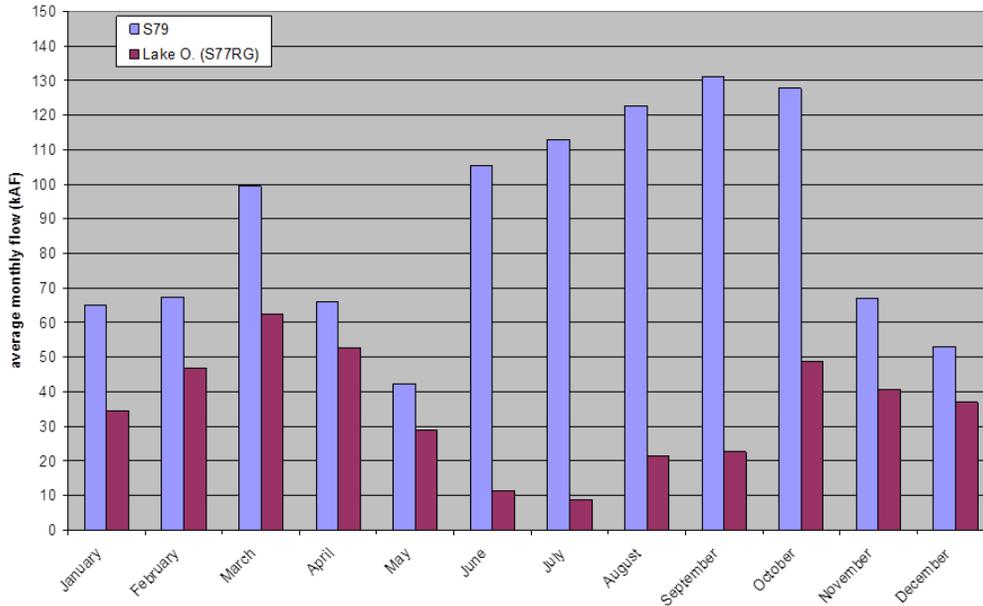
The USACE implemented a new regulation schedule in April 2008 for Lake Okeechobee, referred to as LORS 2008 (USACE, 2007), to protect public health and safety by reducing the lake levels. Since the PIR was completed before LORS 2008 was approved, its effect on the C-43 Reservoir’s operation and performance was not analyzed in the PIR. The revised Lake Okeechobee regulation schedule results in significant changes in the timing and amounts of water discharged from Lake Okeechobee to the Caloosahatchee River compared to the WSE schedule. In particular, with LORS 2008, low-level regulatory releases from the lake are made to the Caloosahatchee River at lower lake stage elevations than with WSE. These low-level regulatory releases during the dry season are intended to avoid larger regulatory releases during wetter periods. The low-level regulatory releases are within the Regulatory Release band and are not an environmental water supply release as called for in the Beneficial Use band (see USACE 2007 for more information).

When studying LORS 2008, the USACE applied the South Florida Water Management Model (SFWMM) using the 36-year period of record (1965 through 2000) to understand the effects of lake regulation schedule changes. The model simulations did not include the C-43 Reservoir. Lake regulatory releases to the Caloosahatchee River (defined as the number of months with a mean monthly flow between 450 and 2800 cfs at the S-79 Structure) increased by 48 percent under LORS 2008. In addition, LORS 2008 was shown to increase the number of months with a mean flow greater than 450 cfs at the S-79 Structure by 34 percent (USACE 2007). Despite these incremental improvements in flows at the S-79 Structure, the targets identified in the PIR still remain unmet under LORS 2008 operations without the reservoir project.

A distribution of annual flows at the S-79 structure, simulated under LORS 2008 and projected against the planned capacity of the reservoir (170,000 ac-ft), is given in **Figure 3-12**. Evaluation of estimated annual flows under LORS 2008 operations shows that sufficient regional water is available to fill the reservoir almost every year during the period of record (**Figure 3-12**). The distribution shows that 95 percent of the time there was regional water sufficient to fill the reservoir. Eighty-four percent of the time, there was more than enough water to fill the reservoir at least twice during the year. The estimated seasonal distribution of flows at the S-79 Structure (**Figure 3-13**) shows that most of the water during the wet season comes from watershed runoff with significantly smaller volumes coming from Lake Okeechobee. On average about 38 percent of the annual flows at S-79 Structure will come from Lake Okeechobee and 62 percent will originate from the upstream basins. The volume of water released from Lake Okeechobee increases toward the end of the wet season reflecting regulatory releases.

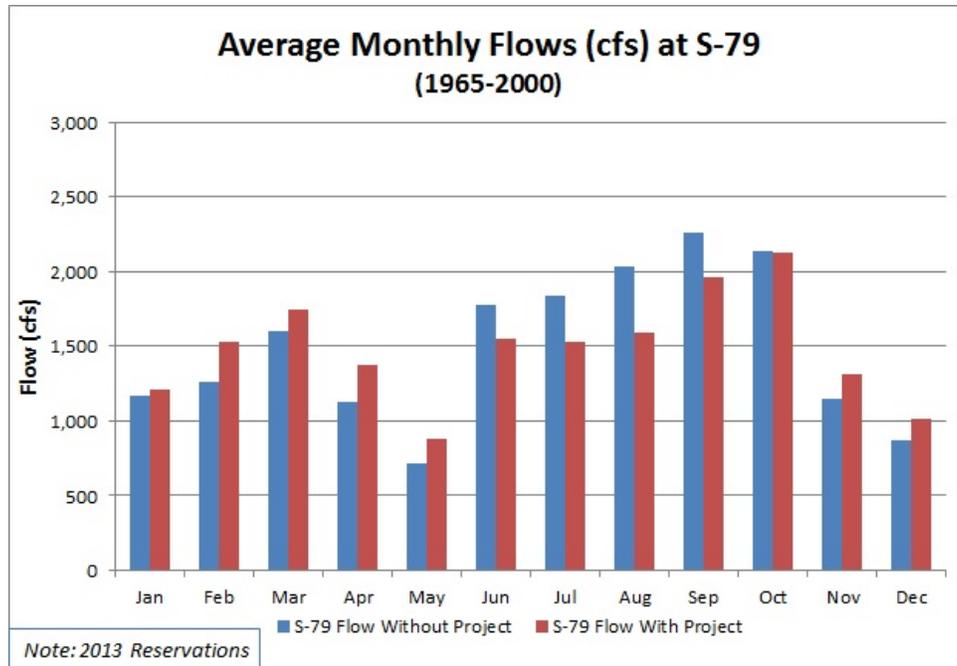


**Figure 3-12.** Annual distribution of flows at the S-79 Structure under LORS 2008.



**Figure 3-13.** Average monthly flows at the S-79 Structure based on LORS 2008 (1965 – 2000).

The spreadsheet model used in the PIR to simulate reservoir operations was updated with the SFWMM time series that uses LORS 2008 for Lake Okeechobee regulatory releases and the period of simulation was extended to 41 years. To compare these updated results to the PIR results, only the output for the first 36 years was used (1965 through 2000). Comparison of monthly average flows with and without the reservoir shows that the reservoir can capture portions of the wet season flows and then release the water primarily in the dry season at the S-79 Structure under LORS 2008 (**Figure 3-14**). With LORS 2008 there will be more surface water available from the lake to the Caloosahatchee River and the C-43 Reservoir during periods when lake stages range between 12.5 and 14.5 ft NGVD (baseflow band of LORS 2008) than was identified in the PIR (**Figure 3-11**). This additional water effectively increases the estimated number of days when water will be available to be captured and stored in the reservoir and reduces the number of days when low flows occur at the S-79 Structure. The net effect is that in some years, the combined flows at the S-79 Structure will be greater under LORS 2008 operations than originally estimated in the PIR under WSE operations. However, despite releasing all water contained in the reservoir to the Caloosahatchee River for the benefit of fish and wildlife, the targets identified in the PIR still remain unmet under LORS 2008.



**Figure 3-14.** Average monthly flows with and without the C-43 Reservoir at the S-79 Structure with LORS 2008 for the 36-year period of record from 1965 through 2000 (see [Figure 3-11](#) for flows during the 36-year period of record as simulated for the PIR).

All water captured in the C-43 Reservoir will be released to improve salinity in the Caloosahatchee River. The PIR concluded, “To achieve the project purpose, all water made available by the project is for the natural system to attain the benefits of the project” (USACE and SFWMD 2010). The analyses provided in the PIR using the WSE regulation schedule and the analysis presented here using the LORS 2008 regulation schedule for the same 36 year period of record (1965 through 2000) (USACE 2007) both confirm the intent of the PIR: All of the surface water contained within and released from the C-43 Reservoir is needed to improve conditions downstream of the S-79 Structure for the benefit of fish and wildlife.

## Section 4. Ecology of the River and Identified Improvements

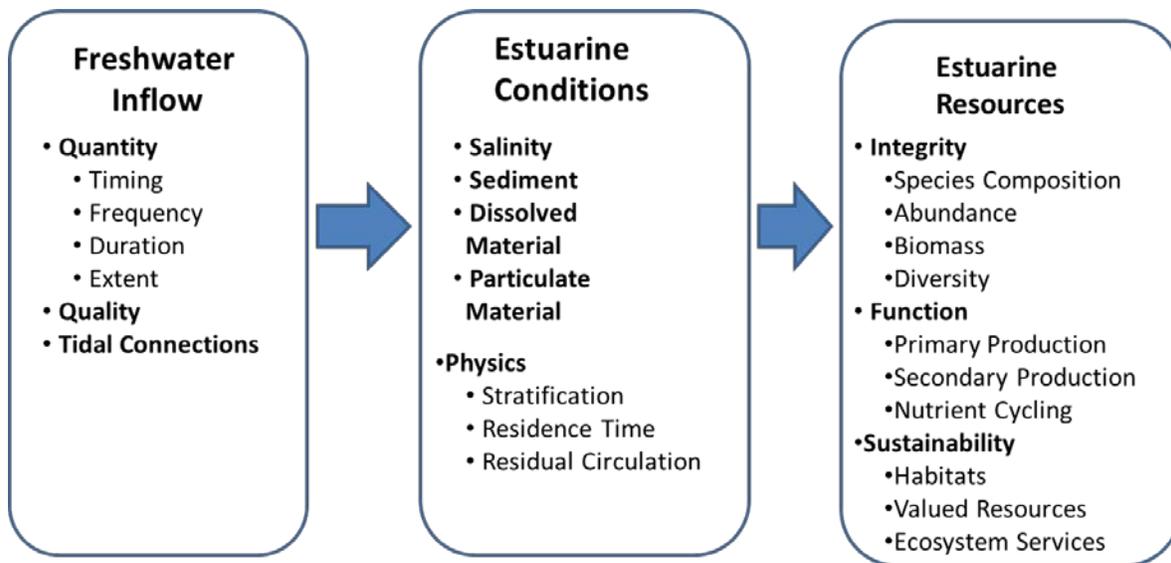
### 4.1 Freshwater and Estuaries

Estuaries comprise a transition zone where freshwater runoff from the land mixes with salt water from the sea. Freshwater inflow is not only a defining characteristic of an estuary, but it also influences biological structure (species composition, abundance, and distribution of flora and fauna) and ecosystem function. The latter includes creation and maintenance of a low salinity (0.5–17) nursery zone (Wasserman and Strydom 2011), the transport of sediments to coastal marshes (Stickney 1984), and the supply of nutrients to support estuarine productivity (Nixon 1981, Gillson 2011).

