SFER Volume I – The South Florida Environment

Kim Richer

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Prepared by the South Florida Water Management District (SFWMD) in cooperation with the Florida Department of Environmental Protection (FDEP) and Florida Department of Agriculture and Consumer Services (FDACS), the 2023 South Florida Environmental Report (SFER) unifies dozens of individual mandated reports and plans into a single document for a "consolidated water management district annual report". The annual SFER updates key scientific results and findings for the reporting period. Overall, this information is the foundation for restoration, management, and protection activities associated with the Kissimmee Basin, Lake Okeechobee, the Everglades, and South Florida's coastal ecosystems.

2023 SFER Volume I

- Summarizes project science, status, and performance
- Provides status updates and data summaries for various research and monitoring efforts during Water Year 2022 (WY2022; May 1, 2021 – April 30, 2022)
- Mandated Peer Review: Chapters 3, 4, 5A, 5B, 5C, 6, and 7; Optional Peer Review: Chapters 8A, 8B, 8C, 8D, and 9
- Public review is conducted concurrently with the peer review
- Facilitated, edited, and produced by staff of the Compliance Assessment & Reporting Section of the Water Quality Bureau

The **Everglades Forever Act (EFA)** is found within the Florida Statutes (F.S.) in §373.4592. The act was first signed into law in 1994.

- There have been periodic updates to the act as new technologies and information became available.
- Act encompasses restoration efforts for the Southern Everglades.
- Reporting requirements for EFA are provided in Chapters 3, 4, 5A, 5B, 5C, 6, and 7 and associated appendices.

To learn more about EFA, scan the QR code:

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The **Northern Everglades and Estuaries Protection Program (NEEPP)** is required by §373.4595, F.S., which was enacted in 2007 and amended in 2016.

- Requires restoration of the Northern Everglades including Lake Okeechobee and its watershed, the St. Lucie River Watershed, and the Caloosahatchee River Watershed.
- Reporting requirements for NEEPP are provided in Chapters 8A, 8B, 8C, and 8D and associated appendices.

To learn more about NEEPP, scan the QR code:

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The **Consolidated Water Management District Annual Report**, required by §373.036(7), F.S., reporting on the management of water resources. Must be submitted annually by March 1 by each water management district within Florida.

- Report must be submitted to the Florida Governor, President of the Senate, and Speaker of the House of Representatives and made available to the public.
- Reporting requirements are fulfilled by Chapters 8A, 8B, 8C, and 8D and associated appendices.

To learn more about §373.036(7), F.S., scan the QR code:

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Chapter/Appendix Number	Chapter/Appendix Title	Reporting Requirements
Chapter 1	Introduction to Overall Report and Volume I	Consolidated Annual Report – §373.036(7)(a), F.S. Everglades Forever Act – §373.4592(13), F.S.
Appendix 1-1	Volume I Peer and Public Review Process and Products	Everglades Forever Act – §373.4592(4)(d)5, F.S.
Appendix 1-2	Comprehensive Everglades Restoration Plan Annual Report – 470 Report	Consolidated Annual Report – §373.036(7)(e)3, F.S. Everglades Restoration Investment Act – §373.470(7), F.S.
Appendix 1-3	Everglades Forever Act Annual Financial Report	Consolidated Annual Report – §373.036(7)(e)4, F.S. Everglades Forever Act – §373.4592(14), F.S. Everglades Trust Fund – §373.45926(3), F.S.
Chapter 2A & Appendices	South Florida Hydrology and Water Management	
Chapter 2B	Water Climate Resilience Metrics	
Chapter 3 & Appendices	Water Quality in the Everglades Protection Area	Consolidated Annual Report – §373.036(7)(e)2, F.S. Everglades Forever Act – §373.4592(4)(d)1, §373.4592(4)(d)5, §373.4592(4)(e), and §373.4592(13), F.S.
Chapter 4 & Appendices	Nutrient Source Control Programs in the Southern Everglades	Consolidated Annual Report – §373.036(7)(e)2, F.S. Everglades Forever Act – §373.4592(4)(d)1, §373.4592(4)(d)5, and §373.4592(13), F.S.
Chapter 5A	Restoration Strategies – Design and Construction Status of Water Quality Improvement Projects	Consolidated Annual Report – §373.036(7)(e)2, F.S. Everglades Forever Act – §373.4592(13), F.S.
Chapter 5B & Appendices	Performance and Operation of the Everglades Stormwater Treatment Areas	Consolidated Annual Report – §373.036(7)(e)2, F.S. Everglades Forever Act – §373.4592(4)(d)1, §373.4592(4)(d)5, and §373.4592(13), F.S.
Chapter 5C & Appendices	Restoration Strategies Science Plan	Consolidated Annual Report – §373.036(7)(e)2, F.S. Everglades Forever Act – §373.4592(4)(d)3, §373.4592(4)(d)5, and §373.4592(13), F.S.
Chapter 6	Everglades Research and Evaluation	Consolidated Annual Report – §373.036(7)(e)2, F.S. Everglades Forever Act – §373.4592(4)(d)2, §373.4592(4)(d)5, and §373.4592(13), F.S.
Chapter 7	Status of Invasive Species	Consolidated Annual Report – §373.036(7)(e)2, F.S. Everglades Forever Act – §373.4592(4)(g) and §373.4592(13), F.S.
Chapter 8A	Northern Everglades and Estuaries Protection Program - Annual Progress Report	Consolidated Annual Report – §373.036(7)(e)1, F.S. Northern Everglades and Estuaries Protection Program – §373.4595(3) and §373.4595(6), F.S. Progress Reports – §403.0675, F.S.
Chapter 8B & Appendix	Lake Okeechobee Watershed Protection Plan Annual Progress Report	Consolidated Annual Report – §373.036(7)(e)1, F.S. Northern Everglades and Estuaries Protection Program – §373.4595(3) and §373.4595(6), F.S.
Chapter 8C & Appendix	St. Lucie River Watershed Protection Plan Annual Progress Report	Northern Everglades and Estuaries Protection Program – §373.4595(4) and §373.4595(6), F.S.
Chapter 8D & Appendix	Caloosahatchee River Watershed Protection Plan Annual Progress Report	Northern Everglades and Estuaries Protection Program – §373.4595(4) and §373.4595(6), F.S.
Chapter 9	Kissimmee River Restoration and Other Kissimmee Basin Initiatives	

South Florida Environmental Report
VOLUME III
Annual Permit Reports

WHAT IS VOLUME III?

- Third and final volume of the South Florida Environmental Report (SFER)
- Consolidated publication that fulfills annual reporting requirements for numerous permits and mandates
- Provides scientific information for the permitted projects, including water quality, hydrological, and ecological information, as well as status updates on project activities and construction progress where applicable
- 2023 SFER Volume III comprises 5 chapters with a total of 20 appendices, each of which is a permit report

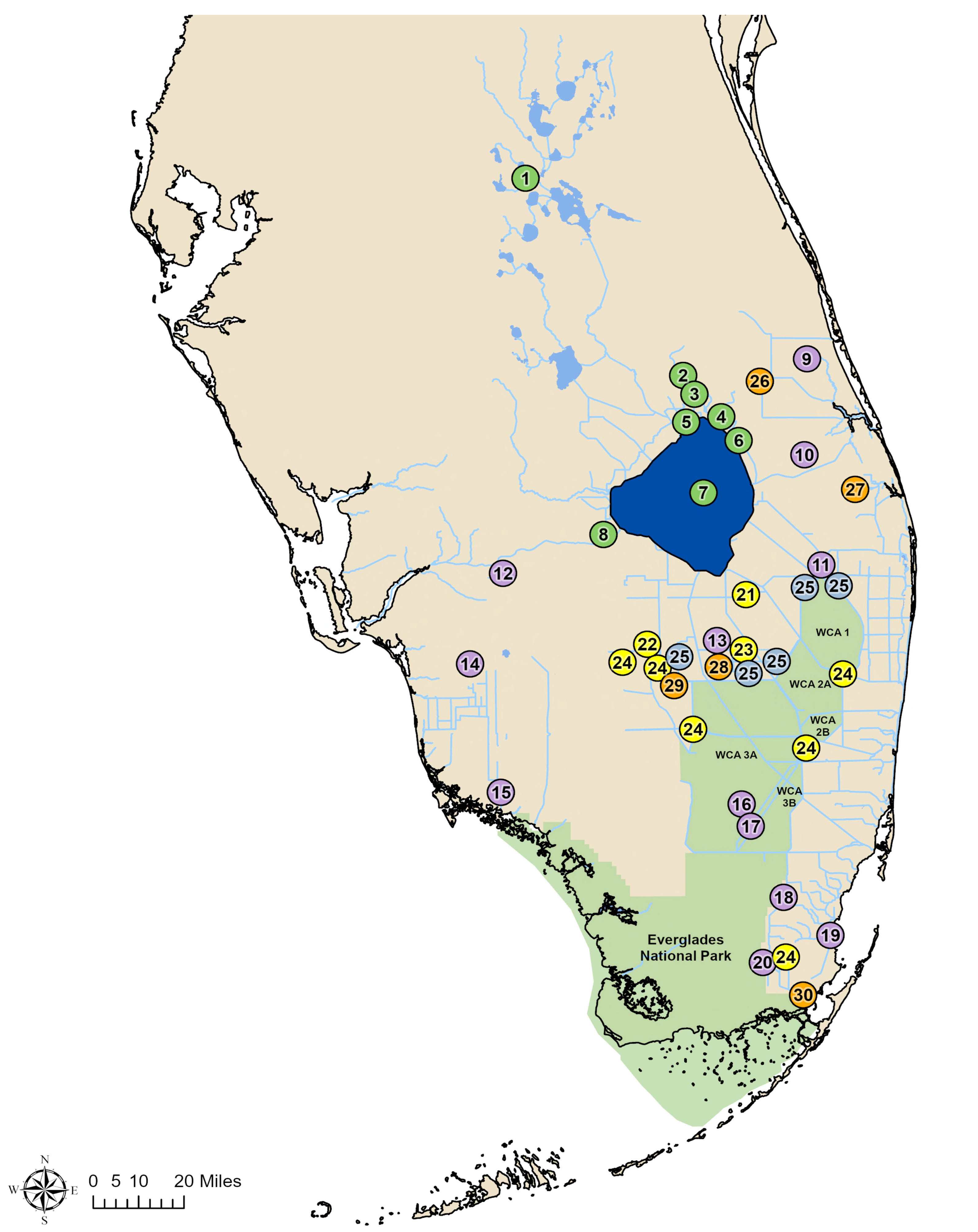
HOW IS IT PREPARED?

- Permit reporting in Volume III is authored, contributed to, and reviewed by SFWMD technical staff from various bureaus
- Facilitated, edited, and produced by staff of the Compliance Assessment & Reporting Section of the Water Quality Bureau

WHEN IS IT PUBLISHED?

