CHAPTER 8D: CALOOSAHATCHEE RIVER WATERSHED PROTECTION PLAN ANNUAL PROGRESS REPORT

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HIGHLIGHTS

Project Spotlight: C-43 West Basin Storage Reservoir and Water Quality Component

As a priority in Executive Order 23-06: Achieving *Even More* Now for Florida's Environment, the South Florida Water Management District (SFWMD), in partnership with the United States Army Corps of Engineers, the C-43 Reservoir opened in July 2025.

The expansive 170,000-acre-foot (ac-ft) capacity reservoir provides water storage and supports healthy salinity levels in the Caloosahatchee River Estuary. It will reduce harmful flows of water from Lake Okeechobee and the local watershed during the wet season and deliver beneficial freshwater flows to the estuary during the dry season.

Construction of the inline alum injection system—the reservoir's water quality component—is also nearing completion by end of 2025, with operations slated to begin in early 2026.

Bird's eye view of the new C-43 Reservoir complex.

Project Spotlight: Lake Hicpochee Hydrologic Enhancement Phase II Expansion

Construction under way at the Lake Hicpochee Expansion project site.

As a priority Northern Everglades and Estuaries Protection Program (NEEPP) project in the East Caloosahatchee Basin, the Lake Hicpochee Expansion (Phase II) project will capture basin runoff for shallow storage on approximately 2,200 acres of SFWMD-owned land and redistribute it into Lake Hicpochee to reduce harmful discharges to the Caloosahatchee River (C-43 Canal). This enhancement includes a new flow equalization basin (FEB), a new pump station to draw water from the C-43 Canal, and associated flow features that will help expand regional storage.

Following completion of final design in late 2024, full construction was launched in summer 2025 and is scheduled to be completed in 2028. Once Phase II is operational, the estimated static storage capacity of the entire project area is expected to total more than 9,300 ac-ft and retain approximately 2.3 metric tons (t) of total phosphorus (TP) per year.

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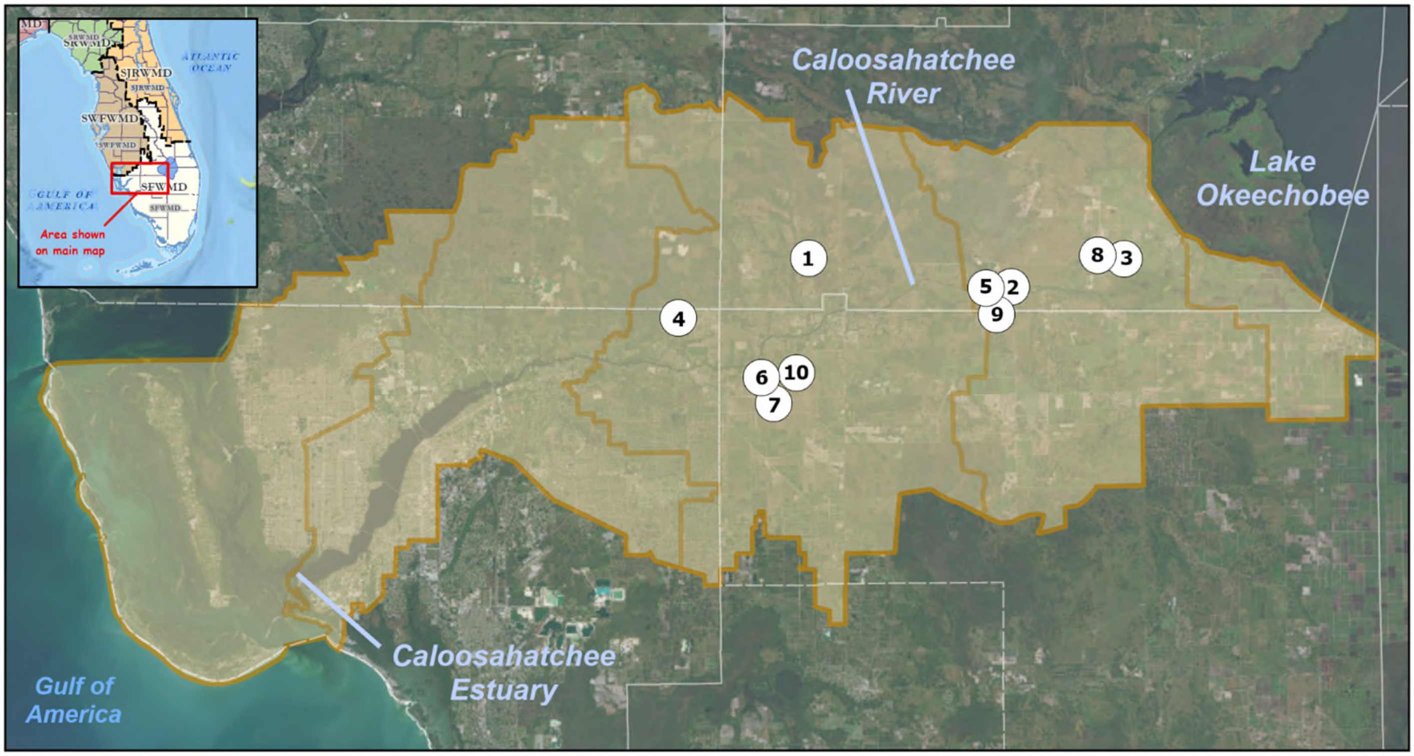
Caloosahatchee River Watershed Protection Plan Highlights

Advancing Watershed Construction Projects



MAJOR PROJECT MILESTONES

COMPLETED AND OPERATIONAL

# PROJECT	PROJECT TYPE	O&M START/ RENEWAL DATE
1. Mudge Ranch	DWM - Passive	2014/2026
2. Boma Interim Storage	DWM - Passive	2019
3. Lake Hicpochee Hydrologic Enhancement Phase I	FEB	2021
4. Four Corners Rapid Infiltration	DWM - Active	2023

Launch of new operations at the C-43 Reservoir (July 2025).

Berry Groves District Lands area.

MAJOR MILESTONES

# PROJECT	PROJECT TYPE	FY2025 ACCOMPLISHMENT	PROJECTED CONSTRUCTION COMPLETION DATE
5. C-43 Water Quality Treatment & Testing Facility – Phase II, Test Cells	Study	Completed Construction and Initiated Research	2025
6. C-43 West Basin Storage Reservoir*	Reservoir	Final Phase of Construction/Opened	2025
7. C-43 Reservoir Water Quality Component*	Water Quality	Advanced Construction	2025
8. Lake Hicpochee Expansion, Phase II*	FEB	Initiated Construction	2028
9. Boma FEB	FEB	Continued Design	2029
10. Berry Groves District Lands Enhancement	DWM - Passive	Initiated Conceptual Design	2030

* Priority projects under Executive Orders 19-12, Achieving More Now For Florida's Environment and 23-06, Achieving Even More Now for Florida's Environment.
Key to abbreviations: DWM – Dispersed Water Management and O&M Operations and Maintenance.

Caloosahatchee River Watershed Protection Plan Highlights

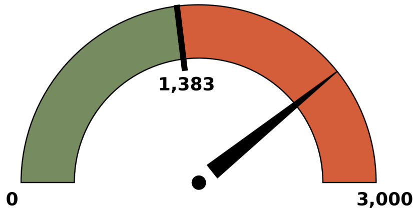
Progress Towards Water Quality and Storage Goals

WY2025 Project Performance in the Caloosahatchee River Watershed (CRW)

- 53.7 metric tons of total nitrogen retention
- 7.8 metric tons of total phosphorus retention
- 26,043 acre-feet per year of dynamic storage

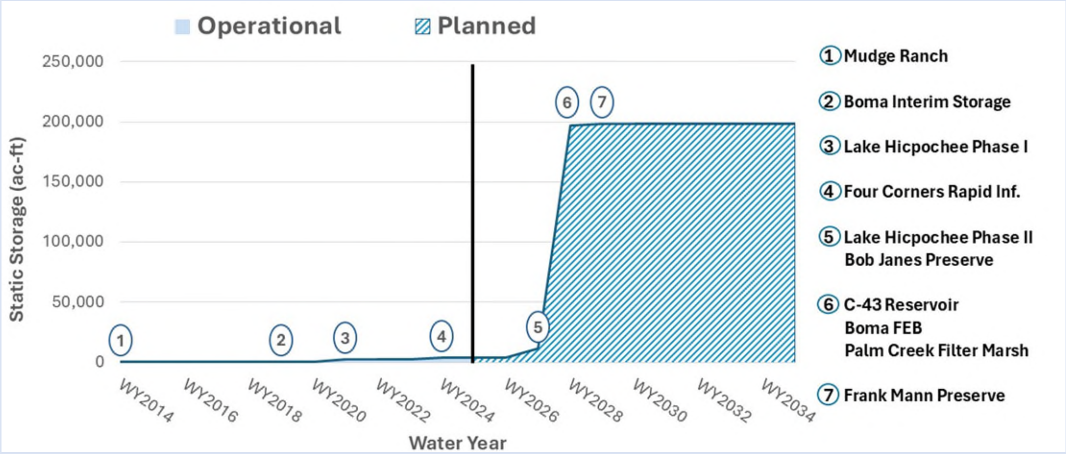
Water Year 2025 (WY2025; May 1, 2024–April 30, 2025)

Total Nitrogen (TN) Loading

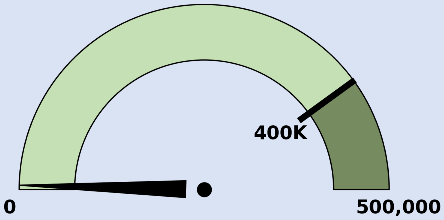


GOAL ≤ 1,383
5-Year Average = 2,355
Unit = metric tons

Increasing Storage Capacity in the Caloosahatchee River Watershed



Total Watershed Static Storage



GOAL ≥ 400,000
WY2025 = 3,744
Unit = acre-feet

SFWMD is the lead agency on hydrologic improvements pursuant to the Caloosahatchee River Watershed Protection Plan (in accordance with NEEPP, Section 373.4595, Florida Statutes).

Four Corners Rapid Infiltration project in the West Caloosahatchee Basin .

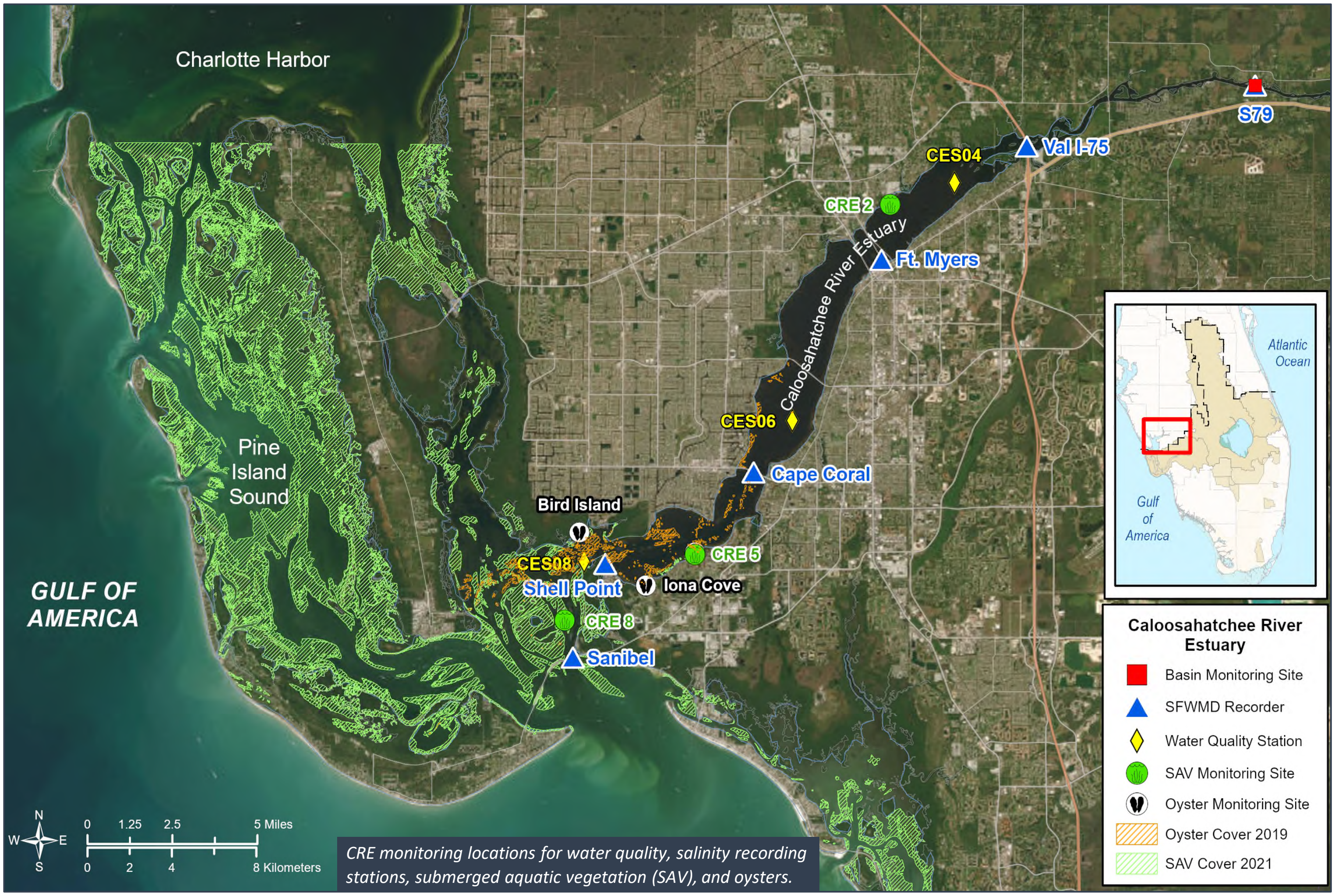
Mudge Ranch project in the West Caloosahatchee Basin.

What is DYNAMIC STORAGE? Dynamic storage considers the total volume held over a specific period of time. In this report, it is used to assess project performance in the watershed during the WY2025 reporting period.

What is STATIC STORAGE? Static storage for water retention projects is defined as the volume retained at maximum capacity, usually up to the point of discharge. The static storage target for the CRW is 400,000 acre-feet.

Caloosahatchee River Watershed Protection Plan Highlights

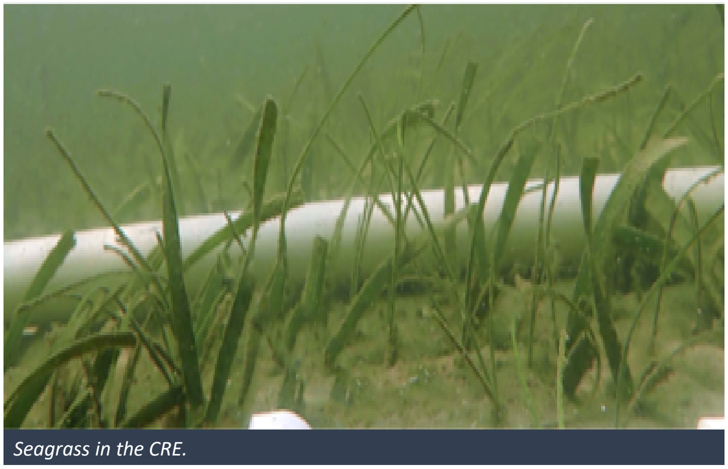
Research and Monitoring Results



CRE monitoring locations for water quality, salinity recording stations, submerged aquatic vegetation (SAV), and oysters.

WY2025 Results – Caloosahatchee River Estuary (CRE)

Hydrologic Conditions	WY2025 Results	Change from WY2021-WY2025
Rainfall (inches)	52	⬇ 5%
Lake Okeechobee Inflows (ac-ft)	2,320,900	⬆ 8%
Total CRW Nitrogen Loading (t)	3,646	⬆ 7%

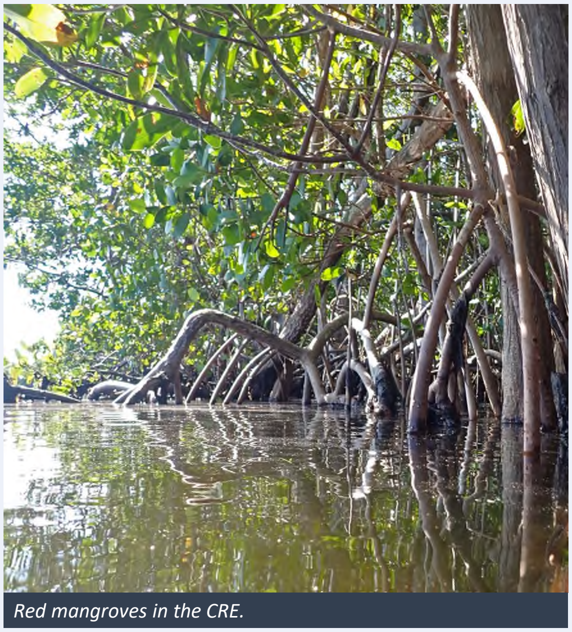


Seagrass in the CRE.

Ecological Conditions	WY2025 Results	Change from WY2021-WY2025
Submerged Aquatic Vegetation Wet Season Percent Cover Dry Season Percent Cover	 3% 1%	 ⬇ 75% ⬇ 74%
Live Oyster Densities – Bird Island (oysters per square meter) Wet Season Dry Season	 515 248	 ⬆ 0.4% ⬇ 65%
Live Oyster Densities – Iona Cove (oysters per square meter) Wet Season Dry Season	 257 393	 ⬆ 41% ⬆ 21%
% of Year in Optimum Salinity Range for Oysters – Cape Coral	62%	⬆ 5%
% of Year in Optimum Salinity Range for Oysters – Shell Point	62%	⬆ 2%

EVEN MORE PROGRESS TOWARD CRW GOALS

New Water Retention Projects Ahead for the Priority West Basin


Red mangroves in the CRE.

Covering over 1.1 million acres, the CRW spans across Lee, Hendry, Charlotte, Glades, and Collier counties in southwestern Florida. The watershed is made up of three freshwater (East and West Caloosahatchee and S-4) and two downstream brackish (Tidal and Coastal) basins.

Importantly, one of the key recommendations from the 2025 Caloosahatchee River Watershed Protection Plan (CRWPP) 5-Year Update is to focus on new storage projects in the West Caloosahatchee Basin to help manage the flow of surface waters and reduce nutrient loads to the estuary.

Building on SFWMD's progress to attain NEEPP water storage goals, the *CRW Water Storage Initiative* request for proposals (RFP) was released in May 2025. Designed to solicit water retention projects in the West Caloosahatchee Basin, the RFP closed in July 2025 and proposals are under review. New future projects will help provide water storage solutions to support the target of an additional 205,000 ac-ft of storage needed to meet the CRWPP goals.

Innovative Research Facility Launched to Maximize Reducing Nitrogen

The state's total maximum daily load (TMDL) calls for a 23% load reduction in total nitrogen into the CRE, as excess nutrients can lead to algal blooms that harm the ecosystem. Yet, efforts to reduce nitrogen levels even further to meet water quality goals is a challenge that requires new treatment methods.

In partnership with Lee County, SFWMD is conducting the multi-phase C-43 Water Quality Treatment and Testing Project (WQTTP) to help demonstrate and implement cost-effective, wetland-based strategies for reducing nitrogen loads to the CRE.


Bird's eye view of the C-43 WQTTP Test Cells research facility.


SAV growing in the newly established test cells.

In early 2025, construction was completed for the C-43 WQTTP – Phase II, Test Cells research facility. Leveraging the study findings of the Phase I mesocosms, Phase II will evaluate the effectiveness of treatment wetlands in reducing nitrogen at a test-cell scale.

The ~80-acre facility is aligned in the footprint of the Boma FEB to maximize both water quality and storage benefits at this public property. Following several months of grow-in to establish plants in the test cells, multiyear research began in summer 2025.

The Phase II study findings will be used to help inform future water quality improvement projects, in support of the state's Caloosahatchee River and Estuary Basin Management Action Plan (BMAP).

INTRODUCTION

As required by Subsection 373.4595(6), Florida Statutes (F.S.), this chapter, in conjunction with Chapters 8A, 8B, and 8C of this volume, fulfills the specific reporting requirements outlined in the Northern Everglades and Estuaries Protection Program (NEEPP) legislation. The chapter provides an annual review for the Caloosahatchee River Watershed Protection Plan (CRWPP), which is critical to maintaining transparency and accountability in the basin management action plan (BMAP) process and collectively moving towards the achievement of total maximum daily loads (TMDLs). The previous CRWPP update was completed in March 2025 as Chapter 8D in the *2025 South Florida Environmental Report (SFER) – Volume I* (Parker et al. 2025).

Specifically, Chapter 8D is organized into three parts and supplemental information is appended as follows.

- Part I – Research and Water Quality Monitoring Program: Caloosahatchee River Watershed
- Part II – Research and Water Quality Monitoring Program: Caloosahatchee River Estuary
- Part III – Caloosahatchee River Watershed Construction Project
- Appendix 8D-1 – Water Year 2025 Caloosahatchee River Watershed Upstream Monitoring

For this reporting period, data for the research and water quality monitoring for the Caloosahatchee River Estuary (CRE) and its watershed are reported through Water Year 2025 (WY2025; May 1, 2024–April 30, 2025), while project-related information is provided for Fiscal Year 2025 (FY2025; October 1, 2024–September 30, 2025).[3]

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[3] Results reported in Chapter 8D include a mixture of International System of Units (SI) and non-SI units. Non-SI units used in this chapter include surface area as acres (ac), flow rate as cubic feet per second (cfs), water volume as acre-feet (ac-ft), and mass as metric tons (t). Conversion factors to express these values in SI units are as follows: 1 ac = 0.40469 hectare or 4,046.9 square meters; 1 cfs = 0.02832 cubic meters per second; 1 ac-ft = 1,233.5 cubic meters; and 1 t = 1,000 kilograms.

PART I: RESEARCH AND WATER QUALITY MONITORING PROGRAM – CALOOSAHATCHEE RIVER WATERSHED

The Caloosahatchee River Watershed (CRW) totals approximately 882,435 acres (ac) or 357,109 hectares (ha), excluding the Coastal Basin, and includes three primary contributing areas: Caloosahatchee Basins, Tidal Basin, and Lake Okeechobee (**Table 8D-1**). The Caloosahatchee Basins include the S-4, East Caloosahatchee, and West Caloosahatchee basins (**Figure 8D-1**).

As part of the Research and Water Quality Monitoring Program (RWQMP), the South Florida Water Management District (SFWMD) maintains a long-term water quality monitoring network within the CRW. SFWMD's current monitoring network consists of stations at two hydrologic levels within the CRW: (1) basin level, and (2) subbasin level (**Figure 8D-1**). Flow and nutrient—total phosphorus (TP) and total nitrogen (TN)—concentrations are monitored, and nutrient loads are calculated at the basin loading stations. At the subbasin level, nutrient concentrations are monitored through a network of upstream stations. These stations are continuously reviewed by the Coordinating Agencies—SFWMD, Florida Department of Environmental Protection (FDEP), and Florida Department of Agriculture and Consumer Services (FDACS)—for efficiency and to ensure all data collection objectives associated with legislatively-mandated and permit-required monitoring are being met. Data collected as part of the RWQMP, along with data collected by other local entities, allow FDEP to evaluate water body conditions, measure progress toward the TMDLs, and ensure that necessary projects and programs are incorporated into the BMAP (FDEP 2020). SFWMD coordinates monitoring efforts with FDEP, FDACS, and the United States Geological Survey (USGS) to leverage existing monitoring sites and reduce duplication of efforts.

Freshwater inflow and water quality concentrations in the CRE are measured at the S-77 (Lake Okeechobee), S-235 (S-4 Basin), S-78 (East Caloosahatchee Basin), and S-79 (West Caloosahatchee Basin) water control structures. Flow contributions from Lake Okeechobee to the CRE were calculated based on the measured flow and water quality concentrations at the S-77, S-78 and S-79 structures. The Tidal Basin inflow and nutrient loads were calculated based on simulated flows using the CRE Tidal Basin Linear Reservoir model (Lin Res model; Wan and Konyha 2015). Additional water quality samples were collected at 15 upstream monitoring sites within the CRW (**Figure 8D-1**) and results from these efforts are summarized in Appendix 8D-1 of this volume.

Table 8D-1. Major contributing areas of the CRW.

Contributing Areas	Basins	Basin Acreage (% of Watershed)	Flows & Loads	Sampling Method and Frequency
Lake Okeechobee	Not applicable	Not applicable	Calculated [a]	S-77, S-78, S-79 (Autosampler & Weekly Grab) [b]
Caloosahatchee Basins (or C-43 Basins)	East Caloosahatchee West Caloosahatchee S-4	221,689 (25.1%) 349,589 (39.6%) 42,145 (4.8%)	Measured Measured Measured	S-78, S-79, S-235 (Autosampler & Weekly Grab) [b]
Tidal Basin	Tidal Caloosahatchee	269,012 (30.5%)	Modeled and Measured [c]	Monthly Grab [d]

a. Lake Okeechobee releases to the CRE are calculated via the measured flows and loads at the S-77, S-78, and S-79 water control structures.

b. Weekly samples are collected at each structure using autosamplers and grab samples and are analyzed by the SFWMD laboratory for parameters including TN and TP. TP loads are typically measured using both autosamplers and grab samples, while TN loads are generally based on grab samples only.

c. The Tidal Basin inflow and nutrient loads were calculated based on simulated flows using the CRE Tidal Basin Linear Reservoir model (Wan and Konyha 2015).

d. Monthly water quality data for TP and TN are provided by Lee County and City of Cape Coral are used to calculate nutrient loads.

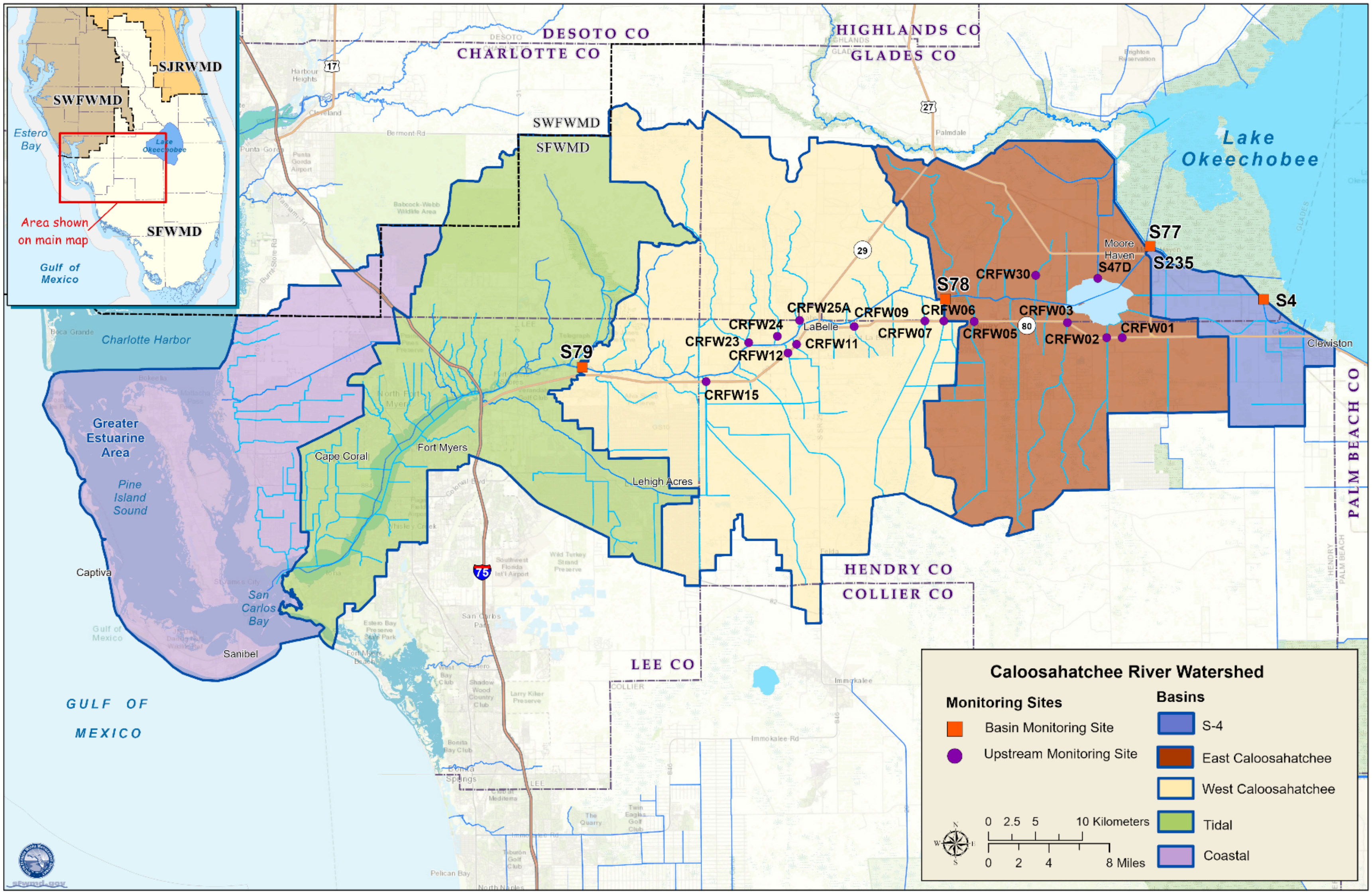

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Figure 8D-1. The Caloosahatchee River Watershed (CRW) with basins, basin monitoring sites (red squares) and upstream monitoring sites (purple circles).

HYDROLOGY

Precipitation

Daily Next Generation Radar (NEXRAD) rainfall data from the long-term period of record (POR; WY1997–WY2025) for each CRW basin were downloaded from the SFWMD environmental database, NEXRAD, accessible at https://nexrad.sfwmd.gov/nrdmain.action. The cumulative amount of rainfall across the watershed was computed using area weighting, which accounts for the different sizes of the basins within the CRW.

Average rainfall across the CRW in WY2025 was 52.48 inches (133.3 centimeters [cm]), which was similar to the long-term POR average (52.5 inches; **Figure 8D-2**). In WY2025, 92% of the annual rainfall occurred during the wet season (May 1–October 31) and 8% in the dry season (November 1–April 30), resulting in a wetter-than-normal wet season and drier-than-normal dry season (**Figure 8D-2**). Rainfall across the watershed in WY2025 was highest in the Coastal Basin (57.2 inches), followed by the Tidal Basin (56.8 inches) (**Figure 8D-3**).

During WY2025, it rained 203 days (56%) in the CRW with 10 days having rainfall > 1.0 inch (2.5 cm; **Figure 8D-4**). These heavier rainfall events occurred in June, August, and October with the highest rainfall event recorded in June (**Figure 8C-4**). On June 12, 2024, the CRW received 4.06 inches of rainfall, followed by another substantial rainfall of 2.27 inches on June 13. These back-to-back events were likely associated with a stationary tropical wave (Invest 90L) that stalled over South Florida from June 11 to 14, producing multi-day, record-breaking rainfall across the region, despite not being classified as a named storm. Another major rainfall event occurred on August 4, 2024, with 2.15 inches recorded. This spike was likely linked to the approaching Hurricane Debby, which made landfall in Florida's Big Bend region August 5, 2024, as a Category 1 hurricane and brought widespread rainfall to southwestern Florida (NHC 2025a). Hurricane Milton swept across the state as a Category 3 hurricane from the Gulf of America eastward towards Georgia between October 9 and 10, 2024 (NHC 2025b). Its expansive rainbands produced substantial rainfall in areas surrounding the CRW.