Estuaries are characterized by high primary and secondary productivity (Nixon et al. 1986, Nixon 1988). It is generally agreed that freshwater inflows contribute significantly to this production (Fisher et al. 1988, Day et al. 1989, Montagna and Kalke 1992). This productivity is attributed in part to the nutrients carried to estuaries by freshwater inflows, with higher freshwater inflows generally leading to higher yields of desirable species. Freshwater inflows stabilize the water column and carry nutrients that stimulate phytoplankton and zooplankton, enhancing the recruitment, growth, and survival of fish and invertebrates (Fisher et al. 1988, Quinones and Montes 2001, Hoffman et al. 2007, Kostecki et al. 2010).

Studies have shown that the low salinity zones of estuaries (practical salinity of 0.5–17) are utilized by larvae and juveniles of estuarine-dependent faunal species (Wasserman and Strydom 2012, Day et al. 1989) and flora. Some fauna require a low salinity zone to complete their development. For example, larvae of the inland silverside fish do not survive past the yolk-sac stage with a salinity of 17 but show no adverse effects with a salinity of 8 (Patillo et al. 1995). In general, however, estuaries are thought to be good nurseries because they provide an increased food supply, shelter, and lower predatory pressure.

There is an abundant literature describing the effects of altered freshwater inflows on estuarine systems (see reviews by Drinkwater and Frank 1994, Sklar and Browder 1998, Gillanders and Kingsford 2002). Evidence supports the hypothesis that maintaining freshwater inflows and their natural variability is a key component of maintaining the ecological structure and function of an estuary (Estevez 2002). **Figure 4-1** presents a conceptual framework for evaluating the effects of freshwater inflow on estuaries (after Alber 2002 and Palmer et al. 2011). It is based on the proposition that freshwater inflow (quantity, quality, and timing) influences estuarine conditions (salinity, nutrient concentrations, etc.), and that these conditions in turn affect different resources (species, communities) or processes (productivity, nutrient cycling) in the estuarine ecosystem.



**Figure 4-1.** Conceptual model of the effects of freshwater inflow on estuaries.

The effects of freshwater inflow on an estuary are largely indirect and mediated through direct effects on chemical and physical conditions. The freshwater-influenced estuarine condition considered to be most strongly associated with the distribution and abundance of estuarine biota is salinity (Emery et al. 1957, Gunter 1961, Kinne 1966, Remane and Schlieper 1971, Bulger et al. 1993, Whitfield et al. 2012). The mechanisms underlying this correlation may be physiological, related to tolerance or specific requirements for development (Bulger et al. 1993, Patillo et al. 1995), as well as ecological, related to refugia from predation, food supply, or preferred habitat (Day et al. 1989, Peterson 2003). Whatever the mechanism, the end result is that few estuarine organisms are found along the entire salinity gradient (0–35). Typically, organisms are found only within certain salinity ranges along the gradient (Bulger et al. 1993).

#### 4.2 Environmental Problems in the Caloosahatchee

Many of the ecological problems in the target area downstream of the S-79 Structure stem from widely fluctuating salinity resulting from high seasonal and inter-annual variation in discharge that occurs at the Franklin Lock and Dam (S-79 Structure) combined with the channelization of the river. During the wet season, watershed runoff from the basins upstream of the S-79 Structure, supplemented by regulatory releases from Lake Okeechobee, drastically reduce salinity levels over most of the estuary, darken the water restricting the depth of light penetration, and disrupt nutrient balance and assimilation capabilities. In turn, during dry periods, freshwater inflow can be so low that salt water migrates up to the S-79 Structure, truncating the salinity gradient within the estuary. The PIR identified several ecological problems arising from this high variance in freshwater inflow:

- Extreme changes in salinity
- Loss of freshwater and marine SAV due to salinity downstream of the S-79 Structure
- Truncation of the estuarine extent and function due to the physical constraint of the S-79 Structure (it effectively blocks tidal flows upstream of that point)
- Reduction of oyster reefs and adult blue crab habitat in the estuary due to low salinity conditions

The PIR summarizes the scientific work that chronicles the deleterious ecological effects of extremes in freshwater inflow to the Caloosahatchee River. Effects of high discharges were acknowledged even

before the S-79 Structure was built (University of Miami 1954, Phillips and Springer 1960, Gunter and Hall 1962). Subsequent research conducted by the SFWMD focused on the impacts of both high and low discharges on environmental factors such as salinity and a suite of estuarine indicator organisms including oysters, SAV, and other general biotic indicators such as plankton and benthic invertebrates (Chamberlain and Doering 1998a, Doering et al. 2002, Volety et al. 2009). This research confirmed that high discharges can lower salinity at the seaward end of the river to levels low enough to cause mortality of organisms that cannot escape (e.g., oysters, seagrass). Conversely, the lack of freshwater discharge allows salinity to increase downstream of the S-79 Structure to levels high enough to cause mortality to brackish water organisms (e.g., tape grass). Furthermore, this research has documented truncation of the salinity gradient at the S-79 Structure and the loss of the low salinity zone utilized as a nursery by many estuarine and estuarine-dependent species (USACE and SFWMD 2010).

Research conducted since the PIR was completed has been summarized in the *Caloosahatchee River Watershed Protection Plan* (SFWMD et al. 2009) and the *Caloosahatchee River Watershed Protection Plan Update* (Balci and Bertolotti 2012). While providing new information and allowing a greater understanding of ecological problems in the Caloosahatchee River, results of these studies are in agreement with previous research. For example, a recent investigation by Tolley et al. (2010) focused on the relationship between freshwater inflow at the S-79 Structure and the geographic position of the density maxima (center of abundance) of larval fish and their prey in the downstream tidal portions of the river. At very low flows during the dry season, some species, notably juvenile bay anchovies and their mysid prey, became impinged on the S-79 Structure and are thus prevented from moving further upstream. These and other species became concentrated in the narrow portion of the river just downstream of the structure resulting in habitat compression and increased exposure to predation by jellyfish. The Tolley et al. (2010) study verified results of a SFWMD study conducted in the 1980s (SFWMD 2003): utilization of the tidally influenced portion of the river by larval fish was highest in the March–June period. These observations underscore the need for fresh water to provide a low salinity nursery zone during the dry season.

In contrast to some previously official opinions (USFWS 1957), the river is now considered a valuable fisheries resource. Recent research and field studies have documented the use of the river as nursery habitat for several species of fish and invertebrates (Hunt and Doering 2013). These include blue crabs (*Callinectes sapidus*), the endangered bull shark (*Carcharhinus leucas*) (Simpfendorfer et al. 2005, Heupel and Simpfendorfer 2008, Ortega et al. 2009, Heupel et al. 2010), and the smalltooth sawfish (*Pristis pectinata*) (Simpfendorfer et al. 2008, Simpfendorfer et al. 2011). Portions of the Caloosahatchee River were designated as critical habitat for the smalltooth sawfish (NMFS 2009). In addition, the National Marine Fisheries (NMFS) website lists the Caloosahatchee River as essential habitat for juvenile brown shrimp (*Penaeus aztecus*), juvenile gray snapper (*Lutjanus griseus*), juvenile pink shrimp (*Penaeus duorarum*), adult and juvenile red drum (*Sciaenopsis ocellatus*), adult and juvenile Spanish mackerel (*Scomberomorus maculatus*), and juvenile stone crab (*Menippe mercenaria*) (USACE and SFWMD 2010).

Research conducted both before and after the PIR leads to the same conclusions: freshwater discharges during the wet season are too high and discharges during the dry season are too low. As the PIR concludes, “The estuary will remain at risk as long as the quantity and timing of freshwater flows into the estuary remains unchanged” (USACE and SFWMD 2010). A combination of reduced flows during the wet season and higher inflows during the dry season is necessary to protect fish and wildlife habitats in the estuarine portions of the Caloosahatchee River.

The PIR (USACE and SFWMD 2010) recognizes that this high variance in discharge results from a lack of storage in the regional water management system and proposes an aboveground reservoir as a solution:

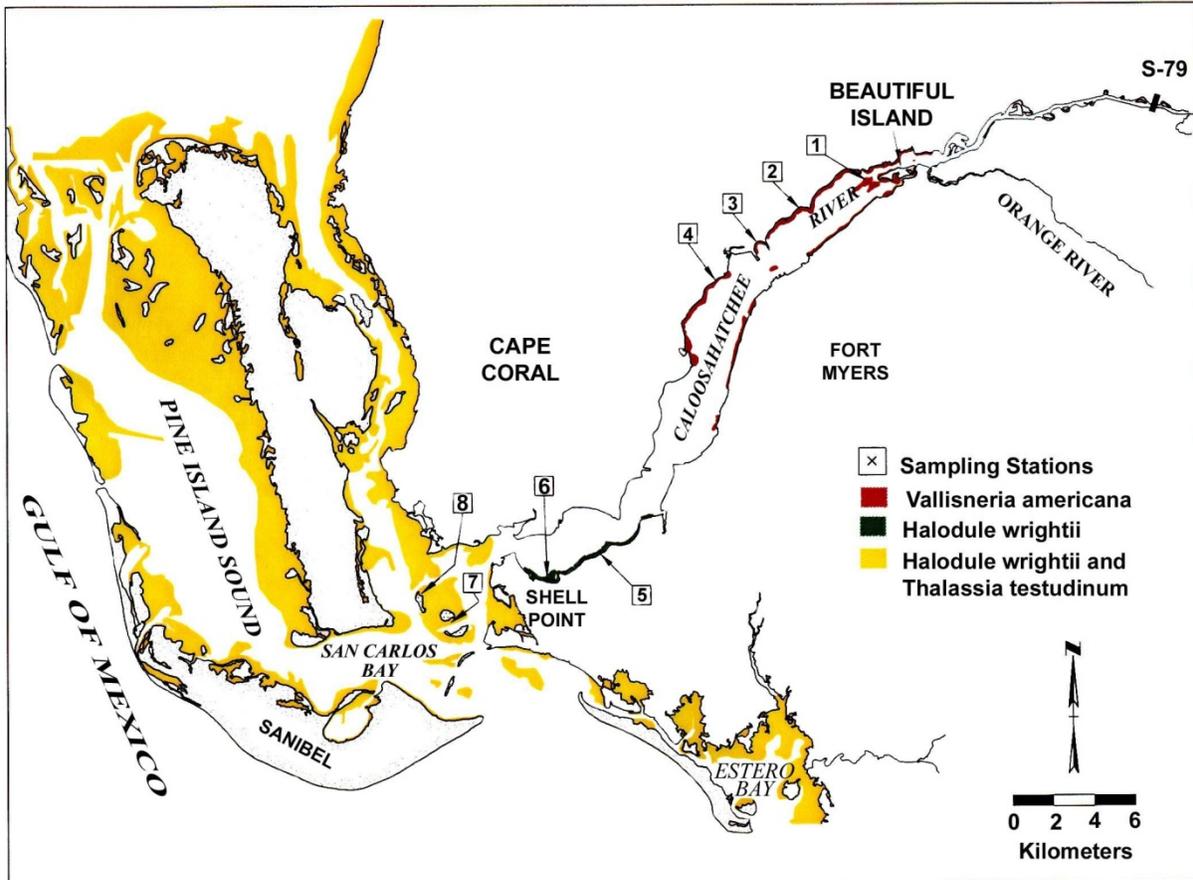
To restore ecological function and productivity in the Caloosahatchee Estuary, CERP, approved by Congress in the WRDA 2000 (US Congress 2000), included an above-ground reservoir along the Caloosahatchee River to capture and store basin runoff and excess freshwater released from Lake Okeechobee. By capturing this excess water the reservoir can also serve as a source of environmental water supply to the estuary during dry periods. The need for additional storage to restore, protect and preserve the Caloosahatchee Estuary, including Federal trust lands and other publically owned and managed areas in and around the Caloosahatchee Estuary has also been validated by other planning efforts, including the Caloosahatchee Water Management Plan (2000) and Lower West Coast Water Supply Plan (2005–2006) prepared by the SFWMD.