- Volume III is published in the SFER annually on March 1

PROJECT LOCATIONS FOR MOST PERMIT REPORTING IN SFER VOLUME III:

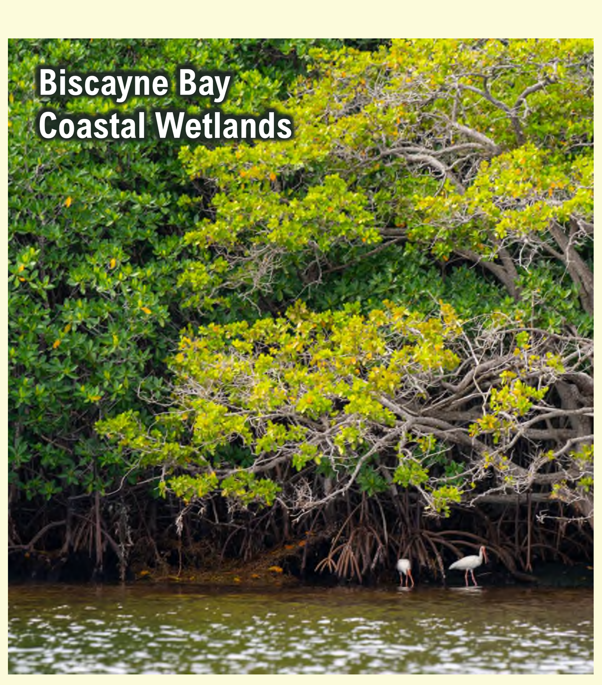


PERMITTED PROJECTS COVERED IN SFER VOLUME III:

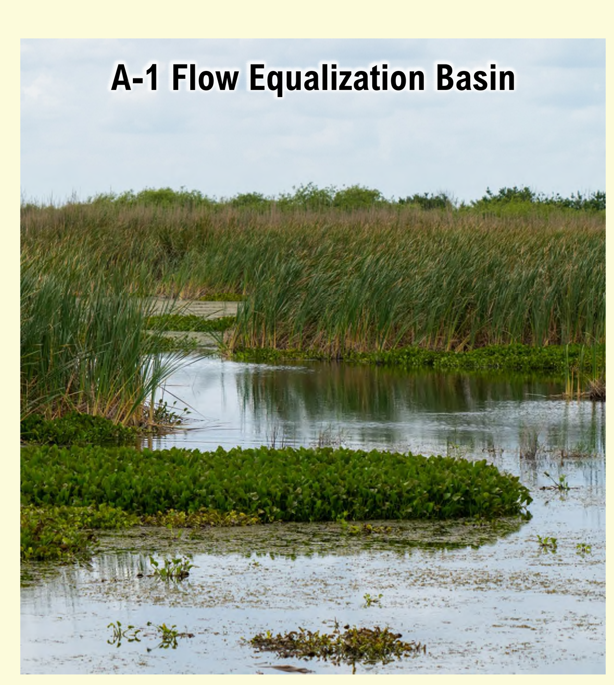
#	PROJECT	PERMIT TYPE*	IN VOLUME III
1	Rolling Meadows Restoration	NEEPP	Appendix 4-5
2	Grassy Island Hybrid Wetland Treatment Technology Project	NEEPP	Chapter 1
3	Taylor Creek Stormwater Treatment Area	NEEPP	Chapter 5
4	Nubbin Slough Stormwater Treatment Area	NEEPP	Appendix 4-4
5	Lemkin Creek Hybrid Wetland Treatment Technology Project	NEEPP	Chapter 1
6	Lakeside Ranch Stormwater Treatment Area	NEEPP	Appendix 4-3
7	Lake Okeechobee Water Control Structures Operation	NEEPP	Appendix 4-1
8	Lake Hicpochee Hydrologic Enhancement	NEEPP	Appendix 4-6
9	Ten Mile Creek Water Preserve Area	CERPRA	Appendix 2-6
10	C-44 Reservoir and Stormwater Treatment Area	CERPRA	Appendix 2-8
11	L-8 Flow Equalization Basin	CERPRA	Appendix 2-2
12	C-43 West Basin Storage Reservoir Project	CERPRA	Chapter 2
13	Everglades Agricultural Area A-2 Reservoir and Stormwater Treatment Area	CERPRA	Chapter 2
14	Southern Corkscrew Regional Ecosystem Watershed (CREW) Restoration	CERPRA	Chapter 1
15	Picayune Strand Restoration Project	CERPRA	Appendix 2-5
16	Central Everglades Planning Project S-333N Gated Spillway	CERPRA	Appendix 2-9
17	Water Conservation Area 3 Decompartmentalization and Sheetflow Enhancement Physical Model (DPM Test Project)	CERPRA	Appendix 2-7
18	Modified Water Deliveries to Everglades National Park and the C-111 South Dade Project	CERPRA	Appendix 2-1
19	Biscayne Bay Coastal Wetlands Project	CERPRA	Appendix 2-3
20	C-111 Spreader Canal	CERPRA	Appendix 2-4
21	Bolles East (L-16) Canal Conveyance Improvement	EFA	Chapter 3
22	C-139 Flow Equalization Basin	EFA	Chapter 3
23	A-1 Flow Equalization Basin	EFA	Appendix 3-3
24	Non-Everglades Construction Project	EFA	Appendix 3-2
25	Everglades Stormwater Treatment Areas	EFA/NPDES	Appendix 3-1
26	Section C Dispersed Water Management Project	ERP	Chapter 1
27	Cypress Creek Restoration Project	ERP	Appendix 5-2
28	Holey Land Wildlife Management Area	ERP	Appendix 5-1
29	C-139 Annex Restoration	ERP	Chapter 5
30	S-197 Structure Replacement	ERP	Appendix 3-2

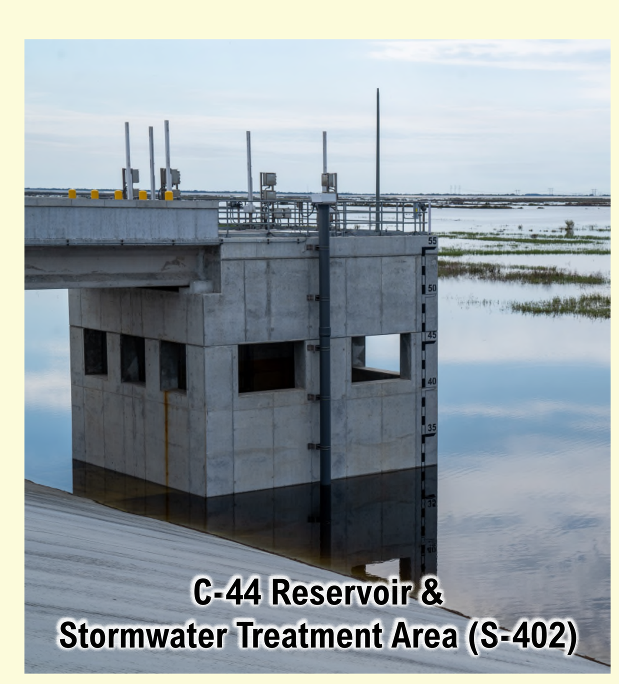
***Permit Types:** CERPRA – Comprehensive Everglades Restoration Plan Regulation Act, EFA – Everglades Forever Act, ERP – Environmental Resource Permit, NEEPP – Northern Everglades and Estuaries Protection Program, and NPDES – National Pollutant Discharge Elimination System.


Lakeside Ranch Stormwater Treatment Area (S-191)


Biscayne Bay Coastal Wetlands


Taylor Creek Stormwater Treatment Area


A-1 Flow Equalization Basin


C-44 Reservoir & Stormwater Treatment Area (S-402)


Picayune Strand Restoration Project

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Chapter 2A: South Florida Hydrology and Water Management

Nicole Cortez

CHAPTER BACKGROUND

Chapter 2A quantifies hydrology and characterizes water management activities each water year, aggregately documenting the daily, weekly, and monthly operational reporting on rainfall (annual, seasonal, monthly), evapotranspiration (ETp), pump volumes, flow volumes, and water levels (stages). In years where water management differs from normal operations, Chapter 2A also memorializes events that altered water management activities, detailing extreme changes in hydrology and the actions taken. These might include tropical storms and hurricanes, extreme dry and/or wet conditions, fire, and much more.

CONNECTION TO RESILIENCY

While the data presented in the chapter is static in nature, showing a moment in time (the water year), it can be interpreted along with long-term norms, trends, and future projections to understand how conditions are evolving in real-time. The annual cycle of analysis, documentation, and reporting supports the identification of evolving conditions as they develop over time and can be used to identify problem areas, validate modeled system deficiencies, and inform planning, enhancements, and investments for resiliency.

2023 SFER CHAPTER UPDATE

In previous chapter reporting years, historical average rainfall was calculated based on the data available from the beginning of the period of record through 1995 at a singular rain gauge within each of South Florida Water Management District's (SFWMD's or District's) rainfall areas. Beginning with this reporting year chapter, historical average rainfall is based on rainfall data from the last 30 years using a combination of rain gauge and radar data. The updated method is aligned with current operational reporting and better represents the current climate of South Florida, serving as a more accurate basis for comparing monthly, seasonal, and annual climate conditions observed each water year to what is normal for SFWMD's regional climate today. The deviations of Water Year 2022 (WY2022; May 1, 2021–April 30, 2022) rainfall from the previous and current methods of calculating historical rainfall averages, help to interpret how hydrology each water year compares to a dynamic and changing climate.

Rainfall averages based on previous method (before the 2023 SFER update)

WY2022 and historical annual average rainfall, and WY2022 rainfall deviation from historical annual average for each SFWMD rainfall area. All values are in inches. Note: EAA – Everglades Agricultural Area, ENP – Everglades National Park, WCA – Water Conservation Area.

Rainfall Area	WY2022 Rainfall	Historical Average Rainfall	Historical Period	WY2022 Rainfall Deviation
Upper Kissimmee	46.37	50.09	1902-1995	-3.72
Lower Kissimmee	41.95	44.45	1966-1995	-2.50
Lake Okeechobee	40.23	45.97	1930-1995	-5.74
East EAA	41.94	53.48	1926-1995	-11.54
West EAA	52.65	54.95	1958-1995	-2.30
WCA-1 & WCA-2	47.34	51.96	1958-1995	-4.62
WCA-3	44.67	51.96	1958-1995	-7.29
Martin/St. Lucie	48.37	54.14	1902-1995	-5.77
Palm Beach	52.58	61.54	1901-1995	-8.96
Broward	58.33	58.13	1946-1995	0.20
Miami-Dade	53.74	57.11	1903-1995	-3.37
East Caloosahatchee	48.14	50.68	1920-1995	-2.54
Big Cypress Preserve	53.49	54.12	1999-1995	-0.63
Southwest Coast	54.08	54.12	1915-1995	-0.04
District Average	**47.93**	**52.75**	**1933-1995**	**-4.82**
ENP	49.76	54.55	1942-2021	-4.79

(a) Rainfall over the Atlantic Ocean east of Port St. Lucie. (b) Groundwater and rainfall monitoring station in Water Conservation Area 3. (Source: SFWMD staff photos.)