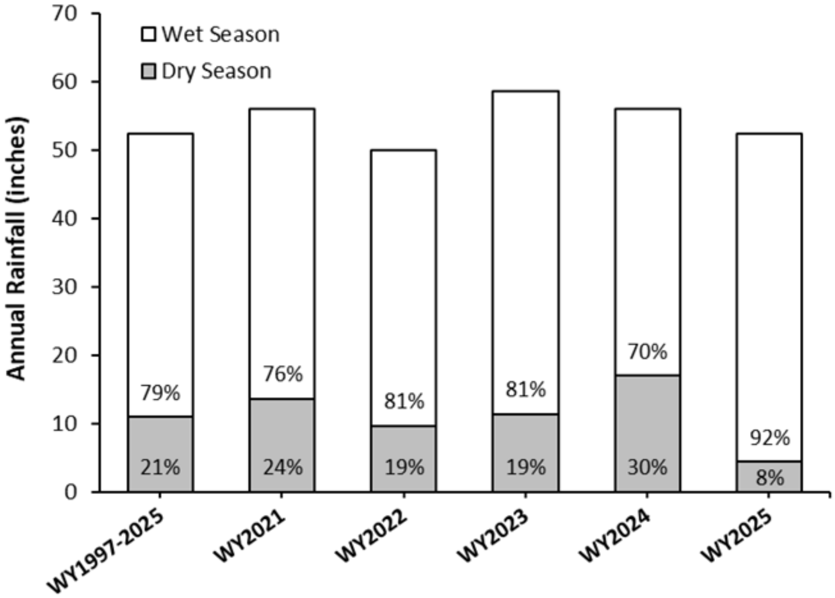


Figure 8D-2. Total annual rainfall for the CRW by water year for the most recent 5-year period (WY2021–WY2025) and the long-term average for the POR (WY1997–WY2025) with percent contributed by season.

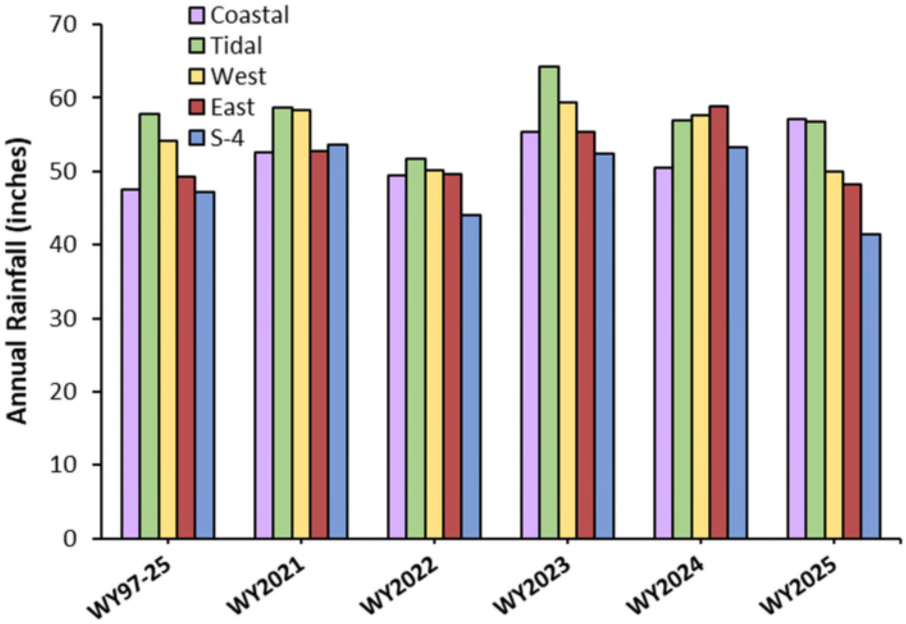


Figure 8D-3. Total annual rainfall by basin in the CRW by water year for the most recent 5-year period (WY2021–WY2025) and the long-term average for the POR (WY1997–WY2025). See **Figure 8D-1** for basin locations.

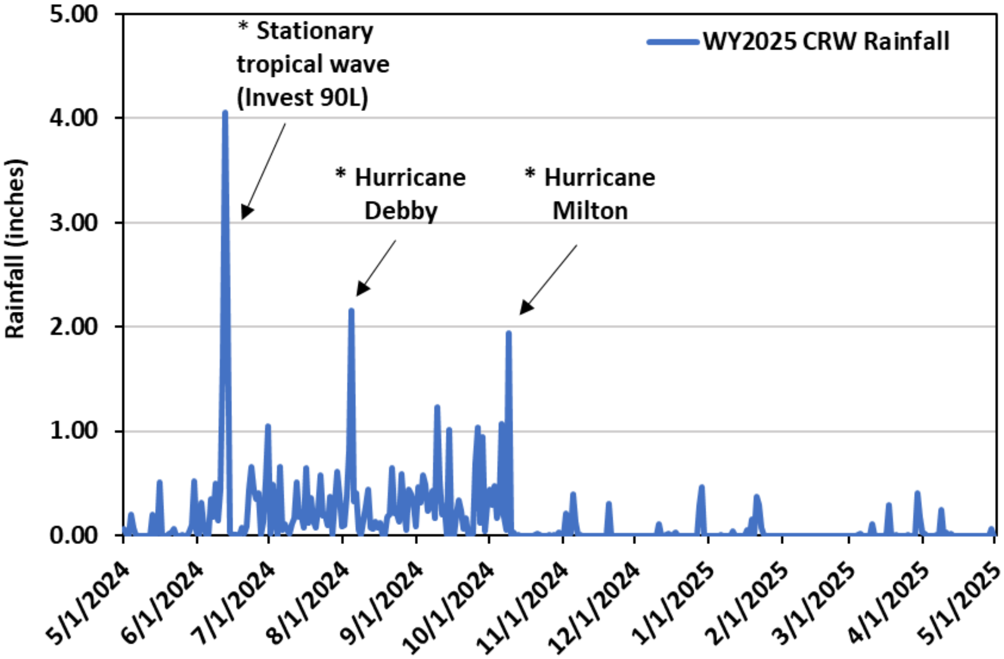


Figure 8D-4. Daily rainfall in inches for the CRW in WY2025. (Note: an * indicates a major storm occurred.)

Freshwater Inflow

The timing, duration, and volume of fresh water entering the estuary is the primary factor affecting water quality in the CRE. The amount of fresh water entering the estuary directly affects the salinity gradient within the estuary and can alter habitat availability for benthic sessile organisms such as seagrass (Doering and Chamberlain 2000, Doering et al. 2002, Kahn et al. 2013) and oysters (Parker and Radigan 2020, Volety et al. 2010, Volety and Haynes 2014, McFarland et al. 2022). Freshwater inflow to the estuary comes from multiple sources including precipitation, runoff from the contributing watershed, groundwater, and managed flow releases from Lake Okeechobee. Fresh water coming from the watershed and Lake Okeechobee also transports nutrients and suspended sediments, which can affect water quality by altering light and nutrient availability (Paczkowska et al. 2020).

Freshwater inflow to the CRE was estimated from three main contributing areas in the CRW: Lake Okeechobee, the Caloosahatchee Basins (69% of the watershed area), and the Tidal Basin and tributaries (31% of the watershed area); see **Figure 8D-1** and **Table 8D-1**. Freshwater inflow was measured at S-77 (Lake Okeechobee), S-235 (S-4 Basin), S-78 (East Caloosahatchee Basin) near the City of LaBelle, and S--79 (West Caloosahatchee Basin) at the upstream boundary of CRE. The contribution of Lake Okeechobee inflows to the CRE were calculated based on measured flow at the S-77 and S-79 structures. All freshwater flows were measured except those from the Tidal Basin, which were simulated using the Lin Res model (Wan and Konyha 2015). Flows from the Coastal Basin (**Figure 8D-1**) were not incorporated as contributing to the Tidal Basin flows since they do not flow into CRE proper (Wan and Konyha 2015). Total daily inflows for WY1997–WY2025 from Lake Okeechobee, the Caloosahatchee Basins, and the Tidal Basin were used to quantify total inflow annually and seasonally to evaluate intra- and interannual variations and relative contributions by basin.

Total freshwater inflow to the CRE in WY2025 (2,320.9 x 10^3 acre-feet or ac-ft) was 21% higher than the long-term POR (1,919.0 x 10^3 ac-ft) and 2% higher than WY2024 (2,276.0 x 10^3 ac-ft; **Figure 8D-5** and **Table 8D-2** in the *Caloosahatchee River Watershed Basin Loading* subsection). The Caloosahatchee Basins were the largest contributor of flow to the CRE (54%; 1,243.6 x 10^3 ac-ft) in WY2025, increasing from WY2024 (1,124.7 x 10^3 ac-ft) and higher than the POR (918.5 x 10^3 ac-ft). Within the Caloosahatchee Basins, the West Caloosahatchee accounted for the majority at 39%, followed by the East Caloosahatchee and S-4 basins, with 13 and 2%, respectively (**Figure 8D-6**). The East Caloosahatchee and S-4 Basin percent contributions were slightly lower in WY2025 than in WY2024, but the West Caloosahatchee Basin percent contribution increased from 32% in WY2024 to 39% in WY2025. Lake Okeechobee was the second highest flow contributor to the CRE in WY2025 (27%; 626.6 x 10^3 ac-ft), and flows were lower than WY2024 (762.5 x 10^3 ac-ft) and slightly higher than the POR (613.9 x 10^3 ac-ft).

Freshwater inflows for WY2025 followed the general seasonal pattern of higher flows in the wet season months and lower flows in the dry season to the estuary (**Figure 8D-7**). September and June had the highest monthly flows to the CRE in WY2025 and coincided with the heavy rains in the wet season as well as Hurricane Milton. During the wet season, flows to the CRE were primarily from the West Caloosahatchee Basin, the East Caloosahatchee Basin, and the Tidal Basin. This shifted to Lake Okeechobee dominated flows in the dry season. In WY2025, the United States Army Corps of Engineers initiated "Lake Okeechobee Recovery Operations" from December 7, 2024, until March 29, 2025. These operations aimed to gradually lower Lake Okeechobee water levels to support the recovery of submerged aquatic vegetation (SAV) in the lake. Even with recovery operations occurring in WY2025, the total flow and percent contribution from Lake Okeechobee in WY2025 (27%; 626.65 x 10^3 ac-ft) was less than WY2024 (34%; 762.5 x 10^3 ac-ft; **Figure 8D-5**). The lowest flows in WY2025 occurred in April during drier months when less rainfall occurred and recovery operations concluded.

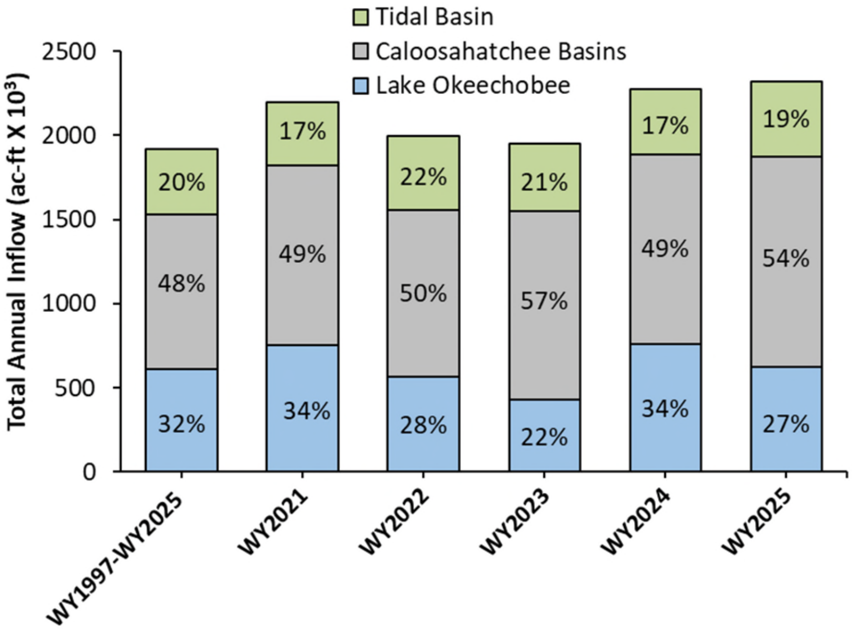


Figure 8D-5. Total annual freshwater inflow to the estuary for each contributing area by water year for the most recent 5-year period (WY2021–WY2025) and the long-term average for the POR (WY1997–WY2025) with relative percent contribution to total.

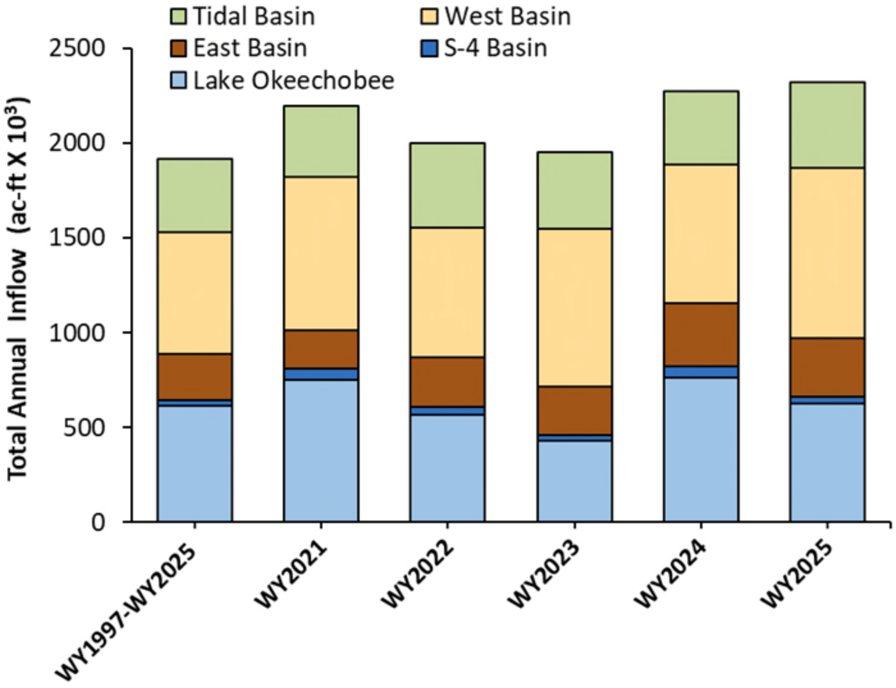


Figure 8D-6. Total annual freshwater inflow from the CRW into the CRE by water year for the most recent 5-year period (WY2021–WY2025) and the long-term average for the POR (WY1997–WY2025).

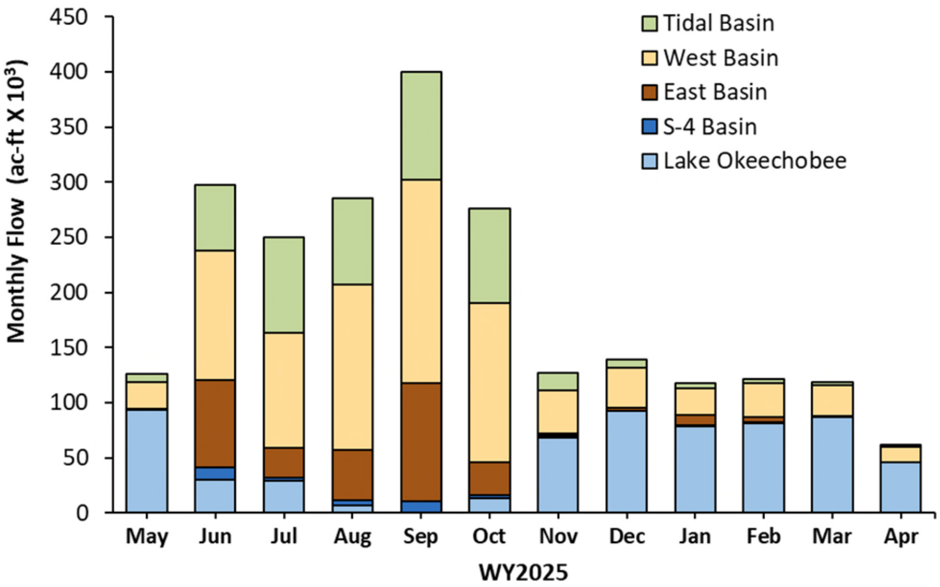


Figure 8D-7. Total monthly freshwater inflow from the CRW into the CRE for WY2025.

CALOOSAHATCHEE RIVER WATERSHED BASIN LOADING

Basin loading and flow from the primary contributing areas in the CRW for the past five water years (WY2021–WY2025) and the long-term POR (WY1997–WY2025) are summarized in **Table 8D-2** and **Figures 8D-6** through **8D-11**. The CRE is considered impaired for nitrogen and hence has a BMAP compliance TN load of 1,383 metric tons per year (t/yr) (FDEP 2009, 2022).

The Caloosahatchee Basins represented the largest contribution to the CRE in WY2025, accounting for 70% of TP load, and 56% of TN load. These contributions increased compared to WY2024 and exceeded the long-term averages observed over the POR. In contrast, Lake Okeechobee contributed 19% of TP load, and 31% of TN load in WY2025. These contributions represent a decrease from WY2024 and are lower than the POR averages (**Figures 8D-8** and **8D-10**). Within the Caloosahatchee Basins, the West Basin contributed the highest TP load (212.5 metric tons or t), and TN load (1,331.1 t) in WY2025. These values were greater than those reported for WY2024 and the POR averages (**Table 8D-2** and **Figures 8D-9** and **8D-11**).

An overview of the recent 5-year TP and TN loads and flow-weighted mean concentrations (FWMCs) from each basin to the CRE, is provided in **Table 8D-2** and **Figures 8D-12** and **8D-13**. These data show that the S-4 Basin had the highest TP and TN FWMCs, based on the average of the past five water years. The 5-year average TN load for the CRW, excluding Lake Okeechobee contributions, was 2,354.8 t, which is above the BMAP compliance load. A time series of flow, TN load, TP load, TN FWMC, and TP FWMC is provided for the long-term POR (WY1997–WY2025) in **Figure 8D-14**.

Table 8D-2. Annual flow volumes, and TP and TN loads and FWMCs for the contributing areas of the CRW to the CRE.

	Lake Okeechobee	Caloosahatchee Basins [a]	Tidal Basins	Total to CRE	Caloosahatchee Basins [a]		
					West Basin	East Basin	S-4 Basin
Flow (ac-ft X 10^3)							
WY2021	753	1,066	377	2,196	808	198	59
WY2022	568	986	445	1,998	681	263	42
WY2023	428	1,119	403	1,951	829	256	34
WY2024	763	1,125	389	2,276	733	334	58
WY2025	627	1,244	451	2,321	898	308	37
5-Year Average [b]	628	1,108	413	2,148	790	272	46
5-Year % [c]	29%	52%	19%	100%	37%	13%	2%
WY1997–WY2025	614	919	387	1,919	646	240	32
TP Load (t)							
WY2021	82.1	193.8	49.6	325.5	129.3	45.4	19.2
WY2022	56.3	185.2	64.0	305.4	118.8	54.9	11.4
WY2023	59.6	216.2	71.5	347.3	155.0	52.7	8.5
WY2024	82.5	196.4	41.9	320.8	108.6	64.9	22.9
WY2025	82.3	311.4	47.2	440.8	212.5	85.2	13.8
5-Year Average [b]	72.6	220.6	54.8	348.0	144.8	60.6	15.2
5-Year % [c]	21%	63%	16%	100%	42%	17%	4%
WY1997–WY2025	73.2	185.0	48.9	307.1	121.2	56.3	7.4
TP FWMC (micrograms per liter or µg/L)							
WY2021	88	147	106	120	130	185	262
WY2022	80	152	117	124	141	169	222
WY2023	113	157	144	144	152	167	202
WY2024	88	142	87	114	120	157	322
WY2025	106	203	85	154	192	224	300
5-Year Average [b]	95	160	108	131	147	181	262
5-Year FWMC [d]	94	161	108	131	149	181	267
WY1997–WY2025	97	163	103	130	152	190	190

Table 8D-2. Continued.

	Lake Okeechobee	Caloosahatchee Basins [a]	Tidal Basins	Total to CRE	Caloosahatchee Basins [a]		
					West Basin	East Basin	S-4 Basin
TN Load (t)							
WY2021	1,142.8	2,064.3	486.7	3,693.8	1,357.6	532.2	174.4
WY2022	942.5	1,667.4	463.5	3,073.5	1,042.5	516.8	108.2
WY2023	728.7	1,871.3	420.9	3,020.9	1,307.8	491.2	72.3
WY2024	1,323.1	1,834.8	444.0	3,601.9	1,011.7	664.2	158.8
WY2025	1,125.7	2,046.1	474.7	3,646.4	1,331.1	607.4	107.6
5-Year Average [b]	1,052.6	1,896.8	458.0	3,407.3	1,210.1	562.4	124.3
5-Year % [c]	31%	56%	13%	100%	36%	17%	4%
WY1997–WY2025	1,067.1	1,607.5	441.5	3,116.1	1,028.0	494.1	85.4
TN FWMC (micrograms per liter or mg/L)							
WY2021	1.23	1.57	1.05	1.36	1.36	2.18	2.38
WY2022	1.35	1.37	0.85	1.25	1.24	1.59	2.11
WY2023	1.38	1.36	0.85	1.26	1.28	1.56	1.72
WY2024	1.41	1.32	0.93	1.28	1.12	1.61	2.23
WY2025	1.46	1.33	0.85	1.27	1.20	1.60	2.35
5-Year Average [b]	1.37	1.39	0.91	1.28	1.24	1.71	2.16
5-Year FWMC [d]	1.36	1.39	0.90	1.29	1.24	1.68	2.19
WY1997–WY2025	1.41	1.42	0.93	1.32	1.29	1.67	2.18

a. The Caloosahatchee Basins are the West, East, and S-4 basins.

b. 5-Year Average refers to the arithmetic mean of annual data.

c. 5-Year % refers to the percent of Total Caloosahatchee from Lake Okeechobee, Caloosahatchee Basins (West, East, and S-4 basins), and Tidal Basins.

d. 5-Year FWMC is the overall FWMC for the 5-year period (calculated from 5-year load and 5-year flow).

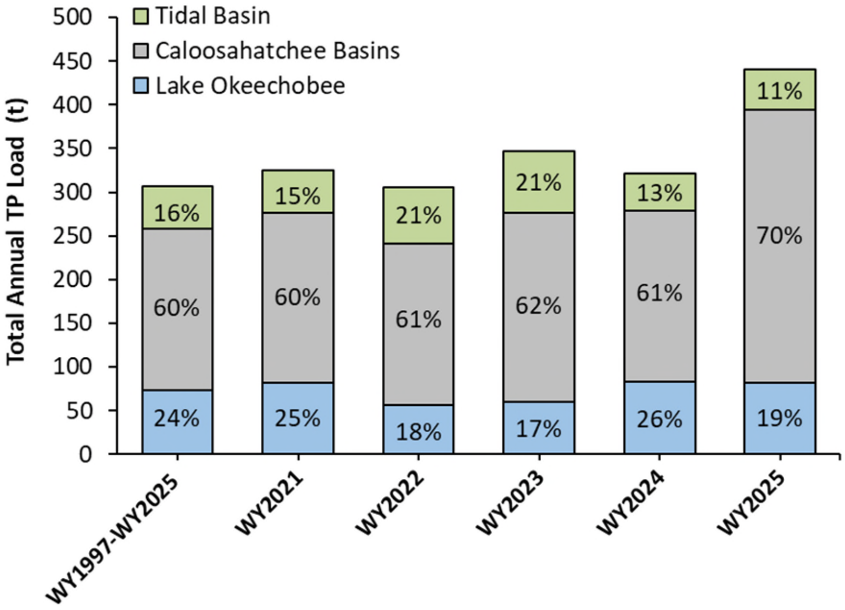


Figure 8D-8. Total annual TP load for the CRW and from each contributing area by water year for WY2021–WY2025 and the long-term annual average (WY1997–WY2025) with relative percent contribution to total.

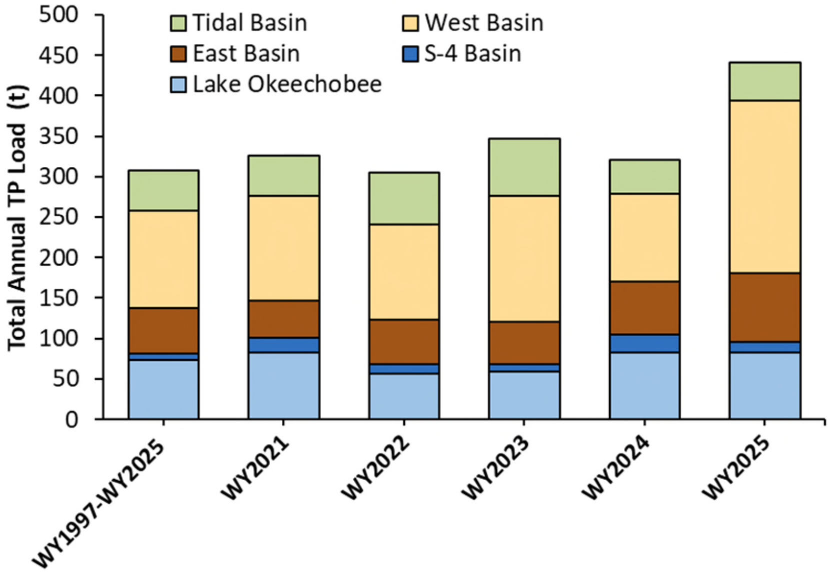


Figure 8D-9. Total annual TP load for the contributing basins by water year for WY2021–WY2025 and the long-term annual average (WY1997–WY2025).

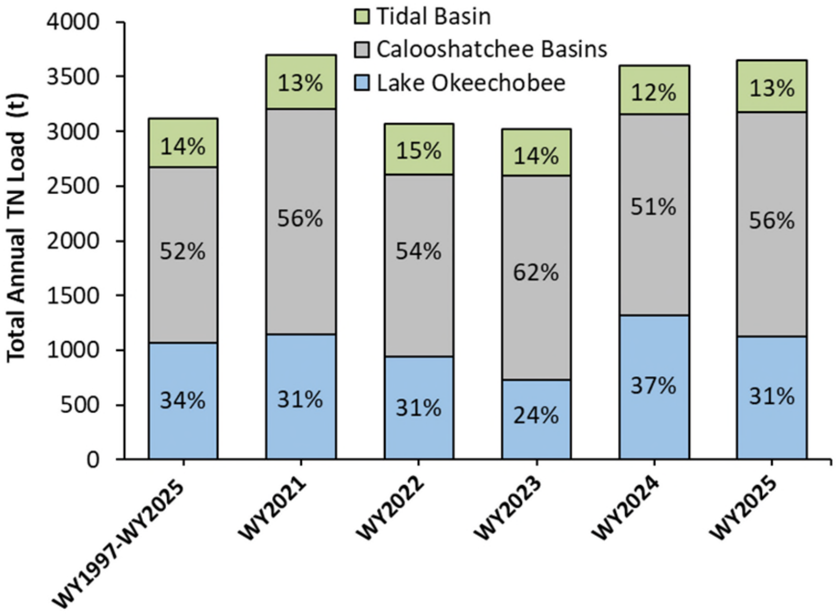


Figure 8D-10. Total annual TN load for the CRW and from each contributing area by water year for WY2021–WY2025 and the long-term annual average (WY1997–WY2025) with relative percent contribution to total.

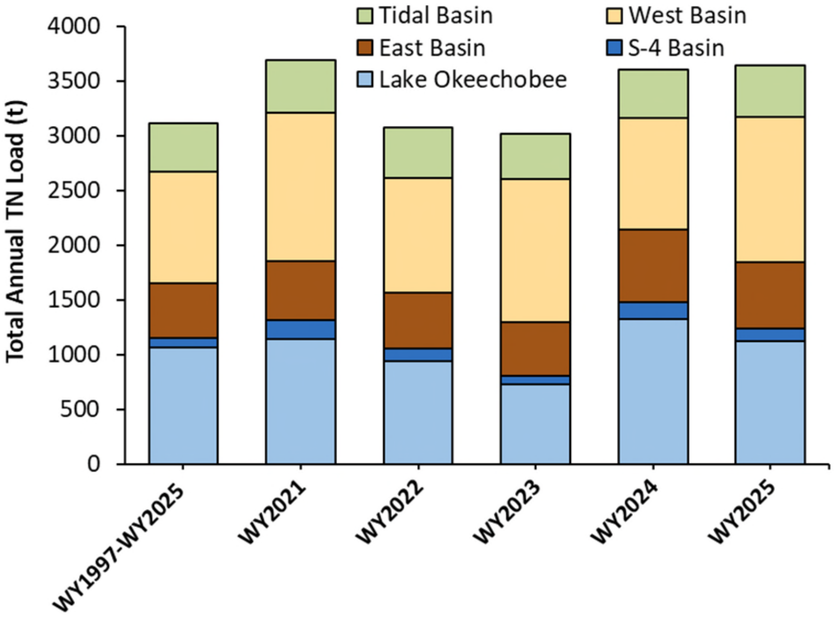


Figure 8D-11. Total annual TN load for the contributing basins by water year for WY2021–WY2025 and the long-term annual average (WY1997–WY2025).