### 4.3 Aquatic Habitat and Improvements Identified in the PIR

To evaluate the water made available by the C-43 Reservoir, the PIR focused on existing habitat-forming species found throughout the length of the river downstream of the S-79 Structure: tape grass, *Vallisneria americana*, in the upper low salinity (oligohaline) region of the river; eastern oysters, *Crassostrea virginica*, in the lower mesohaline region of the river, and seagrasses (turtle grass, *Thalassia testudinum*, and shoal grass, *Halodule wrightii*) in the more marine portion of the system in San Carlos Bay.

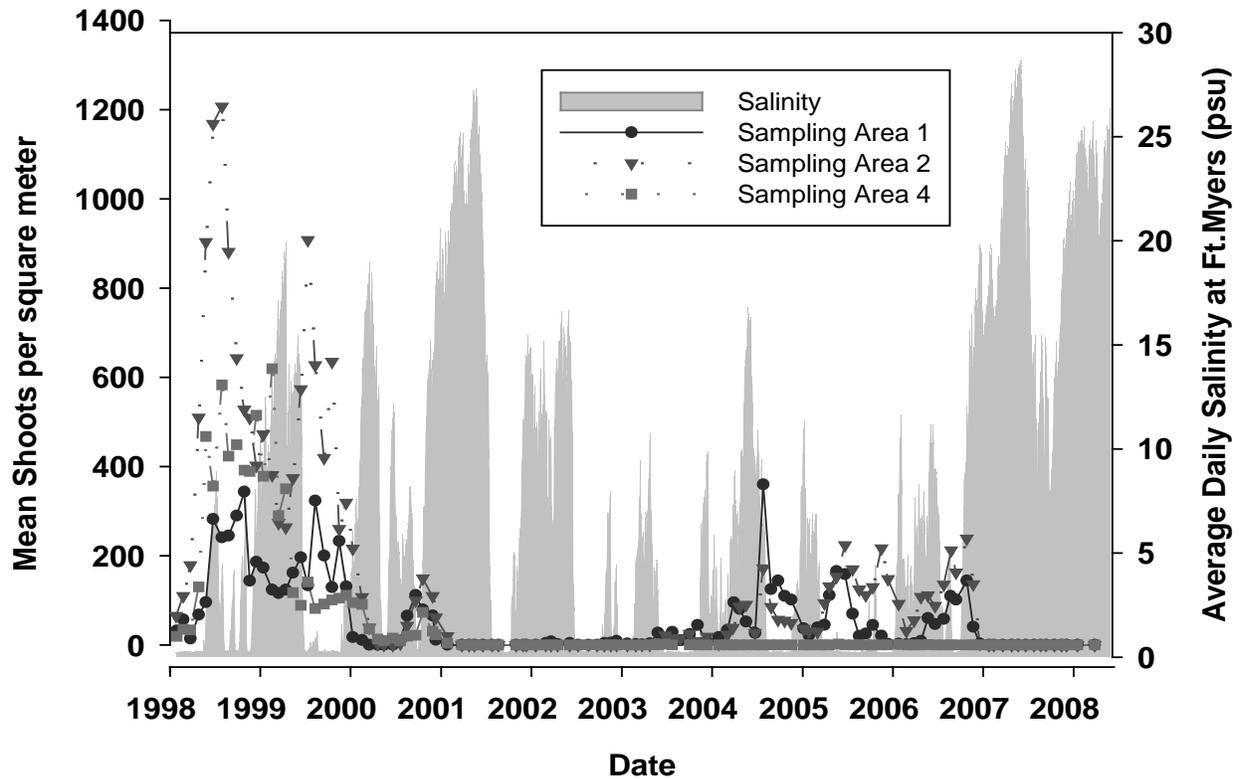
SAV beds are important to the ecology of shallow estuarine and marine environments. SAV provides habitat for many benthic and pelagic organisms, functions as nurseries for juveniles and other early life stages, stabilizes sediments, improves water quality, and forms the basis of a detrital food web (Kemp et al. 1984, Fonseca and Fisher 1986, Carter et al. 1988, Killgore et al. 1989, Lubbers et al. 1990). Because of the importance of SAV beds, estuarine restoration initiatives often focus on SAV (Batiuk et al. 1992, Johansson and Greening 2000, Virnstein and Morris 2000). SAV are commonly monitored to gauge the health of estuarine systems (Tomasko et al. 1996) and their environmental requirements can form the basis for water quality goals (Dennison et al. 1993, Stevenson et al. 1993). Although there are species-specific variations, SAV distributions in coastal areas are limited by four environmental factors: light, salinity, temperature, and nutrients (Dennison et al. 1993, Kemp et al. 2004).

Downstream of the S-79 Structure, the spatial distribution of SAV along the longitudinal axis of the river reflects their salinity tolerances ([Figure 4-2](#)). Sparse beds of the marine seagrass *Halodule wrightii* (shoal grass) extend up from San Carlos Bay almost to the Cape Coral Bridge (Hoffacker et al. 1994, Chamberlain and Doering 1998b) and are restricted to the shoreline margins. Downstream of Shell Point, *Halodule* forms mixed beds with *Thalassia testudinum* and other less common species in San Carlos Bay and Pine Island Sound.



**Figure 4-2.** Historic distributions of *Vallisneria americana* and *Halodule wrightii* in the Caloosahatchee River (Hoffacker et al. 1994).

Tape grass, *Vallisneria americana*, is an important upper estuarine SAV species (Figure 4-2) and is sensitive to saltwater intrusion. It is therefore a good indicator of the effects of varying freshwater inflow to the river, especially during periods of low flow in the dry season. When present, this species is located near the shoreline in the upper portions of the river to a depth of about 1.0 m. Tape grass is a salt-tolerant freshwater angiosperm that provides important nursery habitat for blue crabs, white shrimp, and other species in the oligohaline zone (see Rozas and Minello 2006). Downstream of the S-79 Structure, its greatest coverage occurs from Beautiful Island to the Ft. Myers Bridges (15 to 20 miles [24 to 32 km] upstream of Shell Point, Hoffacker et al. 1994, Chamberlain and Doering 1998b). In this portion of the river, salinity during the dry season routinely exceeds the accepted threshold of 10 for a sustainable population. Saltwater migration during the dry season is of sufficient magnitude to routinely cause mortality of tape grass in the upper river (Doering et al. 2001, Figure 4-3). Hunt and Doering (2005) examined the effects of salinity relative to other environmental drivers (light and temperature) using a numerical model and showed that in some years salinity intrusion in the upper portions of the river (downstream of the S-79 Structure) was a major driver of tape grass decline. Supplemental flows at the S-79 Structure during the dry season would help alleviate mortality due to salinity intrusion.



**Figure 4-3.** *Vallisneria americana* downstream of the S-79 Structure (sampling areas correspond to [Figure 4-2](#)). The years 1999–2001 and 2007–2008 were characterized by drought conditions with daily dry season salinities in excess of 20.

Reefs formed by the eastern oyster are a prominent feature of estuarine landscapes in Florida (Barnes et al. 2007) and historically were abundant in the Caloosahatchee River’s estuary (Sackett 1888). Oyster reefs are important because they filter water, which can enhance water clarity, remove nutrients, protect shorelines, and provide essential fish habitat (Coen et al. 1999, Wall et al. 2008, Beck et al. 2009). Existing oyster reef habitat in the river has been estimated to cover approximately 18 acres (0.07 km<sup>2</sup>) based on a survey conducted in 2004 ([Figure 4-4](#), RECOVER 2007) and is much reduced relative to the historical distribution (Sackett 1888). While oyster reef habitat in the Caloosahatchee River is centered around Shell Point, clumps of oysters may be found up to the Cape Coral Bridge (about 6 miles [10 km] upstream of Shell Point, SFWMD 2003).



Figure 4-4. Oyster reefs (in yellow) in the Caloosahatchee River in 2004 (RECOVER 2007).

#### 4.4 Reservoir Freshwater Releases and Ecological Improvements

The PIR assessed potential ecological improvements from operation of the C-43 Reservoir using Habitat Suitability Index models. Habitat Suitability Index models are typically driven by environmental variables such as temperature and salinity and measure how conducive conditions are for the survival and growth of the target species. The target species included in this analysis were the tape grass *V. americana*, oysters, and the seagrasses, *Halodule wrightii* and *Thalassia testudinum*. Enhanced conditions for these species in the Caloosahatchee River will also benefit resident fish and other wildlife. To achieve the habitat improvement shown in the PIR, all the water that the project made available was assumed to flow to the Caloosahatchee River downstream of the S-79 Structure. The analysis showed that construction and operation of the reservoir will improve conditions for fish and wildlife by improving conditions for their habitat. As described in the PIR, “Fish and wildlife habitat benefits of the Caloosahatchee River (C-43) West Basin Storage Reservoir project includes improving the timing of water deliveries to the estuary thereby providing a salinity range suitable for a healthy ecosystem and reestablishment of natural hydropatterns within existing natural areas, improvement in seagrass beds in the estuary, and increase habitat for the eastern oyster, blue crab, and other fish and marine organisms” (USACE and SFWMD 2010).

## **Section 5. Identification of Water to be Reserved**

A component of establishing a water reservation pursuant to subsection 373.223(4) F.S., is the identification of locations and seasonal quantities of water, which in the judgment of the District, may be required for the protection of fish and wildlife or the public health and safety. Rules which withhold such waters from allocation are drafted when there is a reasonable expectation that demands for waters from the identified sources will occur at a time of year and in an amount, singularly or cumulatively, to reduce the availability of water needed for the protection of fish and wildlife. This section identifies the water associated with the C-43 reservoir project which is needed for the protection of fish and wildlife.

The scope of this reservation rulemaking is the protection of water stored in and discharged from the C-43 Reservoir from allocation to consumptive use withdrawals. As described earlier, protection of project waters under state regulatory authority is a prerequisite of a Project Partnership Agreement which in turn, is needed for authorization and appropriations of a CERP project component. State regulatory rules allow for reservations to be adopted prospectively for water anticipated to be made available from a project to be constructed in the future. The water to be reserved prospectively for the C-43 West Basin Storage Reservoir shall be consistent with the fish and wildlife benefits outlined in the Project Implementation Report (PIR).

Details regarding the volumes and timing of water needs for the protection of fish and wildlife that occur within the Caloosahatchee River downstream of S-79 as identified for the C-43 Reservoir project can be found in Volume 3; Annex C of the Caloosahatchee River (C-43) West Basin Storage Reservoir Project Implementation Report and Environmental Impact Statement Final, November 2010 (PIR). The PIR is a project scoping and alternative evaluation level document in which project alternatives are formulated and evaluated against a defined set of performance measured to identify a final preferred option. Final design, construction and operations are determined after the Project Partnership Agreement is executed and funding appropriations are made.

A component of the PIR is the identification of water made available for the natural system and other water related needs of the Caloosahatchee River. Section 8.5.3.1 of the main report identifies that: "To achieve the project purpose, all water made available by the project is for the natural system to attain the benefits of the project. Therefore, there will be no water made available for other water-related needs of the region by the project." The benefits identified in the Appendix C of the PIR assumed that all of the surface water discharged from the C-43 reservoir is required to provide 12,809 average annual habitat units (HU) to the estuary downstream of the S-79 Structure. The PIR went on to quantify the water made available by the project based on assumptions associated with reservoir operations and spreadsheet analysis (section C.2.1.2 of Volume 3; Annex C) and a hydrologic performance indicator for the natural system related to beneficial flows at the S-79 Structure.