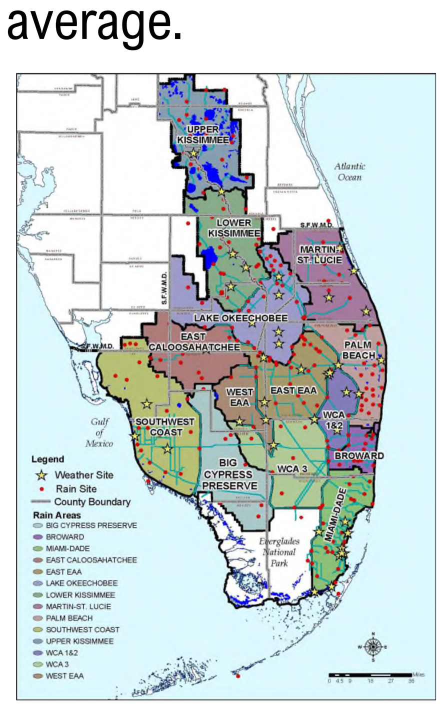
Rainfall averages based on current method (beginning with the 2023 SFER)

WY2022 and historical annual average rainfall, and WY2022 rainfall deviation from historical annual average for each SFWMD rainfall area. All values are in inches.

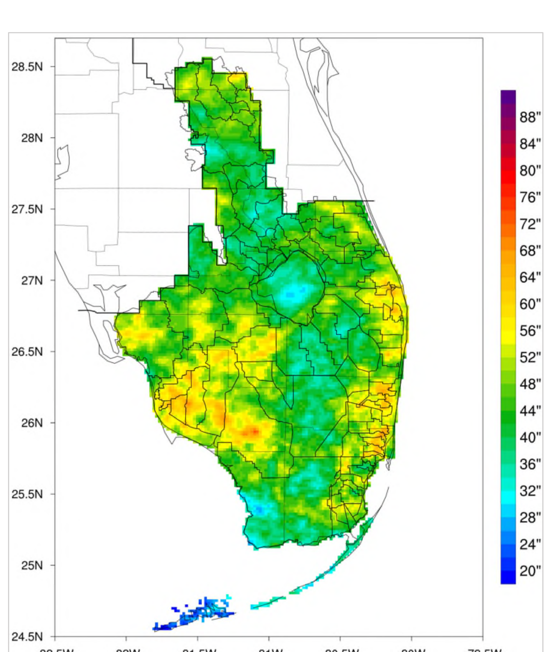
Rainfall Area	WY2022 Rainfall	Historical Average Rainfall	Historical Period	WY2022 Rainfall Deviation
Upper Kissimmee	46.37	50.90	1991–2020	-4.53
Lower Kissimmee	41.95	48.25	1991–2020	-6.30
Lake Okeechobee	40.23	44.56	1991–2020	-4.33
East EAA	41.94	49.15	1991–2020	-7.21
West EAA	52.65	53.32	1991–2020	-0.67
WCA-1 & WCA-2	47.34	53.93	1991–2020	-6.59
WCA-3	44.67	53.00	1991–2020	-8.33
Martin/St. Lucie	48.37	55.00	1991–2020	-6.63
Palm Beach	52.58	60.45	1991–2020	-7.87
Broward	58.33	60.30	1991–2020	-1.97
Miami-Dade	53.74	59.73	1991–2020	-5.99
East Caloosahatchee	48.14	53.72	1991–2020	-5.58
Big Cypress Preserve	53.49	55.59	1991–2020	-2.10
Southwest Coast	54.08	57.58	1991–2020	-3.50
District Average	**47.93**	**53.22**	**1991–2020**	**-5.29**
ENP	40.93	54.4	1942–2020	-13.47

WY2022 HYDROLOGY AND WATER MANAGEMENT

The 2023 SFER documented hydrology and water management during WY2022. WY2022 was characterized by slightly below average annual rainfall, receiving 47.9 inches of rainfall over the area managed by SFWMD, which is 5.3 inches below the historical average rainfall for the 1991–2020 period of record. Rainfall amounts in the wet season (June 2021–September 2021) were around the historical wet season average and rainfall amounts in the dry season (November 2021–April 2022) were below the historical dry season average.



SFWMD's rainfall areas.



WY2022 total rainfall.
(Source: SFWMD Weather)

WY2022 monthly rainfall (in inches)
for each SFWMD rainfall area and ENP.

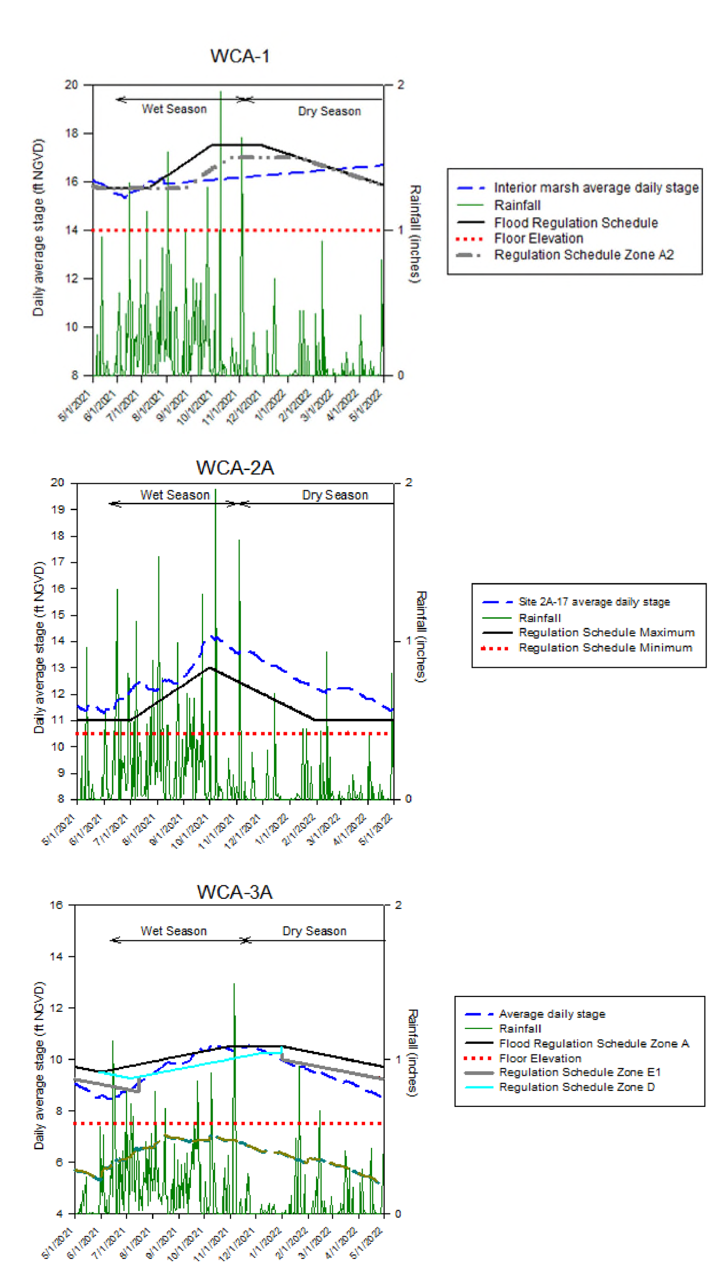
Month	Upper Kissimmee	Lower Kissimmee	Lake Okeechobee	East EAA	West EAA	WCA-1 & WCA-2	WCA-3	Martin/St Lucie	Palm Beach	Broward	Miami-Dade	East Caloosahatchee	Big Cypress Preserve	Southwest Coast	District Average	ENP
May 2021	1.04	1.24	1.17	1.44	1.80	2.04	1.65	1.15	1.64	2.48	2.22	1.75	1.44	0.95	**1.43**	0.98
June 2021	8.68	7.33	7.46	7.22	6.69	7.77	7.48	7.78	6.88	10.64	8.93	6.38	8.87	10.44	**8.06**	7.08
July 2021	7.32	7.78	7.60	7.22	10.55	7.20	7.59	6.51	7.56	7.95	6.82	9.50	8.62	10.12	**8.02**	5.30
August 2021	4.85	6.85	6.69	6.39	8.73	6.79	5.63	8.34	6.74	6.07	6.86	7.80	8.44	9.05	**7.17**	5.92
September 2021	6.10	7.70	6.65	7.61	9.94	8.42	7.38	6.28	7.55	7.26	7.40	9.70	9.71	8.47	**7.73**	5.99
October 2021	2.71	2.54	2.68	3.66	3.83	3.83	3.51	3.65	5.01	4.84	4.99	3.81	3.75	3.47	**3.55**	3.94
November 2021	3.33	2.68	2.73	2.90	3.98	3.47	3.47	5.19	5.30	5.59	5.56	3.11	3.67	3.91	**3.73**	2.95
December 2021	1.24	0.51	0.43	0.50	0.26	1.46	0.35	1.13	2.61	1.75	1.15	0.47	0.28	0.48	**0.79**	0.42
January 2022	1.59	1.22	1.35	1.18	1.99	1.35	2.01	2.33	2.08	3.52	4.00	1.71	1.50	1.56	**1.80**	2.04
February 2022	0.70	0.40	0.47	0.79	0.71	2.13	1.81	0.81	2.15	3.39	1.48	0.44	1.34	0.72	**1.01**	1.73
March 2022	5.70	1.59	1.51	0.81	1.05	0.55	1.57	2.42	1.71	1.25	1.64	1.06	1.45	0.51	**1.77**	1.71
April 2022	3.11	2.11	1.49	2.22	3.12	2.33	2.22	2.78	3.35	3.59	2.69	2.41	4.42	4.40	**2.87**	2.87
Total	**46.37**	**41.95**	**40.23**	**41.94**	**52.65**	**47.34**	**44.67**	**48.37**	**52.58**	**58.33**	**53.74**	**48.14**	**53.49**	**54.08**	**47.90**	**40.93**

WY2022 monthly evapotranspiration
(in inches) for each SFWMD rainfall area and ENP.