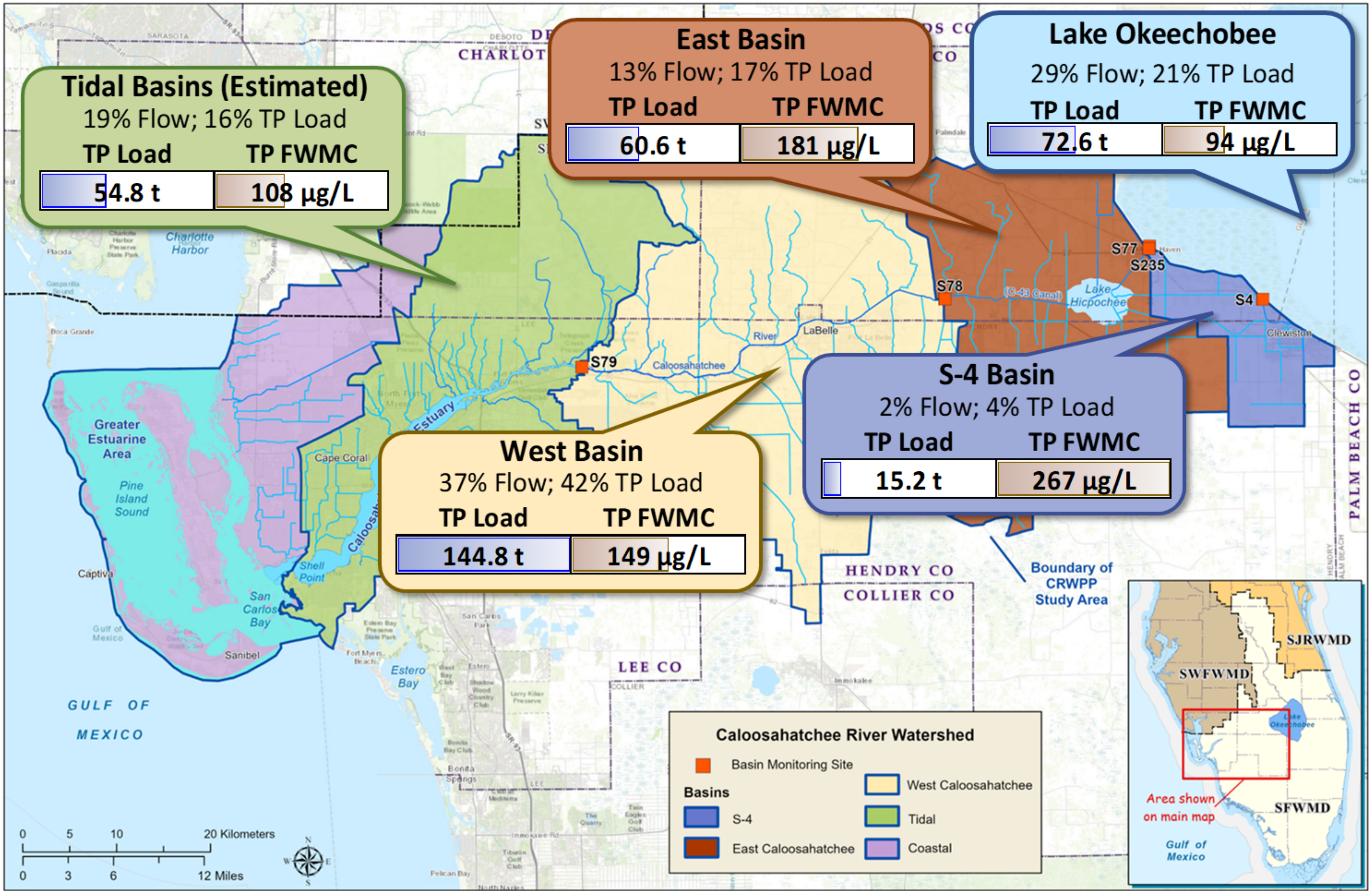


Figure 8D-12. Five-year average (WY2021–WY2025) flow and TP load contributions, expressed as percentages of total, by basin. TP load and FWMC magnitudes are shown in bar graphs.

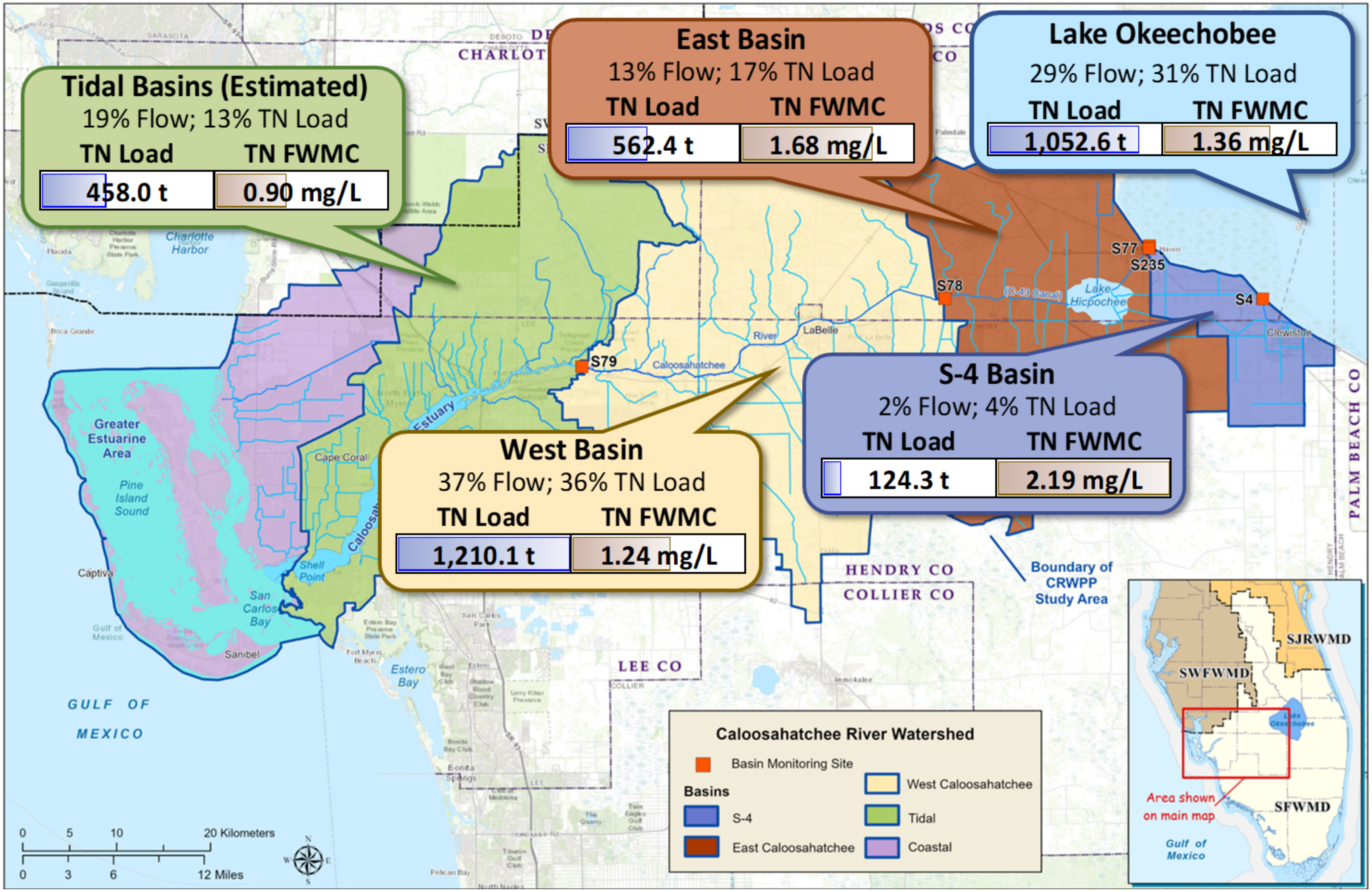


Figure 8D-13. Five-year average (WY2021–WY2025) flow and TN load contributions, expressed as percentages of total, by basin. TN load and FWMC magnitudes are shown in bar graphs.

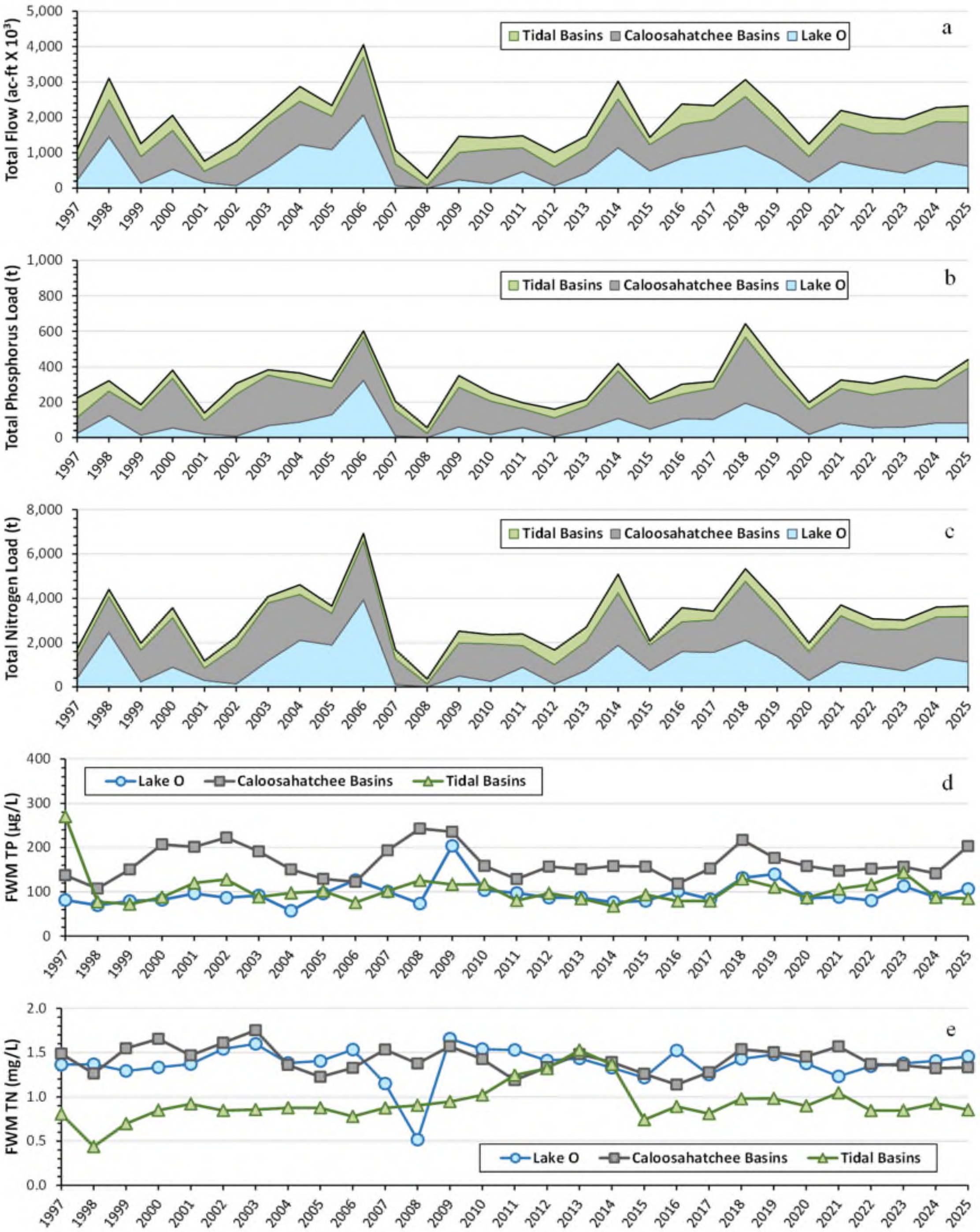


Figure 8D-14. Time series of (a) flow in x 10^3 acre-feet (ac-ft), (b) TP load in metric tons (t), (c) TN load in metric tons (t), (d) TP FWMC in micrograms per liter (µg/L), and (e) TN FWMC in milligrams per liter (mg/L) for the Tidal Basin (green), Caloosahatchee Basins (gray), and Lake Okeechobee (blue) for WY1997–WY2025 (x-axis is in water years).

PART II: RESEARCH AND WATER QUALITY MONITORING PROGRAM – CALOOSAHATCHEE RIVER ESTUARY

Inflows to the CRE exhibit intra- and interannual variability depending on the source and magnitude of those inflows due to changes in water management, weather, and climate, which may subsequently affect water quality and ecology (Doering and Chamberlain 1999, Buzzelli et al. 2013a, 2014a, Rumbold and Doering 2020). Estuaries naturally exhibit gradients in water quality parameters from upstream to downstream. Anthropogenically-impacted estuarine systems with modified hydrology can have reduced ecosystem function and increased instability. For example, estuarine organisms may experience prolonged periods outside the organisms' optimal environmental conditions, thereby promoting mortality or negatively impacting reproduction strategies (Gunter 1961, Doering and Chamberlain 2000, Barletta et al. 2005, Kahn and Durako 2006, Volety et al. 2009, Petes et al. 2012) leading to ecosystem impairment.

The volume and source of freshwater inflow to the tributaries and the estuary directly affect water quality within the CRE and can alter salinity conditions, nutrient concentration, and light availability. Changes in water quality and flushing rate due to the timing, duration, and volume of freshwater delivery can also affect the abundance, distribution, and health of key benthic indicator species such as seagrass and oysters (Lirman and Cropper 2003, La Peyre et al. 2003, Borja and Tunberg 2011, Parker et al. 2013, McKeon et al. 2015), as well as other benthic macrofauna, fish, and shellfish populations in the CRE (Tolley et al. 2010, Simpfendorfer et al. 2011, Stevens et al. 2013, Olin et al. 2014, Palmer et al. 2016, Doering and Wan 2018). Higher volumes of freshwater inflows decrease salinity levels and can alter the concentration and form of nutrients (such as TP and TN), the levels of colored dissolved organic matter (CDOM or color), and the amount of suspended solids in the water column (Wan et al. 2012, Buzzelli et al. 2013a, 2014, 2015, Hanisak and Davis 2018, Paczkowska et al. 2020, Rumbold and Doering 2020). Increased levels of CDOM in the system are a major contributor to reduced light availability in the estuarine water column (Doering and Chamberlain 1999, Chen et al. 2015, Chen and Doering 2016, Rumbold and Doering 2020), which can reduce biological processes such as photosynthesis. Higher nutrient levels can lead to increased concentrations of algae as measured by chlorophyll *a*, and together with suspended solids, further reduce light availability in the water column and negatively impact seagrass growth (Buzzelli et al. 2013b, Paczkowska et al. 2020).

To represent current and past ecological conditions in the CRE, this report summarizes monitoring data for the following water quality parameters and benthic habitat indicators at select sites in the estuary: TP, TN, chlorophyll *a*, eastern oysters (*Crassostrea virginica*), and SAV (**Figure 8D-15**).

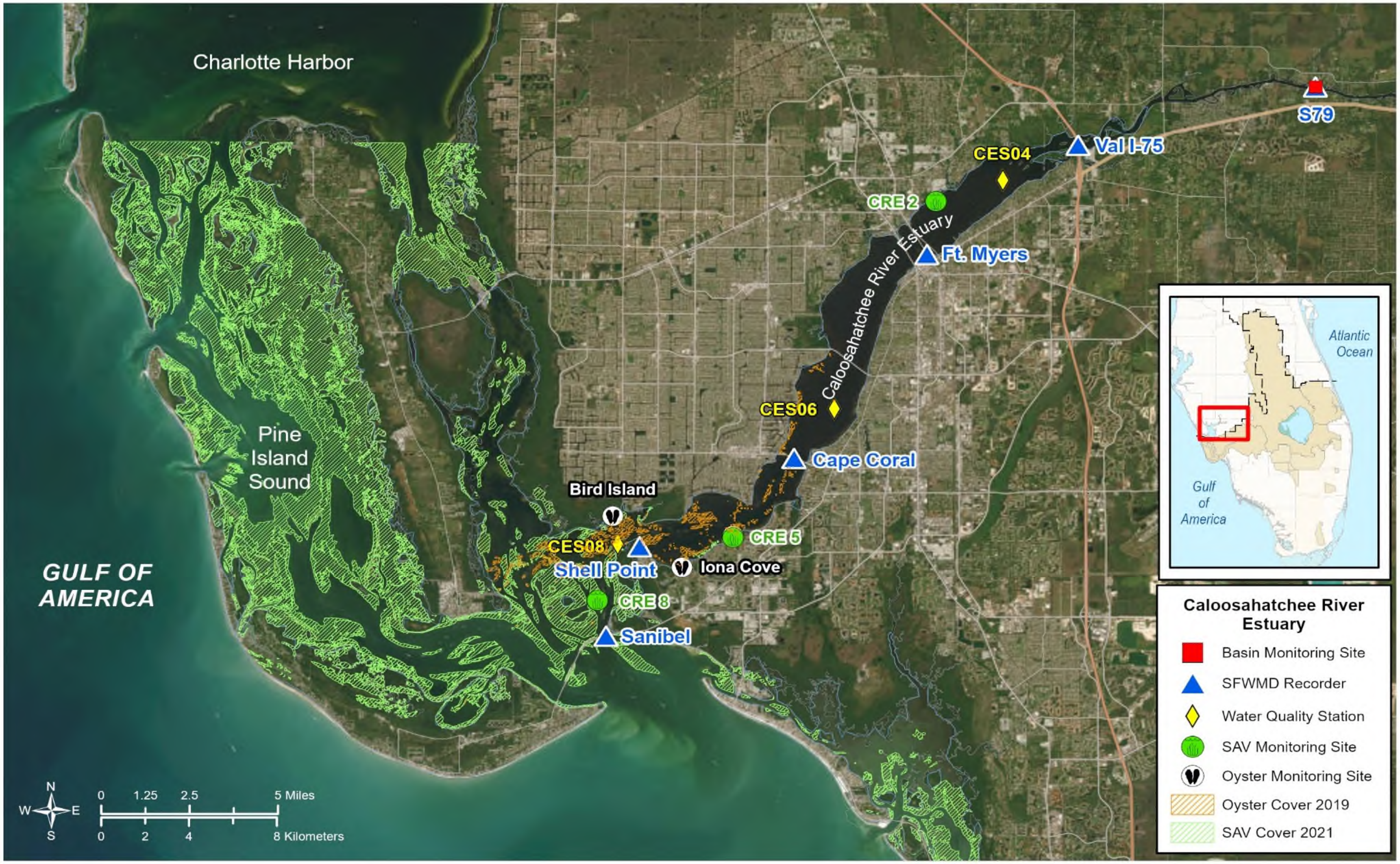


Figure 8D-15. CRE monitoring locations for water quality (CES04, CES06, and CES08), salinity recording stations (S-79, Val I-75, Ft. Myers, Cape Coral, Shell Point, and Sanibel), SAV, and oysters. SAV cover data are based on aerial imagery collected in 2021 from Boca Grande in southern Charlotte Harbor to Wiggins Pass in southern Estero Bay, and oyster cover data are based on data from 2019 sidescan-sonar mapping results for oyster substrate, which includes live oysters and oyster shell.

WATER QUALITY

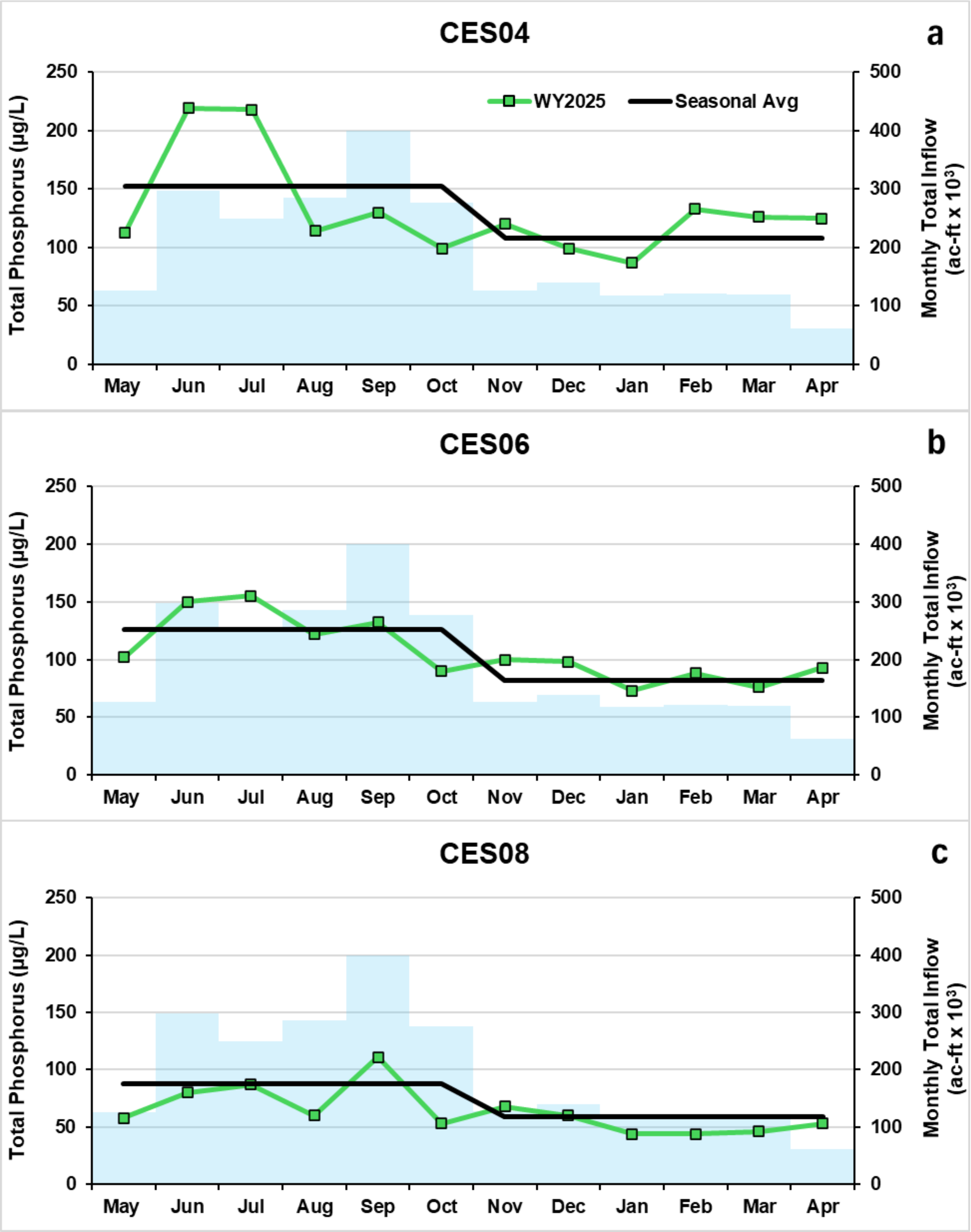
Water samples were collected via grab sample at a depth of 0.5 meter (m) from the surface of the water for TP and TN, and at half Secchi depth (depth at which the Secchi disk can no longer be seen from the surface when lowered into the water) for chlorophyll *a* at eight stations throughout the CRE as part of the RWQMP. Water samples were collected at monthly intervals and processed according to the SFWMD *Field Sampling Manual* (SFWMD 2020a) and *Quality Manual* (SFWMD 2020b). The stations with the most complete records (CES04, CES06, and CES08) were selected to characterize water quality along the estuarine gradient (**Figure 8D-15**). This assessment focuses on summarizing TP, TN, and chlorophyll *a* concentrations seasonally, annually, and for the long-term POR (WY2000–WY2025) available for each station. Seasonal concentrations for the last five water years (WY2021–WY2025) and for the POR (WY2000–WY2025) are presented as average and standard deviation for TP, TN, and chlorophyll *a* for each station.

Total Phosphorus

Generally, TP concentrations were higher within the upstream region (CES04, 87–219 micrograms per liter or µg/L) and decreased further downstream in the estuary (CES08, 44–111 µg/L). During WY2025, average wet season TP concentrations were lower than the POR at all sites in the CRE (**Table 8D-3**). Peak TP concentrations occurred in the wet season, from June through September, at all stations (**Figure 8D-16**), with the highest TP concentration recorded at CES04 (219 µg/L) in June. TP concentrations in the dry season of WY2025 remained lower than the POR at CES08 but were higher than the POR at both CES04 and CES06 (**Table 8D-3**). Unique to CES04, a secondary peak in TP concentrations (125–133 µg/L) began in February and persisted through the end of the dry season (**Figure 8D-16**).

Table 8D-3. Wet and dry season average (Avg) and standard deviation (SD) of TP concentrations at three stations in the CRE for the most recent 5-year period (WY2021–WY2025) and the POR (WY2000–WY2025) for each site: CES04 (Upper Estuary), CES06 (Middle Estuary), and CES08 (Lower Estuary).

Total Phosphorus (µg/L)						
Wet Season (May–October)						
Period	**CES04 (Upper Estuary)**		**CES06 (Middle Estuary)**		**CES08 (Lower Estuary)**	
	Avg	**SD**	**Avg**	**SD**	**Avg**	**SD**
POR	152	78	126	73	88	87
WY2021	147	32	116	29	59	12
WY2022	138	23	115	29	74	32
WY2023	152	25	119	35	67	42
WY2024	158	23	141	24	64	22
WY2025	149	55	125	26	75	22
Dry Season (November–April)						
Period	**CES04 (Upper Estuary)**		**CES06 (Middle Estuary)**		**CES08 (Lower Estuary)**	
	Avg	**SD**	**Avg**	**SD**	**Avg**	**SD**
POR	108	45	81	36	59	28
WY2021	102	26	74	22	51	14
WY2022	80	12	75	15	51	9
WY2023	121	25	98	20	61	19
WY2024	95	22	84	18	70	17
WY2025	115	18	88	11	53	10



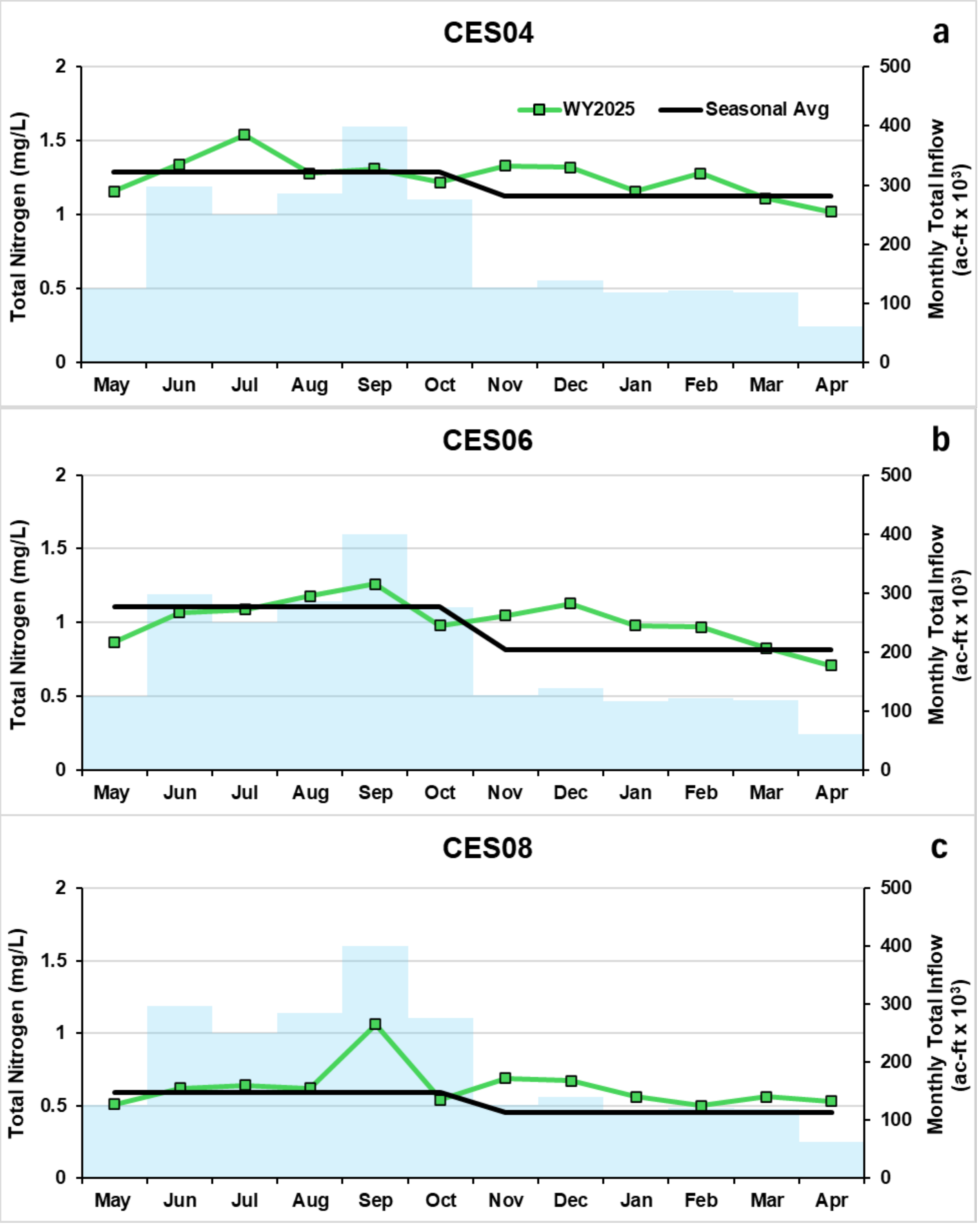
Figures 8D-16. Monthly TP concentration (green) at (a) CES04, (b) CES06, and (c) CES08 for WY2025, and the seasonal average for the POR (black). Blue bars represent the monthly total inflow (ac-ft x 10^3) in WY2025.

Total Nitrogen

Generally, higher TN concentrations were observed upstream (CES04, 1.02–1.54 milligrams per liter or mg/L) and decreased further downstream in the estuary (CES08, 0.5–1.06 mg/L). In both the wet and dry seasons of WY2025, average TN concentrations were greater than the POR at all stations except at CES06 in the wet season (1.08 mg/L), which had slightly lower TN than the POR (1.10 mg/L) (**Table 8D-4**). Peak TN values occurred at all sites within the wet season, primarily during summer months from June to September (**Figure 8D-17**). The highest monthly TN concentration was recorded at CES04 (1.54 mg/L) in July, and the lowest concentration occurred at CES08 (0.5 mg/L) in February. In September, TN concentrations at CES08 were almost twice the seasonal average and coincided with the month of greatest freshwater inflow to the CRE in WY2025. Otherwise, TN concentrations remained near or slightly above the POR average concentration at each station, but the relative magnitude above POR seasonal averages per station was higher in the dry season (**Table 8D-4** and **Figure 8D-17**).

Table 8D-4. Wet and dry season average (Avg) and standard deviation (SD) of TN concentrations in milligrams per liter (mg/L) for three stations in the CRE for the most recent 5-year period (WY2021–WY2025) and the POR (WY2000–WY2025) for each site: CES04 (Upper Estuary), CES06 (Middle Estuary), and CES08 (Lower Estuary).