This quantification, in the form of a volume probability distribution, is presented in section C.3.2.3 of Volume 3; Annex C, with annual volumes identified at the 10<sup>th</sup>, 50<sup>th</sup>, and 90<sup>th</sup> percentiles of 159,485, 105,990 and 27,619 ac-ft/year.

Defining the water reservation using the volume probability distributions contained in the PIR has potential drawbacks due to changes in operations and assumptions which have occurred since the completion of the evaluations conducted in the PIR as described in Section 3. Based on these changes, it is possible that the volume probability curves identified under estimate the amounts of water that will be available in the C-43 reservoir and needed to meet the project salinity target identified in the PIR. As a result, basing the water reservation on the volume probability curve presented in the PIR may have the unintended consequence of protecting less water than may be available for restoration of the natural system. Therefore, staff recommends all C-43 reservoir project water should be reserved from allocation for the protection of fish and wildlife rather than the specific volumes identified in the PIR. It is recognized that once constructed, the volume of water flowing from Lake Okeechobee and the upstream

basins along with the operations of the reservoir will be refined. At that time it would be prudent to revisit the availability of the ‘as built’ project water to determine if this reservation needs to be updated.

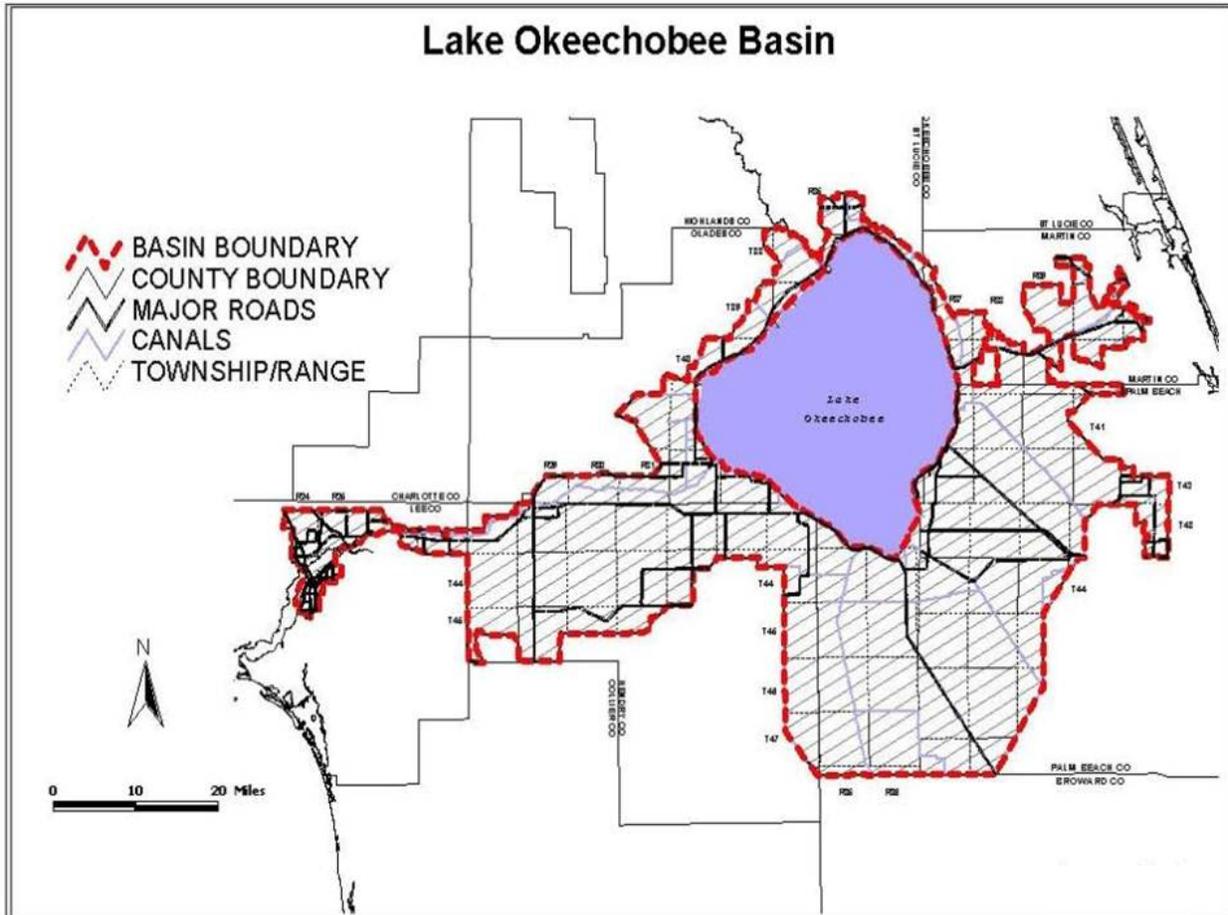
## **5.1 Protection of Project Waters**

In order to determine where water reservation rules are needed to protect project water, four areas were evaluated to determine if there is a sufficient risk that future increases in consumptive use would occur to a degree that the project water would be otherwise diminished to a degree of affecting the C-43 reservoir project objectives. These areas include the following; 1) the upstream watershed area where Lake discharges and watershed runoff flows contribute waters for storage, 2) waters stored within the reservoir, 3) groundwater withdrawals in the vicinity of the project, and 4) C-43 canal water downstream from the discharge point of the reservoir to the S-79 Structure.

### **5.1.1 Upstream Watershed Evaluation**

Inflows to the project reservoir will consist of regulatory releases from Lake Okeechobee along with watershed runoff from the upstream basins (**Figure 3-1**). These flows occur primarily during the wet season. The C-43 Reservoir project operations will be capable of capturing watershed runoff in the event of high rainfall events during the dry season. As discussed in **Section 3.4**, annual total flows at the S-79 Structure are expected to exceed the capacity of the reservoir (170,000 acre feet) 95 percent of the time under the LORS 2008 regulation schedule (**Figure 3-14**).

Water use rules were used to assess the potential risk of future increases in consumptive uses. The use of surface water from Lake Okeechobee is capped at a 2008 baseline use rate within the Lake Okeechobee Basin (Water Use Basis of Review Section 3.2.1(G) - **Figure 5-1**). This Restricted Allocation Area rule prevents increases in water use from the Lake and therefore eliminates the risk of future water use impacting the volume of Lake water available for storage by the reservoir.



**Figure 5-1.** The Restricted Allocation Area Rule Boundary for Lake Okeechobee and the Lake Okeechobee Service Area.

There are no specific rules capping the use of surface water generated from the upstream watershed basins between S-77 to S79 (**Figure 3-1**). However, in considering if a proposed use is reasonable and beneficial the applicant must demonstrate that the water supply is available during those times of demand up to a drought event with a return probability of 1 in 10 years. Water use within the S-4, Caloosahatchee West and East basins is predominately agriculture which requires supplemental irrigation water during the dry season months when watershed runoff is mostly unavailable. Therefore new uses in the basin would not be able to be permitted surface water (from watershed runoff) unless it was associated with a storage facility. The construction of onsite storage facilities capable of supporting agriculture throughout the dry season has not been feasible or permitted to date. Stormwater management facilities have on occasion been used to supply supplemental irrigation for short times until stored water runs out but these facilities are not sized to meet water demands throughout the dry season.

The 2012 Lower West Coast (LWC) Water Supply Plan (SFWMD 2012) indicates that agriculture continues to be the LWC Planning Area's largest water user through the 2030 planning horizon. The LWC Planning Area includes all of Lee County, most of Collier County and portions of Hendry, Charlotte, Glades and mainland Monroe County. The Agriculture self-supply represents approximately 57-59 percent of the planning area's total gross demands by 2030. The annual gross water demands for Agricultural Self-Supply are estimated to be 630 MGD for 2010 while the projected demands are between 695.9 and 740.9 MGD for 2030. This is an increase of 10-18 percent throughout the entire LWC planning

area. The percentage change within the Caloosahatchee watershed, which encompasses four different counties, was not evaluated as part of the 2012 water supply planning effort (SFWMD 2013).

Due to regulatory limits on new uses for Lake Okeechobee and watershed runoff, combined with the ample supply of wet season runoff available to recharge the reservoir on an annual basis, there is a low risk that new uses will be permitted to the degree sufficient to reduce the volumes of water available for storage in the C-43 Reservoir. It is concluded that additional water use rules which further limit the use of Lake Okeechobee surface water and watershed runoff upstream of the reservoir for the protection of water to be captured and stored in the C-43 are not necessary.

### **5.1.2 Water Stored Within the Reservoir**

Currently there are no existing rules that would prevent direct withdrawals of surface water from the reservoir once constructed. Such withdrawals will need to be prohibited by the reservation rule. This conclusion is consistent Section C.2.3., of Volume 3; Annex C, of the PIR which identifies there will be no water made available for other water related needs by the reservoir and all water made available by the project is provided to the natural system. Water stored within the C-43 Reservoir will come from regulatory releases from Lake Okeechobee and watershed runoff (located west of Lake Okeechobee) and is not used to meet any water supply demands. Rather than discharging this “excess surface water” downstream to the Caloosahatchee River it will be captured and stored in the C-43 Reservoir. Proposed subsection 40E-10.041(3)(a) F.A.C., provides that all surface water contained within and released, via operation, from the Caloosahatchee River (C-43) West Basin Storage Reservoir is reserved from allocation.

### **5.1.3 Groundwater Withdrawals in the Vicinity of the Project**

In addition to direct surface water withdrawals, staff evaluated the potential for well withdrawals removing significant volumes of reservoir water via seepage. Test well data from the reservoir site identify two freshwater aquifers occur beneath the site. The water table aquifer extends from land surface to depths of approximately 20 feet. The thin nature of the unit combined with the low permeability of the sediments limits the use of this aquifer to small withdrawals (generally less than 50 gallons per minute (gpm) per well). In addition, the design of the reservoir includes the construction of a fully penetrating seepage barrier constructed through the levee and into the naturally occurring clay confining unit beneath the water table aquifer to protect the efficacy of the surrounding dike and to prevent seepage impacts to adjacent lands. This design feature will effectively prevent seepage from the reservoir to any nearby water table well. As a result, no additional water use rules restricting water use from the water table aquifer will be needed.

The second aquifer, the sandstone aquifer occurs at depths between 45 and 160 below land surface in the vicinity of the site. These depths are based on the geologist log for the Caloosahatchee Aquifer Storage and Recovery (ASR) test core. The aquifer is separated from the water table aquifer by approximately 30 feet of low permeable clays that restrict the vertical movement from the overlying aquifer into the sandstone aquifer. The sandstone in this area produces significant yields of freshwater (upwards of 500 gpm per well) and is used for irrigation supply and self-supplied potable water. Staff evaluated the potential impacts of a string of four wells hypothetically located inside the reservoir. Model runs were made using different pumping rates in order to assess the amounts of seepage that could result from groundwater withdrawals from the well operations. Pumping was simulated under steady-state conditions and hypothetically locating the wells within the reservoir represents a worse-case scenario to evaluate potential negative impacts to the reservoir.