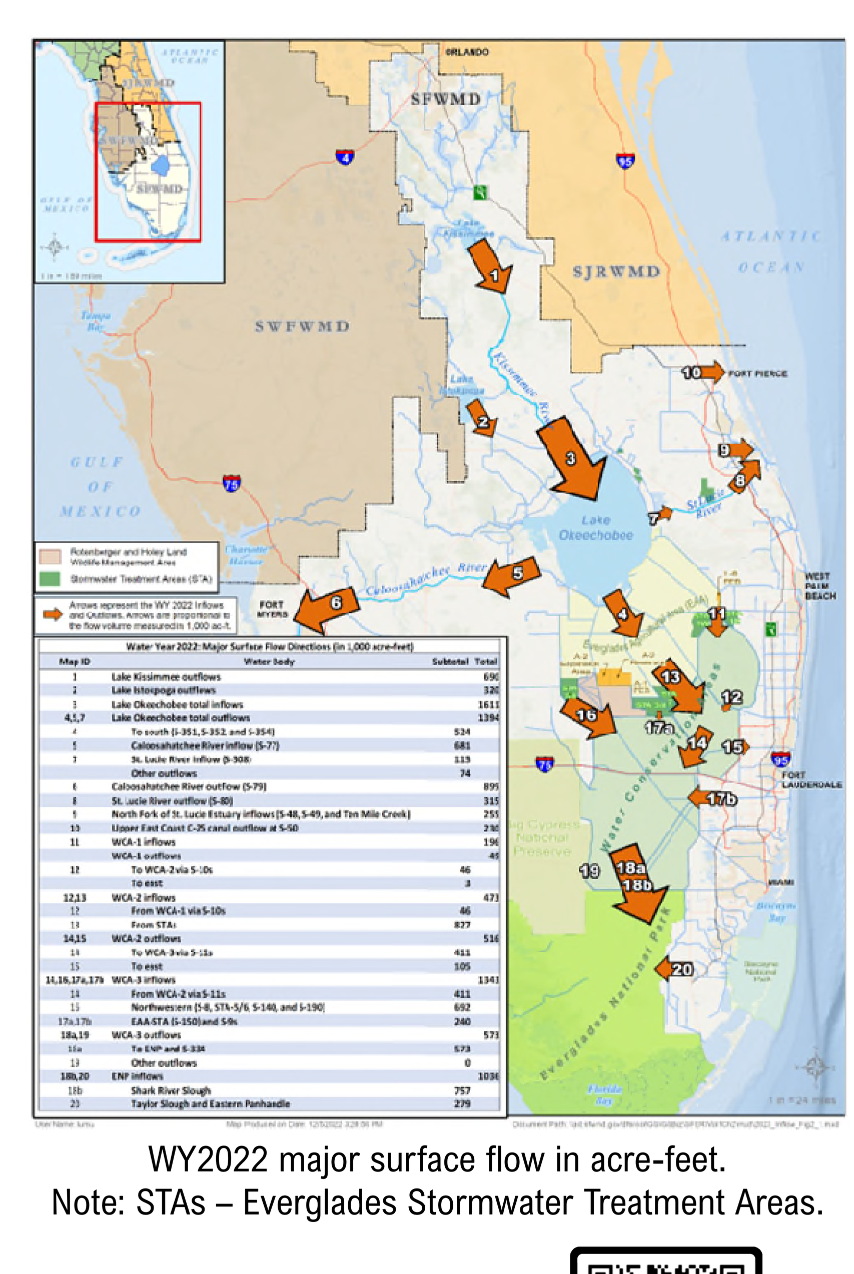
Month	Upper Kissimmee	Lower Kissimmee	Lake Okeechobee	East EAA	West EAA	WCA-1 & WCA-2	WCA-3	Martin/St Lucie	Palm Beach	Broward	Miami-Dade	East Caloosahatchee	Big Cypress Preserve	Southwest Coast	District Average	ENP
May 2021	6.17	6.29	6.82	5.94	5.87	6.37	5.83	5.70	5.77	5.77	5.77	5.85	5.77	5.79	**5.98**	5.77
June 2021	4.61	4.77	4.84	4.34	4.09	4.62	4.61	4.16	3.94	3.94	3.94	4.15	3.94	4.13	**4.29**	3.94
July 2021	4.76	5.32	5.60	4.89	4.79	5.20	4.84	4.56	4.66	4.66	4.66	4.62	4.66	4.49	**4.83**	4.66
Augusts 2021	4.40	4.75	5.14	4.69	4.52	5.23	4.56	4.33	4.71	4.71	4.71	4.54	4.71	4.09	**4.65**	4.71
September 2021	4.22	4.62	5.49	4.52	4.25	4.70	4.31	4.72	4.33	4.33	4.33	4.46	4.33	3.92	**4.47**	4.33
October 2021	4.12	4.18	4.90	3.58	3.88	4.19	3.96	4.14	4.09	4.09	4.09	4.37	4.09	3.84	**4.11**	4.09
November 2021	3.01	3.24	3.55	3.05	3.05	3.19	2.80	2.94	2.91	2.91	2.91	3.38	2.91	3.10	**3.07**	2.91
December 2021	3.19	3.22	3.58	3.06	3.16	3.44	3.15	3.22	2.86	2.86	2.86	3.33	2.86	3.16	**3.14**	2.86
January 2022	3.10	3.24	3.40	3.12	2.97	3.32	2.93	3.08	2.87	2.87	2.87	3.16	2.87	3.14	**3.07**	2.87
February 2022	3.39	3.45	3.94	3.54	3.46	3.81	3.32	3.52	3.62	3.62	3.62	3.43	3.62	3.61	**3.57**	3.62
March 2022	4.62	5.08	5.46	4.82	4.88	5.11	4.74	4.92	4.83	4.83	4.83	4.90	4.83	4.90	**4.91**	4.83
April 20221	5.06	5.26	5.99	5.16	5.21	5.38	5.34	5.11	5.18	5.18	5.18	5.18	5.18	5.15	**5.25**	5.18
Total	**50.65**	**53.43**	**58.69**	**50.70**	**50.14**	**54.55**	**50.39**	**50.41**	**49.76**	**49.76**	**49.76**	**51.36**	**49.76**	**49.30**	**51.33**	**49.76**

WY2022 and historical stage statistics for major lakes and impoundments. (Note: stages are in feet (ft) National Geodetic Vertical Datum of 1929 (NGVD29).

Lake or Impoundment	WY2022 Average	Stage in Periods of Records			
		Average	Minimum	Maximum	Historic period
Alligator Lake	63.29	62.74	58.13	64.52	1993-2021
Lake Myrtle	61.07	60.90	58.45	65.22	1993-2021
Lake Mary Jane	60.31	60.25	57.34	62.31	1993-2021
Lake Gentry	60.98	60.76	58.31	61.97	1993-2021
East Lake Tohopekaliga	56.61	56.57	52.24	59.13	1993-2021
Lake Tohopekaliga	53.65	53.63	48.28	56.82	1993-2021
Lake Kissimmee	50.38	50.41	42.87	56.64	1929-2021
Lake Istokpoga	38.95	38.80	35.84	39.78	1993-2021
Lake Okeechobee	14.48	14.01	8.82	18.77	1931-2021
Water Conservation Area 1	13.69	15.77	10.00	18.16	1953-2021
Water Conservation Area 2A	12.50	12.51	9.33	15.64	1961-2021
Water Conservation Area 3A	9.54	9.64	4.78	12.80	1962-2021
Everglades National Park, Slough	6.65	6.07	2.01	8.08	1952-2021
Everglades National Park, Wet Prairie	2.44	2.25	-2.69	7.10	1953-2021



WY2022 average daily water levels (stage), regulation schedule, and rainfall for the Everglades WCAs.



WY2022 major surface flow in acre-feet.
Note: STAs – Everglades Stormwater Treatment Areas.

The full chapter and references are available via the QR code to the right.

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Chapter 2B: Water and Climate Resilience Metrics

Groundwater Levels and Coastal Saltwater Intrusion Trends in South Florida

Nicole Cortez and Kris Esterson

BACKGROUND

South Florida's coastal aquifers are vulnerable to saltwater intrusion and the challenge of maintaining these aquifers as sustainable sources for water supply will be compounded by the effects of sea level rise, other changing conditions, and water management activities. Improved understanding of the multifaceted response of coastal aquifers in South Florida to sea level rise will help in preparing for resiliency and adaptation planning.

DRIVERS AND INFLUENCING FACTORS

Figure 1. A limestone outcropping seen along the shoreline of Florida's lower east coast. The Biscayne aquifer consists of highly permeable limestone and less-permeable sandstone and sand. (Source: The nature Conservancy)

Factors that may shift the saltwater interface inland in South Florida:

- Less aquifer recharge from rain
- Higher ET losses
- Groundwater extraction for water supply
- Pumping, ditching, or channeling for flood control
- Port dredging

Balance between Freshwater Aquifers and Saltwater: Elevation of the inland water table in natural (i.e., unmanaged) coastal areas is in dynamic equilibrium with sea level. As sea level rises, however, this equilibrium is upset (figure 2).

Groundwater Shoaling: As sea level rises, coastal water tables are elevated in response.

Reduced Unsaturated Zone: As rising sea level drives the water table upward, the unsaturated zone is reduced in thickness. This effect reduces aquifer recharge capacity, increases runoff potential, and increases flood risks.

Groundwater Emergence: In low lying areas sufficient freeboard space may not be present in the unsaturated zone to accommodate rising groundwater. Where the water table rises to meet topographic lows, newly inundated areas may form over time.

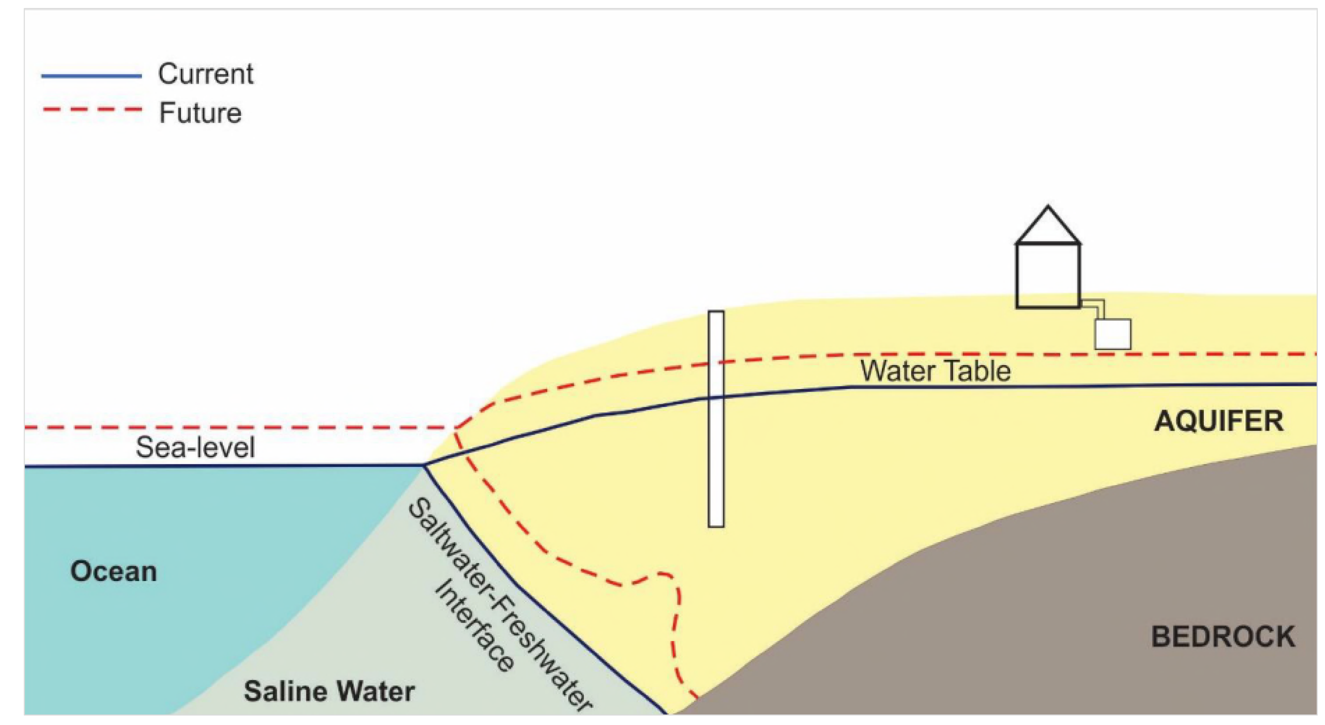


Figure 2. Ghyben-Herzberg relationship between fresh and saltwater in an unconfined coastal aquifer with sea level rise. Inland movement of the saltwater-freshwater interface and elevation of the water table in response to sea level rise. (Source: United States Geological Survey (USGS))