Total Nitrogen (mg/L)						
Wet Season (May–October)						
Period	**CES04 (Upper Estuary)**		**CES06 (Middle Estuary)**		**CES08 (Lower Estuary)**	
	Avg	**SD**	**Avg**	**SD**	**Avg**	**SD**
POR	1.29	0.31	1.10	0.39	0.59	0.34
WY2021	1.30	0.24	1.02	0.35	0.57	0.16
WY2022	1.27	0.16	1.04	0.27	0.68	0.31
WY2023	1.19	0.08	0.90	0.26	0.58	0.33
WY2024	1.33	0.15	1.04	0.13	0.54	0.11
WY2025	1.31	0.13	1.08	0.14	0.66	0.20
Dry Season (November–April)						
Period	**CES04 (Upper Estuary)**		**CES06 (Middle Estuary)**		**CES08 (Lower Estuary)**	
	Avg	**SD**	**Avg**	**SD**	**Avg**	**SD**
POR	1.13	0.39	0.82	0.29	0.45	0.23
WY2021	1.17	0.09	0.94	0.23	0.58	0.23
WY2022	1.11	0.08	0.92	0.10	0.58	0.12
WY2023	1.27	0.14	0.97	0.16	0.58	0.14
WY2024	1.32	0.16	1.12	0.13	0.83	0.12
WY2025	1.20	0.13	0.94	0.15	0.58	0.08



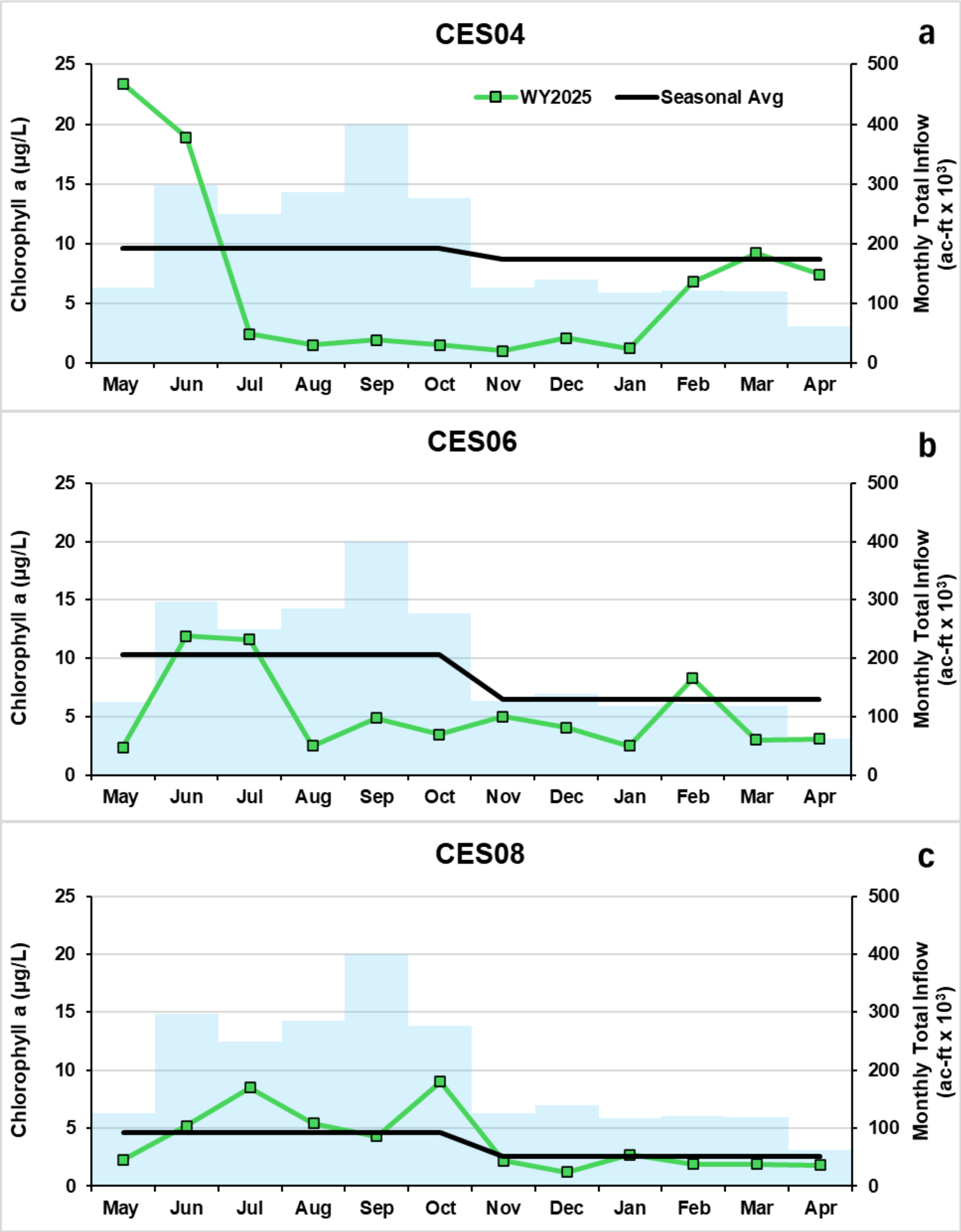
Figures 8D-17. Monthly TN concentration (green) in milligrams per liter (mg/L) at (a) CES04, (b) CES06, and (c) CES08 for WY2025, and the seasonal average for the POR (black). Blue bars represent monthly total inflow (ac-ft x 10^3) in WY2025.

Chlorophyll *a*

Average chlorophyll *a* concentrations in WY2025 were lower than the POR at all stations in the CRE during both the wet and dry seasons, except at CES08 in the wet season when the WY2025 average was higher (**Table 8D-5** and **Figure 8D-18**). Chlorophyll *a* concentrations at CES04 peaked in May (23.4 µg/L), which was consistent with elevated chlorophyll *a* at the end of WY2024, then fell below the POR from July to January (1.5–2.0 µg/L) before ending near the dry season POR average in the spring (**Figure 8D-18**). The early decline and subsequent stabilization of low chlorophyll *a* concentrations experienced at CES04 in WY2025 may be attributed to potential flushing of materials from elevated inflows during that time frame; as the most upstream site, this location is most likely to be influenced by flows through S-79, which have the potential to reduce residence times for algal growth and flush planktonic cells downstream. Chlorophyll *a* concentrations at CES06 remained relatively stable, ranging from 2.5 to 5.0 µg/L with peak concentrations occurring in June (11.9 µg/L), July (11.6 µg/L), and February (8.3 µg/L). Average chlorophyll *a* concentrations at CES08 were highest in October (9.0 µg/L). Algal blooms, defined by FDEP as 40 µg/L chlorophyll *a* in Lake Okeechobee, were not observed at any station in the CRE during WY2025.

Table 8D-5. Wet and dry season average (Avg) and standard deviation (SD) of chlorophyll *a* concentrations for three stations in the CRE for the most recent 5-year period (WY2021–WY2025) and the POR (WY2000–WY2025) for each site: CES04 (Upper Estuary), CES06 (Middle Estuary), and CES08 (Lower Estuary).

Chlorophyll *a* (µg/L)						
Wet Season (May–October)						
Period	**CES04 (Upper Estuary)**		**CES06 (Middle Estuary)**		**CES08 (Lower Estuary)**	
	Avg	**SD**	**Avg**	**SD**	**Avg**	**SD**
POR	9.6	14.8	10.3	13.5	4.6	3.5
WY2021	6.3	4.9	4.5	3.5	4.7	2.0
WY2022	5.6	5.4	5.1	4.2	3.8	1.6
WY2023	8.9	6.1	5.9	2.3	5.2	4.2
WY2024	5.9	4.5	6.8	5.6	5.4	4.0
WY2025	8.3	10.1	6.1	4.4	5.8	2.5
Dry Season (November–April)						
Period	**CES04 (Upper Estuary)**		**CES06 (Middle Estuary)**		**CES08 (Lower Estuary)**	
	Avg	**SD**	**Avg**	**SD**	**Avg**	**SD**
POR	8.7	11.0	6.5	7.2	2.5	2.7
WY2021	8.6	5.4	4.5	1.9	2.6	0.4
WY2022	7.2	7.5	3.6	0.6	2.8	1.6
WY2023	5.5	3.6	4.7	2.9	2.5	1.2
WY2024	16.1	17.5	13.3	20.0	7.1	9.1
WY2025	4.6	3.6	4.3	2.1	1.9	0.5



Figures 8D-18. Monthly chlorophyll *a* concentration (green) at (a) CES04, (b) CES06 and (c) CES08 for WY2025, and the seasonal average for the POR (black). Blue bars represent the monthly total inflow (ac-ft x 10^3) in WY2025.

AQUATIC HABITAT

Eastern Oysters (*Crassostrea virginica*)

Eastern oysters (*C. virginica*) are benthic, immobile, filter-feeding organisms that contribute valuable ecosystem services by filtering phytoplankton and suspended particles from the water column and by providing food, shelter, and habitat for other estuarine organisms. This makes them an ideal indicator species for assessing the effects of water quality restoration on estuarine ecosystems (Volety et al. 2009). Oyster monitoring in the CRE was initiated in 2000 and is supported by the Comprehensive Everglades Restoration Plan (CERP) Restoration Coordination and Verification (RECOVER) program. This long-term monitoring program measures the effects of CERP restoration efforts on oyster population health and distribution. Data also provide adaptive management information to assist in determining the flows and volumes required to maintain and promote healthy oyster populations in the CRE. Oyster density, juvenile recruitment, and disease prevalence and intensity were monitored at two sites in the CRE: Iona Cove and Bird Island (**Figure 8D-19**). Results from the last five water years (WY2021–WY2025) are presented in this section. More comprehensive statistical comparisons of oyster monitoring results can be found in the most recent report submitted by the Florida Fish and Wildlife Research Institute (Levine 2024).

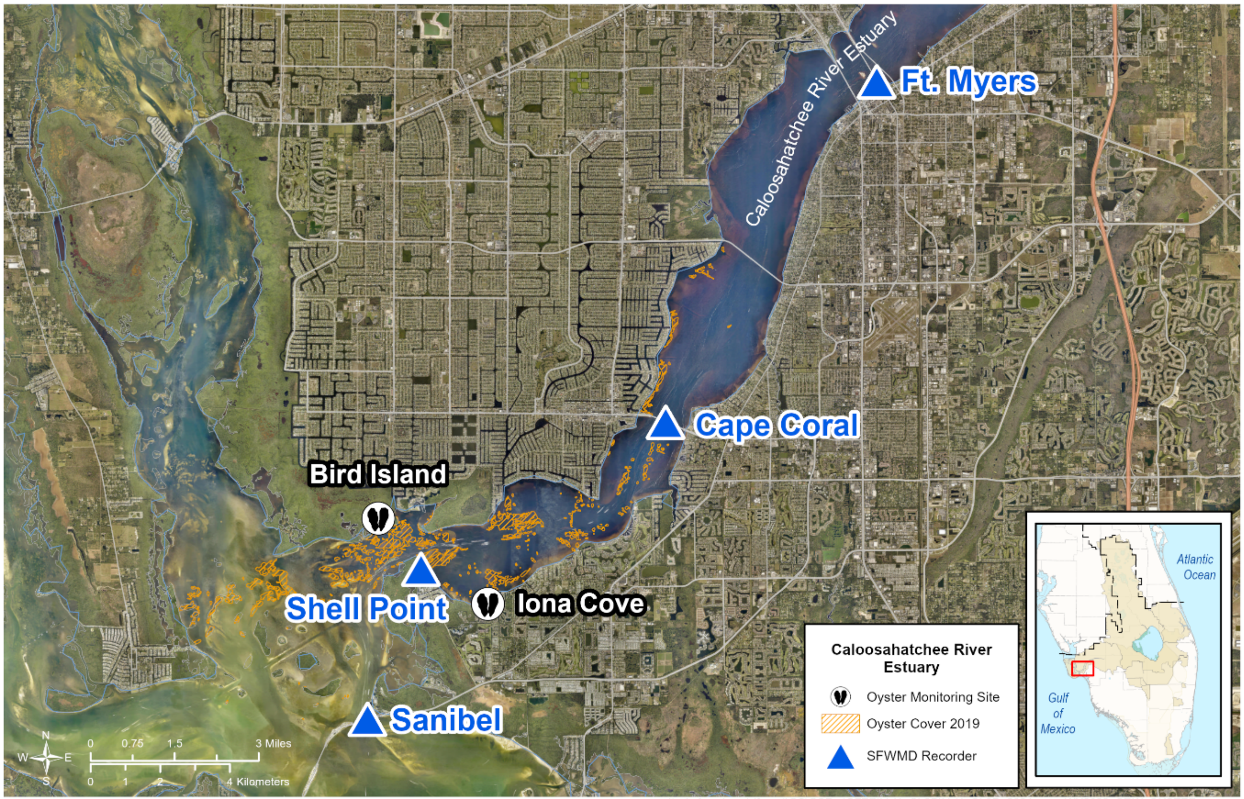


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Figure 8D-19. CRE oyster monitoring site locations, oyster cover in 2019, and salinity recording stations (Ft. Myers, Cape Coral, Shell Point, and Sanibel). Oyster cover data are based on 2019 sidescan-sonar mapping results for oyster substrate, which includes live oysters and oyster shell.

Salinity

The health, survivorship, and distribution of oyster populations are greatly influenced by water quality. Changes in salinity, high temperatures, low dissolved oxygen concentrations, and siltation can all be stressors (Parker 2015, Parker and Radigan 2020). Temperature and salinity are two of the most influential environmental factors affecting oyster populations (Shumway 1996). Oysters are capable of tolerating salinities from 5 to 40 (Galtsoff 1964) though salinities of approximately 14 to 28 have been widely recognized as an ideal range for *C. virginica* (Shumway 1996, McFarland et al. 2022). Estuarine salinity regimes, and the frequency and magnitude of variations in those regimes, are the driving force behind patterns of oyster survival, abundance, and health in the CRE (Parker and Radigan 2020, Levine 2024). The CERP RECOVER salinity performance measure defines the optimal salinity envelope for adult oysters (*C. virginica* specifically) as 10 to 25 (**Table 8D-6**; RECOVER 2020). Salinities outside of this range are considered stressful (5 to 9; > 25) or damaging (< 5) as prolonged periods with salinities in these ranges can have increasingly detrimental effects on the oysters.

Table 8D-6. Salinity envelopes for adult eastern oysters (*Crassostrea virginica*) from the CERP RECOVER salinity performance measure (RECOVER 2020).

	Salinity Envelopes [a]		
	Optimal	**Stressful**	**Damaging**
Crassostrea virginica	10 to 25	5 to 9; > 25	< 5
Description of Envelope	Yielding highest response variables (e.g., growth, density, recruitment, and photosynthesis).	Decline in some response variables (e.g., growth) but tolerable. Survivability and persistence possible or likely for a time.	Significant declines in all response variables. Survivability and persistence low, and loss over the long-term likely.

a. Salinity is reported as a dimensionless value (Fofonoff and Millard 1983).

Salinity at the Cape Coral and Shell Point stations, located near the CRE oyster monitoring sites (**Figure 8D-19**), was measured every 15 minutes at the surface and bottom. Salinity measures at each station were averaged to obtain daily water column means as well as annual means for the most recent five water years and the POR (WY2003–WY2025). To relate salinity conditions to oyster population responses in the CRE, the RECOVER salinity performance measure was applied by calculating 14-day moving average water column salinities and determining the percentage of time when salinities were within and outside the optimal salinity envelope at each station (**Table 8D-6**).

The 14-day moving average water column salinities at the Shell Point station, ranged from 14 to 30 in WY2025 (**Figure 8D-20**). Salinity was in the optimal range for oysters 62% of days in WY2025, which was comparable with the previous four water years and higher than the POR (45%) (**Table 8D-7**). The percentage of days with high salinity stress (14-day moving average > 25) was 38% in WY2025, comparable to WY2021, WY2022, and WY2024 but lower than the long-term POR average of 52%. Salinities did not decrease to below the optimal range at Shell Point in WY2025 or during the past four water years.

At the Cape Coral station, the 14-day moving average water column salinity ranged from 1 to 17 in WY2025 (**Figure 8D-20**) and was in the optimal range for oysters 62% of days (**Table 8D-7**), an improvement over WY2024, comparable to water years WY2021 to WY2023 and greater than the long-term POR (54%). In WY2025, salinities were in the lower stressful range (5 to 9) 14% of days, which was an improvement over WY2024 (43% of days) and comparable to WY2021 and WY2023. The percentage of days in the damaging range (< 5) in WY2025 (24%) was higher than the previous three water years but similar to the POR (23%). Salinities did not exceed 25 (upper stressful salinity range) in WY2025 or during the past four water years. All days with salinities in the damaging range occurred over the WY2025 wet season months, during a period with increased daily freshwater inflows (**Figure 8D-20**). For the remainder of WY2025, salinities were within the optimal range.

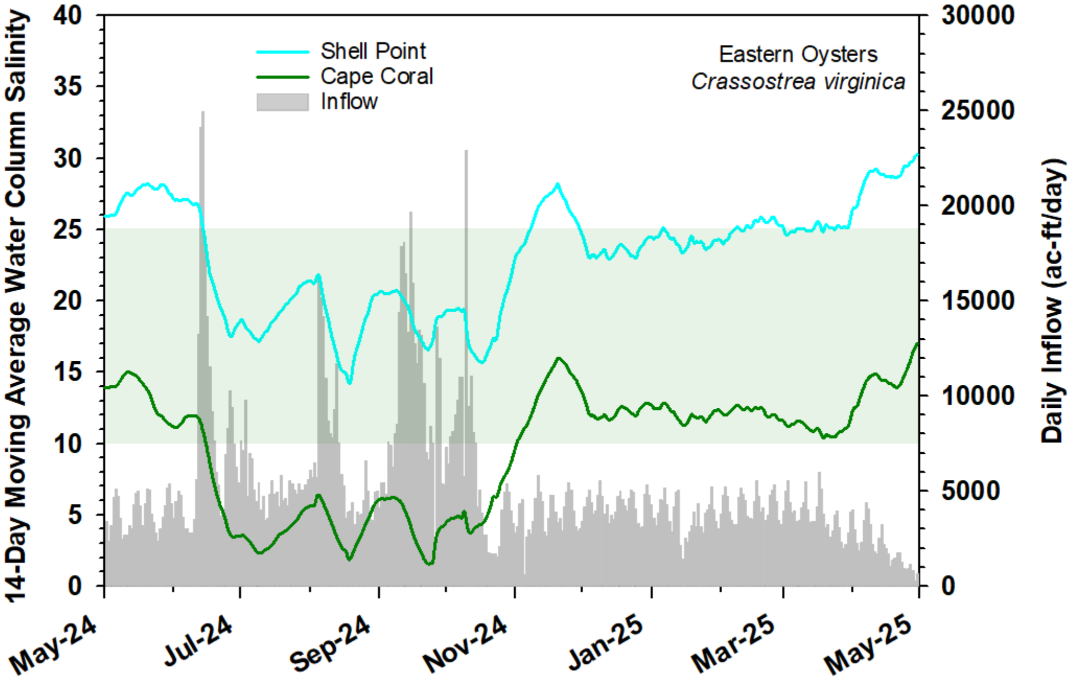

Figure 8D-20. Time series of 14-day moving average water column salinity at the Cape Coral (green) and Shell Point (teal) salinity monitoring stations and daily total freshwater inflow (gray) for WY2025. Green shading indicates the optimal salinity envelope (10 to 25) for adult oysters (*C. virginica*).

Table 8D-7. Percent of days for the most recent 5-year period and the POR (WY2003–WY2025) when the 14-day moving average salinity in the water column was in each salinity envelope for oysters (*C. virginica*) at the Cape Coral and Shell Point salinity monitoring stations.

***Crassostrea virginica*: 14-Day Moving Average Water Column Salinity**								
Period	**Days with Damaging Salinity < 5 (%)**		**Days with Stressful Salinity 5 to 9 (%)**		**Days with Optimal Salinity 10 to 25 (%)**		**Days with Stressful Salinity > 25 (%)**	
	Shell Point	**Cape Coral**	**Shell Point**	**Cape Coral**	**Shell Point**	**Cape Coral**	**Shell Point**	**Cape Coral**
WY2003–WY2025	0	23	3	17	45	54	52	6
WY2021	0	28	0	12	58	60	42	0
WY2022	0	11	0	27	67	63	33	0
WY2023	0	14	0	16	48	70	52	0
WY2024	0	15	0	43	69	42	31	0
WY2025	0	24	0	14	62	62	38	0

Live Oyster Density

Live oyster densities were measured biannually (fall and spring) using methods adapted from Lenihan and Peterson (1998) and Grizzle et al. (2005) at the Iona Cove and Bird Island sites in the CRE. At each site, 15 replicate 0.25-square meter (m^2) quadrats were haphazardly deployed, and all live oysters within were collected and counted. At Iona Cove, mean oyster densities ranged from 81 oysters/m^2 (September 2020) to 413 oysters/m^2 (March 2024) (**Figure 8D-21**). At the downstream Bird Island site, mean densities ranged from 248 oysters/m^2 (September 2020 and March 2025) to 1,184 oysters/m^2 (March 2022) (**Figure 8D-22**). The WY2025 live oyster density means at Iona Cove were similar to WY2024, and the wet season mean was the greatest recorded over the past five water years. At Bird Island, the mean wet and dry season densities in WY2025 were lower than the previous two water years. Declines in mean density at Bird Island during the wet season may be attributed to slightly higher occurrence (38% in WY2025) of salinities in the upper stressful range (> 25) than in the previous water year.

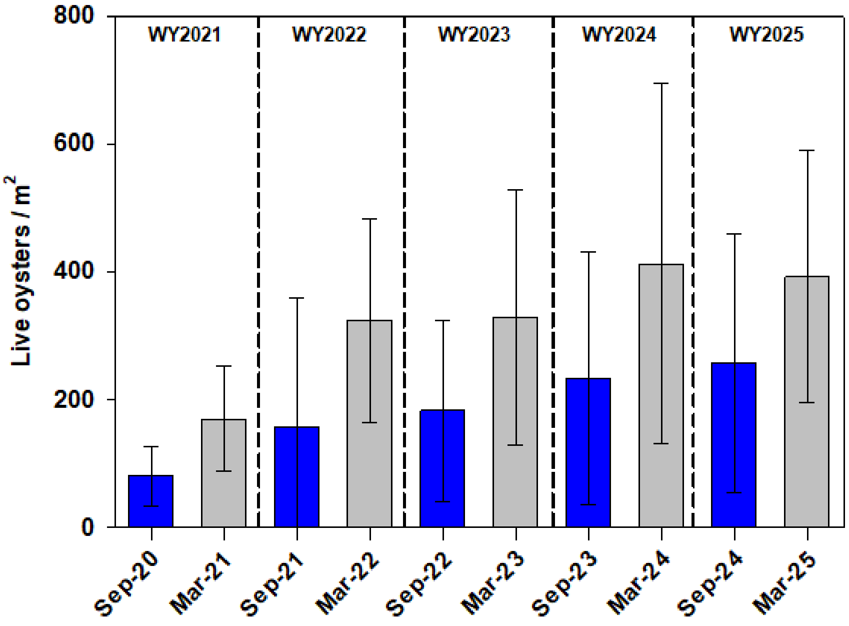

Figure 8D-21. Mean live oyster density (± standard deviation) at the Iona Cove site in the CRE for WY2021–WY2025. Blue bars represent wet season sampling and gray bars represent dry season sampling.

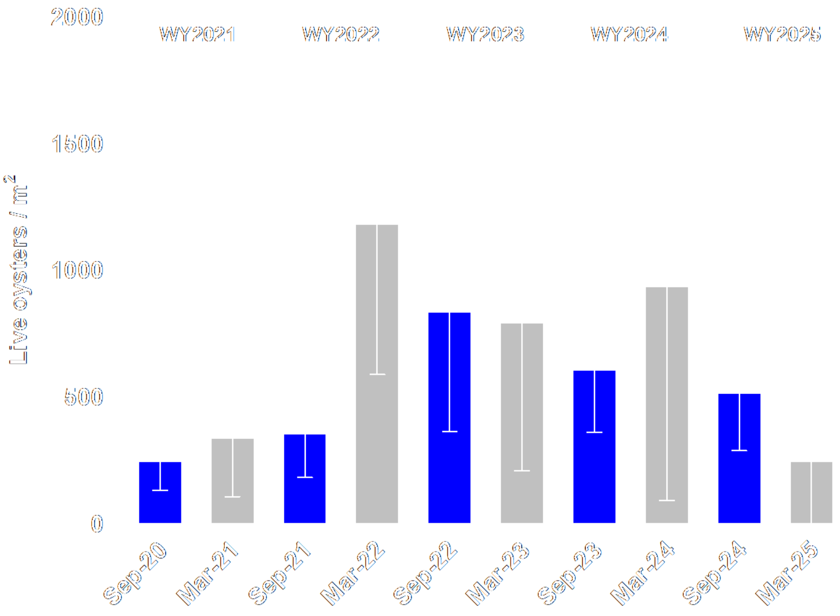

Figure 8D-22. Mean live oyster density (± standard deviation) at the Bird Island site in the CRE for WY2021–WY2025. Blue bars represent wet season sampling and gray bars represent dry season sampling.

Recruitment

Juvenile recruitment, or settlement of oyster larvae to substrate, was measured by counting settled oyster spat (permanently attached juvenile oysters) from the underside of shells strung on three replicate arrays deployed at the Iona Cove and Bird Island sites in the CRE. Recruitment rates were determined by dividing the number of spat per shell by the number of days the shell was deployed and then standardizing to a 28-day month. Spawning and larval settlement typically occurred during the wet season months. In the CRE, the first spring recruits were most often detected in April with recruitment rates peaking in the summer or fall (Parker and Radigan 2020, Levine 2024). Over the last five water years, recruitment occurred consistently from May through November (when sampling was conducted) at both the Iona Cove and Bird Island sites. In late September 2022, Hurricane Ian made landfall on the west coast of Florida. The impacts from this category 4 storm were mainly from a high storm surge that caused displaced debris and unsafe water conditions disrupting monitoring efforts from October to December 2022. Monitoring was able to resume at both sites in January 2023.

Mean monthly recruitment rates over the last five water years at Iona Cove ranged from 0 to 65 spat/shell (November 2024) (**Figure 8D-23**). Rates were higher in WY2025 compared to previous years. In WY2025, daily mean salinities at Cape Coral fell below 10 for almost 130 consecutive days from June through October then were within the optimal range (10 to 25) from November through April prior to the start of the spawning season (**Figure 8D-20**). The high recruitment rates in WY2025 may also be attributed to increased live oyster density at Iona Cove in March (**Figure 8D-21**).

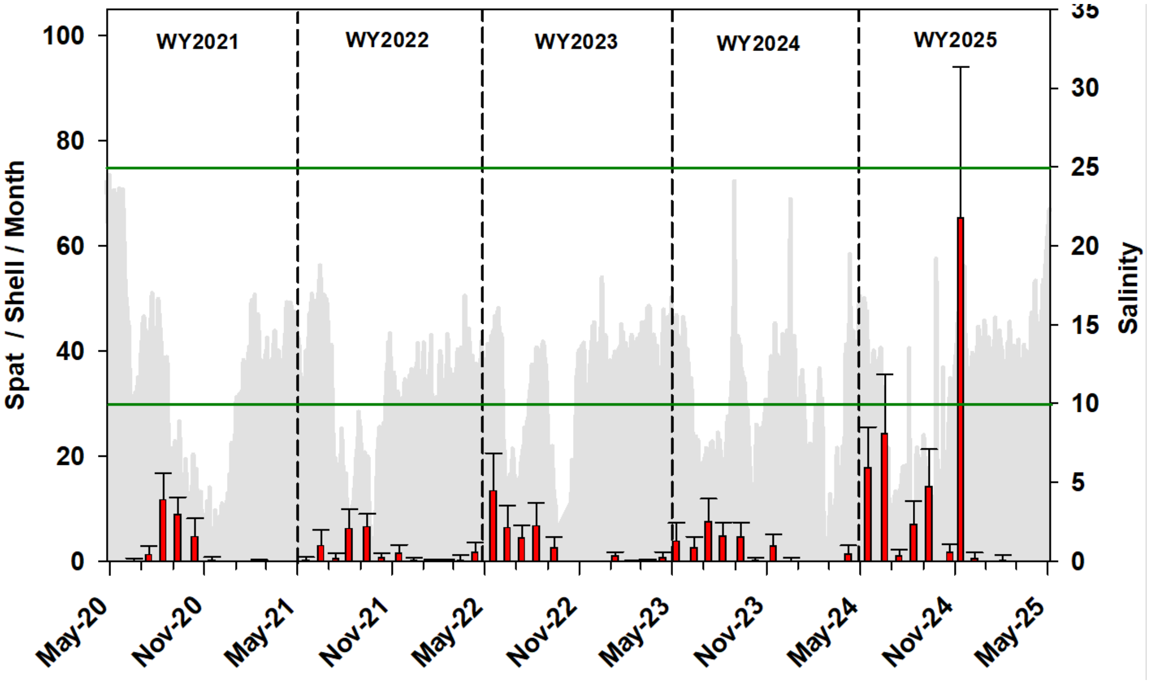

Figure 8D-23. Mean monthly juvenile recruitment (± standard deviation; red bars) at the Iona Cove site in the CRE from WY2021–WY2025 and mean daily salinity (gray) at Cape Coral. The optimal salinity envelope (10 to 25) is indicated by the green lines. Note no recruitment data was collected from October 2022 to January 2023 due to Hurricane Ian.

Recruitment rates were higher at the Bird Island site where salinities were more often in the optimal range for larval settlement and upstream freshwater flows drive larvae to this downstream site. Mean monthly recruitment rates from WY2021 to WY2025 ranged from 0 to 73 spat/shell (November 2024) (**Figure 8D-24**). During the past five water years, recruitment rates were the greatest in WY2025 when they remained high from May through November. The number of days salinities were in the optimal range at Shell Point in WY2025 was similar to most previous water years (**Table 8D-7**), so the higher recruitment rates may be a result of the increased live oyster density in the WY2024 dry season (**Figure 8D-22**).

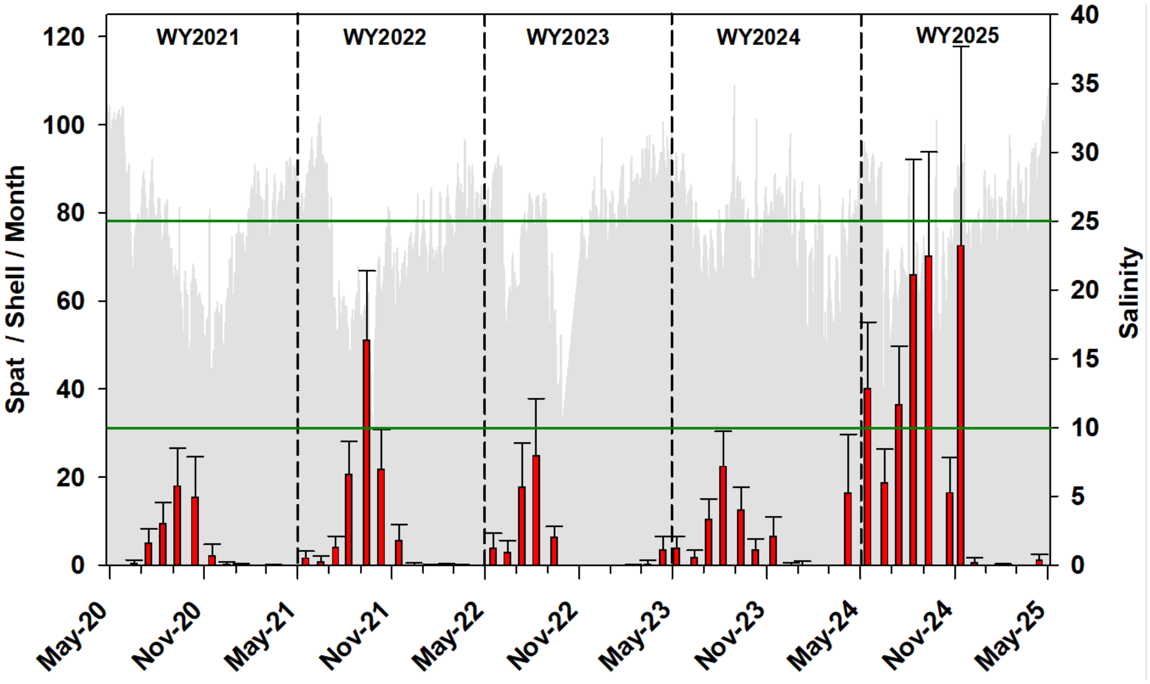

Figure 8D-24. Mean monthly juvenile recruitment (± standard deviation; red bars) at the Bird Island site in the CRE from WY2021–WY2025 and mean daily salinity (gray) at Shell Point. The optimal salinity envelope (10 to 25) is indicated by the green lines. Note no recruitment data were collected from October 2022 to January 2023 due to Hurricane Ian.