Model results, using a calibrated model, do not predict any impacts on the reservoir as a result of withdrawing limited quantities from the sandstone aquifer. The quantities are limited by the maximum

allowable drawdown in the sandstone aquifer as established in water use rules pertaining to maximum developable limits (MDL) for semi-confined freshwater aquifers on the Lower West Coast (Section 3.2.4 of the Basis of Review for Water Use Applications). This MDL for the sandstone aquifer was established as part of the prevention strategy to ensure that the minimum aquifer level (Section 40E-8.331, F.A.C.) is met in the future. Therefore, additional water use rules which would limit the use of the sandstone aquifer in the vicinity of the C-43 reservoir are not necessary. A more detailed description of the site conditions and model simulations are provided in **Appendix A**.

#### **5.1.4 Downstream Watershed Evaluation (C-43 Canal Water between S-79 Structure and the Reservoir)**

A segment of the C-43 Canal, occurring between the S-79 Structure and the C-43 Reservoir, will serve as the conveyance path for reserved water being delivered to the Caloosahatchee River. As such, it is possible that new direct withdrawals from within this reach of the C-43 Canal could intercept reserved water and prevent it from reaching the estuarine portion of the Caloosahatchee River. Accordingly, additional consumptive use permit rules will be needed by the time the reservoir is operational that will be applied to applicants for new or increased C-43 surface water supplies within this reach of the canal. Such rules should include criteria for demonstrating that such withdrawals will not divert and use water reserved from allocation originating from the C-43 Reservoir. Proposed subsection 40E-10.041(3) F.A.C., requires the “Basis of Review for Water Use Permit Applications within the South Florida Water Management District,” incorporated by reference in Section 40E-2.091, F.A.C., shall be revised pursuant to subsection 373.223(4), F.S., in light of changed conditions or new information and prior to the reservoir becoming operational. Specific permit criteria identifying how an applicant for withdrawal of C-43 surface water from a location downstream of the reservoir can demonstrate that reserved water will not be withdrawn will be determined and incorporated by rule once the final operation plan for the C-43 reservoir is completed.

#### **5.2 Existing Legal Uses/Existing Legal Sources**

Subsection 373.223(4) F.S. states that when establishing a water reservation, all presently existing legal uses of water shall be protected so long as such use is not contrary to the public interest. Section 385.36 of the federal Programmatic Regulations requires that project implementation reports determine if existing legal sources of water are to be eliminated or transferred as a result of project implementation. If a project is expected to result in an elimination or transfer of an existing legal source of water, the PIR shall include an implementation plan that ensures a new source of water of comparable quantity and quality is available to replace the source that is being transferred or eliminated.

In determining the water made available by the project, the PIR found that sources of water to meet agricultural and urban demand in the Caloosahatchee River (C-43 Canal) Basin will remain the same as before the project and therefore, there will be no elimination or transfer as a result of this project on existing legal sources of supply. Since the project design does not depend on water supplies being utilized by area uses, there is no basis upon which to conclude that the reservation of water made available by the project will compete against existing legal uses. Therefore, it is concluded that all presently existing legal uses of water, as they relate to the proposed water reservation for this project, are not contrary to the public interest.

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## **Appendix A**

### **Groundwater Evaluation to Support the Reservation Rule for the CERP Caloosahatchee River (C-43) West Basin Storage Reservoir Project**

## **Groundwater Evaluation to Support the Reservation Rule for the Caloosahatchee River C-43 West Basin Storage Reservoir Project**

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January 30, 2014

### **Purpose**

The purpose of the document is to briefly describe the geologic and hydrogeologic framework at the C-43 West Basin Storage Reservoir (WBSR or reservoir) site and analyze the potential for groundwater use impacts on the water being stored and reserved from consumptive use. An aerial photograph of the C-43 proposed WBSR site is attached as Plate 1.

### **Geologic Framework**

The elevation of the site is approximately +20 to +21 feet North American Vertical Datum of 1988 (NAVD). The water surface elevation in the reservoir will be +42 feet at “normal pool” (NAVD), with the average depth ranging from +17-19 feet. The description of the subsurface, based on 92 core borings on-site, is as follows:

- Pliocene and Pleistocene-Holocene age: Subsurface lithology from land surface to approximately 20 feet below land surface (bls) includes clean sands, clayey sands and a minor sequence of limestone just beneath the clean sands to a depth of 20 to 25 feet.
- Miocene-age: The Hawthorn Group extends to approximately 500 feet bls and is divided into an upper clastic sequence and a lower carbonate sequence. At the site the upper unit consists of a clayey sand layer ranging from 20 to 80 feet thick which overlays siliciclastic sands, sandstones and clayey sands that make up the upper Peace River Formation.

Plate 2 shows two cross-sections illustrating core boring results striking east-west along the northern and southern boundaries of the reservoir.

A portion of the geologic log, from ground surface to a depth of 180 feet bls of the Caloosahatchee Aquifer Storage and Recovery (ASR) Test Core conducted at the site, is included in Attachment A. The geologic log indicates clays, limestone, and shell beds from 50 feet bls to 90 feet bls which appear to occur as a thin layer at the western boundary of the site and is not noted in any other cores.

## Hydrogeology

Three major freshwater aquifers provide the majority of groundwater in Hendry County. The water table (WTA) and the lower Tamiami (LTA, not present at this site) aquifers are part of the surficial aquifer system and the sandstone aquifer (SA, the primary groundwater source in the area) is in the intermediate aquifer system. There is also minor use of the brackish mid-Hawthorn aquifer (MHA), also within the intermediate aquifer system, and the Floridan aquifer system (FAS). Plate 3 shows the location of aquifer performance tests in the area and the associated aquifer characteristics.

### Surficial Aquifer System

- According to SFWMD Technical Publication 90-04, hydraulic conductivity of the surficial aquifer is 100 ft/day with an aquifer thickness of approximately 20 feet, (transmissivity of 2,000 ft<sup>2</sup>/day). Due to its thinness and low hydraulic conductivity, this aquifer is not widely used as a source of groundwater in the area of the C-43 WBSR. Therefore, for the purpose of this evaluation, groundwater withdrawals from the Surficial Aquifer System are considered to have no impact on the stored surface water of the proposed C-43 WBSR.

### Intermediate Aquifer System

- Sandstone aquifer: According to two local pump tests, documented in SFWMD Technical Publication 88-12, transmissivity ranges from 14,000 to 70,000 gpd/ft (1,870 to 9,358 ft<sup>2</sup>/day) in the project area. Transmissivity ranges from 10,000 to 240,000 gpd/ft (1,400 to 32,000 ft<sup>2</sup>/day) where the aquifer occurs in Lee, Hendry and Collier counties, depending on if both the clastic and carbonate portions of the aquifer occur. Local values of storage are 0.0002 to .00004 and leakance is approximately 0.0002 gpd/ft<sup>2</sup>. The Sandstone aquifer is the principle source of fresh groundwater in the area and is the focus of the model evaluation described below.
- The mid and lower Hawthorn aquifers supply groundwater to the area, however, these aquifers occur at great depth, are separated from the surface by a semi-confining lithology, and the aquifers are generally low yield and saline. Therefore for the purpose of this evaluation groundwater withdrawals from these aquifers are considered to have no impact on the stored surface water of the proposed C-43 WBSR.

## Water Use Impact Assessment

Please refer to Plate 4 for the location of existing water use permits and permitted groundwater facilities. The surface water facilities are not shown on Plate 4.

Existing Water Use (within permitted boundary of the drainage district)

- Surface water pump facilities:
  - 26-00082-W Labelle Private Drainage District. Townsend Canal, Header Canal
  - 26-00106-W DUDA Labelle Farm.

#### Existing Water Use

- Surface water pump facilities:
  - 26-00022-W – Banana Branch Groves, C-43, Banana Branch
  - 26-00076-W – Murphy Groves, Townsend Canal
  - 26-00957-W – Murphys Landing, Townsend Canal
- Well facilities:
  - 26-00022-W – Banana Branch Groves, 1 MHA well, 3,800' north
  - 26-00082-W – LaBelle Private DD, 10 LHA wells, 1,100' east
  - 26-00265-W – Bob Paul, 14 LHA, 5 SA wells (freeze protection, backup),
  - 26-00399-W – B&W Growers, 7 SA wells
  - 26-00498-W – Sun Belt Citrus Nursery, 1 SA well, 550' west
  - 26-00573-W – Daniels Farm, 1 WTA well, 2,700' north
  - 26-00659-W – Shults Commercial, 2 Surficial aquifer, 2,900 north
  - 26-00739-W – Smith PWS, 1 SA well, 3,000' north
  - 26-00741-W – Zarecky PWS, 1 SA well, 2,300' north
  - 26-00789-W – Glen Acres Storage, 1 SA well, 2,100' north
  - 26-00739-W – David Smith, 1 SA well, 2,300' north
  - 26-00741-W – Zarecky, 1 SA well, 2,400' north
  - 26-00789-W – Glenn Acres Storage, 1 SA well, 2,500' north
  - 26-00840-W – Gator Golf Cars, 1 SA well, 2,600' north
  - 26-00874-W – Riverbend Resort, 4 SA wells, 4,000' north
  - 26-00941-W - Hendry County EOC, 2 SA wells, 2,000' north
  - 26-00946-W – LaBelle Farms, 1 Surficial well, 1 mile south
  - 26-01014-W –River Landings, 2 SA wells, 3,500' north
  - 26-01027-W - Domingo Rios Salinas, 1 SA well, 2,500' north
  - 26-01144-W – Oak Creek Hammock (GP), 2 SA wells, 1,800' west
  - 26-01162-W – '4825 SR80', 1 SA well, 2,600' north
  - 36-01134-W – Le Hi Tree Farm, 1 SA well, 2,700' west
  - 36-01498-W – Brett's Back Forty, 1 SA well, 4,000' west
  - 36-02141-W – Roberge Farms, 7 Surficial, 1 LHA well, 1.3 miles west

Surface water bodies can receive recharge from groundwater if they are connected to the water table. This is not the case with the C-43 WBSR because the above ground design places the reservoir bottom above the prevailing water table. In addition, an impermeable clay wall to the top of the clay in the formation is also proposed in the design to separate the C-43 WBSR from the water table aquifer around the site. Seepage studies at test cells with and without the barrier indicate that the barrier design significantly reduced the seepage losses by 76 percent. Any existing or future withdrawals from adjacent surface water bodies connected to the water table aquifer would not affect the water in the reservoir because of this proposed physical barrier (clay wall).

A series of monitor wells were installed to a depth above, within, and below the clays both near the test cells and around the perimeter of the WBSR to get background water levels for the seepage analysis. In the year of data collection, the wells below the clay layer (Sandstone aquifer wells) had water levels that appeared to be independent of surface water levels in the test cells (Plate 5). Fluctuations in water levels in the Sandstone aquifer were related to regional and seasonal weather and recharge. Water levels in the Sandstone aquifer immediately below the test cells were consistent with those observed in background piezometers located at the C-43 WBSR boundary.