Factors that may shift the saltwater interface seaward in South Florida include:

- More aquifer recharge from rain
- Lower ET losses
- Reduced or shifted groundwater extraction for water supply
- Reduced pumping, ditching, channeling for flood control
- Holding higher stages on conveyances and coastal canals

Sea Level Rise Trend

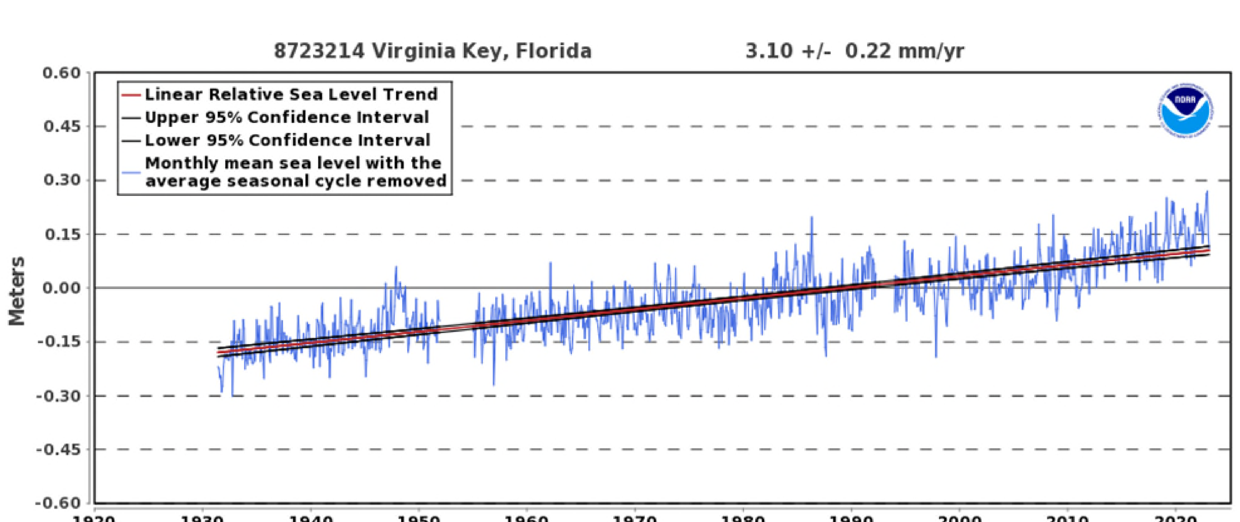


Figure 3. Relative Sea Level Trend at the Virginia Key, Florida tide station. (Source: NOAA Tides & Currents - Sea Level Trends)

Future Rainfall Projections

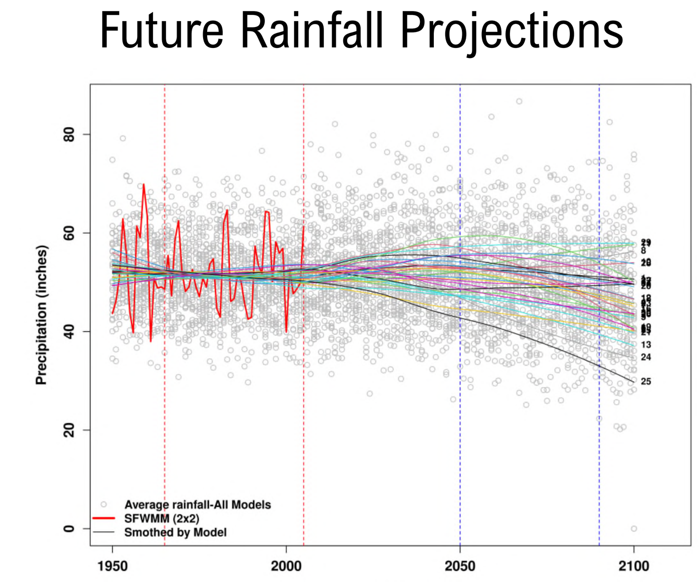


Figure 4. Time series of historically observed average rainfall and smoothed simulated future average. (Source: FIU SLSC)

Evapotranspiration Trends

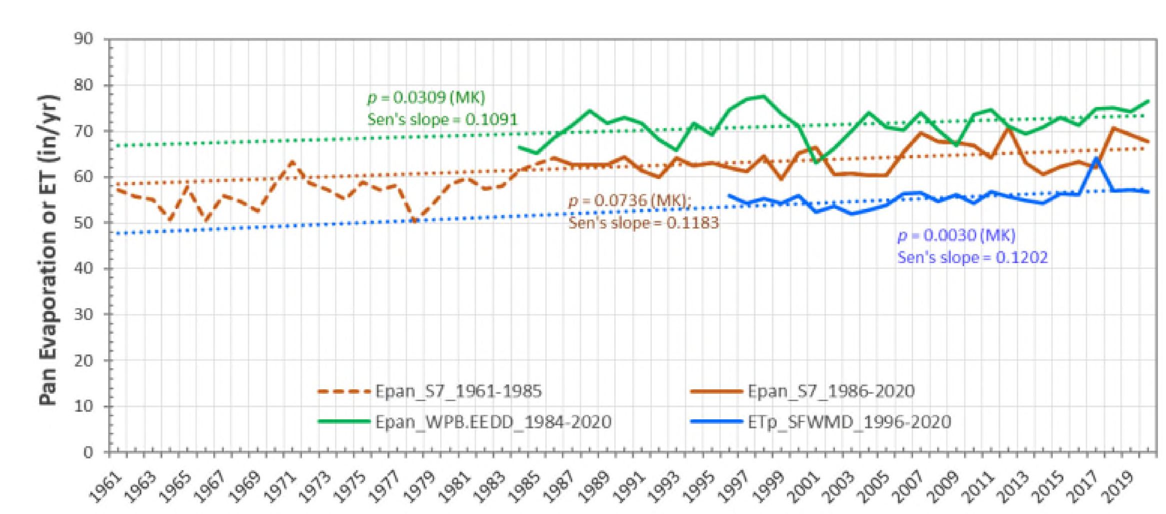


Figure 5. Trend analysis results show statistically significant upward trends in annual pan evaporation (Epan) and potential evapotranspiration (ETp) in South Florida. (Source: v1_ch2b.pdf (sfwmd.gov))

OBSERVED TRENDS

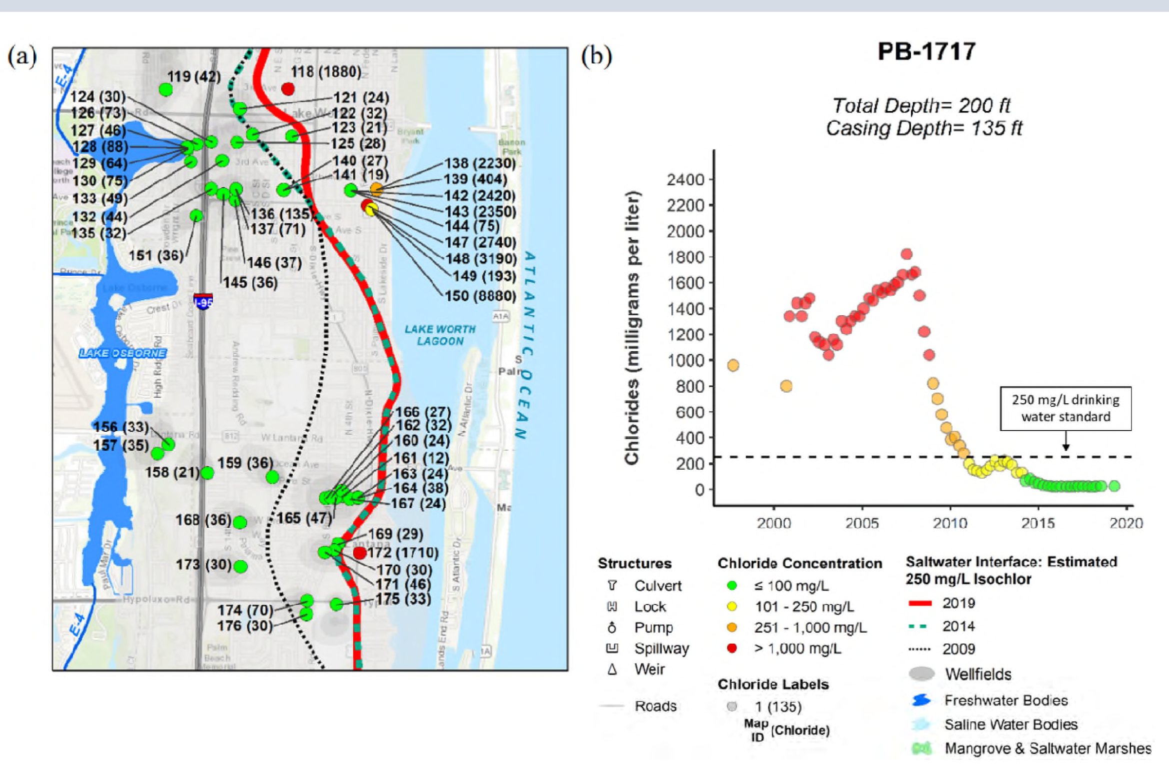


Figure 6. (a) Evidence of eastward (seaward) saline migration around Lake Worth Beach and Lantana and (b) time series plot for monitor well PB-1717, which shows a decline in chloride concentrations. (Notes: ft – feet and source – Shaw and Zamorano 2020.)

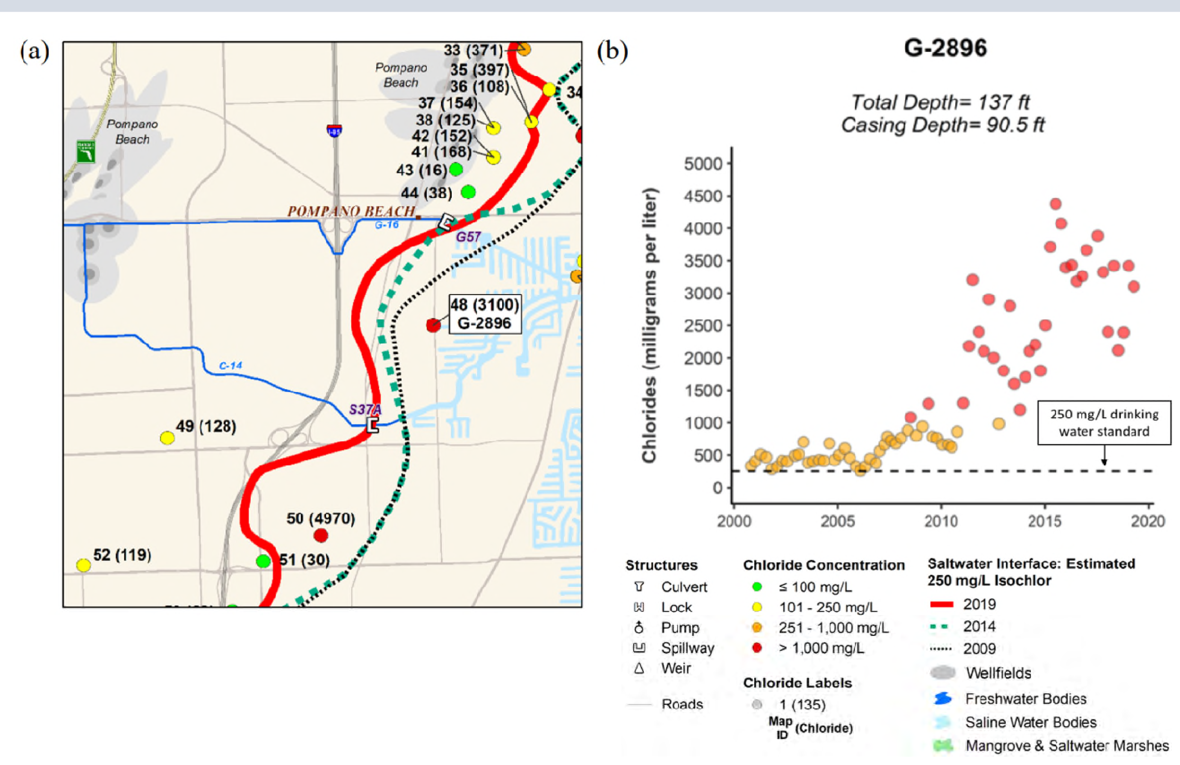


Figure 7. (a) Evidence of westward (inland) saline migration in Pompano Beach and (b) time series plot showing the saltwater interface passing through monitor well G-2896. (Source: Shaw and Zamorano 2020.)