Dermo Infection Prevalence and Intensity

Dermo (*Perkinsus marinus*) is a marine protozoan parasite of bivalve mollusks that occurs naturally in the waters along the east coast of the United States (Reece et al. 2001, García-Ulloa et al. 2023). The dermo parasite favors high salinity and high temperature environments, so infection rates and severity often increase in oysters living in those conditions. Dermo infection prevalence (% infected) and intensity (severity of infection) were assessed by examining mantle and gill tissues from individual oysters collected monthly from the Iona Cove and Bird Island sites. Mean monthly dermo prevalence ranged from 20 to 100% at Iona Cove and 0 to 100% at Bird Island from WY2021 through WY2025. Mean prevalence at Iona Cove ranged from 47 to 90% during the wet seasons and from 60 to 72% during the dry seasons (**Table 8D-8**). Bird Island mean prevalence ranged from 27 to 60% during the wet seasons and from 33 to 63% during the dry seasons (**Table 8D-8**). In recent water years, dermo infection rates at Iona Cove have generally increased while those at Bird Island have declined. In WY2025, the mean percentage of oysters infected was higher at Iona Cove than at Bird Island half of the year. Higher infection prevalence at Iona Cove may be due to oysters already being stressed and weakened from being exposed more frequently to sub-optimal salinities (< 10), thus making the oysters more susceptible to dermo infection.

Dermo infection intensity was scored according to the Mackin scale of 1 to 5 (Mackin 1962) with mean monthly values ranging from 0.5 (very light infection) to 2.1 (light to moderate infection) at Iona Cove and 0 (no infection) to 1.4 (light infection) at Bird Island from WY2021 to WY2025. Mean infection intensities at Iona Cove ranged from 0.24 to 0.85 in the wet seasons and from 0.46 to 1.06 in the dry seasons (**Table 8D-8**). At Bird Island, mean infection intensities in the wet seasons ranged from 0.15 to 0.76 and from 0.22 to 0.76 in the dry seasons over the last five water years. Although high percentages of oysters collected from both Bird Island and Iona Cove in WY2025 were infected with dermo, mean infection intensity remained light.

Table 8D-8. Mean prevalence (% infected) and intensity (0 to 5 based on the Mackin scale with 0 = no infection and 5 = heavy infection; Mackin 1962) of dermo (*Perkinsus marinus)* infections in oysters from the Iona Cove and Bird Island sites in the CRE from WY2021 through WY2025.

Water Year	Season	Dermo Prevalence (%)		Dermo Intensity (0 to 5)	
		Iona Cove	Bird Island	Iona Cove	Bird Island
WY2021	Wet	46.7 [a]	40.0 [a]	0.64 [a]	0.32 [a]
	Dry	72.0	56.0	1.06	0.76
WY2022	Wet	46.7	50.0	0.43	0.63
	Dry	66.7	63.3	0.60	0.68
WY2023	Wet	90.0 [b]	60.0 [b]	0.85 [b]	0.76 [b]
	Dry	68.0 [b]	48.0 [b]	0.63 [b]	0.28 [b]
WY2024	Wet	66.7	26.7	0.49	0.15
	Dry	60.0	33.3	0.46	0.22
WY2025	Wet	59.4	56.7	0.24	0.41
	Dry	63.3	43.0	0.46	0.24

a. No *C. virginica* were collected in May 2020 due to COVID-19 restrictions.

b. No *C. virginica* were collected from October to December 2022 due to Hurricane Ian.

Submerged Aquatic Vegetation

Submerged aquatic vegetation (SAV) includes freshwater and marine flowering plants (angiosperms), like seagrasses, that can form dense beds providing structural habitat and food for a variety of fish, invertebrates, manatees, and sea turtles (Williams and Heck 2001, Unsworth et al. 2019). Beyond their interactions with aquatic organisms, SAV provides a multitude of other ecosystem services, including the assimilation of nutrients from the water column and sediments, carbon sequestration (McLeod et al. 2011, Fourqurean et al. 2012), and sediment stabilization (Bos et al. 2007, Furman et al. 2019). Through their ecosystem services, SAV are not only considered foundation species, but also indicator species (Morris et al. 2022) signaling when environmental conditions are suboptimal. Stressed or damaged SAV will not grow and may lose overall biomass and diversity, therefore reducing their overall ecological function (Morris et al. 2022). Monitoring the abundance and health of SAV habitats provides insight into the overall health of an estuary.

The distribution, diversity, and abundance of SAV were assessed within the CRE to detect changes in SAV habitat across multiple spatial and temporal scales. Large-scale monitoring involved estimating the percent cover of each seagrass species annually during the wet season at spatially random sites throughout the estuary to determine changes in SAV distribution and diversity. Small-scale monitoring was conducted at least four times per year at three fixed transect sites to evaluate SAV percent cover and diversity (**Figure 8D-25**). Photosynthetically active radiation (PAR, wavelengths of 400–700 nanometers or nm) data were collected during both annual and quarterly monitoring events and then converted to percent of subsurface irradiance using the Lambert-Beer equation (Morris et al. 2021). This multiscale approach enables the detection of long-term trends and subtle changes within the SAV communities throughout the estuary.

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Figure 8D-25. CRE SAV monitoring site locations, SAV cover in 2021, and salinity recording stations (S-79, Val I-75, Ft. Myers, Cape Coral, Shell Point, and Sanibel). SAV extent data are based on aerial imagery collected in 2021 from Boca Grande in southern Charlotte Harbor to Wiggins Pass in southern Estero Bay. SAV aerial mapping is not possible upstream of the CRE 5 monitoring station due to lack of water clarity needed for image capture.

Salinity

Table 8D-9. Salinity ranges for SAV within the CRE.

Florida SAV	Optimal Salinity Range
Vallisneria americana	0 to 10 [a,b]
Ruppia maritima	0 to 25 [c,d]
Halodule wrightii	15 to 45 [a,c,e]
Halophila engelmannii	20 to 35 [e]
Thalassia testudinum	24 to 40 [c,e]
Halophila decipiens	26 to 35 [e]
Syringodium filiforme	28 to 40 [c,e]

a. RECOVER 2020
b. French and Moore 2003
c. Koch et al. 2007
d. Kantrud 1991
e. Morris et al. 2021

SAV health and distribution are driven by water quality conditions within the estuary. Salinity, water temperature, and light availability are the three most important environmental factors affecting SAV populations in South Florida (Morris et al. 2021). Salinity and light availability dictate the distribution, depth, and diversity of SAV beds, while water temperature has more influence on growth (biomass and expansion) (Morris et al. 2021, 2022). Each SAV species has a unique range of tolerance for environmental factors, such as salinity (**Table 8D-9**), and thrives when those conditions are within their optimal range. The CERP RECOVER salinity performance measure defines the optimal salinity envelope for *Vallisneria americana* (tape grass) as < 10 (**Table 8D-10**; RECOVER 2020). Salinities above this range are considered stressful (10 to 15) or damaging (> 15) to *V. americana*. For *Halodule wrightii* (shoal grass), the optimal salinity envelope is 15 to 45 and salinities outside of this range are considered stressful (5 to 15 or > 45) or damaging (< 5). Salinity conditions outside of optimal for either indicator species may result in loss of critical SAV habitat.

Table **8D-10.** Salinity envelopes for SAV indicator species in the CRE based on the CERP RECOVER salinity performance measure (RECOVER 2020).

	Salinity Envelopes [a]		
	Optimal	**Stress**	**Damaging**
Vallisneria americana	< 10	10 to 15	> 15
Halodule wrightii	15 to 45	5 to 15; > 45	< 5
Description of Envelope	Yielding highest response variables (e.g., growth, density, recruitment, and photosynthesis).	Decline in some response variables (e.g., growth) but tolerable. Survivability and persistence possible or likely for a time.	Significant declines in all response variables. Survivability and persistence low, and loss over the long-term likely.

a. Salinity is reported as a dimensionless value (Fofonoff and Millard 1983).

Continuous salinity data were recorded at four stations in the CRE, two in the upper estuary (Val I-75 and Ft. Myers) and two in the lower estuary (Shell Point and Sanibel), adjacent to SAV monitoring sites (**Figure 8D-25**). Salinity was measured every 15 minutes near the surface and at the bottom of the water column. Surface salinity was used to determine optimal salinity conditions for *V. americana* at Val I-75 and Ft. Myers, and average water column salinity was used to determine the optimal salinity conditions for *H. wrightii* at Shell Point and Sanibel. To relate salinity conditions to SAV responses in the CRE, the RECOVER salinity performance measures were applied by calculating 14-day moving average salinities and determining the percentage of time when those salinities were within and outside the optimal salinity envelope at each station for *V. americana* and *H. wrightii* (**Table 8D-10**).

The Val I-75 and Ft. Myers salinity monitoring stations are in the upstream portion of the CRE in primarily fresh water. Surface salinity from these stations was used to evaluate salinity conditions for

V. americana. The 14-day moving average surface salinity in WY2025 ranged from 0.2 to 1.9 at Val I-75 and from 0.2 to 11.5 at Ft. Myers (**Figure 8D-26**). Salinity conditions at Val I-75 were ideal for *V. americana* the entire water year and during the four previous water years (**Table 8D-11**). At Ft. Myers, similar to the previous two water years, salinity conditions were close to ideal for *V. americana* for the entire water year with only 4% of time when salinity exceeded 10 into the stress range (10 to 15). In contrast, salinity frequently exceeded optimal and climbed into the stressful (10 to 15) or damaging (> 15) ranges during WY2020 and WY2021 (**Table 8D-11**).

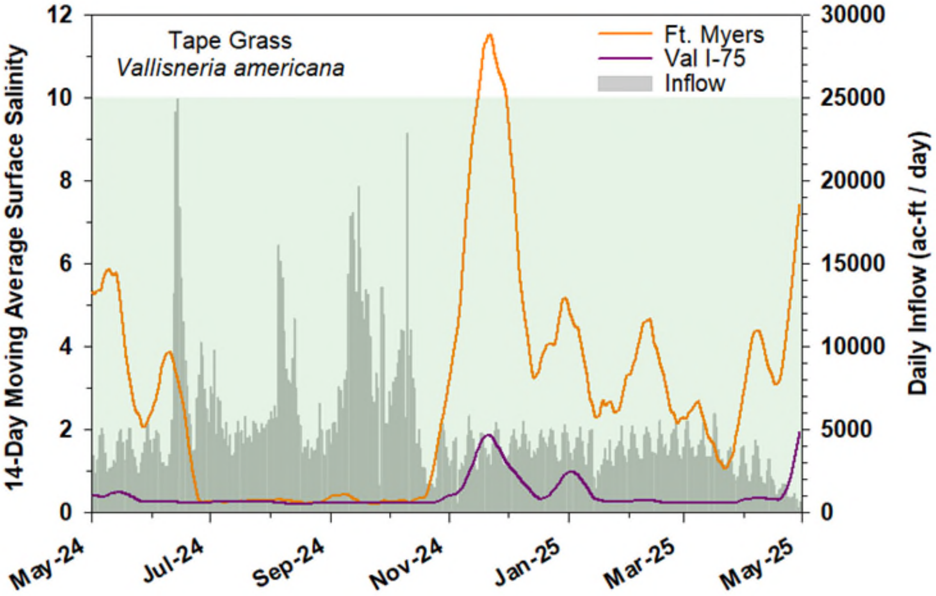


Figure 8D-26. Time series of the 14-day moving average surface water salinity at the Val I-75 (purple) and Ft. Myers (orange) salinity monitoring stations and daily total freshwater inflow (gray) for WY2025. Green shading indicates the optimal salinity envelope (< 10) for *V. americana*.

Table 8D-11 Percent of days for the most recent 5-year period and the POR when the 14-day moving average surface salinity was in each salinity envelope for tape grass (*V. americana)* at the Val I-75 and Ft. Myers salinity monitoring stations. Long-term POR is WY2007–WY2025 for Val I-75 and WY2001–WY2025 for Ft. Myers.

***Vallisneria americana*: 14-Day Moving Average of Surface Salinity**						
Period	**Days with Optimal Salinity < 10 (%)**		**Days with Stressful Salinity 10 to 15 (%)**		**Days with Damaging Salinity > 15 (%)**	
	Val I-75	**Ft. Myers**	**Val I-75**	**Ft. Myers**	**Val I-75**	**Ft. Myers**
POR	92	76	5	14	3	10
WY2021	100	90	0	8	0	2
WY2022	100	100	0	0	0	0
WY2023	100	100	0	0	0	0
WY2024	100	100	0	0	0	0
WY2025	100	96	0	4	0	0

Mean water column salinities at Cape Coral, Shell Point and Sanibel were used to evaluate salinity conditions for *H. wrightii* in the middle and lower estuary (**Figure 8D-27**). The 14-day moving average water column salinity at Cape Coral ranged from 1.2 to 17.2 and was mostly within the lower stressed range (5 to 15) and damaging range (< 5) for *H. wrightii*. Only 4% of the water year salinity was within the optimal range at Cape Coral. The 14-day moving average water column salinity at Shell Point ranged from 14 to 30 and was mostly within the optimal range (15 to 45) for *H. wrightii*. Only 1% of the water year salinity was slightly below 15. Salinity conditions at Shell Point were close to ideal for *H. wrightii* in the most recent two water years, which was an improvement over previous water years and the POR when salinities occasionally dropped below optimal into the stressful range (5 to 15) (**Table 8D-11**). The 14-day moving average water column salinity at Sanibel ranged from 24 to 34 and was within the optimal range (15 to 45) for *H. wrightii* for the last five water years and is consistent with the POR (**Table 8D-12**).

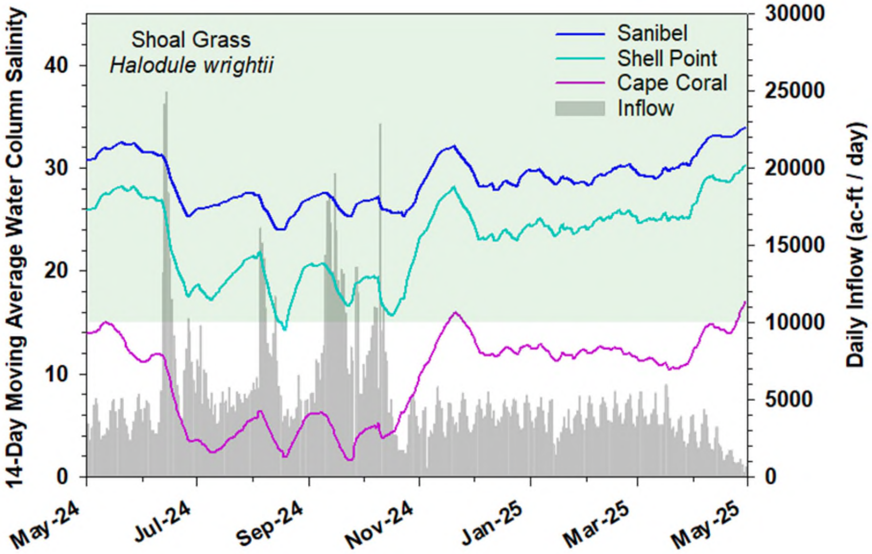


Figure 8D-27. Time series of the 14-day moving average water column salinity at the Shell Point (teal) and Sanibel (blue) salinity monitoring stations and daily total freshwater inflow (gray) for WY2025. Green shading indicates the optimal salinity envelope (15 to 45) for *H. wrightii.*

Table 8D-12. Percent of days for the most recent 5-year period and the POR (WY2003–WY2024) when the 14-day moving average water column salinity was in each salinity envelope for shoal grass (*H. wrightii)* at the Shell Point and Sanibel salinity monitoring stations.

***Halodule wrightii*: 14-Day Moving Average Water Column Salinity**												
Period	**Days with Damaging Salinity < 5 (%)**			**Days with Stressful Salinity 5 to 15 (%)**			**Days with Optimal Salinity 15 to 45 (%)**			**Days with Stressful Salinity > 45 (%)**		
	Sanibel	**Shell Point**	**Cape Coral**	**Sanibel**	**Shell Point**	**Cape Coral**	**Sanibel**	**Shell Point**	**Cape Coral**	**Sanibel**	**Shell Point**	**Cape Coral**
POR	0	0	23	0	10	41	100	90	35	0	0	0
WY2020	0	0	11	0	5	13	100	95	76	0	0	0
WY2021	0	0	28	0	1	60	100	99	12	0	0	0
WY2022	0	0	11	0	3	80	100	97	9	0	0	0
WY2023	0	0	14	0	6	86	100	94	0	0	0	0
WY2024	0	0	16	0	0	84	100	100	0	0	0	0
WY2025	0	0	24	0	1	72	100	99	4	0	0	0

Large-Scale Monitoring

Large-scale monitoring was conducted in the wet season (June) of WY2025 to determine the variation in the distribution, diversity, and abundance of SAV within the CRE. SAV percent cover was assessed using eight haphazardly placed 0.25-m^2 (50 cm x 50 cm) quadrats at randomly selected sites within the four segments of the CRE (**Figure 8D-28**). Segment A is the most upstream portion of the CRE, where the mean salinity typically remains below 5; however, the segment is tidally influenced, and salinity can exceed 10 during times of low freshwater flow and drought conditions. The middle CRE was divided into two segments, Segment B (upper middle) and Segment C (lower middle). Salinity ranges historically from 0 to 10 in Segment B and from 10 to 28 in Segment C. Segment D includes the lower tidal region of the CRE and extends into San Carlos Bay. The tides strongly influence salinity in Segment D, which ranges from 22 to 35. The mean percent cover of SAV present and the relative SAV species composition within the CRE were determined for WY2025. Relative species composition is the proportion each SAV species contributes to the total SAV abundance within the study area and provides an estimate of the species diversity. Sites without SAV were not included in the relative species composition estimates. SAV percent cover and diversity directly relate to the functionality of SAV habitats as well as their resiliency to and recovery from disturbances (McCloskey and Unsworth 2015, Nowicki et al. 2017, Furman et al. 2019).

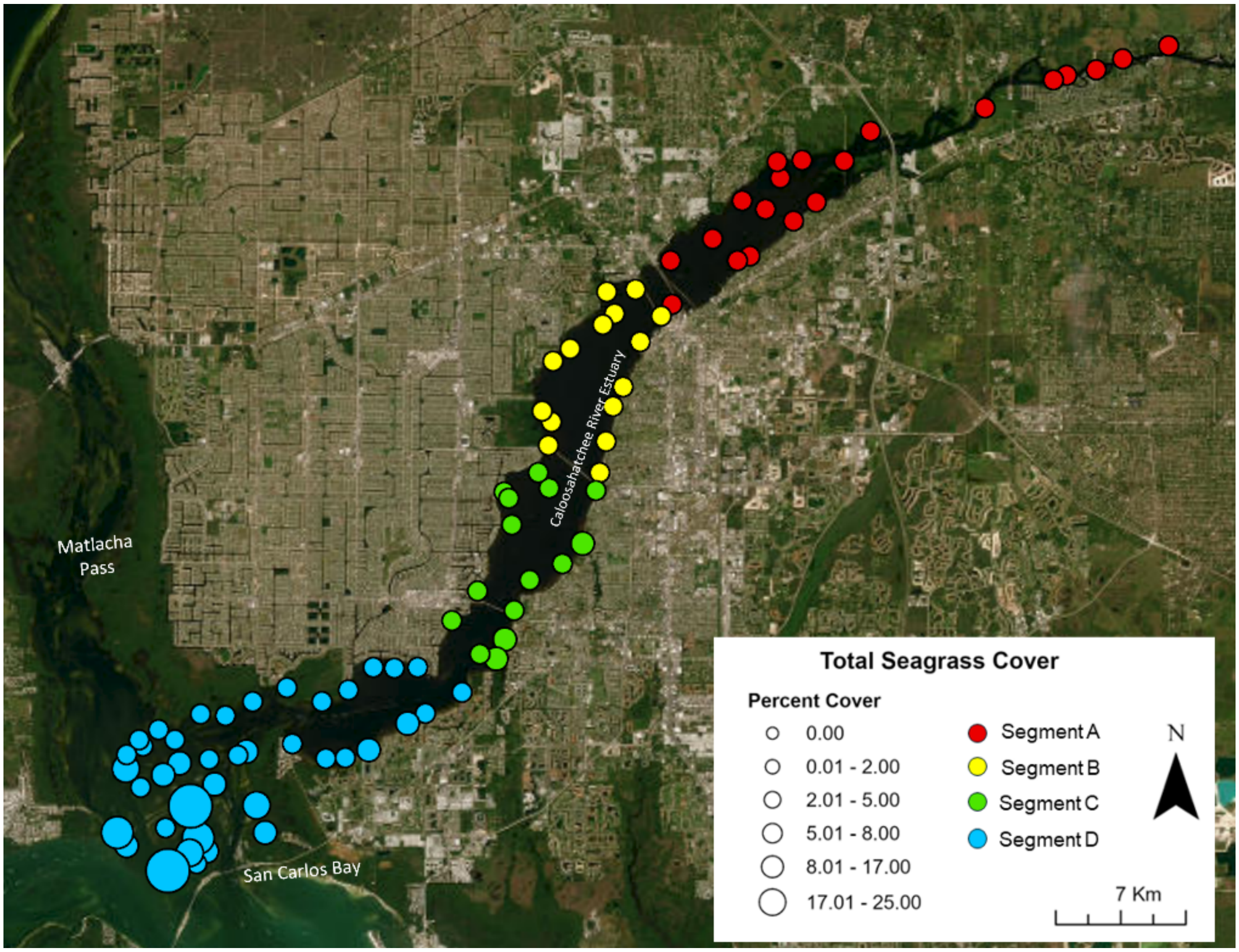


Figure 8D-28. SAV percent cover within the large-scale sampling area of the CRE in WY2025. Each point represents the randomly sampled sites during the wet season throughout the four segments: A (red), B (yellow), C (green), and D (blue). The size of each circle corresponds to the mean total SAV percent cover (0 to 25%).

Total (all observed species) SAV mean percent cover ranged from 0 to 25% throughout the estuary (**Figure 8D-28**). SAV was absent from approximately 79% of the sites (sample size [n] = 90) monitored across all four segments (**Figure 8D-28**). On average, Segment D had the highest overall mean percent cover (± standard error or SE), which was 1.84 ± 0.06%, This is approximately 73% less than the overall cover observed in the segment in WY2024. Overall mean SAV percent cover in Segment C increased to 0.04 ± 0.07% from 0% the previous water year. SAV was not observed in Segments A and B (**Figures 8D-28** and **8D-29**) in WY2025.

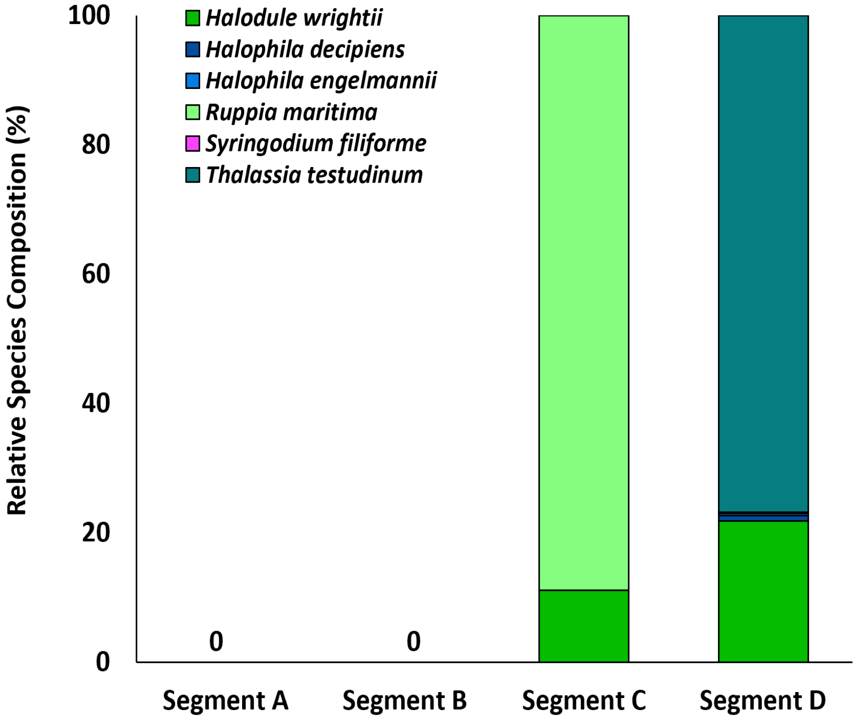


Figure 8D-29. The relative SAV species composition during the WY2025 wet season for Segments A, B, C, and D. The "0" indicates that no SAV was observed in that segment in WY2025.

The distribution of individual species was restricted within each segment based on their physiological tolerances (i.e., salinity). The salinity in Segment D was between 24 and 34 for the entire water year (**Figure 8D-27**), providing optimal conditions for several seagrass species. Five species were observed in Segment D in WY2025, including *H. wrightii*, *Halophila decipiens* (paddle grass), *Halophila engelmannii* (star grass), *Syringodium filiforme* (manatee grass), and *Thalassia testudinum* (turtle grass) (**Figure 8D-29**). The salinity in Segment C was more variable, ranging between 0.3 and 20 with 41 days within the optimal range for *Halodule wrightii* (**Table 8D-9** and **Figure 8D-27**). The large fluctuations in salinity throughout Segment C may have contributed to the persistent low SAV cover in recent water years (**Figure 8D-30**). *Ruppia maritima* (widgeon grass) and *H. wrightii* are euryhaline species capable of tolerating a wide salinity range (**Table 8D-9**), and both were observed in Segment C in WY2025 (**Figure 8D-29**). Although salinity was within the optimal range for *V. americana* in Segment A and the upstream portion of Segment B, the percent of available light was low (**Figure 8D-30**). The combination of suboptimal salinity and reduced light availability creates a stressful environment for SAV, resulting in slow SAV growth and limited recruitment (Morris et al. 2021).

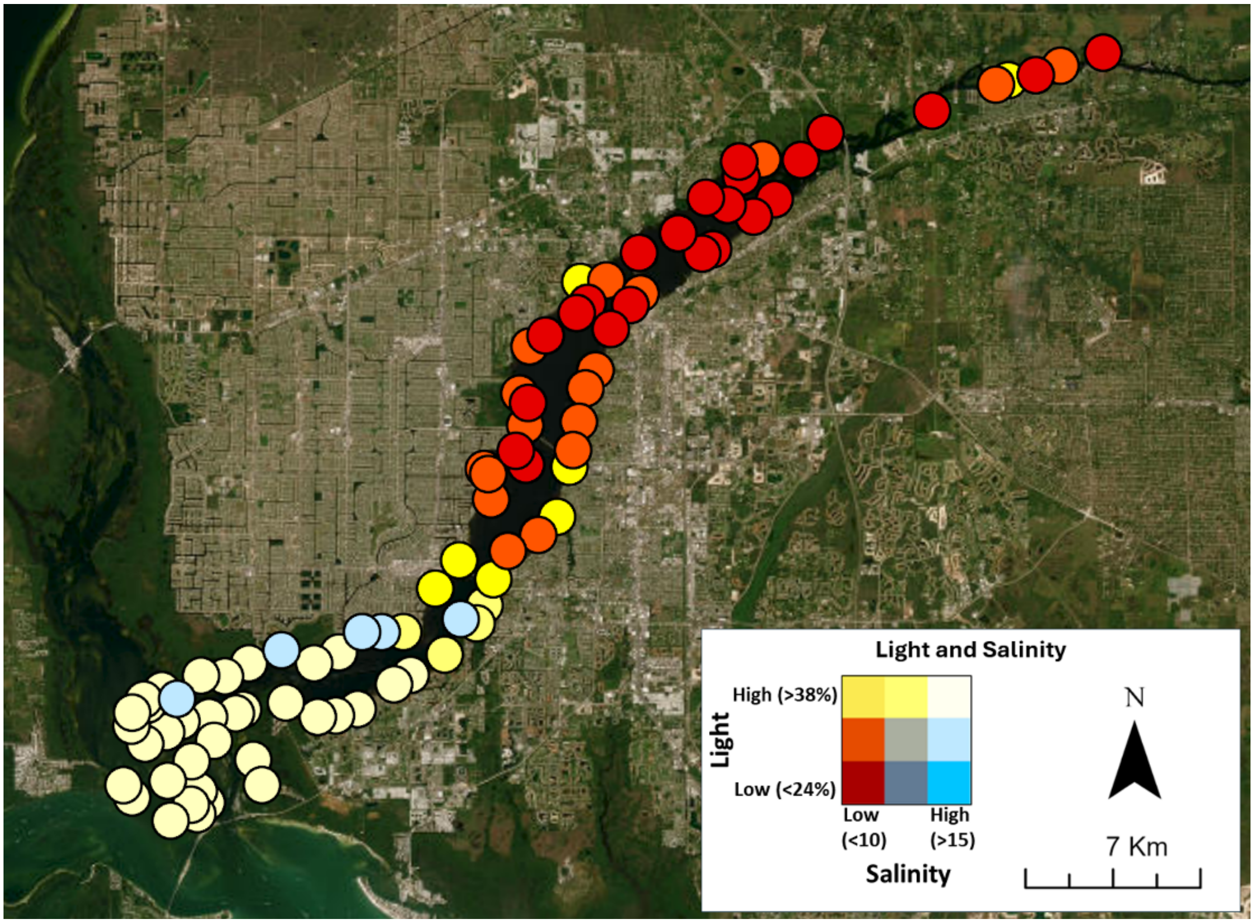


Figure 8D-30. Percent light availability combined with salinity provides a snapshot of the environmental conditions during the June monitoring events in WY2025 (3 days). Dark red circles represent sites with low light and low salinity conditions. Pale yellow circles represent sites with high light availability and high salinity.

Small-Scale Monitoring

Small-scale monitoring using fixed transects was initiated in the WY2019 wet season to allow repeated surveys to be taken at fixed locations at frequent temporal intervals. Transect sites were established in Segment A (upper estuary) and Segment D (lower estuary) to evaluate changes in seagrass percent cover and species diversity (**Figure 8D-25**). The upper estuary transect site, CRE 2, is a shallow, nearshore habitat characterized by soft sand and low salinity (0 to 2). Two transect sites, CRE 5 and CRE 8, are in the lower estuary region. CRE 5 is a shallow, protected, soft sand habitat located between Shell Point and Cape Coral (**Figure 8D-25**). Salinity at CRE 5 can be highly variable and occasionally dip below the optimal range for *H. wrightii* (15 to 45). CRE 8 is a deeper (~2 m), sandy habitat located within San Carlos Bay between two navigational channels. CRE 8 is influenced by tidal fluctuations, with salinity typically ranging from 22 to 35, and is subject to strong currents and wave energy. SAV cover was estimated using a 0.25-m^2 quadrat at 10-m increments along three fixed, parallel 100-m transects quarterly from March through November. Mean total seagrass percent cover (all species present) and percent cover for each species were compared between seasons and water years. Changes in species diversity and dominance were evaluated between seasons and water years using relative species composition.

Mean total SAV percent cover remained under 30% at all three sites in the CRE (**Figure 8D-31**). SAV has not been observed at CRE 2 since the WY2023 wet season. CRE 2 is the furthest upstream transect site and is primarily an oligohaline environment, most suitable for freshwater SAV. Previously, CRE 2 consisted of a low cover (mean < 1%) monoculture of the euryhaline species, *R. maritima*, from WY2021 to the WY2022 wet season until *V. americana* appeared (**Figures 8D-32**). Although salinity remained within the optimal range for *V. americana* for the majority of WY2025 (**Figures 8D-26**), SAV has not reappeared at the site. The low or lack of SAV cover at CRE 2 and throughout the estuary may be the result of reduced light availability at each site (**Figure 8D-33**). Light availability at CRE 2 was frequently measured below the 20% minimum threshold required by *V. americana* for survival and growth (Guan et al. 2020; **Figure 8D-33**).