Groundwater withdrawals from the Lower Tamiami, Sandstone and mid-Hawthorn aquifers are subject to existing rules [Prevention and Recovery Strategies in subsection 40E-8.421(4), Florida Administrative Code and Section 3.2.4 of the Basis of Review for Water Use Applications] which restrict those permitted withdrawals so that the potentiometric head within each aquifer cannot be lowered to less than 20 feet above the top of the uppermost geologic strata of the aquifer during a 1-in-10 year drought. For example, in the vicinity of the WBSR, the top of the Peace River Formation (Sandstone aquifer) is identified as 40 feet below land surface (-19 feet NAVD). Therefore, drawdown would be limited to 20 feet above this, or 20 feet below land surface (+1 feet NAVD). During the test cell seepage monitoring in 2006, water levels in the Sandstone aquifer fluctuated between +15 feet NAVD and +7 feet NAVD (Plate 5). Long term monitor data from Sandstone aquifer wells HE-557 (north of reservoir), HE-559 and HE-560 (south boundary of reservoir) documents water levels of +13 feet NGVD at the south end of the reservoir and +6 feet NGVD at the north end (well locations shown on Plate 4 and data on Plate 6). Any new user on the north side of the reservoir (near HE-557) would have to demonstrate that their withdrawals do not have additional drawdowns of more than 5 feet at a distance of 50 feet from the withdrawal point. To the south of the reservoir the drawdown limit is approximately 13 additional feet at a distance of 50 feet from the withdrawal point. Based on model results, withdrawals to the north would be limited to approximately 100,000 gallons per day and to 500,000 gallons per day to the south.

### **Groundwater Modeling**

The groundwater model for Hendry County, documented in SFWMD Technical Publication 90-04, was used to assess impacts due to withdrawals from the Sandstone aquifer. The model cell size in the vicinity of the reservoir was reduced from one mile down to 660 feet. A simulated sandstone aquifer well and also a string of four wells were simulated inside the reservoir at withdrawal rates of 0.1 million gallons per day (MGD) and 0.5 MGD were used to evaluate the potential drawdown in the water table aquifer, layer 1, and the semi-confined Sandstone aquifer, layer 3. Pumping was simulated under steady-state conditions and would represent a worse-case scenario. Results indicated no drawdown in layer 1. Table 1 summarizes the drawdown in layer 3. As similar result is expected for the surface water within the reservoir since Layer 1 showed no drawdown.

TABLE 1  
C-43 WEST BASIN STORAGE RESERVOIR  
MODEL OUTPUT SUMMARY

PUMPING RATE (MGD)	DRAWDOWN IN LAYER 3 (Sandstone aquifer) (FEET)	DRAWDOWN IN LAYER 1 (Water Table) (FEET)
0.1 (1 well)	1.2	0
0.1 each (4 wells)	5	0
0.5 (1 well)	11	0
0.5 each (4 wells)	31	0

**Potential Water Losses**

Vertical and horizontal seepage can occur from the reservoir through the bottom and sides of the above ground impoundment prior to slurry wall installation. Dipping, semi-confining lithologic layers are present under the site beginning at depths ranging from 20 to 30 feet below land surface in the water table aquifer and at greater depths between additional water producing zones in the Peace River Formation. Based on the site hydrogeologic framework, impacts causing minor loss of water from the proposed storage reservoir are possible from nearby water table aquifer groundwater withdrawals. However, due to the reservoir design with a slurry wall and the low yield of the aquifer in the area, significant withdrawals are not possible from the water table aquifer or reservoir and minor withdrawals (10,000 gpd) would have no impacts. As shown on Plate 3, there are very few permits in the area withdrawing from the water table aquifer or surficial aquifer system. Wells withdrawing from the Sandstone aquifer are the primary groundwater source in the area and are the water use with the least potential for impacts to the reservoir due to overlying semi-confining lithology. Groundwater modeling represents a worse-case scenario of potentially permissible Sandstone aquifer withdrawals predicted no losses of surface water from the reservoir.

**Conclusions:**

Groundwater modeling was used to evaluate the potential impacts of groundwater use near the proposed WBSR by simulating withdrawals from specific depths and volumes in a three dimensional, multi-layered framework. The impact at the simulated ground surface, under the reservoir, is calculated by the amount of water removed from the model cells under the reservoir and by predicted drawdown of water levels beneath the reservoir. Using this methodology, the model did not predict any water loss or predict any drawdown in layer 1 of the model under the reservoir due to Sandstone aquifer withdrawals. The reservoir design, which includes a slurry wall, and the low yield of the water table aquifer in the area prevents seepage due to water table aquifer withdrawals. Therefore, groundwater withdrawals adjacent to the reservoir are not expected to remove significant volumes of reservoir water via seepage and do not need to be restricted or regulated as part of this reservation rule.

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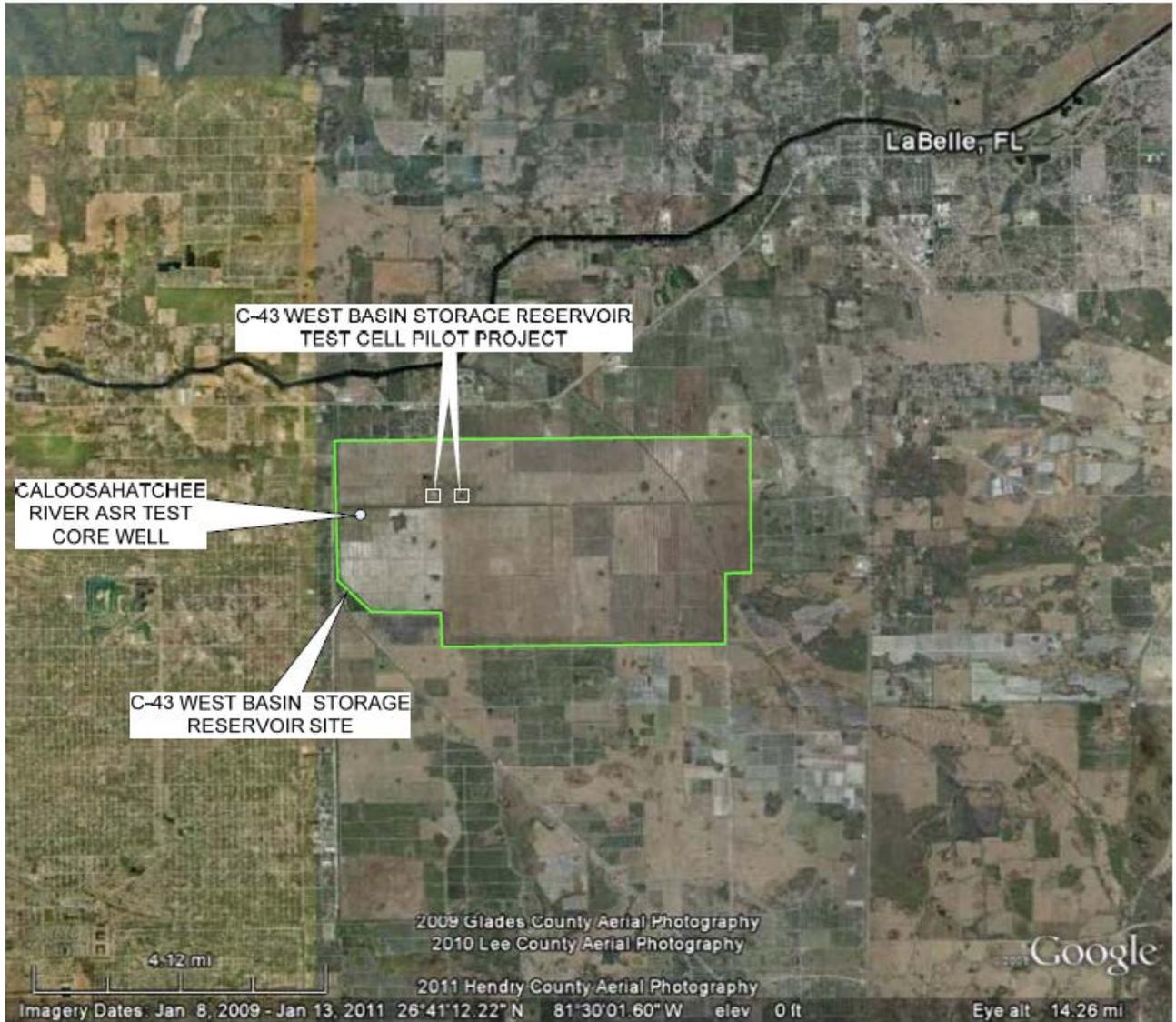
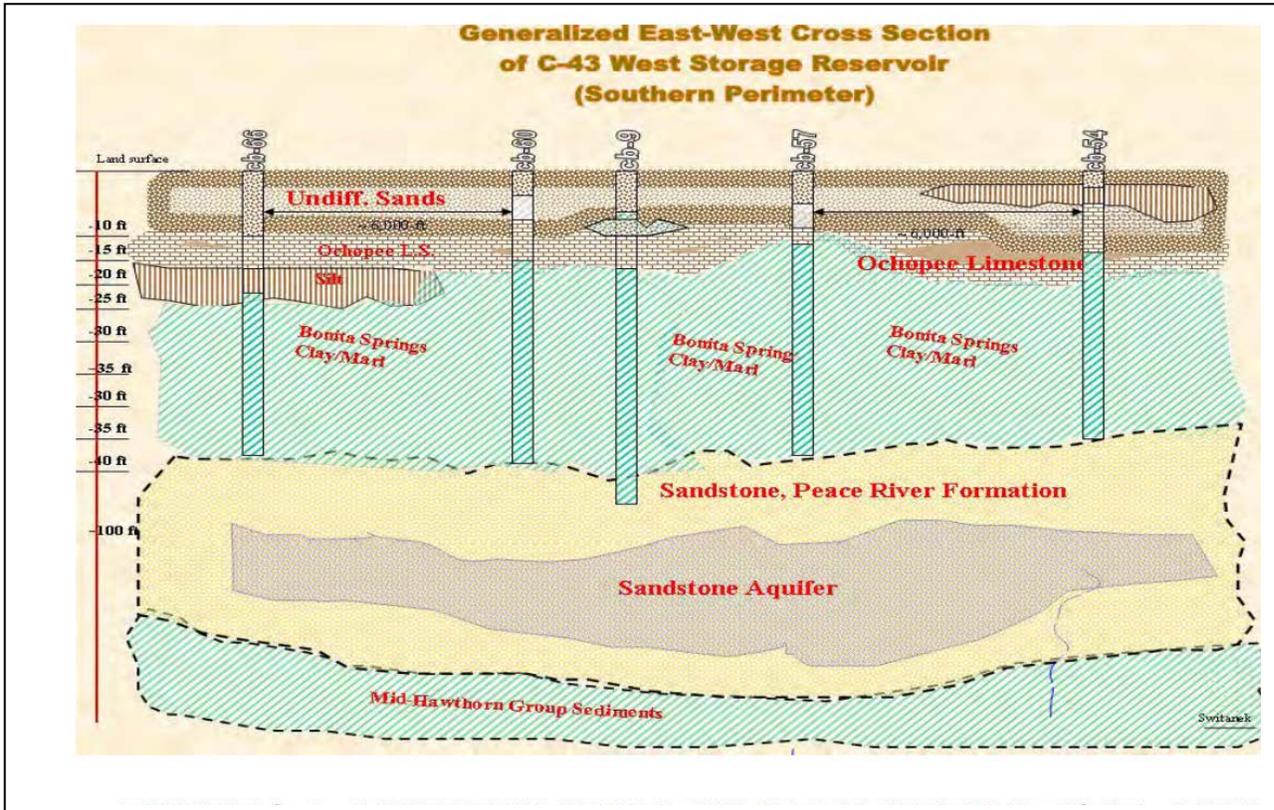
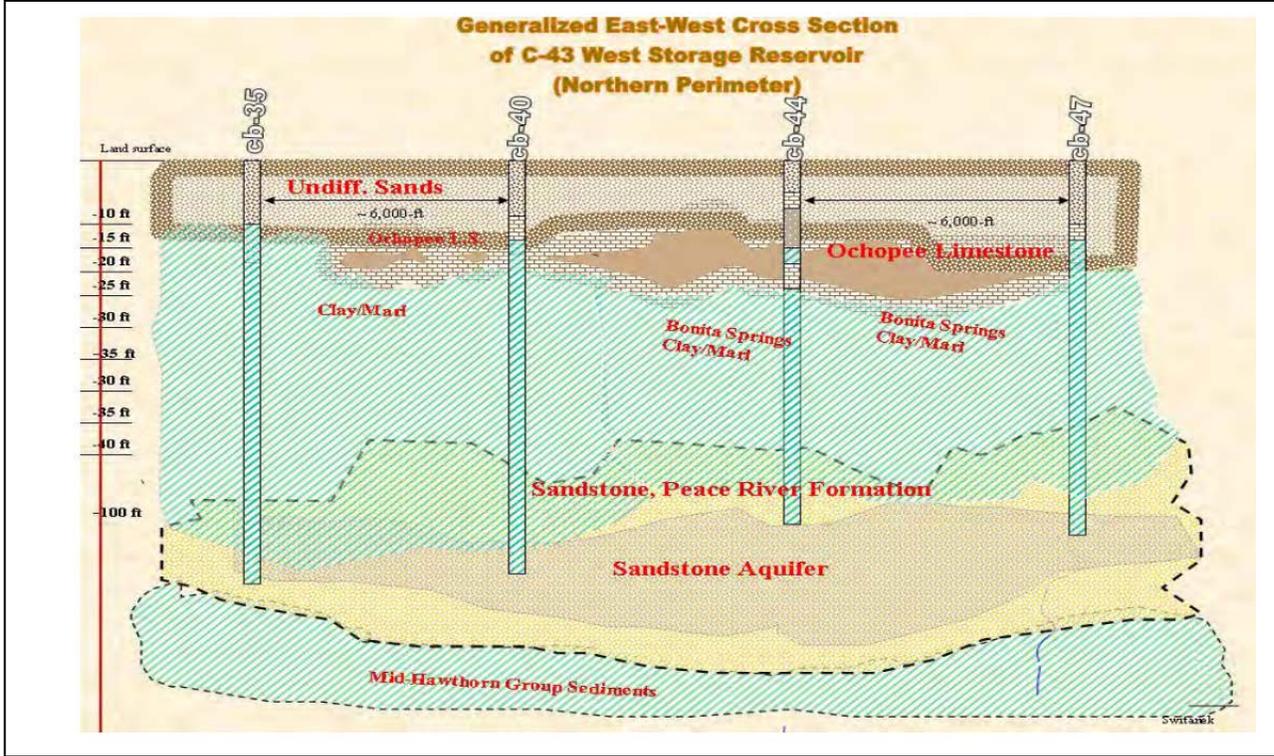