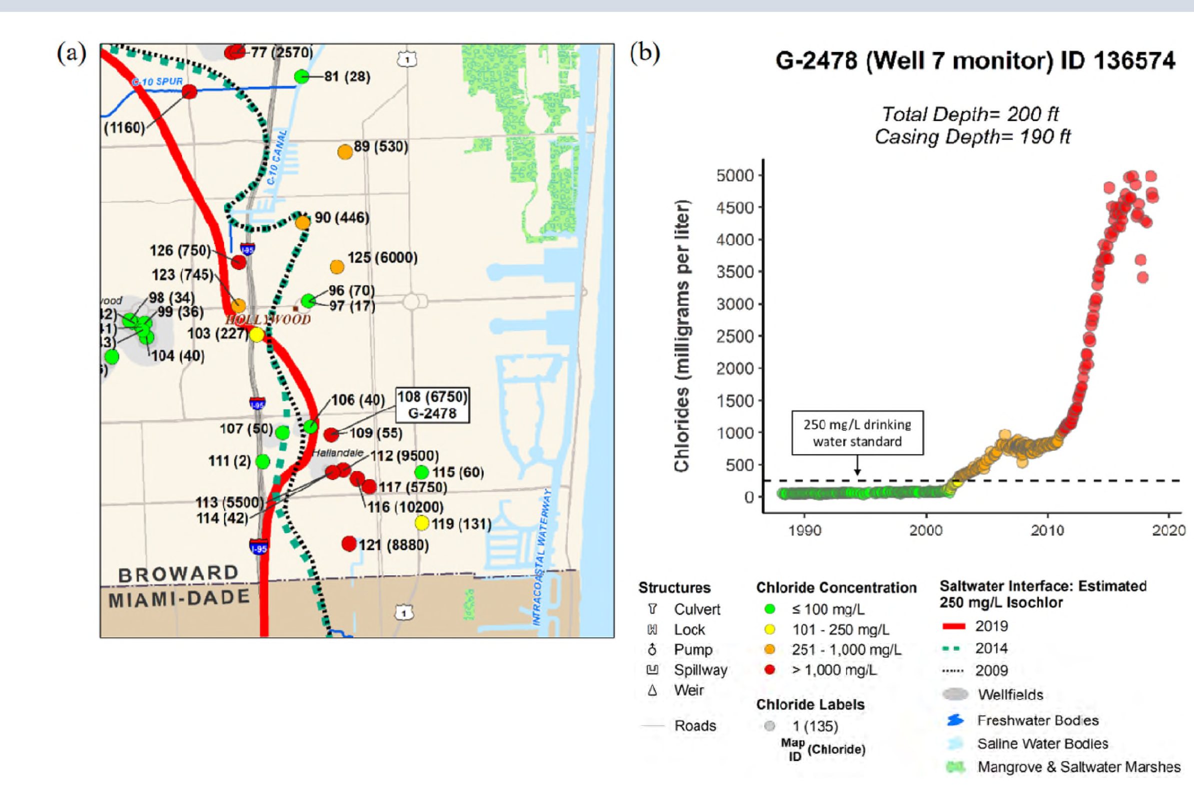


Figure 8. (a) Westward (inland) movement of the saltwater interface impacting Dania Beach and Hallandale wellfields and (b) time series plot showing the saltwater interface passing through monitor well G-2478. (Source: Shaw and Zamorano 2020.)

CONCLUSION

- The challenges of changing groundwater levels and saltwater intrusion in South Florida are complex and multi-decadal in nature.
- Resiliency planning and future water management will rely on accurate data collected in the right places, in the right formats, and archived in a way that allows for future statistical and modeling analyses. To meet these needs, SFWMD should continue to cultivate and support a regional network of saltwater intrusion monitoring wells. Given the complexities of spatially analyzing the effects of sea level rise in the South Florida environment, the development and refinement of appropriate modelling tools will be an ongoing focus.
- Water managers should consider the contribution of sea level rise to saltwater intrusion and consider the interplay, and potential trade-offs, between flood mitigation and adaptation projects and water supply in long-term adaptive resilience planning. As the saltwater interface approaches, and potentially reaches coastal wellfields, adaptation projects will be required to continue to meet water supply needs.

The full chapter and references are available via the QR code below.

SCAN ME

Chapter 2B: Water and Climate Resilience Metrics

Trends in Surface Water Salinity, Accretion and Elevation Change, and Mangrove Migration in South Florida

Nicole Cortez and Carlos Coronado

BACKGROUND

South Florida's estuaries and bays are vulnerable to the impacts of climate change, including sea level rise and changes in rainfall and evapotranspiration. These natural systems rely on water management activities to deliver adequate freshwater flows. SFWMD monitors and reports ecosystem response to water management, climate conditions, and restoration projects. In Florida Bay and Biscayne Bay, freshwater flow, salinity, and nutrients are the main drivers of ecosystem change and vegetation dynamics. The salinization of previously freshwater and brackish habitats due to reduced freshwater inputs and increasing sea level rise leads to habitat loss of tidal marshes, poses a threat to the flora and fauna that inhabit them, impacts soil accretion and elevation change, and mangrove response to increasing sea levels.

INFLUENCING FACTORS

Dynamic Coastal Wetlands

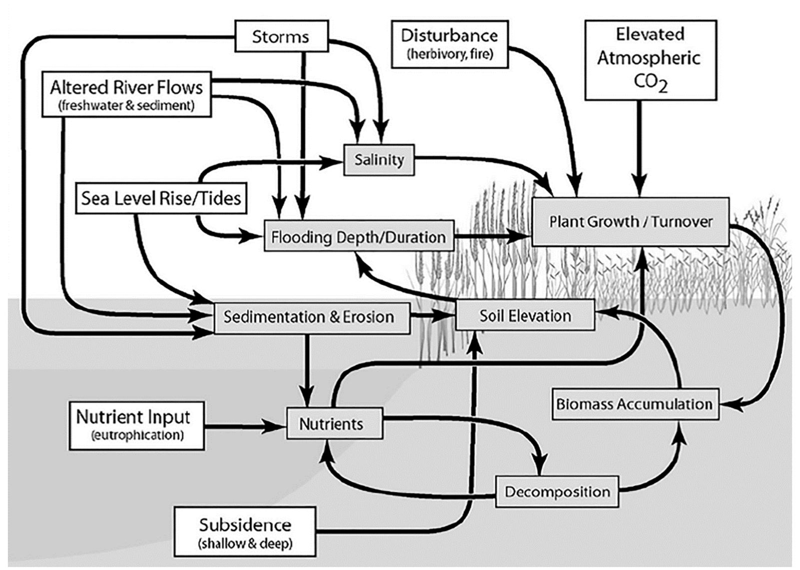


Figure 1. Conceptual model illustrating links and feedback relationships among factors controlling habitat stability and nutrient and carbon dynamics in coastal wetlands. External forcing functions that may destabilize the system are indicated in white boxes. Figure reproduced from Cahoon et al. (2010).

Surface Water and Rainfall

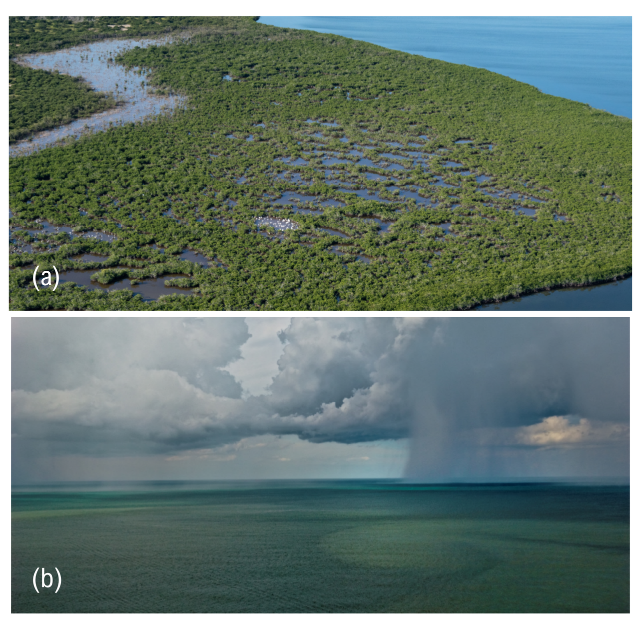


Figure 2. Fresh water enters Florida Bay via (a) surface water flows from the Everglades and (b) rainfall. (Source: SFWMD staff photos)

Sea Level Rise Trend

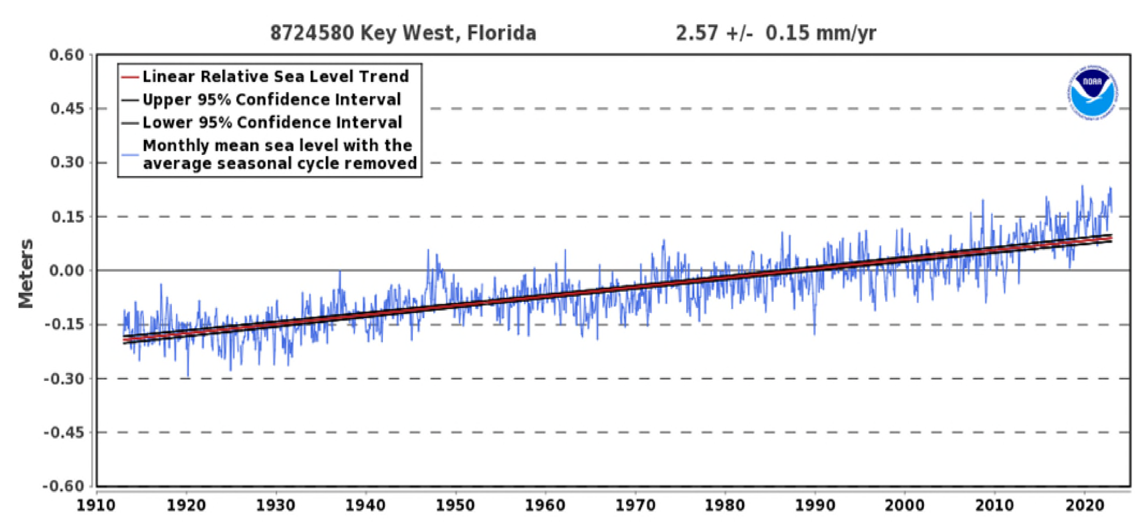


Figure 3. Historical relative sea level shows upward trend Key West, Florida. (Source: https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?id=8724580)