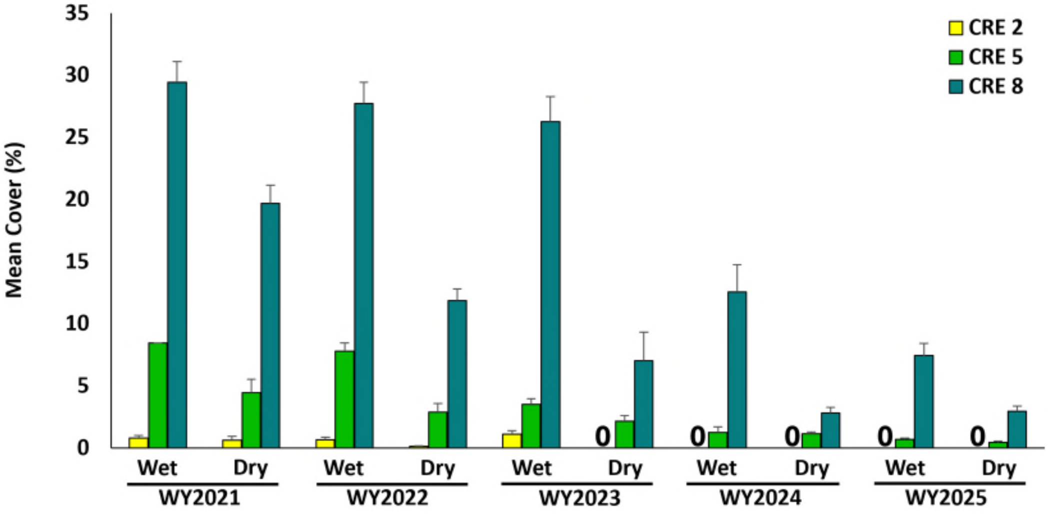


Figure 8D-31. Mean total SAV percent cover (± SE) at the CRE 2 (yellow bars), CRE 5 (green bars), and CRE 8 (teal bars) fixed transect sites from WY2021 through WY2025. SAV was not present (0% cover) at CRE 2 from the WY2023 dry season through WY2025.

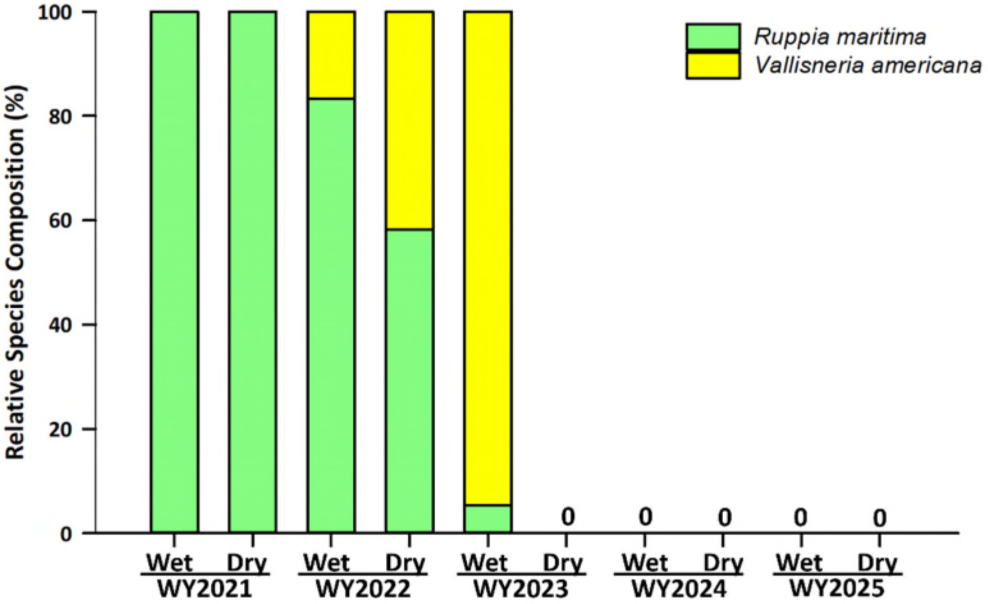


Figure 8D-32. Relative SAV species composition at the CRE 2 site from WY2021 through WY2025. SAV was not present (0% cover) from the WY2023 dry season through WY2025.

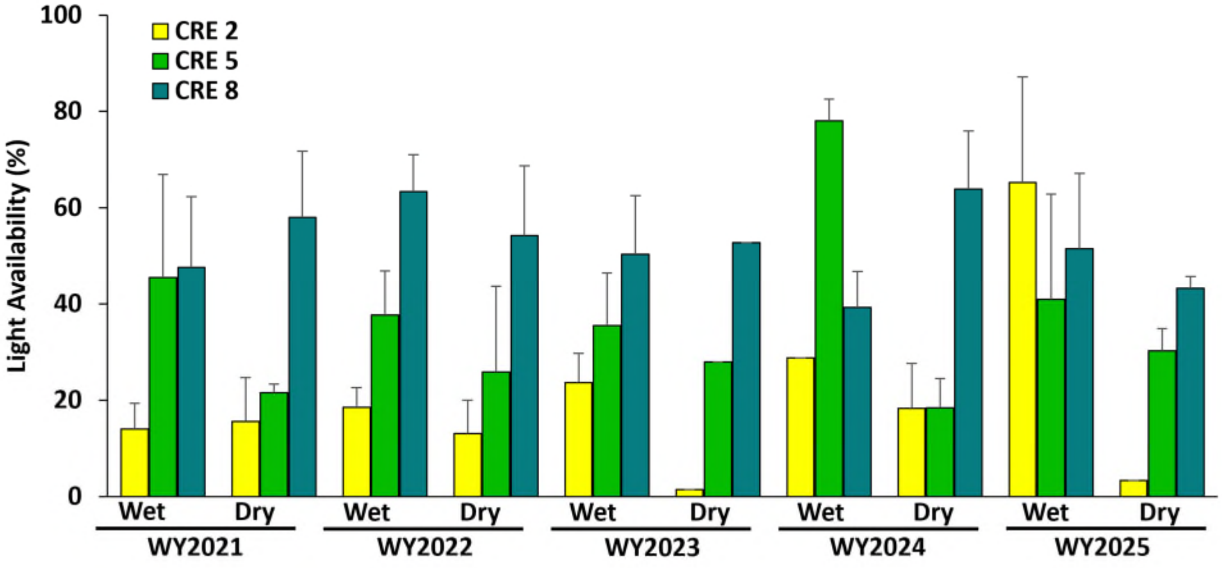


Figure 8D-33. Seasonal percent light availability (mean ± SE) at CRE 2 (yellow bars), CRE 5 (green bars), and CRE 8 (teal bars) fixed transect sites from WY2021 to WY2025. Note: light data were obtained during the quarterly SAV monitoring, providing a snapshot of light availability at each site.

Mean SAV cover at CRE 5 in WY2025 was 0.58 ± 0.06%, which was a 52% decrease from WY2024 (**Figure 8D-31**). **S**ince monitoring began in WY2019, *H. wrightii* has been the dominant SAV at CRE 5 (**Figure 8D-34**). The salinity at the Cape Coral station is representative of the salinity at CRE 5 and ranged between 0.3 and 25 throughout the water year. The large fluctuations in salinity (**Figures 8D-27**), combined with variability in light availability (**Figure 8D-33**) most likely contributed to the sparse SAV cover observed at the site. Dry conditions at the end of WY2025 resulted in higher salinity (**Figure 8D-27**), allowing marine SAV species like *Halophila decipiens* to colonize the site (**Figure 8D-34**).

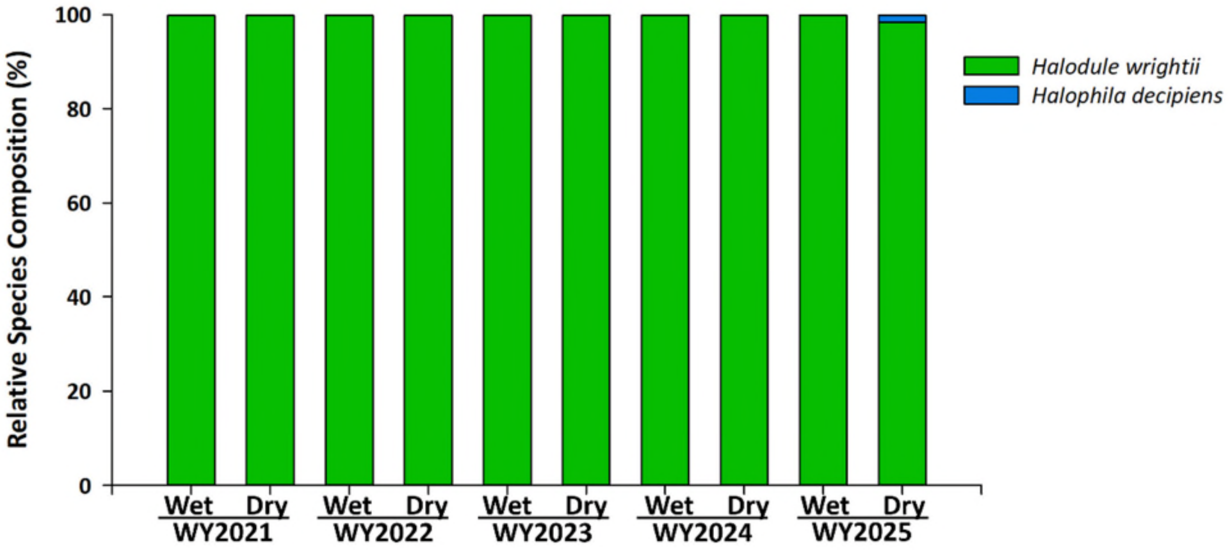


Figure 8D-34. Relative SAV species composition at the CRE 5 site from WY2021 through WY2025.

CRE 8 is the only site with persistent SAV cover and subsequently has the highest mean (± SE) SAV percent cover (5.2 ± 1.1%) among the three sites. Cover declined by more than 32% over the last water year, reaching its lowest recorded value (**Figure 8D-31**) since monitoring began in WY2019. Approximately 29% of *H. wrightii* cover was lost between the WY2024 and WY2025 wet seasons despite salinity being in the optimal range for *H. wrightii* 100% of the time in WY2025 compared to previous years (**Figure 8D-27**). *T. testudinum* has a higher optimal salinity range than *H. wrightii* (**Table 8D-9**) and is more susceptible to a reduction in cover when salinity drops below 24. Though *T. testudinum* cover declined by approximately 54% between the wet seasons of both water years, it remained the dominant species in WY2025 (**Figure 8D-35**). *Halophila decipiens*, an ephemeral species usually observed in the wet season, cover increased in WY2025 and contributed approximately 7% to the total SAV cover (**Figure 8D-35**). The decline in SAV cover at this site may be the result of salinity lower than the optimal ranges for *T. testudinum*, *S. filiforme*, and *H. decipiens*, though light availability was within optimal levels (> 20%) (Morris et al. 2021; **Figures 8D-27**, **8D-33**, and **8D-34**).

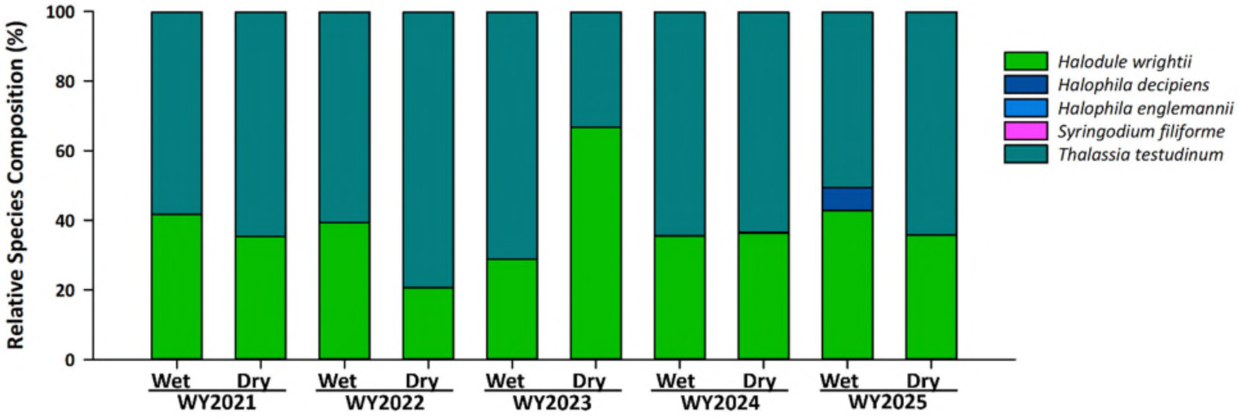


Figure 8D-35. Relative SAV species composition at CRE 8 from WY2021 to WY2025.

Percent cover of SAV remained low (< 20%) throughout the CRE with most of the cover occurring in the lower portions of the estuary. The loss of SAV over the last few years was most likely the result of prolonged periods of salinity below the SAV optimal thresholds throughout the middle and lower portions of the estuary (**Figure 8D-27**), where most SAV was observed. While optimal salinity is important for survival, other environmental parameters and disturbances can affect SAV distribution and density. Freshwater inputs (e.g., managed lake releases and basin runoff) not only lower salinity but may also lead to increased CDOM or resuspended sediments, which reduce the available light needed for SAV growth and survival. The loss of SAV throughout the estuary may be the result of reduced light availability due to changes in water clarity (**Figures 8D-30** and **8D-33**). Other physical disturbances, such as excessive waves and currents can also affect SAV distribution and density, especially in high energy environments (Stevens and Lacey 2012). Wave energy from wind, tides, and boat traffic directly impacts shallow SAV sites. Excessive exposure to such physical disturbances contributes to particle resuspension (reducing light) and sediment erosion, which can result in the burial of diminutive SAV species such as the *Halophila* spp., patchy beds, or their absence (Koch et al. 2007). The differences in total SAV cover throughout the CRE reflect the variability of site-specific characteristics (e.g., salinity, light availability, and wave energy) and species composition within each site.

PART III: CALOOSAHATCHEE RIVER WATERSHED CONSTRUCTION PROJECT

In accordance with the NEEPP, the Caloosahatchee River Watershed Construction Project (CRWCP) consists of projects and programs to improve the hydrology and water quality of the CRE. SFWMD provides updates to the CRWCP to ensure that it is consistent with the CRE BMAP adopted pursuant to Section 403.067, F.S., and conducts annual reviews of the CRWCP to maintain transparency and accountability in the BMAP process and to assist in progressively achieving TMDLs.

Part III of Chapter 8D describes how the collective efforts of the Coordinating Agencies—FDEP, FDACS, and SFWMD—contribute to the CRWPP and documents progress made for the reporting period. Information is summarized within the following subsections:

- Overview of Project Benefits
- Overview of Programs
- Basin Updates

The CRWCP is SFWMD's comprehensive strategy for tracking project and program benefits (e.g., water storage/attenuation and nutrient reduction) and planning new efforts to assist in achieving the CRE TMDL and other watershed restoration objectives. This iterative strategy utilizes an adaptive management approach consistent with FDEP's BMAP process and the Florida Watershed Restoration Act, Subparagraph 403.067(7)(a)1, F.S. The CRWCP annual review considers the latest results of the RWQMP (Parts I and II above) and project-specific monitoring to verify project benefits and identify new projects. This approach allows for improved hydrology, water quality, and aquatic habitat through implementation of projects and programs while simultaneously monitoring system conditions and researching important environmental dynamics (sources and response variables) for improved management.

A key aspect of the annual CRWCP review is the basin updates. The objective of the updates is to relate project and program activities within each basin to measured progress in hydrology and water quality metrics. The sections below present basin characteristics, such as descriptions of the regional drainage system and basin-level monitoring stations. Information on basin upstream-level monitoring stations can be found in Appendix 8D-1 of this volume. Basin updates also present an inventory of Coordinating Agencies projects and associated attributes including location, status (e.g., planning, design, construction, and operation), and project benefits (storage and nutrient reductions).

Basin updates also lay the foundation for more detailed assessments, which focus additional resources on priority areas by gathering information, identifying water quality concerns, evaluating existing and planned projects, and recommending strategic actions where deficits can be identified. Basin-specific detailed assessments within priority areas are underway. The *Focus Assessment Report for the West Caloosahatchee Basin* was published in October 2024 (Olson et al. 2024). As part of the 2025 CRWPP 5-Year Update, a high-level assessment for the CRW was presented in the final 2025 SFER – Volume I, Appendix 8D-3 (Acevedo and Olson 2025).

OVERVIEW OF PROJECT BENEFITS

As hydrologic and water quality concerns are identified, this information is used to develop new projects, refine existing projects, and make effective progress in achieving the CRE TMDL and Caloosahatchee tributaries TMDLs (FDEP 2020).

The CRWCP static storage target is 400,000 ac-ft (SFWMD et al. 2009, Frye et al. 2025), and the CRE BMAP compliance load for TN is 1,383 t (FDEP 2022). Static storage in a water detention project is defined as the volume retained at maximum capacity, usually up to the point of discharge. In contrast, dynamic storage considers the total volume held throughout a particular period (i.e., a water year), considering storage changes from hydrologic conditions and project operations, and it is typically reported to assess performance over time (**Figure 8D-36**). Both types of storage are presented in the tables below. In some instances, initial estimates for dynamic storage match the static storage until the project is further along in design or operational.

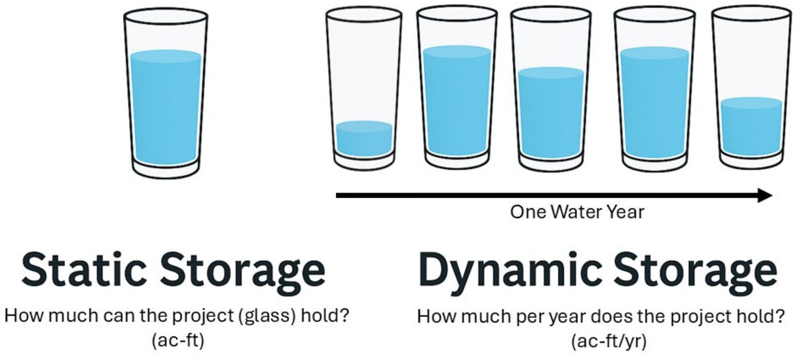


Figure 8D-36. Conceptual illustration of static versus dynamic storage.

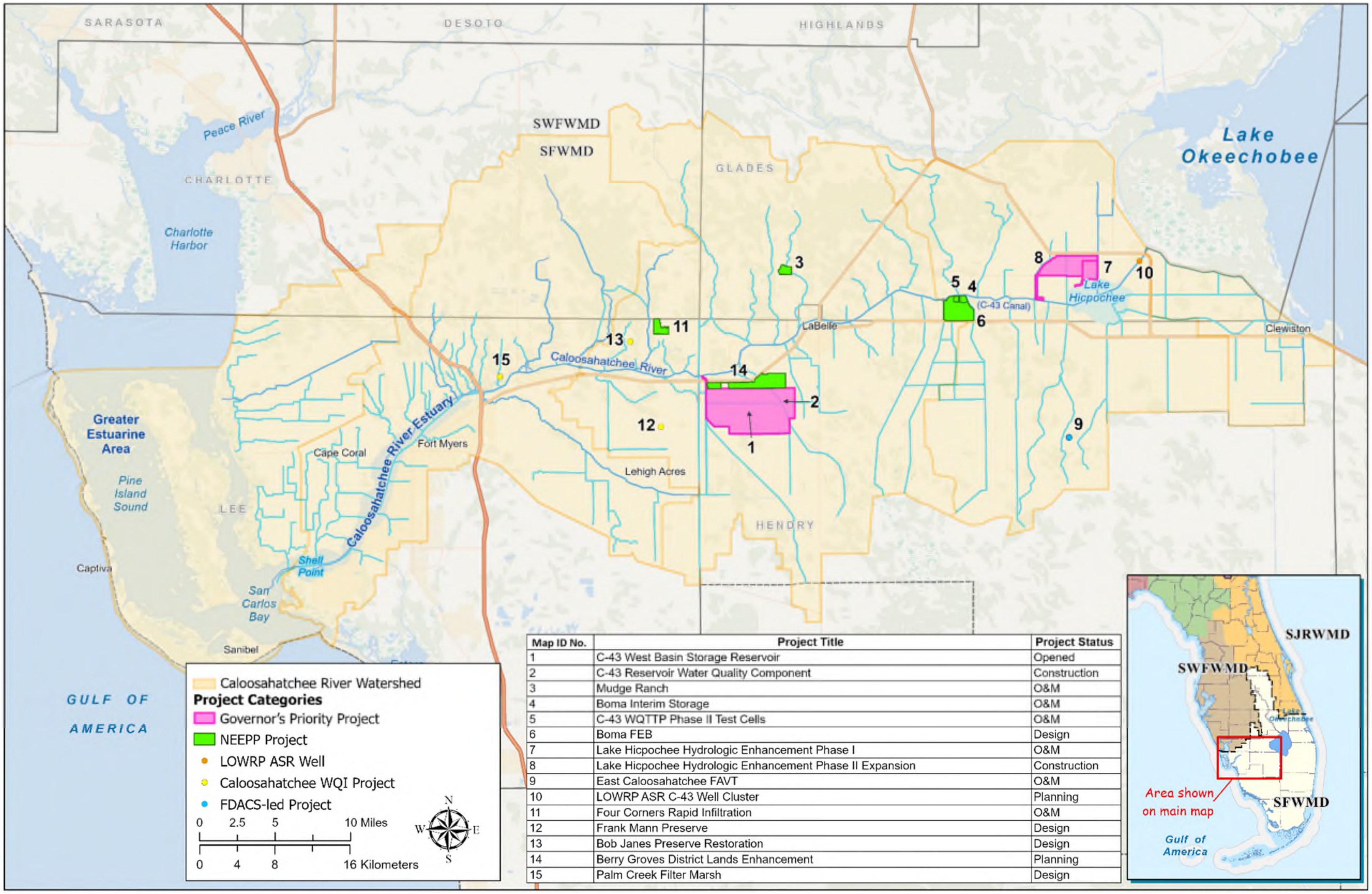
As part of the 2025 CRWPP 5-Year Update, SFWMD undertook a comprehensive reevaluation of storage in the Northern Everglades watersheds. The reevaluation built upon the *Lake Okeechobee Watershed Construction Project Phase II Technical Plan* (SFWMD et al. 2008) and the 2009 CRWPP (SFWMD et al. 2009) and utilized the Regional Simulation Model – Basins (RSMBN) to evaluate existing, future, and various potential alternatives. The RSMBN assessment included an updated evaluation of existing CRWCP planning targets (400,000 ac-ft of static storage) and estimated the impact of planned and conceptual water storage and treatment projects to improve watershed objectives (e.g., Minimum Flow and Minimum Water Level [MFL] compliance, estuary salinity targets). The CRWCP storage planning target of 400,000 ac-ft includes an estimated 195,000 ac-ft of storage in current and future planned projects and an estimated 205,000 ac-ft of unmet storage needs to be developed and implemented as part of the iterative CRWCP process. Additional information regarding the Northern Everglades and Estuaries Protection Planning and Regional Simulation Model Update can be found in the final 2025 SFER – Volume I, Appendix 8A-1 (Frye et al. 2025). Note that the model static storage numbers may not reflect storage numbers present in **Table 8D-13** as the model represents a certain point in time. The static storage numbers in **Table 8D-13** include the latest information.

Table 8D-13. Estimates of static storage, dynamic storage, and estimated nutrient removal for planned and existing projects along with WY2025 storage and nutrient removal estimates for select Coordinating Agencies' existing projects in each basin.

Basin	Project Static Storage (ac-ft)	Project Estimated Dynamic Storage (ac-ft/yr)	WY2025 Dynamic Storage (ac-ft/yr)	Estimated TP Removal (t/yr)	WY2025 TP Removal Performance (t/yr)	Estimated TN Removal (t/yr)	WY2025 TN Removal Performance (t/yr)
East Caloosahatchee	16,969	21,292	761	9.0	2.4	64.2	14.8
West Caloosahatchee	181,603	194,209	25,282	5.4	5.4	77.0	38.9
Tidal	18	18	0	0.3	0.0	2.1	0.0
S-4	-	-	-	-	-	-	-
CRW Totals [a]	**198,590**	**215,519**	**26,043**	**14.7**	**7.8**	**143.3**	**53.7**

a. Totals do not include projects where information is unavailable and do not include other BMAP efforts within the basin. The estimated storage and nutrient removal totals include planning numbers.

A summary of WY2025 project reductions, storage, and estimated project benefits is provided in **Table 8D-13**. Note, in this table and throughout data reporting in this section, WY2025 dynamic storage and nutrient (TP and TN) removal reflect measured data collected for projects in operation. Also, note that **Tables 8D-13**, **8D-14**, **8D-16**, and **8D-18** include information on planned as well as operating projects for static storage, estimated dynamic storage, and the estimated nutrient removals. Inclusion of planning estimates for future projects provides the information needed to determine how much and where future reductions are expected, which informs project decision making. Also, as part of the protection plan process, future project reductions are compared to water quality data to determine where additional projects are needed (Acevedo and Olson 2025). It should also be noted that project planning estimates are based on long-term timeframes, five years or more, and are developed using an assortment of methods each having a wide variety of assumptions. Actual annual project performance can vary from year to year based on rainfall, hydrology, operations, etc., so the results can be higher or lower than the estimated long-term averages. In the CRW, select Coordinating Agency projects removed an estimated 7.8 t of TP load and 53.7 t of TN load from operating projects in WY2025. FDEP's *2024 Statewide Annual Report on Total Maximum Daily Loads, Basin Management Action Plans, Minimum Flows or Minimum Water Levels, and Recovery or Prevention Strategies* (FDEP 2025) provides the estimated total TP and TN reductions from all completed and ongoing BMAP projects through December 31, 2024. The Caloosahatchee River and Estuary BMAP (FDEP 2020) states: "To achieve the TMDLs within the required 20 years, stakeholders must identify and submit additional local projects and the Coordinating Agencies (DEP, Florida Department of Agriculture and Consumer Services [FDACS], and South Florida Water Management District [SFWMD]) must identify additional regional projects as well as determine the significant funding that will be necessary. Enhancements to programs addressing basin-wide sources will also be required." Additional reductions can be accomplished through projects and programs implemented by local BMAP stakeholders and the Coordinating Agencies. An overview of the CRW and select Coordinating Agency projects is provided in **Figure 8D-37**. Refer to the CRE BMAP (FDEP 2020) and Statewide Annual Report (FDEP 2025) for a comprehensive list of other local stakeholder projects.



Map ID No.	Project Title	Project Status
1	C-43 West Basin Storage Reservoir	Opened
2	C-43 Reservoir Water Quality Component	Construction
3	Mudge Ranch	O&M
4	Boma Interim Storage	O&M
5	C-43 WQTTP Phase II Test Cells	O&M
6	Boma FEB	Design
7	Lake Hicpochee Hydrologic Enhancement Phase I	O&M
8	Lake Hicpochee Hydrologic Enhancement Phase II Expansion	Construction
9	East Caloosahatchee FAVT	O&M
10	LOWRP ASR C-43 Well Cluster	Planning
11	Four Corners Rapid Infiltration	O&M
12	Frank Mann Preserve	Design
13	Bob Janes Preserve Restoration	Design
14	Berry Groves District Lands Enhancement	Planning
15	Palm Creek Filter Marsh	Design

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Figure 8D-37. Overview of the CRW and select Coordinating Agency projects.
(Note: Circles depicted on map are centroids of the general location and do not represent the boundary for project area.
Key to abbreviations: ASR – Aquifer Storage and Recovery; FAVT – Floating Aquatic Vegetative Technology;
FEB – Flow Equalization Basin; LOWRP – Lake Okeechobee Watershed Restoration Project; O&M – Operations and Maintenance;
WQI – Water Quality Improvement; and WQTTP – Water Quality Treatment and Testing Project.)

OVERVIEW OF PROGRAMS

Table 8B-13 in Chapter 8B of this volume provides an overview of existing nutrient source control programs. These incentive-based and regulatory programs of the Coordinating Agencies are essential for controlling nutrients at the source and reducing nutrient loads to Lake Okeechobee. Both point and nonpoint nutrient sources are addressed through these collective programs (SFWMD et al. 2011). SFWMD is responsible for two source control programs: (1) Environmental Resource Permitting (ERP) and (2) Chapter 40E-61, Florida Administrative Code (F.A.C.). Updates on FDACS and FDEP programs can be found in Chapter 8A of this volume.

SFWMD's ERP program regulates any activity involving the alteration of surface water flows and includes residential and commercial development, roadway construction, and agriculture. An operating agreement specifies the division of responsibilities between FDEP and SFWMD and is used to determine which agency processes the ERP applications. Senate Bill 712 required FDEP and the water management districts to initiate rulemaking to update ERP rules to include best management practices (BMPs) and design criteria to increase the removal of nutrients from stormwater discharges. In response, SFWMD published a Notice of Rule Development regarding Rule 40E-4.091 on December 18, 2020. SFWMD has updated the *Environmental Resource Permit Applicant's Handbook Volume II for Use Within the Geographic Limits of the South Florida Water Management District* (SFWMD 2024) in conjunction with FDEP's rulemaking effort in accordance with Section 5 of Chapter 2020-150, Laws of Florida, to update the stormwater design and operation regulations adopted under Section 373.4131, F.S., using the most recent scientific information available. FDEP and SFWMD have developed amendments to update the stormwater design and operation regulations and have considered and addressed low-impact design BMPs and design criteria that increase the removal of nutrients from stormwater discharges, and measures for consistent application of the net improvement performance standard to ensure significant reductions of any pollutant loadings to a water body. FDEP's rulemaking includes amendments to Chapter 62-330, F.A.C., and the *Environmental Resource Permit Applicant's Handbook Volume I (General and Environmental)* (FDEP et al. 2024) that applies statewide. SFWMD adopted its rule on April 13, 2023, and FDEP adopted its rule on April 28, 2023. Senate Bill 7040 ratified the rule, which became effective on June 28, 2024.

Under the 2016 NEEPP legislation, SFWMD was directed to amend Chapter 40E-61, F.A.C., to provide a monitoring program for nonpoint source dischargers that are required to monitor water quality under Section 403.067, F.S. In 2020, SFWMD conducted a series of public workshops related to the amendments, and amendments to Chapter 40E-61 became effective in April 2021. The rules were expanded to encompass the entirety of the three Northern Everglades watersheds and provide a monitoring program for nonpoint source dischargers not implementing BMPs to submit a SFWMD-approved water quality monitoring plan and regularly report associated monitoring data.

BASIN UPDATES

A basin update is presented for each of the basins within the CRW: S-4, East Caloosahatchee, West Caloosahatchee, and Tidal Basin. General hydrologic characteristics are described and comprehensive updates for CRWCP projects are provided for each basin.

Each basin section presents updates for projects where SFWMD is the lead agency or provides funding and other select Coordinating Agency projects. Closed projects which are no longer active and providing water quality benefits are not included in the tables.