PLATE 1  
SITE LOCATION



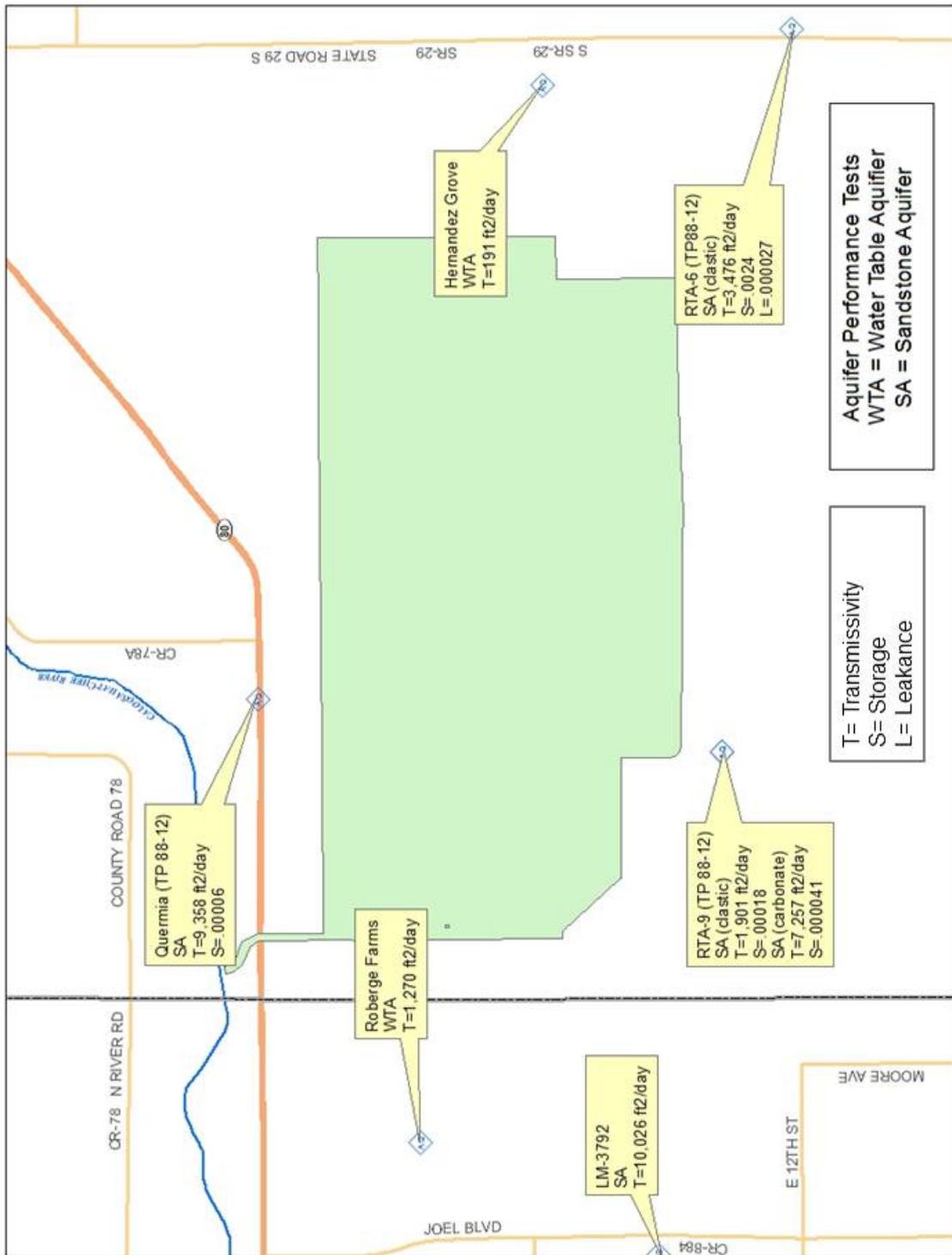


PLATE 3

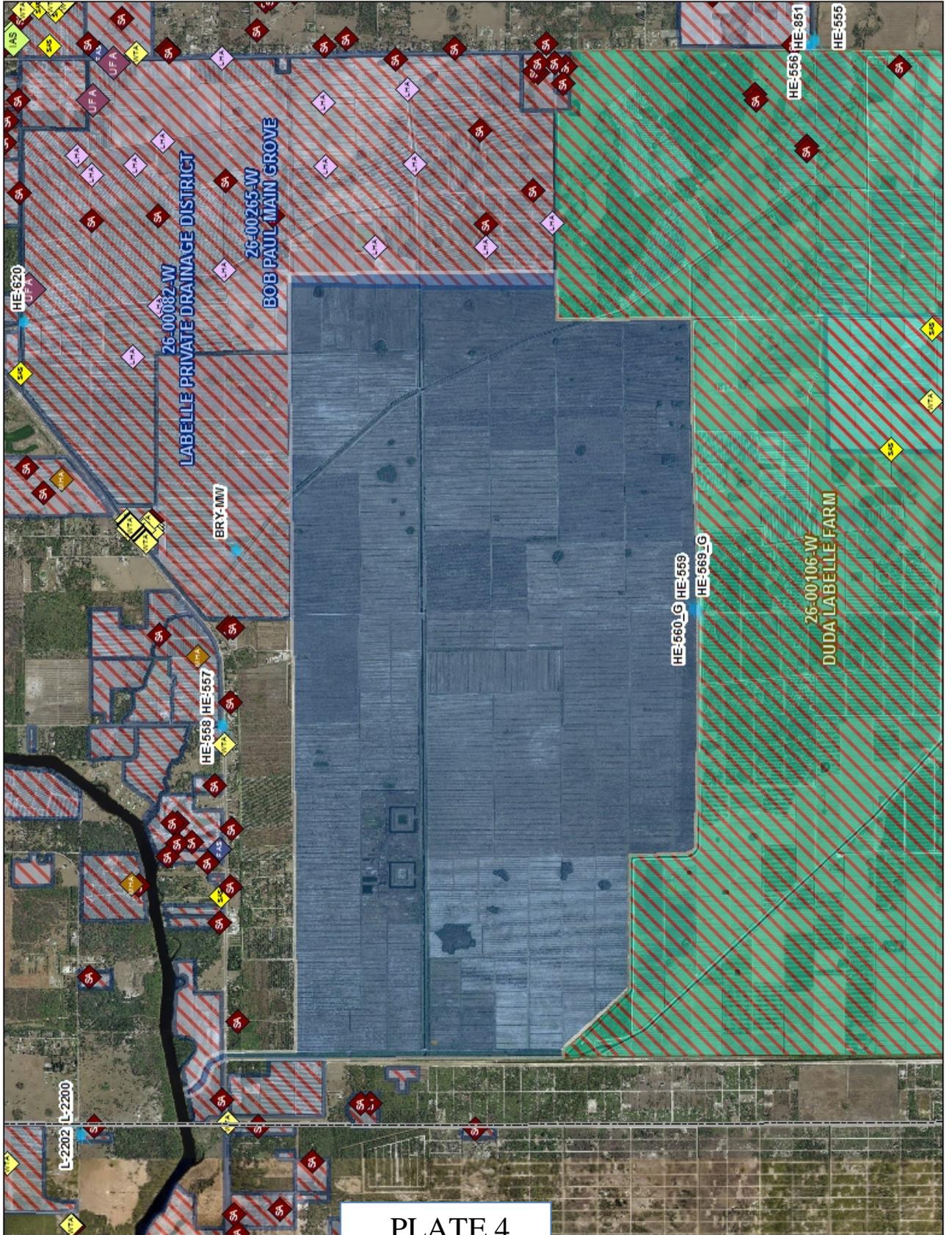
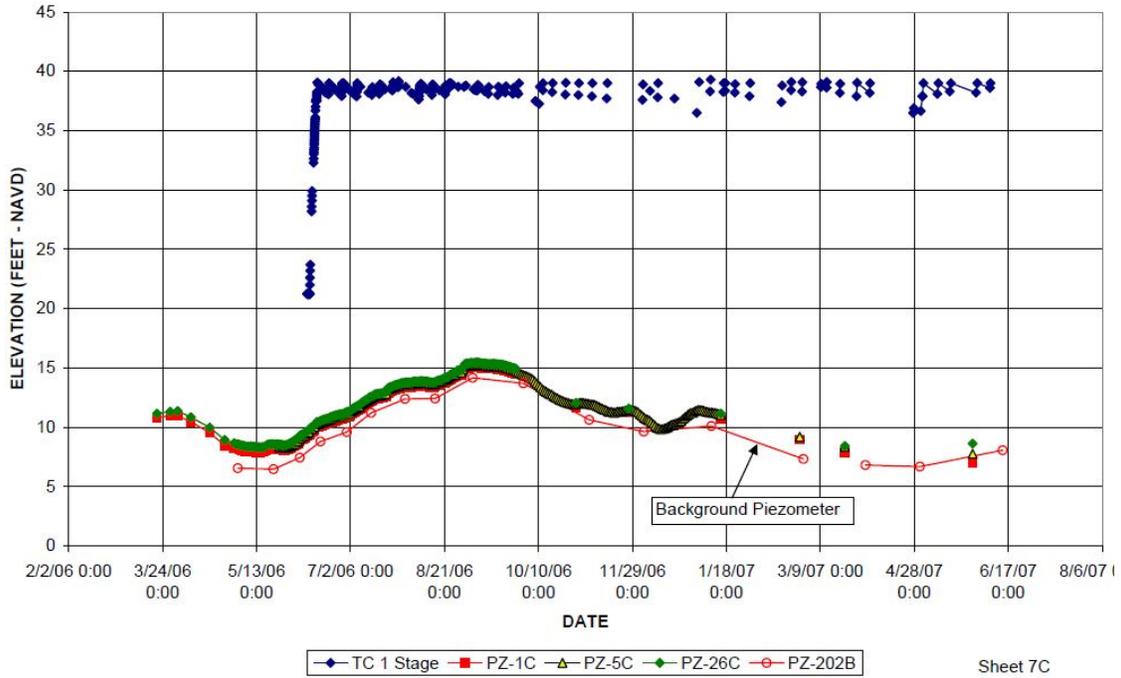
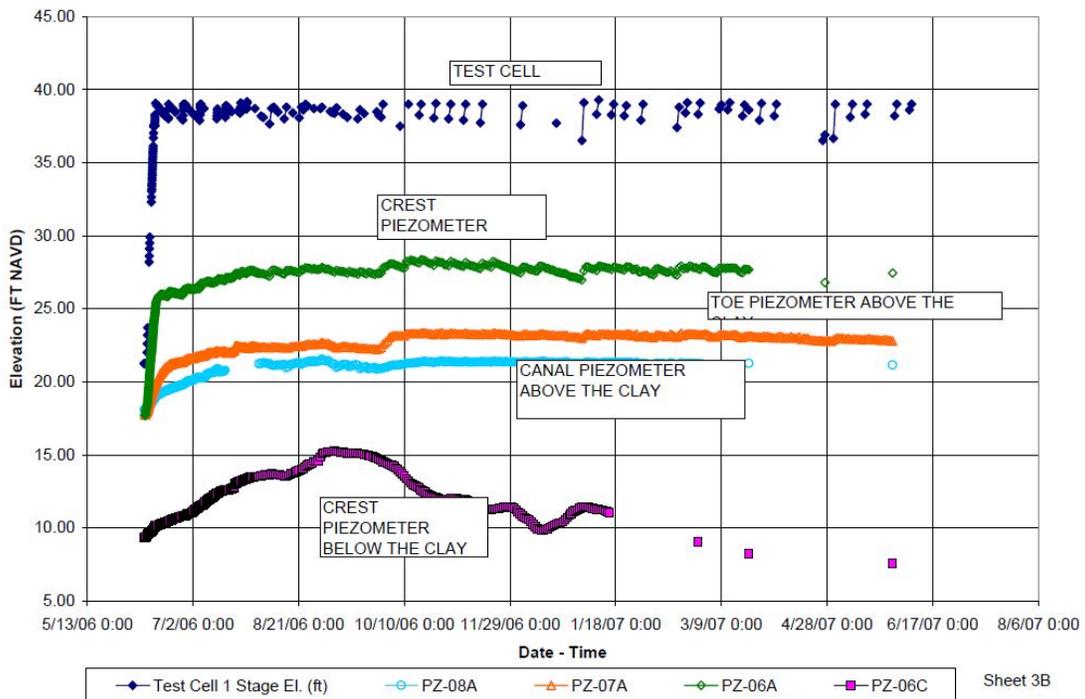