Evapotranspiration Trends

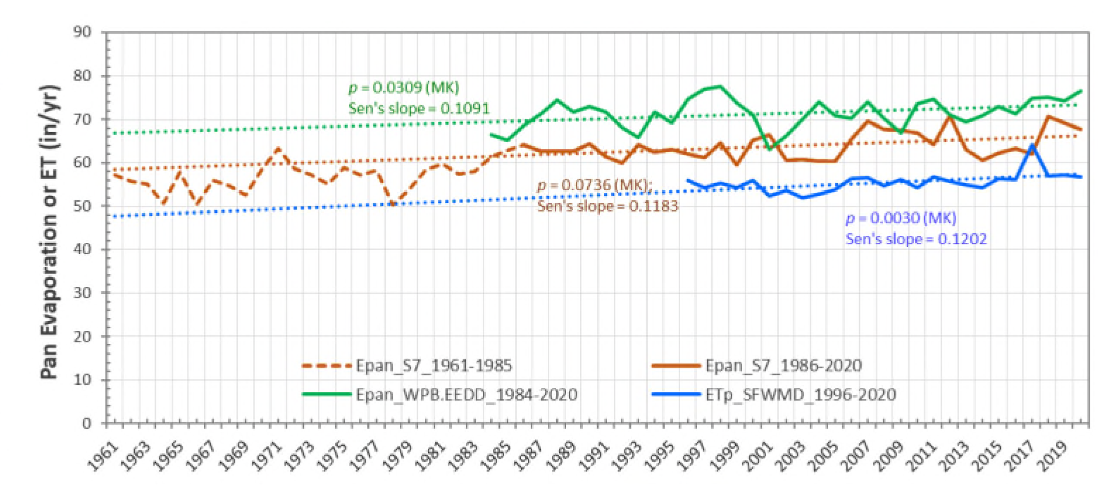


Figure 4. Trend analysis results show statistically significant upward trends in annual pan evaporation (Epan) and potential evapotranspiration (ETp) in South Florida.

SURFACE WATER SALINITY TRENDS

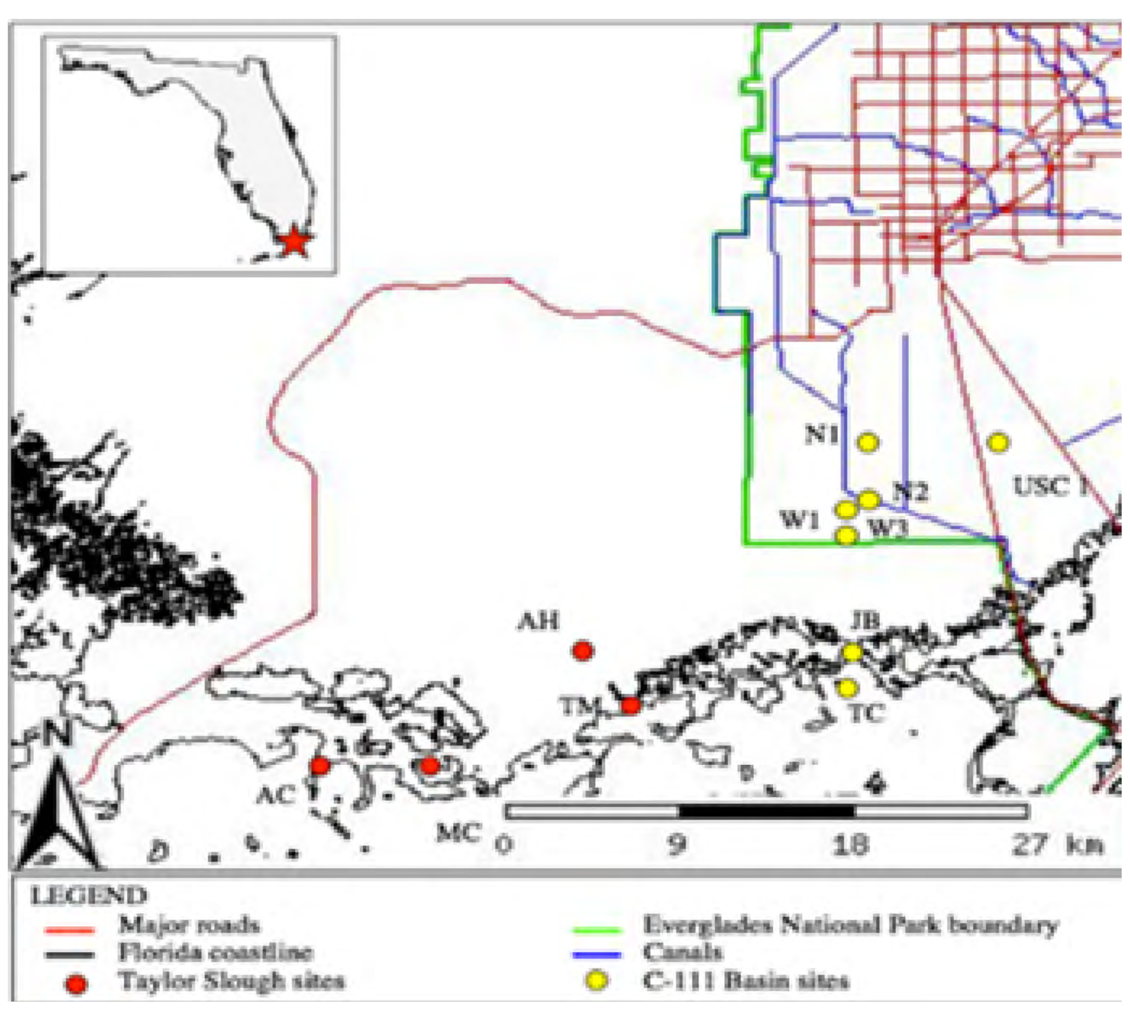


Figure 5. Locations of salinity monitoring sites in Florida Bay

Table 1. Summary of statistics and trend analyses results in Florida Bay.

	AC	MC	AH	TM	JB	TC
Period of Record	2009–2022	2008–2022	2008–2022	2008–2022	2008–2022	2008–2022
Minimum Value	5.60	4.00	0.00	0.40	0.20	0.40
Median Value	35.20	27.30	2.20	17.15	11.00	23.05
Maximum Value	82.00	63.40	47.90	49.70	55.70	56.30
Average	76.40	59.40	47.90	49.30	55.50	55.90
Magnitude	35.42	35.42	8.87	17.62	14.93	23.12
Probability Value	0.74	0.55	0.87	0.55	0.30	0.70
Sen's Slope	0.14	0.35	0.05	0.32	0.70	0.29
Observed Trend	No trend	No trend	No trend	No trend	No trend	No trend

- No significant trends in average annual salinity were observed in Florida Bay.
- Alligator Creek (AC) and McCormick Creek (MC), located in the western and central regions of Florida Bay, exhibited the highest averages in daily salinity and the greatest magnitude between minimum and maximum daily salinity concentrations. The results of this analysis support that observed salinity concentrations in western Florida Bay may be more greatly influenced by tidal inputs than the central and eastern regions of the bay.
- The remaining sites: Argyle Henry (AH), Taylor Mouth (TM), Joe Bay (JB), and Trout Creek (TC), located in central and eastern Florida Bay and the C-111 Basin, where wind, freshwater flows, and evapotranspiration are dominating factors influencing observed salinity concentrations, exhibited lower averages in daily salinity concentration in addition to relatively smaller magnitudes between minimum and maximum daily salinity concentrations.

ACCRETION AND ELEVATION CHANGE

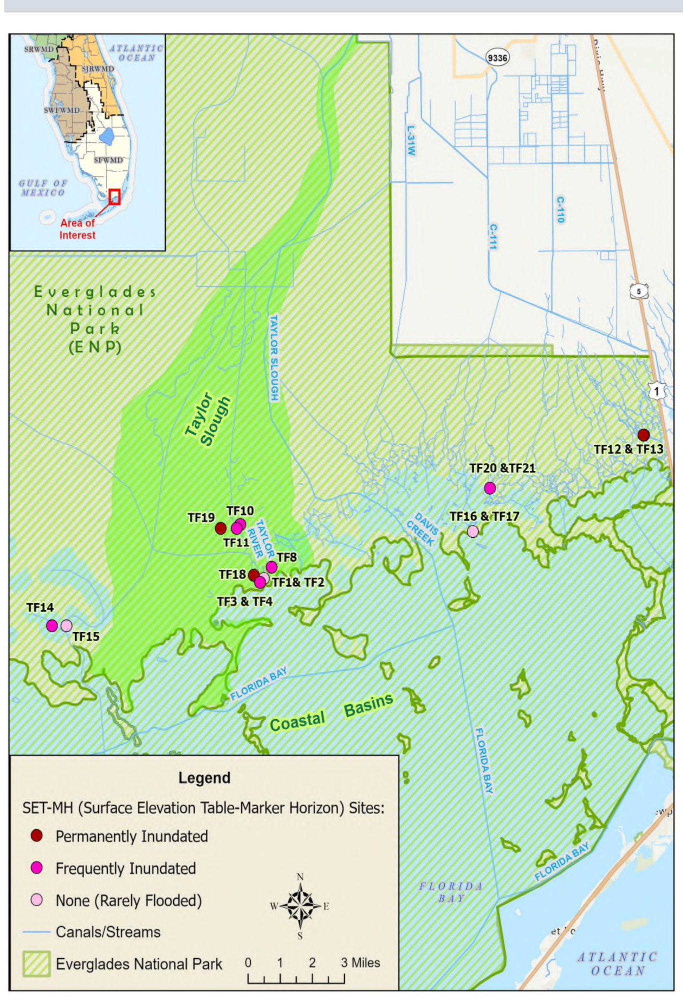


Figure 6. Locations of non-flooded, frequently flooded, and permanently flooded soil monitoring sites in Florida Bay.

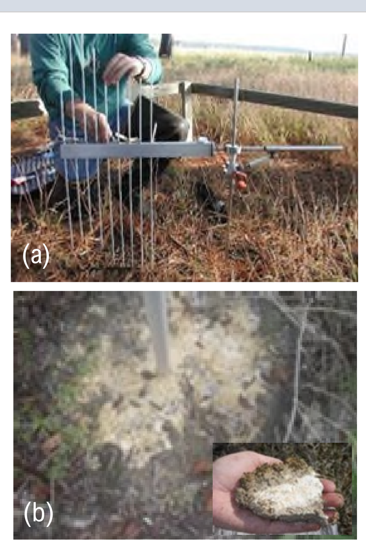


Figure 7. (a) surface elevation table (source: United States Geological Survey) and (b) feldspar sampling plot for measuring soil accretion.