The first table in each basin section provides general information about the projects and lists the status as of the end of FY2025. Projects may be described as passive storage, when the primary objective is to retain direct rainfall and reduce runoff to the regional system, or active storage where project inflow is actively pumped from the regional drainage system into the project for storage. This table also contains information for storage capacity (static and dynamic) and nutrient retention associated with each project and summarized for the basin. Note that all basins are also aggregated in **Table 8D-13**. Project estimates represent expected long-term annual average performance based on observed data or a model simulation. Project-specific monitoring data are analyzed to determine actual WY2025 project benefits. In addition to the benefits quantified here, projects may provide a myriad of secondary benefits such as wetland hydration, groundwater recharge, and flow attenuation, among others. A detailed description of all projects can be found at the end of this chapter in **Table 8D-20**.

The second table in each basin section displays a project timeline including the project phase for the past 7 years and projected phase(s) for the next 5 fiscal years. Associated costs for each project, including total project costs and planned 5-year (FY2026–FY2030) funding information for SFWMD-funded BMAP projects, are presented in Volume II, Appendix 5A-1.

Lastly, results from SFWMD's comprehensive upstream monitoring program within each basin can be found in Appendix 8D-1 of this volume.

S-4 Basin

The S-4 Basin has a total drainage area of approximately 42,145 ac (17,055 ha). It is in northeastern Hendry County and southeastern Glades County. Approximately 15 miles of the northern boundary of the S-4 Basin runs adjacent to Lake Okeechobee. The major drainage canals in the basin include the L-D1 perimeter, C-20, C-21, and Clewiston (Industrial) canals. There are four main structures that regulate flow within the S-4 Basin: S-4 pump station (located at the northern end of the C-20 Canal) that controls flow from the basin into Lake Okeechobee; S-310 navigational lock structure (located between Lake Okeechobee and the Clewiston Canal); S-169 (a series of three-gated culverts connecting the Clewiston and C-21 canals); and S-235 (a pair of gated culverts connecting the L-D1 and C-43 canals). This highly managed drainage basin can discharge to either the Caloosahatchee River (via S-235) or Lake Okeechobee (via S-4 and S-310) according to operational decisions and based on larger regional conditions. The CRWPP addresses only the S-4 Basin's contribution to the CRE. The Lake Okeechobee Watershed Protection Plan considers flow from the S-4 Basin into Lake Okeechobee (see Chapter 8B of this volume).

There are no projects located within the S-4 Basin. The S-4 Basin drainage area and monitoring sites are shown in **Figure 8D-38**.

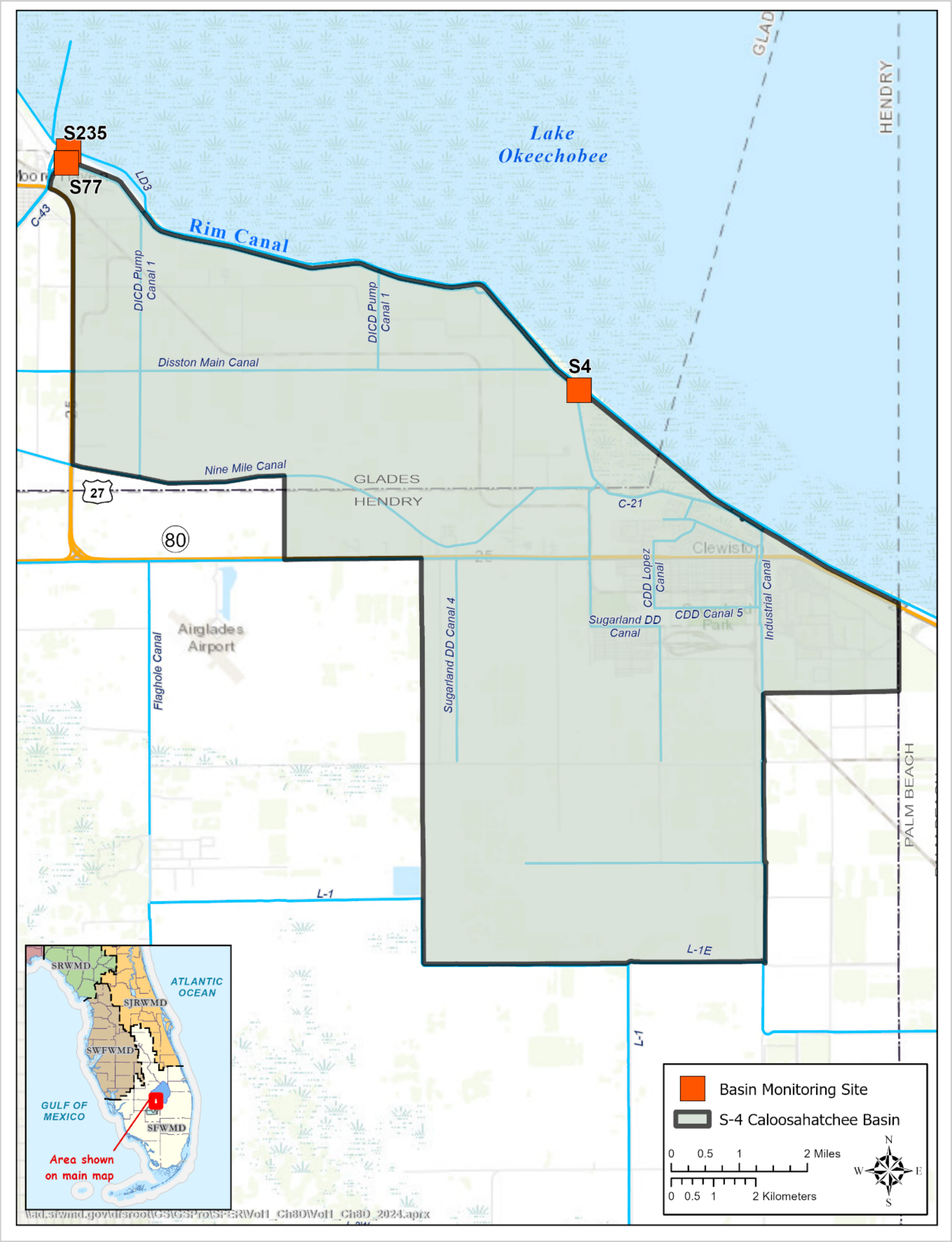


Figure 8D-38. S-4 Basin drainage area and monitoring sites.

East Caloosahatchee Basin

The East Caloosahatchee Basin is in southern Glades County and northern Hendry County. It has a total drainage area of approximately 221,689 ac (89,714 ha). The primary conveyance in the basin is the C-43 Canal (Caloosahatchee River). Two control structures are in the basin: S-77 gated spillway (Moore Haven Lock and Dam) and S-78 gated spillway (Ortona Lock and Dam). The C-43 Canal is intersected by Lake Hicpochee about five miles west of S-77. Water surface elevations in the basin are regulated by the S-78 gated spillway and regulatory releases from Lake Okeechobee are made by way of the S-77 gated spillway. Water flows north to south in the C-19 Canal before discharging into Lake Hicpochee and before entering the C-43 Canal (SFWMD et al. 2009).

Projects within the East Caloosahatchee Basin are displayed in **Figure 8D-39** and described in **Table 8D-14**. A timeline for each project and FY2025 project status is shown in **Table 8D-15**. Significant projects and key milestones that were accomplished in the East Caloosahatchee Basin during the reporting period are listed below:

- Roadrunner C-43 Nutrient Load Reduction, a treatment project, had its agreement executed in March 2025. The project is expected to be operational by WY2026.
- Lake Hicpochee Hydrologic Enhancement Phase II Expansion, a flow equalization basin (FEB) project, began construction in 2025 and is expected to be completed in 2028.
- The Boma FEB is scheduled to complete final design in August 2025. Construction of the approximately 1,600-ac facility is expected to be completed in early 2029.

Lastly, it should be noted that Lake Okeechobee Watershed Restoration Project (LOWRP) Aquifer Storage and Well Cluster is also planned for this basin. For more information on LOWRP ASR, see the Regional Projects section of Chapter 8B of this volume.

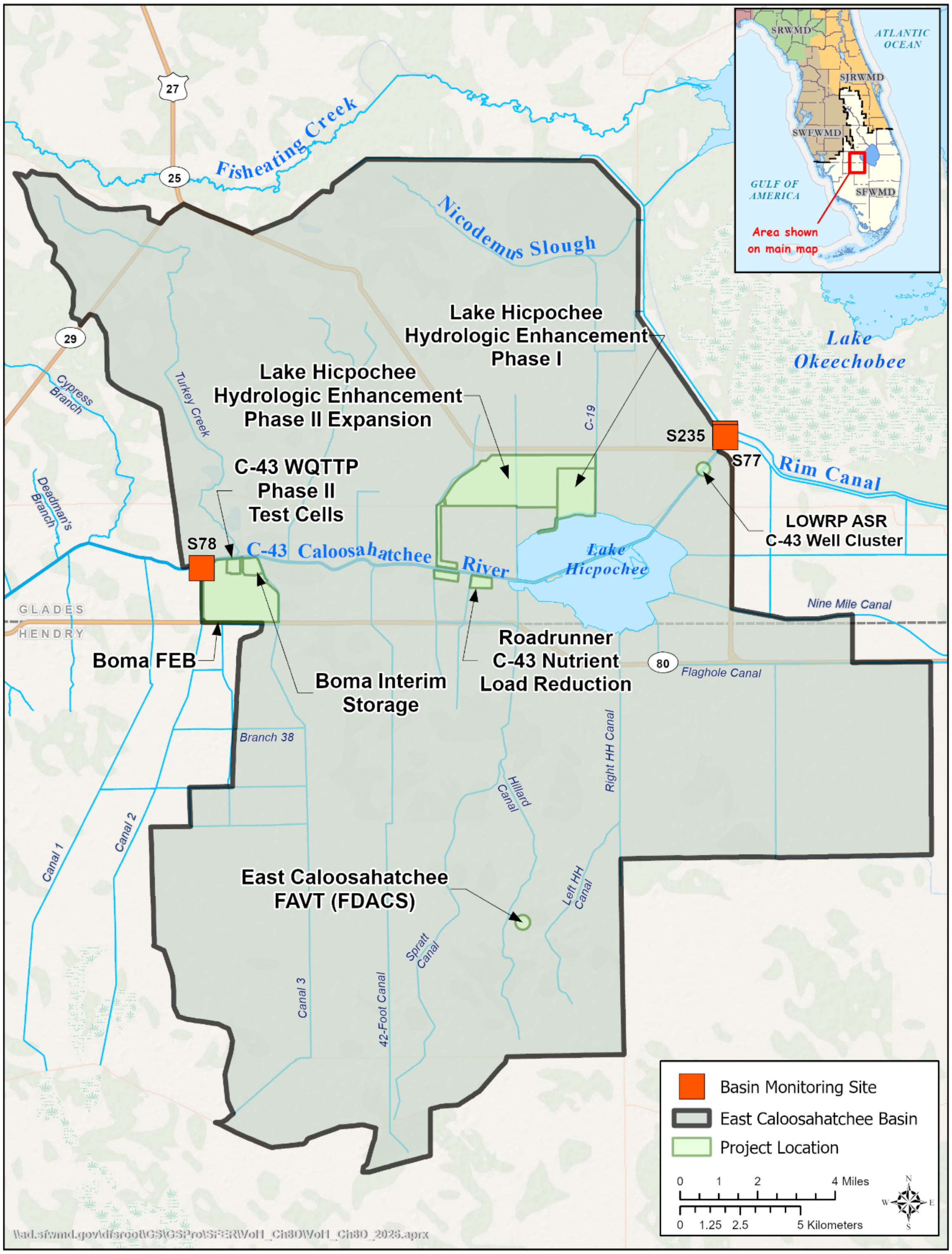


Figure 8D-39. Current projects in the East Caloosahatchee Basin.
(Note: WQTTP – Water Quality Treatment and Testing Project.)

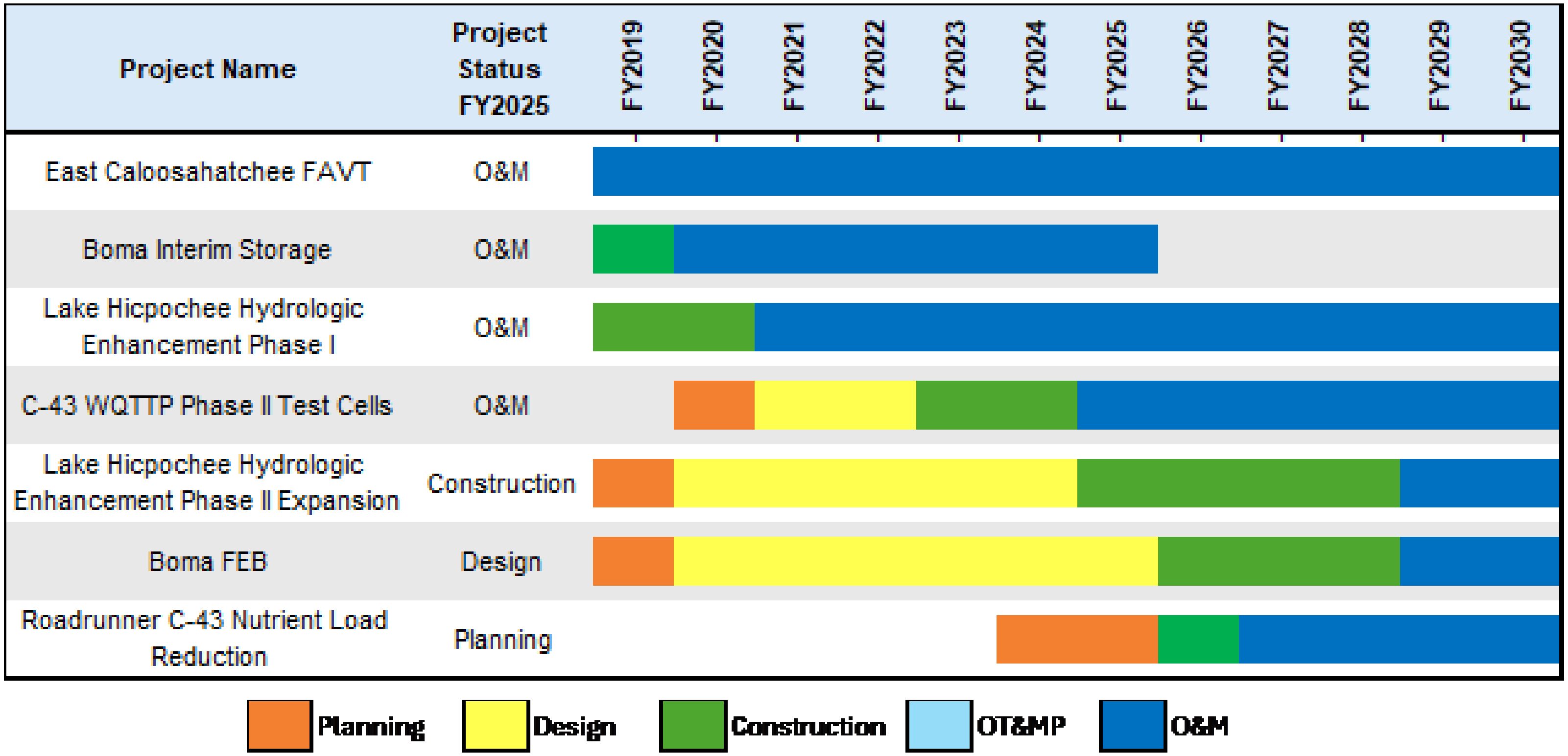
Table 8D-14. Estimates of static storage, dynamic storage, and estimated nutrient removal for planned and existing projects along with WY2025 storage and nutrient removal estimates for select Coordinating Agencies' existing projects in the East Caloosahatchee Basin (N/A – not applicable).

Project Name	Project Area (ac)	Project Status FY2025	Project Type	Static Storage (ac-ft)	Estimated Dynamic Storage (ac-ft/yr)	WY2025 Dynamic Storage (ac-ft/yr)	Estimated TP Removal (t/yr)	WY2025 TP Removal Performance (t/yr)	Estimated TN Removal (t/yr)	WY2025 TN Removal Performance (t/yr)
East Caloosahatchee Floating Aquatic Vegetation Tilling (FAVT)	540	O&M	FAVT	N/A	N/A	N/A	2.6	2.3	16.8	14.5
Boma Interim Storage	143	O&M	Dispersed Water Management (DWM) - Active	396	2,724	761	0.3	0.1	3.6	0.3
Lake Hicpochee Hydrologic Enhancement Phase I	659	O&M	FEB	1,690	3,310	- [a]	1.8	- [a]	11.9	- [a]
C-43 Water Quality Treatment and Testing Project (WQTTP) Phase II Test Cells	80	O&M	Study	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Lake Hicpochee Hydrologic Enhancement Phase II Expansion	2,194	Construction	FEB	7,683	8,058	-	N/A	-	N/A	-
Boma FEB	1,796	Design	FEB	7,200	7,200	-	N/A	-	N/A	-
Roadrunner C-43 Nutrient Load Reduction	150	Planning	Water Quality	N/A	N/A	N/A	4.3	-	31.9	-
East Caloosahatchee Basin totals [b]				**16,969**	**21,292**	**761**	**9.0**	**2.4**	**64.2**	**14.8**

a. Lake Hicpochee Hydrologic Enhancement Phase I project benefits are not available for WY2025.

b. Totals do not include projects where information is unavailable and do not include other BMAP efforts within the basin. The estimated storage and nutrient removal totals include planning numbers.

Table 8D-15. Project timeline for current projects in the East Caloosahatchee Basin. [a]



Project Name	Project Status FY2025	FY2019	FY2020	FY2021	FY2022	FY2023	FY2024	FY2025	FY2026	FY2027	FY2028	FY2029	FY2030
East Caloosahatchee FAVT	O&M	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
Boma Interim Storage	O&M	🟩	🟦	🟦	🟦	🟦	🟦	🟦					
Lake Hicpochee Hydrologic Enhancement Phase I	O&M	🟩	🟩	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
C-43 WQTTP Phase II Test Cells	O&M		🟧	🟨	🟨	🟩	🟩	🟦	🟦	🟦	🟦	🟦	🟦
Lake Hicpochee Hydrologic Enhancement Phase II Expansion	Construction	🟧	🟨	🟨	🟨	🟨	🟨	🟩	🟩	🟩	🟩	🟦	🟦
Boma FEB	Design	🟧	🟨	🟨	🟨	🟨	🟨	🟨	🟩	🟩	🟩	🟦	🟦
Roadrunner C-43 Nutrient Load Reduction	Planning						🟧	🟧	🟩	🟦	🟦	🟦	🟦

🟧 Planning 🟨 Design 🟩 Construction 🟦 OT&MP 🟦 O&M

a. FAVT – Floating Aquatic Vegetation Tilling and WQTTP – Water Quality Treatment and Testing Project.

West Caloosahatchee Basin

A majority of the West Caloosahatchee Basin is in southern Glades and northern Hendry counties, with smaller portions in eastern Charlotte, northeastern Lee, and north-central Collier counties. It has a total drainage area of 349,589 ac (141,474 ha). The primary conveyance in the West Caloosahatchee Basin is the C-43 Canal. Two control structures are in the basin: S-78 gated spillway and S-79 gated spillway (also known as the W.P. Franklin Lock and Dam). S-78 aids in control of water levels on adjacent lands upstream. The S-79 is the most downstream structure and marks the beginning of the CRE. S-79 helps maintain specific water levels upstream, regulates freshwater discharges into the estuary, and serves as an impediment to saltwater intrusion upstream (SFWMD et al. 2009).

Projects within the West Caloosahatchee Basin are displayed in **Figure 8D-40** and described in **Table 8D-16**. A timeline for each project and FY2025 project status is shown in **Table 8D-17**. Significant projects and key milestones that were accomplished in the West Caloosahatchee Basin during the reporting period:

- As a key priority project, the CERP Caloosahatchee River (C-43) West Basin Storage Reservoir project was opened in July 2025.
- The NEEPP C-43 West Basin Storage Reservoir Water Quality Component is a treatment project to design, construct, and operate an Inline Alum Injection System that reduces nutrient loading in the C-43 Reservoir and helps prevent algal growth within the reservoir. A construction Notice to Proceed was issued on November 1, 2024, with completion planned for FY2026.
- Berry Groves District Lands Enhancement is a passive storage project. Conceptual design was started in early 2025 and is expected to be complete by January 2026.
- Frank Mann Preserve is a restoration project that will provide water storage and quality treatment. Phase I construction is expected to begin in August 2026, with completion by December 2027 and operations starting in January 2028. Phase II is expected to begin construction in October 2027, be completed by May 2029, and begin operations in June 2029. Note, although construction is divided into two phases, **Table 8D-17** presents the full construction period as a single continuous timeline, from the start of Phase I to the end of Phase II.

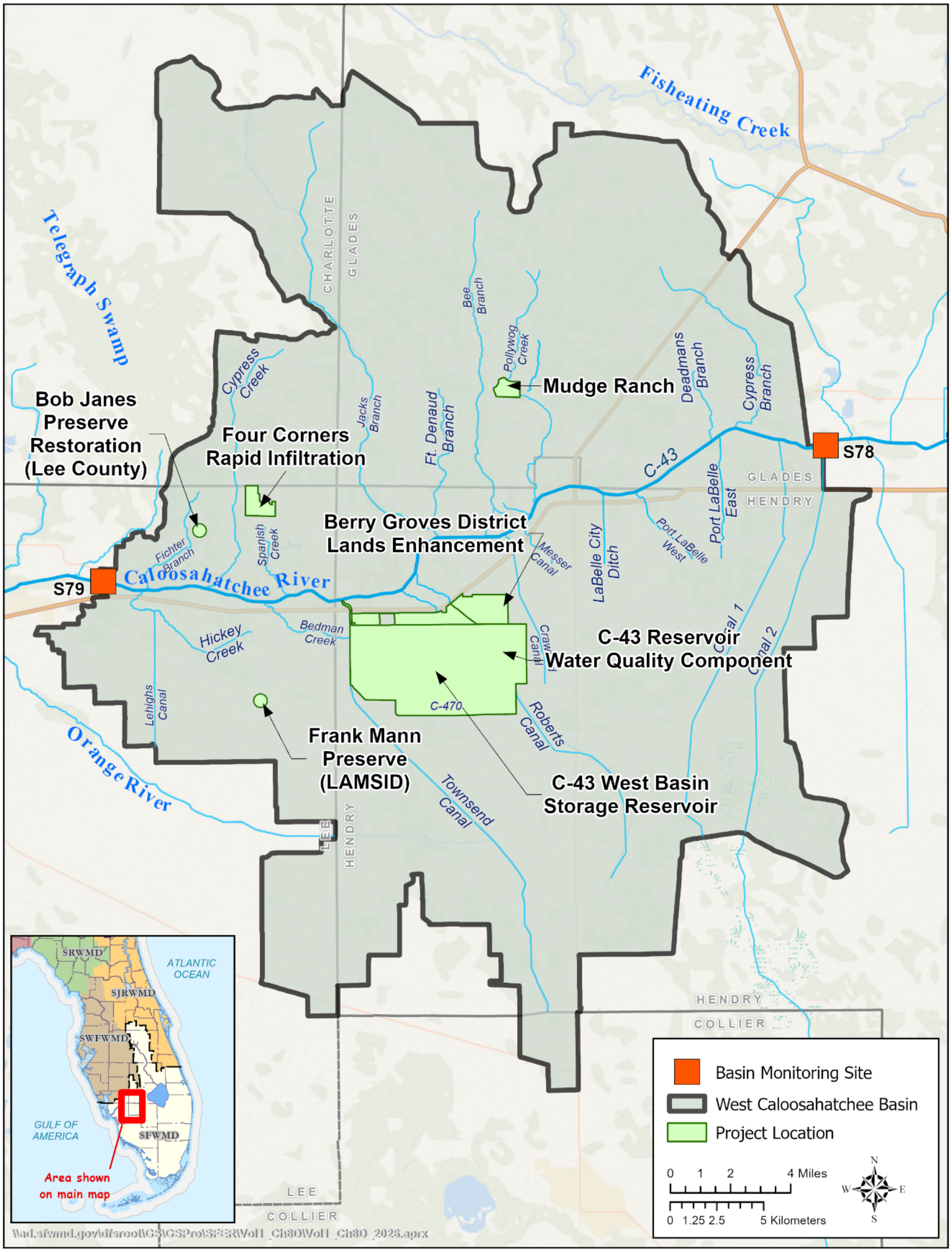


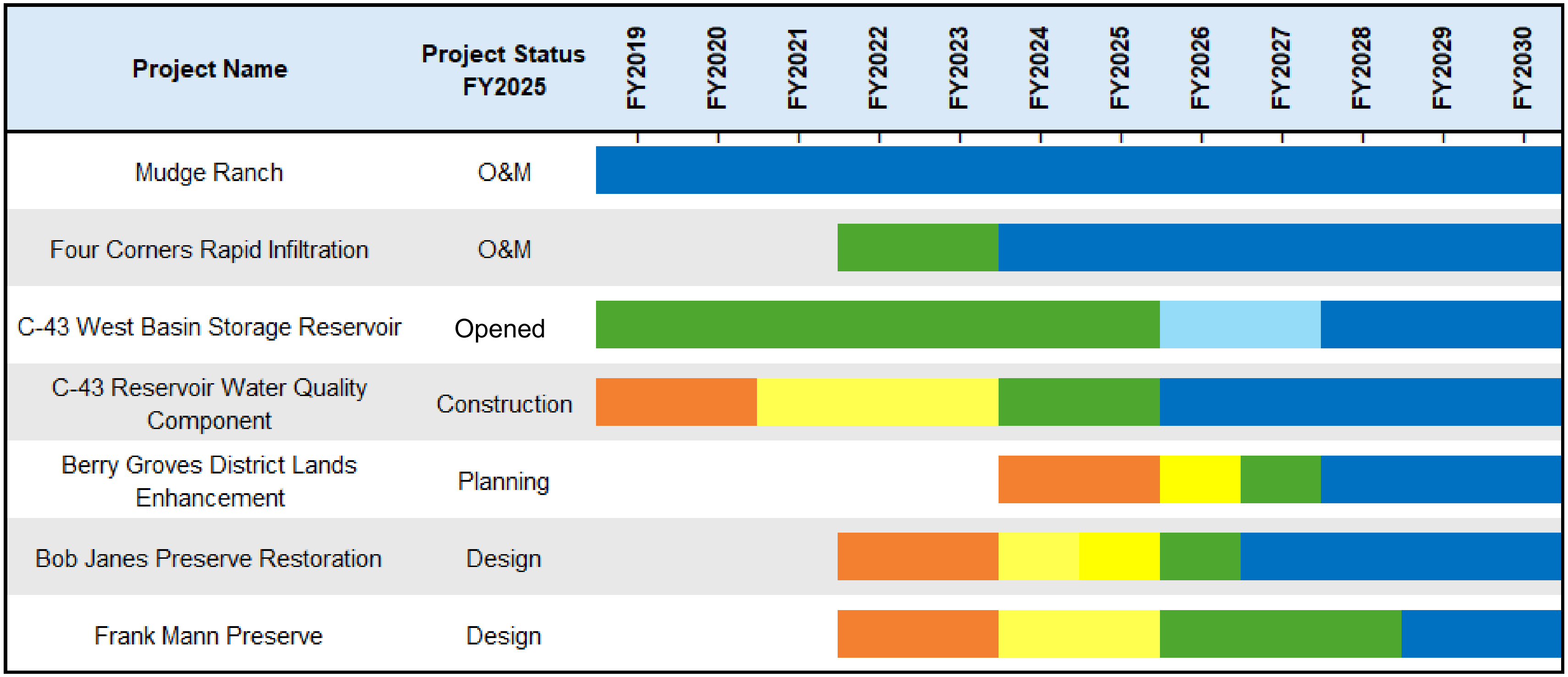
Figure 8D-40. Current projects in the West Caloosahatchee Basin.
(Note: LAMSID – Lehigh Acres-Municipal Services Improvement District.)

Table 8D-16. Estimates of static storage, dynamic storage, and estimated nutrient removal for planned and existing projects along with WY2025 storage and nutrient removal estimates for select Coordinating Agencies' existing projects in the West Caloosahatchee Basin (N/A – not applicable and TBD – to be determined).

Project Name	Project Area (ac)	Project Status FY2025	Project Type	Static Storage (ac-ft)	Estimated Dynamic Storage (ac-ft/yr)	WY2025 Dynamic Storage (ac-ft/yr)	Estimated TP Removal (t/yr)	WY2025 TP Removal Performance (t/yr)	Estimated TN Removal (t/yr)	WY2025 TN Removal Performance (t/yr)
Mudge Ranch	251	O&M	Dispersed Water Management (DWM) - Passive	194	629	574	0.1	0.1	1.0	0.5
Four Corners Rapid Infiltration	463	O&M	DWM - Active	1,464	20,000	24,708	1.2	5.3	39.3	38.4
C-43 West Basin Storage Reservoir	10,700	Opened	Reservoir	178,600	170,000	-	N/A	N/A	N/A	N/A
C-43 Reservoir Water Quality Component	N/A	Construction	Water Quality	N/A	N/A	N/A	3.3	-	33.7	-
Berry Groves District Lands Enhancement	1,900	Planning	DWM - Passive	TBD	TBD	-	TBD	-	TBD	-
Bob Janes Preserve Restoration	47	Design	Restoration	80	80	-	0.1	-	0.5	-
Frank Mann Preserve	627	Design	Restoration	1,265	3,500	-	0.7	-	2.5	-
West Caloosahatchee Basin totals [a]:				**181,603**	**194,209**	**25,282**	**5.4**	**5.4**	**77.0**	**38.9**

a. Totals do not include projects where information is unavailable and do not include other BMAP efforts within the basin. The estimated storage and nutrient removal totals include planning numbers.

Table 8D-17. Project timeline for current projects in the West Caloosahatchee Basin.



Project Name	Project Status FY2025	FY2019	FY2020	FY2021	FY2022	FY2023	FY2024	FY2025	FY2026	FY2027	FY2028	FY2029	FY2030
Mudge Ranch	O&M	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
Four Corners Rapid Infiltration	O&M				🟩	🟩	🟦	🟦	🟦	🟦	🟦	🟦	🟦
C-43 West Basin Storage Reservoir	Opened	🟩	🟩	🟩	🟩	🟩	🟩	🟩	▨	▨	🟦	🟦	🟦
C-43 Reservoir Water Quality Component	Construction	🟧	🟧	🟨	🟨	🟨	🟩	🟩	🟦	🟦	🟦	🟦	🟦
Berry Groves District Lands Enhancement	Planning						🟧	🟧	🟨	🟩	🟦	🟦	🟦
Bob Janes Preserve Restoration	Design				🟧	🟧	🟨	🟨	🟩	🟦	🟦	🟦	🟦
Frank Mann Preserve	Design				🟧	🟧	🟨	🟨	🟩	🟩	🟩	🟦	🟦

🟧 **Planning** 🟨 **Design** 🟩 **Construction** ▨ **OT&MP** 🟦 **O&M**

Tidal Basin

The Tidal Basin is in northern Lee County and southwestern Charlotte County. Numerous tidal creeks drain into the Tidal Basin between S-79 and Shell Point. The total drainage area of the basin is approximately 269,012 ac (108,865 ha). The only control structure located in the Tidal Basin is the S-79 gated spillway, which acts to regulate freshwater discharges to the estuary from the upstream watershed and serves as an impediment to saltwater intrusion further upstream (SFWMD et al. 2009).