PLATE 4

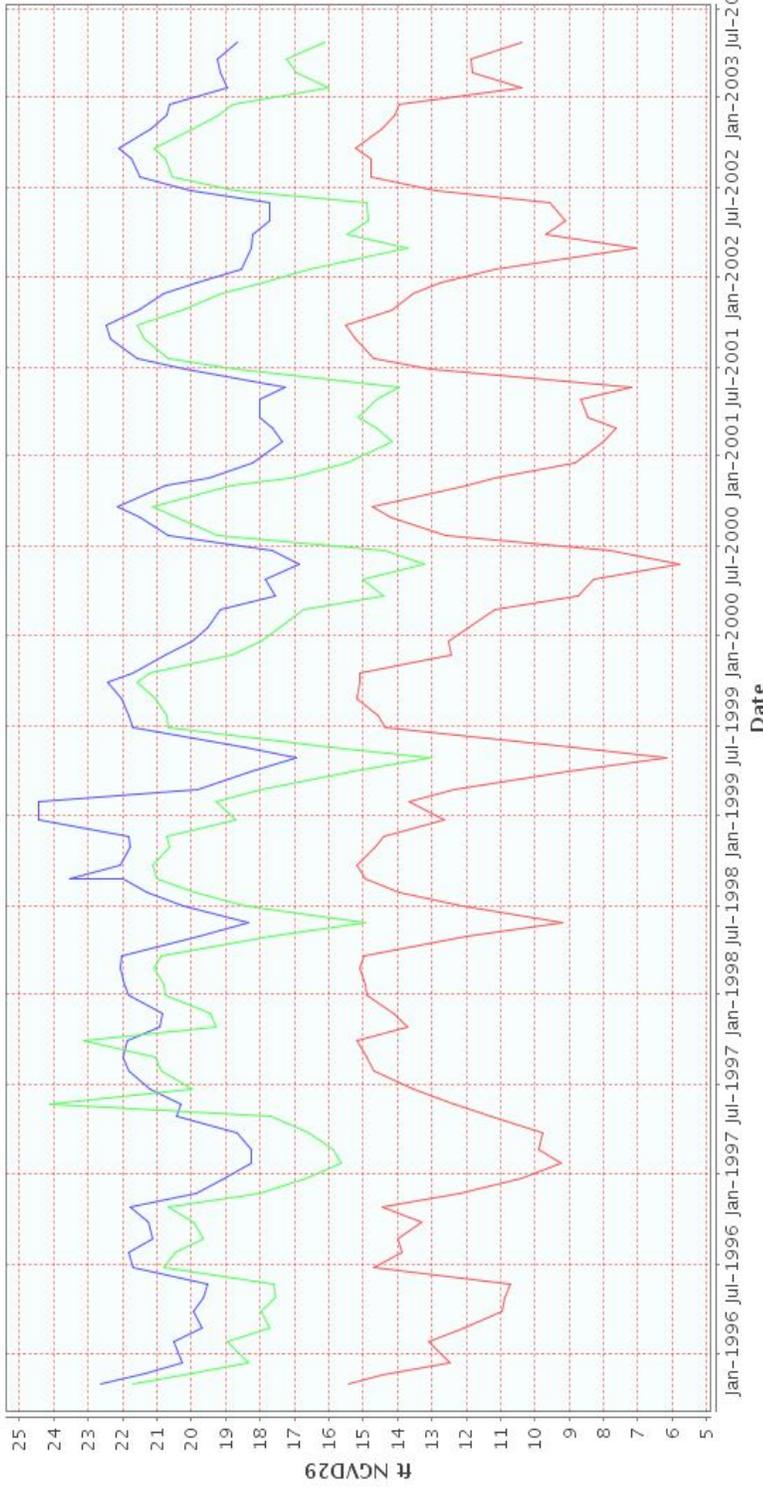
**C-43 TEST CELL PROJECT - OFFSITE IMPACTS  
TEST CELL 1 - BELOW THE CLAY LAYER**



**Test Cell 1 Eastern Quadrant - Groundwater Levels**



**DBHYDRO Chart**  
30-OCT-1995 to 13-MAY-2003



DBKey	Station	Agency	Data Type	Unit	Statistic	Frequency Strata	Gate/Pump#
WH033	HE-557 (80-100')	WMD	WELL	# NGVD29	RAND	RI 102	N/A
WH034	HE-559 (155-165')	WMD	WELL	# NGVD29	RAND	RI 165	N/A
WH035	HE-560 (70-80')	WMD	WELL	# NGVD29	RAND	RI 87	N/A

PLATE 6

## ATTACHMENT 1

### Geologist's Log Caloosahatchee Aquifer Storage (ASR) Test Core

<b>Depth</b>	<b>Lithology</b>
0-1.5	Sand, dark yellowish orange (10YR 6/6), clayey fine quartz, silty, fair porosity, fair to poor apparent permeability
1.5-12	Limestone, very pale orange (10YR 8/2), wackestone, moderately well indurated, silty, good to fair moldic porosity, fair apparent permeability
12-22	Clay, greenish gray (5GY 6/1), fine quartz sand, soft to firm, silty, phosphatic (very fine to coarse), poor apparent permeability
22-38	Clay, greenish gray (5GY 6/1), fine quartz sand, firm to stiff, silty, sticky, variably finely phosphatic, poor apparent permeability
38-40	Limestone, yellowish gray (5Y 7/2), wackestone, fine to coarse quartz sand, moderately well indurated, good to fair moldic porosity, fair to poor apparent permeability
40-48	Clay, light gray (N7), fine quartz sand, soft to firm, finely phosphatic, common medium-coarse to pebble-sized quartz and phosphate, poor apparent permeability
48-65	Shell bed (whole and fragments, incl. Mollusks and Gastropods), yellowish gray (5Y 8/1), with thin interbeds of clay as above, common fine quartz sand, excellent porosity and excellent apparent permeability in the shell beds
65-90.5	Shell bed (whole and fragments, incl. Mollusks and Gastropods), yellowish gray (5Y 8/1), abundant fine to very coarse quartz and phosphate sand, rare pebble-sized quartz, excellent porosity, excellent apparent permeability
90.5-100.5	Sand, light gray (N7), medium to very coarse quartz, poorly sorted, sub-rounded, abundant medium to very coarse phosphate, excellent porosity, excellent apparent permeability

- 100.5-112 Sand, light gray (N7), quartz, medium to very coarse, poorly sorted, sub-rounded, common coarse to very coarse phosphate, occasional shell fragments, excellent porosity, excellent permeability
- 112-113 Limestone, yellowish gray (5Y 8/1), packstone, well indurated, sparry, fine quartz sandy, finely phosphatic, poor porosity, poor apparent permeability
- 113-115 Sand, light gray (N7), quartz, medium coarse to pebble-sized, poorly sorted, sub-rounded, common coarse to very coarse phosphate, excellent porosity, excellent permeability
- 115-126 Clay, greenish gray (5GY 6/1), soft, fine quartz sand, silty, finely phosphatic, poor porosity, poor apparent permeability
- 126-135 Limestone, yellowish gray (5Y 8/1), packstone, sparry, well indurated, very hard, fine quartz sand, finely phosphatic, fair moldic porosity, fair to poor apparent permeability, loss of circulation at approximately 134 feet bls
- 135-151 No recovery
- 151-157 Limestone, yellowish gray (5Y 7/2), fossil packstone, moderately indurated, common shell inclusions in rock (mollusks and gastropods), rare very fine phosphate, good moldic and interparticle porosity, fair apparent permeability
- 157-160 Clay, light greenish gray (5GY 8/1), fine quartz sand, soft, marly, finely phosphatic, common shell fragments, poor apparent permeability
- 160-170 Sand, yellowish gray (5Y 8/1), medium to coarse quartz, sub-rounded, abundant fine to medium coarse phosphate, excellent interparticle porosity, excellent apparent permeability
- 170-180 Clay, greenish gray (5GY 6/1), very fine quartz sand, soft, silty, finely phosphatic, abundant shell fragments, poor apparent permeability
- 180-185 No recovery