There are no Coordinating Agency projects located within the Tidal Basin; however, one project, Lee County's Palm Creek Filter Marsh Project, has received grant funding under the Caloosahatchee Water Quality Improvements Grant Program and is currently in design. This project is shown in **Figure 8D-41** and described in **Table 8D-18**. A timeline for the project is shown in **Table 8D-19**.

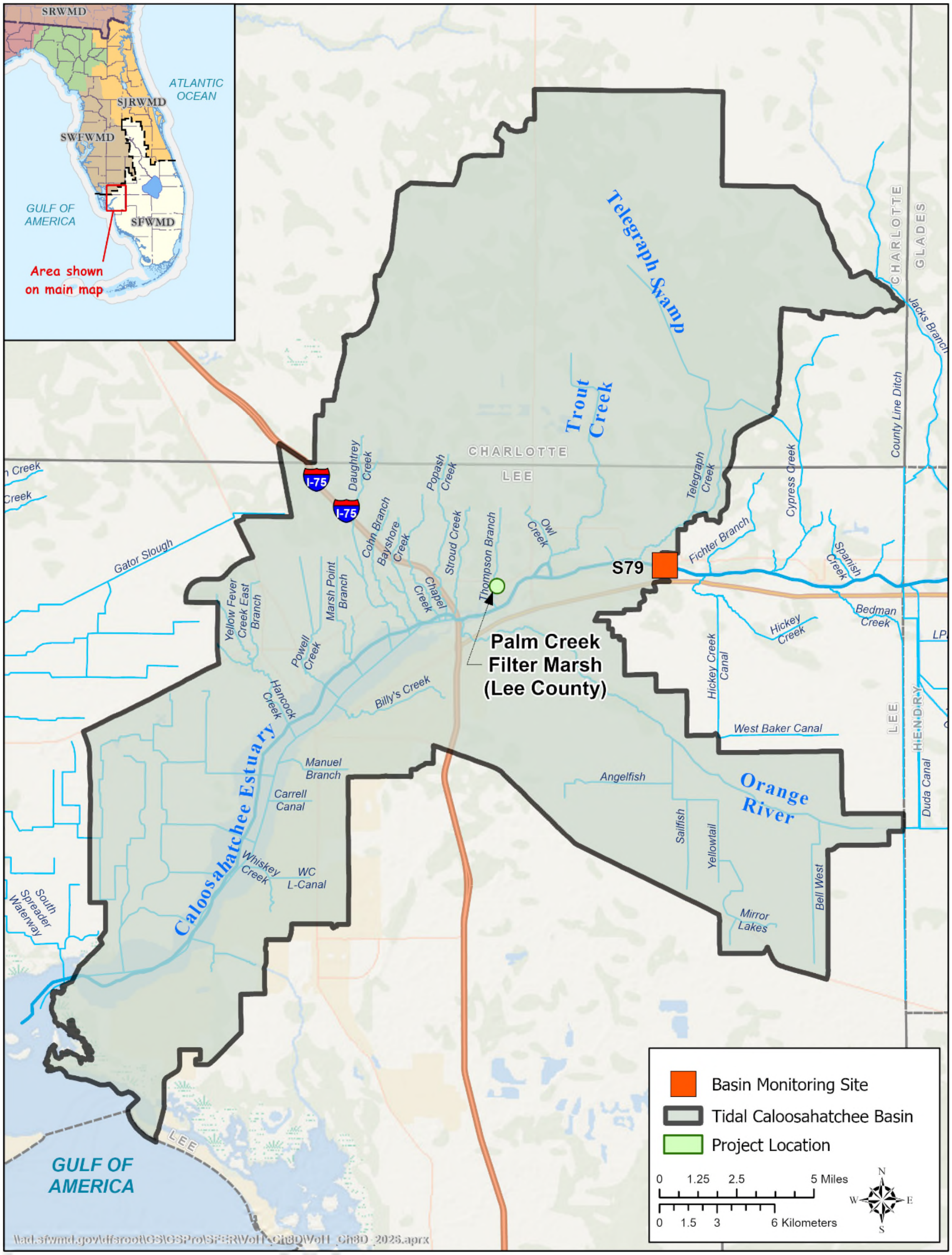


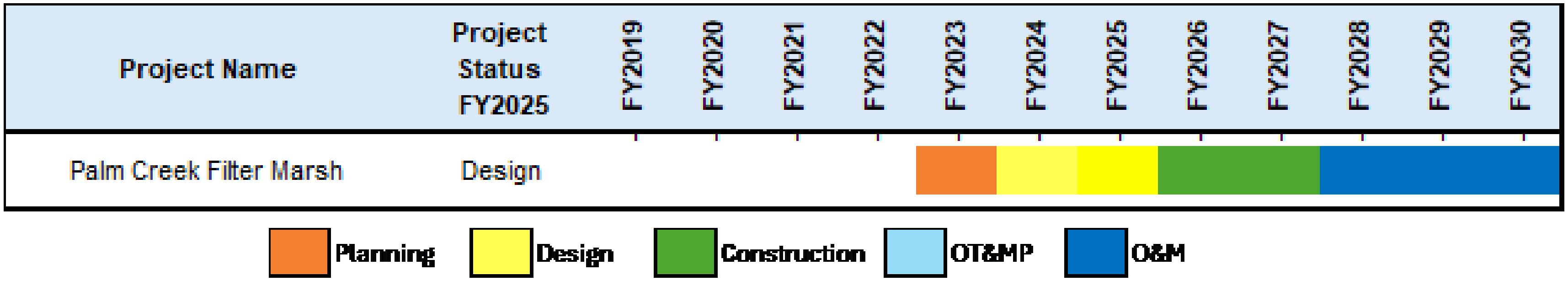
Figure 8D-41. Current projects in the Tidal Basin.

Table 8D-18. Estimates of static storage, dynamic storage, and estimated nutrient removal for planned and existing projects along with WY2025 storage and nutrient removal estimates for select Coordinating Agencies' existing projects in the Tidal Basin.

Project Name	Project Area (ac)	Project Status FY2025	Project Type	Static Storage (ac-ft)	Estimated Dynamic Storage (ac-ft/yr)	WY2025 Dynamic Storage (ac-ft/yr)	Estimated TP Removal (t/yr)	WY2025 TP Removal Performance (t/yr)	Estimated TN Removal (t/yr)	WY2025 TN Removal Performance (t/yr)
Palm Creek Filter Marsh	8	Design	Restoration	18	18	-	0.3	-	2.1	-
Tidal Basin totals [a]				**18**	**18**	**0.0**	**0.3**	**0.0**	**2.1**	**0.0**

a. Totals do not include projects where information is unavailable and do not include other BMAP efforts within the basin. The estimated storage and nutrient removal totals include planning numbers.

Table 8D-19. Project timeline for current projects in the Tidal Basin.



Project Name	Project Status FY2025	FY2019	FY2020	FY2021	FY2022	FY2023	FY2024	FY2025	FY2026	FY2027	FY2028	FY2029	FY2030
Palm Creek Filter Marsh	Design												

DETAILED PROJECT DESCRIPTIONS

Table 8D-20 below provides a detailed description of each CRW project.

Table 8D-20. Detailed project descriptions for projects in the CRW.

Project Name	Basin	Description
East Caloosahatchee Floating Aquatic Vegetation Tilling (FAVT)	East Caloosahatchee	FAVT technology uses the direct assimilation of nutrients from the water column using floating plant roots, and all the biomass is rapidly incorporated directly into the soil through tilling. Operational since 2014, this FDACS-led project is comprised of 540 ac (219 ha) of floating aquatic vegetation (FAV) and SAV communities and has a treatment capacity of approximately 90 cubic feet per second (cfs) or 2.55 cubic meters per second (m^3/s).
Boma Interim Storage	East Caloosahatchee	Aboveground impoundment stores excess water pumped from local drainage canals and the C-43 Canal. Temporary project until FEB begins construction.
Lake Hicpochee Hydrologic Enhancement Phase I	East Caloosahatchee	A multiphase project intended to enhance hydration of the historic lakebed of Lake Hicpochee through storage and water quality improvement. Completed in 2021, Phase I captures water from the C-19 Canal and holds it in a shallow storage feature to enhance flows and improve the timing and volume of water to the Caloosahatchee River (C-43 Canal).
C-43 Water Quality Treatment and Testing Project (WQTTP) Phase II Test Cells	East Caloosahatchee	The project evaluates the effectiveness of constructed wetland treatment systems in reducing nitrogen at a test-cell scale.
Lake Hicpochee Hydrologic Enhancement Phase II Expansion	East Caloosahatchee	A multiphase project intended to enhance hydration of the historic lakebed of Lake Hicpochee through storage and water quality improvement. Phase II includes a new 2,200-ac FEB, a new pump station to draw water from the C-43 Canal, and associated flow features to connect to the existing Phase I project and expand regional storage in the CRW.
Boma FEB	East Caloosahatchee	The project expands regional storage on publicly-owned land. Project will attenuate high flows and store excess runoff to reduce harmful releases to the CRE.
Roadrunner C-43 Nutrient Load Reduction	East Caloosahatchee	The project will divert water from the C-43 Canal into two existing impoundments to provide nutrient reduction via chemical (alum) flocculation and wetland entrapment.
Lake Okeechobee Watershed Restoration Project (LOWRP)	East Caloosahatchee	LOWRP is being implemented in partnership between the United States Army Corps of Engineers and SFWMD. The current recommended plan reflects storage north of Lake Okeechobee is key to reducing harmful discharges to the Caloosahatchee and St. Lucie estuaries. Continuous cores and test wells are the key components to evaluate the geology and hydrogeology of the cluster site to determine suitability.
Mudge Ranch	West Caloosahatchee	As a public-private partnership, this passive storage project retains excess storm water on 304 ac of pasture land.
Four Corners Rapid Infiltration	West Caloosahatchee	The project captures direct precipitation and stormwater runoff for water retention and nutrient load reduction to help reduce harmful discharges to the CRE.
Caloosahatchee River (C-43) West Basin Storage Reservoir	West Caloosahatchee	The project is designed to capture excess C-43 Basin runoff and regulatory releases from Lake Okeechobee during the wet season and release water from the reservoir during the dry season. It will reduce the extreme salinity changes in the CRE by providing a more consistent flow of water discharging into the estuary and will also provide water supply benefits and some flood attenuation.
C-43 Reservoir Water Quality Component	West Caloosahatchee	Inline alum injection system at the C-43 West Basin Storage Reservoir project to reduce nutrients and prevent algal blooms within the reservoir.

Table 8D-20. Continued.

Project Name	Basin	Description
Berry Groves District Lands Enhancement	West Caloosahatchee	The project will improve public lands to retain rainfall and create suitable habitat for wildlife.
Bob Janes Preserve Restoration	West Caloosahatchee	This Lee County project has two major components: Fichter's Creek Restoration Area and West Cypress Creek Restoration Area. The project will provide flood protection, aquifer recharge, and water quality benefits.
Frank Mann Preserve	West Caloosahatchee	This Lehigh Acres-Municipal Services Improvement District (LAMSID) project is a former excavated sand mine that will connect with Greenbriar Swamp and the adjacent canal network. Project will provide storage and water quality treatment via created filter marshes and natural areas.
Palm Creek Filter Marsh	Tidal	This Lee County project is comprised of a cellular pond and wetland network to assist in the treatment of surface water for nutrient removal and related water quality improvement.

LITERATURE CITED

Acevedo, S., and S. Olson. 2025. Appendix 8D-3: Caloosahatchee River Watershed Basin Assessments. In: *2025 South Florida Environmental Report – Volume I*, South Florida Water Management District, West Palm Beach, FL.

Barletta, M., A. Barletta-Bergan, U.S.G.H. Saint-Paul, and G. Hubold. 2005. The role of salinity in structuring the fish assemblages in a tropical estuary. *Journal of Fish Biology* 66(1):45-72.

Borja, A., and B.G. Tunberg. 2011. Assessing benthic health in stressed subtropical estuaries, eastern Florida, USA using AMBI and M-AMBI. *Ecological Indicators* 11:295-303.

Bos, A.R., T.J. Bouma, G.L.J. de Kort, and M.M. van Katwijk. 2007. Ecosystem engineering by annual intertidal seagrass beds: Sediment accretion and modification. *Estuarine Coastal and Shelf Science* 74:344-348.

Buzzelli, C., P. Doering, Y. Wan, and J. Boyer. 2013a. Seasonal dissolved inorganic nitrogen and phosphorus budgets for two sub-tropical estuaries in South Florida. *Biogeosciences* 10:6721-6736.

Buzzelli, C., Z. Chen, T. Coley, P. Doering, R. Samimy, D. Schlesinger, and B. Howes. 2013b. Dry season sediment-water exchanges of nutrients and oxygen in two Floridian estuaries: Patterns, comparisons, and internal loading. *Florida Scientist* 76(1):54-79.

Buzzelli, C., B.M. Boutin, M. Ashton, B. Welch, Y. Wan, P. Gorman, and P. Doering. 2014. Fine-scale detection of estuarine water quality with managed freshwater releases. *Estuaries and Coasts* 37:1134-1144.

Buzzelli, C., K. Carter, L. Bertolotti, and P. Doering. 2015. Chapter 10: St. Lucie and Caloosahatchee River Watershed Protection Plan Annual and Three-Year Updates. In: *2015 South Florida Environmental Report – Volume I*, South Florida Water Management District, West Palm Beach, FL.

Chen, Z., and P.H. Doering. 2016. Variation of light attenuation and the relative contribution of water quality constituents in the Caloosahatchee River Estuary. *Florida Scientist* 79(23):93-108.

Chen, Z., P.H. Doering, M. Ashton, and B.A. Orlando. 2015. Mixing behavior of colored dissolved organic matter and its potential ecological implication in the Caloosahatchee River Estuary, Florida. *Estuaries and Coasts* 38(5):1706-1718.

Doering, P.H., and R.H. Chamberlain. 1999. Water quality and source of freshwater discharge to the Caloosahatchee Estuary, Florida. *Journal of the American Water Resources Association* 35(4):793-806.

Doering, P.H., and R.H. Chamberlain. 2000. Experimental studies on the salinity tolerance of turtle grass, *Thalassia testudinum*. Pages 81-98 in: S.A. Bortone (ed.), *Seagrasses: Monitoring Ecology, Physiology, and Management*, CRC Press, Boca Raton, FL.

Doering, P.H., and Y. Wan. 2018. Ecohydrological controls on blue crab landings and minimum freshwater inflow to the Caloosahatchee Estuary, Florida. *Wetlands Ecology and Management* 26(2):161-174.

Doering, P.H., R.H. Chamberlain, and D.E. Haunert. 2002. Using submerged aquatic vegetation to establish minimum and maximum freshwater inflows to the Caloosahatchee Estuary, Florida. *Estuaries and Coasts* 25(6):1343-1354.

FDEP. 2009. *Final TMDL Report: Nutrient TMDL for the Caloosahatchee Estuary (WBIDs 3240A, 3240B, and 3240C).* Florida Department of Environmental Protection, Tallahassee, FL. September 2009.

FDEP. 2020. *Caloosahatchee River and Estuary Basin Management Action Plan.* Florida Department of Environmental Protection, Tallahassee, FL, with participation from the Caloosahatchee River and Estuary Stakeholders. January 2020.

FDEP. 2022. *2022 5-Year Review of the Caloosahatchee River and Estuary Basin Management Action Plan.* Florida Department of Environmental Protection, Tallahassee, FL, with participation from the Caloosahatchee River and Estuary Stakeholders. December 2022.

FDEP. 2025. *2024 Statewide Annual Report on Total Maximum Daily Loads, Basin Management Action Plans, Minimum Flows or Minimum Water Levels, and Recovery or Prevention Strategies*. Florida Department of Environmental Protection, Tallahassee, FL. July 2025. Available online at https://floridadep.gov/dear/water-quality-restoration/content/statewide-annual-report.

FDEP, NWFWMD, SRWMD, SJRWMD, SWFWMD, and SFWMD. 2024. *Environmental Resource Permit Applicant's Handbook Volume I (General and Environmental)*. Florida Department of Environmental Protection, Tallahassee, FL; Northwest Florida Water Management District, Havana, FL; Suwannee River Water Management District, Live Oak, FL; St. Johns River Water Management District, Palatka, FL; Southwest Florida Water Management District, Fort Myers, FL; and South Florida Water Management District, West Palm Beach, FL. Effective date: June 28, 2024.

Fofonoff, N.P., and R.C. Millard, Jr. 1983. *Algorithms for Computation of Fundamental Properties of Seawater.* UNESCO Technical Papers in Marine Science 44, Division of Marine Sciences, United Nations Educational, Scientific and Cultural Organization (UNESCO), Paris, France.

Fourqurean, J., C. Duarte, H. Kennedy, N. Marbia, M. Holmer, M.A. Mateo, E.T. Apostolaki, G.A. Kendrick, D. Krause-Jensen, K.J. McGlathery, and O. Serrano. 2012. Seagrass ecosystems as a globally significant carbon stock. *Nature Geoscience* 5:505-509.

French, G.T., and K.A. Moore. 2003. Interactive effects of light and salinity stress on the growth, reproduction, and photosynthetic capabilities of *Vallisneria americana* (wild celery). *Estuaries* 26:1255-1268.

Frye, A., A. Betts, J. Bobsein, Z. Welch, M. Parker, R. May, C. Brcka, C. Brown, and C. Avila. Appendix 8A-1 Northern Everglades and Estuaries Protection Plan Regional Simulation Model Update. In: *2025 South Florida Environmental Report – Volume I*, South Florida Water Management District, West Palm Beach, FL.

Furman, B.T., M. Merello, C.P. Shea, W.J. Kenworthy, and M.O. Hall. 2019. Monitoring of physically restored seagrass meadows reveals a slow rate of recovery for *Thalassia testudinum*. *Restoration Ecology* 27(2):421-430.

Galtsoff, P.S. 1964. The American oyster. *Fishery Bulletin* 64:1-480.

García-Ulloa, M., A.M. Góngora Gómez, J.A. Hernández-Sepúlveda, J.A. Chávez-Medina, B.P. Villanueva-Fonseca, and T.E. Isola. 2023. A new bivalve host record for the exotic parasite *Perkinsus marinus* in the Gulf of California. *Bio Invasions Records* 12(2):393-401.

Grizzle, R.E., L.G. Ward, J.R. Adams, S.J. Dijkstra, and B. Smith. 2005. Mapping and characterizing subtidal oyster reefs using acoustic techniques, underwater videography, and quadrat counts. *American Fisheries Society Symposium* 41:153-159.

Guan, J., Jacoby, C. A., & Frazer, T. K. (2020). Light attenuation by periphyton on *Vallisneria americana*. *Ecological Indicators*, *116*, 106498.

Gunter, G. 1961. Some relations of estuarine organisms to salinity. *Limnology and Oceanography* 6(2):182-190.

Hanisak, M.D., and K.S. Davis. 2018. Interannual variability in the Indian River Lagoon, Florida, measured by a network of environmental sensors. *Ocean Sensing and Monitoring X. International Society for Optics and Photonics* 10631:106310A.

Kahn, A.E., and M.J. Durako. 2006. *Thalassia testudinum* seedling responses to changes in salinity and nitrogen levels. *Journal of Experimental Marine Biology and Ecology* 335(1):1-12.

Kahn, A.E., J.L. Beal, and M.J. Durako. 2013. Diurnal and tidal variability in the photobiology of the seagrass *Halophila johnsonii* in a riverine versus marine habitat. *Estuaries and Coasts* 36:430-443.

Kantrud, H.A. 1991. *Wigeongrass (*Ruppia maritima *L.): A Literature Review*. Fish and Wildlife Research No. 10, United States Fish and Wildlife Survey, Washington, DC.

Koch, M.S., S.A., Schopmeyer, C. Kyhn-Hansen, C.J. Maden, and J.S. Peters, 2007. Tropical seagrass species tolerance to hypersalinity stress. *Aquatic Botany* 86:14-24.

La Peyre, M.K., A.D. Nickens, A.K. Volety, G. Tolley, and J.F. La Peyre. 2003. Environmental significance of freshets in reducing *Perkinsus marinus* infection in eastern oysters *Crassostrea virginica*: Potential management applications. *Marine Ecology Progress Series* 248:165-176.

Lenihan, H.S., and C.H. Peterson. 1998. How habitat degradation through fishery disturbance enhances impacts of hypoxia on oyster reefs. *Ecological Applications* 8:128-140.

Levine, E., 2024. *Oyster Monitoring in the Northern Estuaries on the Southeast and Southwest Coasts of Florida, Five Year Report 2019-2023*. Submitted under Contract 4600004040 to the South Florida Water Management District, West Palm Beach, FL.

Lirman, D., and W.P. Cropper. 2003. The influence of salinity on seagrass growth, survivorship, and distribution within Biscayne Bay, Florida: Field, experimental, and modeling studies. *Estuaries* 26:131-141.

Mackin, J.G. 1962. Oyster diseases caused by *Dermocystidium marinum* and other microorganisms in Louisiana. *Publication of the Institute of Marine Sciences, University of Texas* 7:132-229.

McCloskey, R.M., and R.K.F. Unsworth. 2015. Decreasing seagrass density negatively influence associated fauna. *PeerJ* 3:e1053; doi 10.7717/peerj.1053.

McFarland, K., D. Rumbold, A.N. Loh, L. Haynes, S.G. Tolley, P. Gorman, B. Welch, P. Goodman, T.K. Barnes, P.H. Doering, P. Soudant, and A.K. Volety. 2022. Effects of freshwater release on oyster reef density, reproduction, and disease in a highly modified estuary. *Environmental Monitoring and Assessment* 194(2):96.

McKeon, C.S., B.G. Tunberg, C.A. Johnston, and D.J. Barshis. 2015. Ecological drivers and habitat associations of estuarine bivalves. *PeerJ* 3:1348.

McLeod, E., G.L. Chmure, S. Bouillon, R. Salm, M. Bjork, C.M. Duarte, C.S. Lovelock, W.H. Schlesinger, and B.R. Silliman. 2011. A blueprint for blue carbon: Toward an improved understanding of the role of vegetated coastal habitats in sequestering CO_2. *Frontiers in Ecology and the Environment* 7:362-370.

Morris, L.J., L.M. Hall, J.D. Miller, M.A. Lasi, R.H. Chamberlain, R.W. Virnstein, and C.A. Jacoby. 2021. Diversity and distribution of seagrasses as related to salinity, temperature, and availability of light in the Indian River Lagoon, Florida. *Proceedings of Indian River Lagoon Symposium* 2020.

Morris L.J., L.M. Hall, C.A. Jacoby, R.H. Chamberlain, M.D. Hanisak, J.D. Miller, and R.W. Virnstein. 2022. Seagrass in a Changing Estuary, the Indian River Lagoon, Florida, United States. *Frontiers in Marine Science* 8:789818.

NHC. 2025a. *National Hurricane Center Tropical Cyclone Report, Hurricane Debby (AL042024)*. National Hurricane Center, Miami, FL. February 4, 2025. Available online at: https://www.nhc.noaa.gov/data/tcr/AL042024_Debby.pdf.

NHC. 2025b. *National Hurricane Center Tropical Cyclone Report, Hurricane Milton (AL142024)*. National Hurricane Center, Miami, FL. March 31, 2025. Available online at: https://www.nhc.noaa.gov/data/tcr/AL142024_Milton.pdf

Nowicki, R.J., J.A. Thomson, D.A. Burkholder, J.W. Fourqurean, M.R. Heithaus. 2017. Prediciting seagrass recovery times and their implications following an extreme climate event. *Marine Ecology Progress Series* 567:79-93.

Olin. J.A., P.W., Stevens, S.A. Rush, N.E. Hussey, and A.T. Fisk. 2014. Loss of seasonal variability in nekton community structure in a tidal river: Evidence for homogenization in a flow-altered system. *Hydrobiologia* 744(1):271-286; doi 10.1007/s10750-014-2083-2.

Olson, S., A. Frye, M. Junod, M. Mahmoudi, C. Bedregal, J. Landfield, and J. Iudicello. 2024. *Focus Assessment Report: West Caloosahatchee Basin*. South Florida Water Management District, West Palm Beach, FL.

Paczkowska, J., S. Brugel, O. Rowe, R. Lefebure, A. Brutemark, and A. Andersson. 2020. Response of coastal phytoplankton to high inflows of terrestrial matter. *Frontiers in Marine Science* 28.

Palmer, T.A., P.A. Montagna, R.H. Chamberlain, P.H. Doering, Y. Wan, K.M. Haunert, and D.J. Crean. 2016. Determining the effects of freshwater inflow on benthic macrofauna in the Caloosahatchee Estuary, Florida. *Integrated Environmental Assessment and Management* 12(3):529-539.

Parker, M.L. 2015. *Oyster Monitoring in the Northern Estuaries on the Southeast Coast of Florida 2005-2014, Final Report*. Prepared under Contract 4600002548 for South Florida Water Management District, West Palm Beach, FL.

Parker, M.L., and R. Radigan. 2020. *Oyster Monitoring in the Northern Estuaries on the Southeast Coast of Florida 2005-2018, Final Report*. Prepared under Contract 4600002548 for South Florida Water Management District, West Palm Beach, FL.

Parker, M., M.S. Arnold, S.P. Geiger, P. Gorman, and E.H. Leone. 2013. Impacts of freshwater management activities on eastern oyster (*Crassostrea virginica*) density and recruitment: Recovery and long-term stability in seven Florida estuaries. *Journal of Shellfish Researc*h 32(3):695-708.

Parker, M., S. Webb, D. Taylor, and J. Bobsein. 2025. Chapter 8D: Caloosahatchee River Watershed Protection Plan 2025 Update In: *2025 South Florida Environmental Report – Volume I*, South Florida Water Management District, West Palm Beach, FL.

Petes, L.E., A.J. Brown, and C.R. Knight. 2012. Impacts of upstream drought and water withdrawals on the health and survival of downstream estuarine oyster populations. *Ecology and Evolution* 2(7):1712-1724.

RECOVER. 2020. *Northern Estuaries Performance Measure, Salinity Envelopes Documentation Sheet, July 2020*. Restoration Coordination and Verification, c/o United States Army Corps of Engineers, Jacksonville, FL, and South Florida Water Management District, West Palm Beach, FL.

Reece, K.S., D. Bushek, K.L. Hudson, and J.E. Graves. 2001. Geographic distribution of *Perkinsus marinus* genetic strains along the Atlantic and Gulf coasts of the USA. *Marine Biology* 139:1047-1055.

Rumbold, D.G., and P.H. Doering. 2020. Water quality and source of freshwater discharge to the Caloosahatchee Estuary, Florida: 2009–2018. *Florida Scientist* 83(1):1-20.

SFWMD. 2020a. *Field Sampling Manual*. SFWMD-FIELD-FSM-001-11, South Florida Water Management District, West Palm Beach, FL. Effective September 21, 2020.

SFWMD. 2020b. *Quality Manual*. SFWMD-FIELD-QM-001-11, South Florida Water Management District, West Palm Beach, FL. Effective December 15, 2020.

SFWMD. 2024. *Environmental Resource Permit Applicant's Handbook Volume II for Use within the Geographic Limits of the South Florida Water Management District*. South Florida Water Management District, West Palm Beach, FL. Effective June 28, 2024. Available online at https://www.sfwmd.gov/sites/default/files/documents/swerp_applicants_handbook_vol_ii.pdf.

SFWMD, FDEP, and FDACS. 2008. *Lake Okeechobee Watershed Construction Project Phase II Technical Plan*. South Florida Water Management District, West Palm Beach, FL; Florida Department of Environmental Protection, Tallahassee, FL; and Florida Department of Agriculture and Consumer Services, Tallahasee, FL. February 2008.

SFWMD, FDEP, and FDACS. 2009. *Caloosahatchee River Watershed Protection Plan*. South Florida Water Management District, West Palm Beach, FL; Florida Department of Environmental Protection, Tallahassee, FL; and Florida Department of Agriculture and Consumer Services, Tallahasee, FL. January 2009.

SFWMD, FDEP, and FDACS. 2011. *Lake Okeechobee Protection Plan Update*. South Florida Water Management District, West Palm Beach, FL; Florida Department of Environmental Protection, Tallahassee, FL; and Florida Department of Agriculture and Consumer Services, Tallahassee, FL.

Shumway, S.E. 1996. Natural environmental factors. Pages 467–513 in: V.S. Kennedy, R.I.E. Newell, and A.F. Eble (eds.), *The Eastern Oyster* Crassostrea virginica. Maryland Sea Grant College, University of Maryland System, College Park, MD.

Simpfendorfer, C.A., B.G. Yeiser, T.R. Wiley, G.R. Poulakis, P.W. Stevens, and M.R. Heupel. 2011. Environmental influences on the spatial ecology of juvenile smalltooth sawfish (*Pristis pectinata*): Results from acoustic monitoring. *PLoS One* 6(2):e16918.

Stevens, A. W., & Lacy, J. R. (2012). The influence of wave energy and sediment transport on seagrass distribution. *Estuaries and coasts*, *35*(1), 92-108.

Stevens, P.W., M.F. Greenwood, and D.A. Blewett. 2013. Fish assemblages in the oligohaline stretch of a Southwest Florida river during periods of extreme freshwater inflow variation. *Transactions of the American Fisheries Society* 142(6):1644-1658.

Tolley, S.G., D. Fugate, M.L. Parsons, S.E. Burghart, and E.B. Peebles. 2010. *The Responses of Turbidity, CDOM, Benthic Microalgae, Phytoplankton, and Zooplankton to Variation in Seasonal Freshwater Inflow to the Caloosahatchee Estuary*. Prepared for South Florida Water Management District, West Palm Beach, FL, and United States Department of Education, Washington, DC.

Unsworth, R.K.F., L.M. Nordlund, and L.C. Cullen-Unsworth. 2019. Seagrass meadows support global fisheries production. *Conservation Letters* 12(1):e12566.

Volety, A.K, and L. Haynes. 2014. *Oyster Monitoring in the Caloosahatchee River and Estuary, Annual Report 2014*. Prepared under Contract 4600002271 for South Florida Water Management District, West Palm Beach, FL.

Volety, A.K., M. Savarese, S.G. Tolley, W.S. Arnold, P. Sime, P. Goodman, R.H. Chamberlain, and P.H. Doering. 2009. Eastern oysters (*Crassotrea virginica*) as an indicator for restoration of Everglades ecosystems. *Ecological Indicators* 9:S120-S136.

Volety, A.K., S.G. Tolley, A.N. Loh, and A. Abeels. 2010. *Oyster Monitoring Network for the Caloosahatchee Estuary, Final Report*. Prepared under Contract 4600000815 for South Florida Water Management District, West Palm Beach, FL.

Wan, Y., and K. Konyha. 2015. A simple hydrologic model for rapid prediction of runoff from ungauged coastal catchments. *Journal of Hydrology* 28:571-583.

Wan, Y., Z. Ji, J. Shen, G. Hu, and D. Sun. 2012. Three dimensional water quality modeling of a shallow subtropical estuary. *Marine Environmental Research* 82:76-86.

Williams, S.L., and K.L. Heck. 2001. Seagrass community ecology. Pages 317–338 in: M.D. Bertness, S.D. Gaines, and M.E. Hay (eds.), *Marine Community Ecology*, Sinauer Associates, Sunderland, MA.