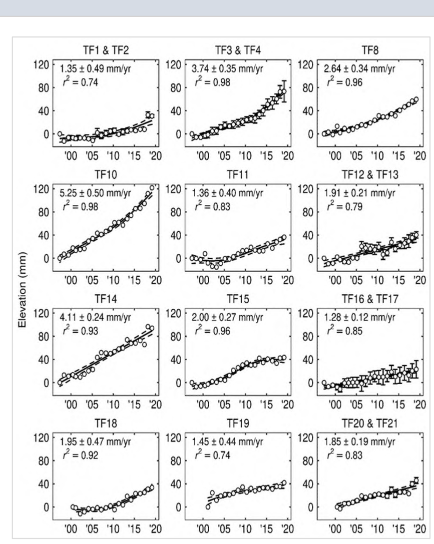


Figure 8. Elevation change rates.

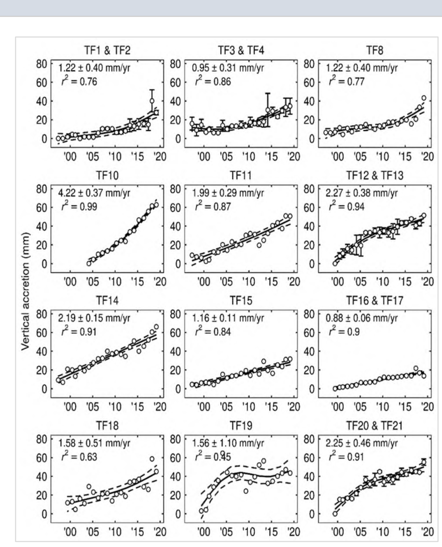


Figure 9. Soil accretion rates.

- Accretion is the accumulation of organic matter and sediment.
- The greatest elevation change and accretion rates were observed at TF10, a frequently flooded site.
- The lowest elevation change and accretion rates were observed at rarely flooded sites TF16/17 and TF1/2, respectively.
- The results highlight the importance of microtopography and hydrology in the soil dynamics of mangrove forests along the Taylor River and Florida Bay.

MANGROVE MIGRATION TRENDS

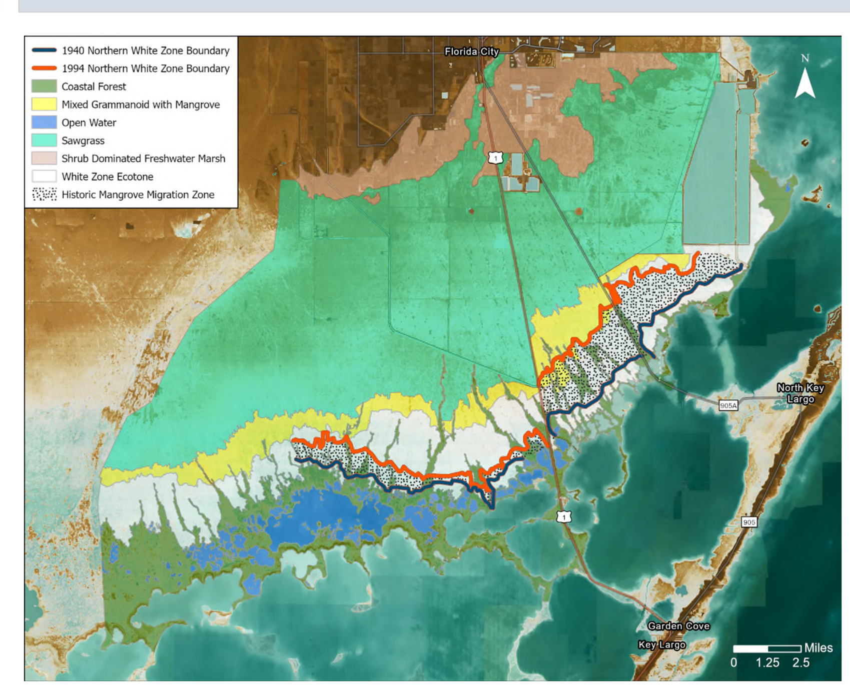


Figure 10. Vegetation types in the southeastern glades showing the 1940 and 1994 northern white zone boundary.

- On average, the interior boundary of the low productivity zone moved 2.01 km inland east of US-1 and 0.80 km west of US-1.
- The smaller shift observed on the west side of US-1 is attributed to the area receiving more freshwater flows from the water management system, while greater change occurred in areas cut off from upstream freshwater sources by roads or levees on the east side of US-1.
- These large-scale vegetation shifts are the combined result of changes to natural water flow in the Everglades and sea level rise.

CONCLUSIONS

- The impacts of climate change in South Florida's estuaries are complex in nature and vary throughout the landscape. The role of water management is critical in staving off these impacts.
- Resilience in coastal ecosystems may be enhanced through freshwater inputs that promote lower surface water salinity concentrations, increase soil accretion, and to enhance mangrove recruitment and growth.
- SFWMD should continue to maintain and support a regional ecological monitoring network that enhances data collection and analyses, aids the understanding of ecosystem responses to the effects of climate change and water management activities, and the identification of opportunities for adaptive management in restoration and water management which must be incorporated as part of resiliency planning.

The full chapter and references are available via the QR code below:

SCAN ME

Chapter 7: Long-term Invasive Plant Species Trends in the Everglades: Successes and Challenges

Alexandra Onisko, LeRoy Rodgers (Land Resouces Bureau), and Amy Peters (Geospatial Services)

Background

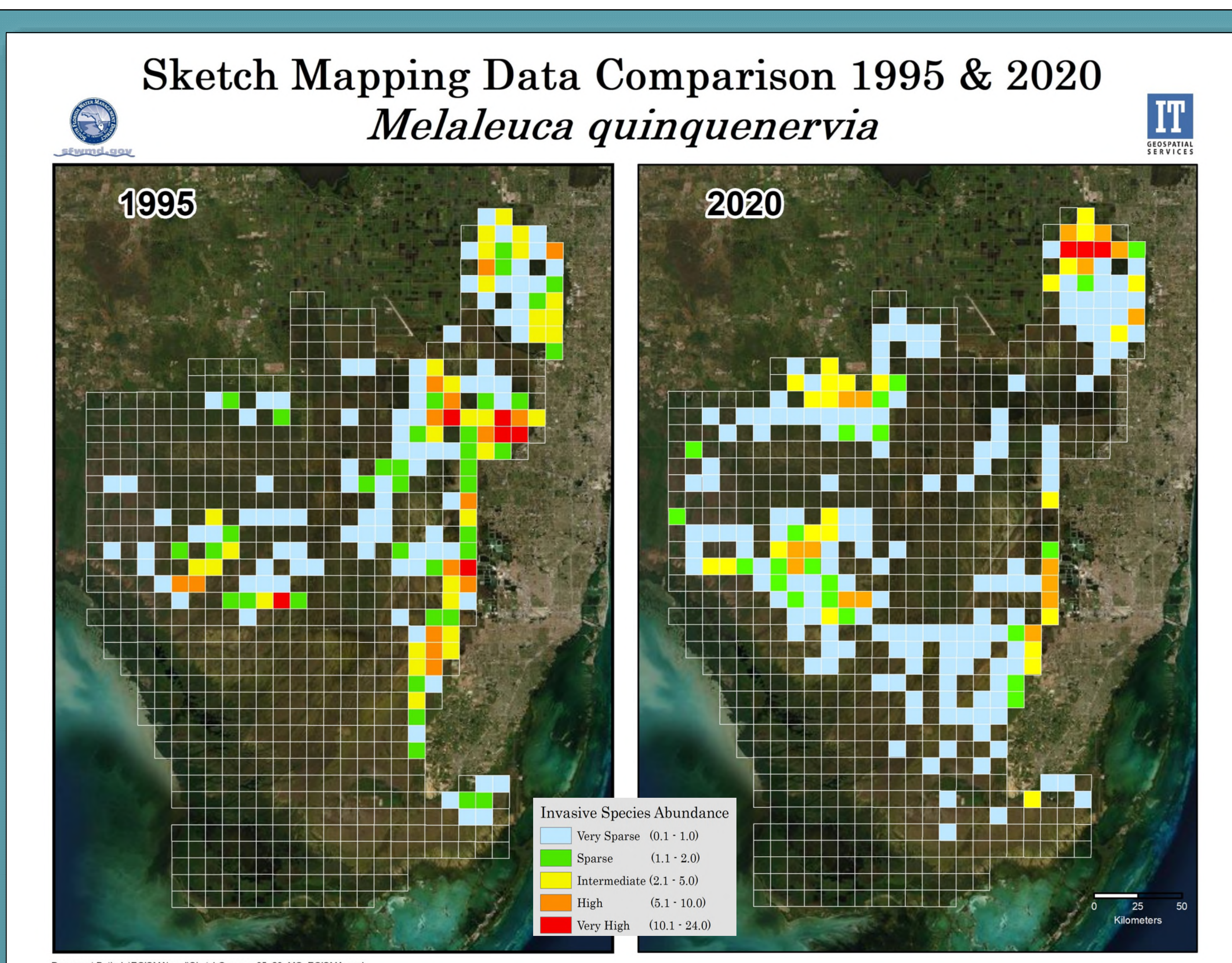
Invasive plant management in large natural areas requires monitoring programs to direct control efforts, understand distribution patterns, detect new invasions, and assess progress of control. Priority species have been monitored in the Everglades using the systematic reconnaissance flight methodology since 1995.

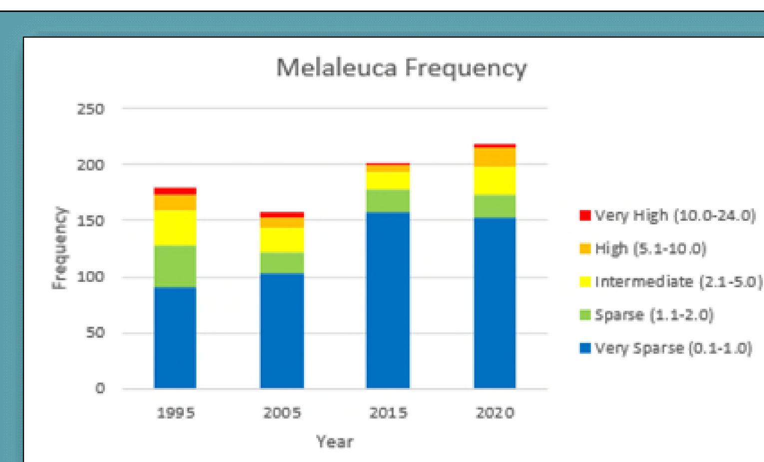
Methods

Invasive plant cover is measured throughout the Everglades using specialized mapping software along transects within a 4-kilometer grid system. Species' distribution and abundance are represented with maps. Quantitative estimates demonstrate changes in area of occurrence (grid cell frequency) and abundance over time.

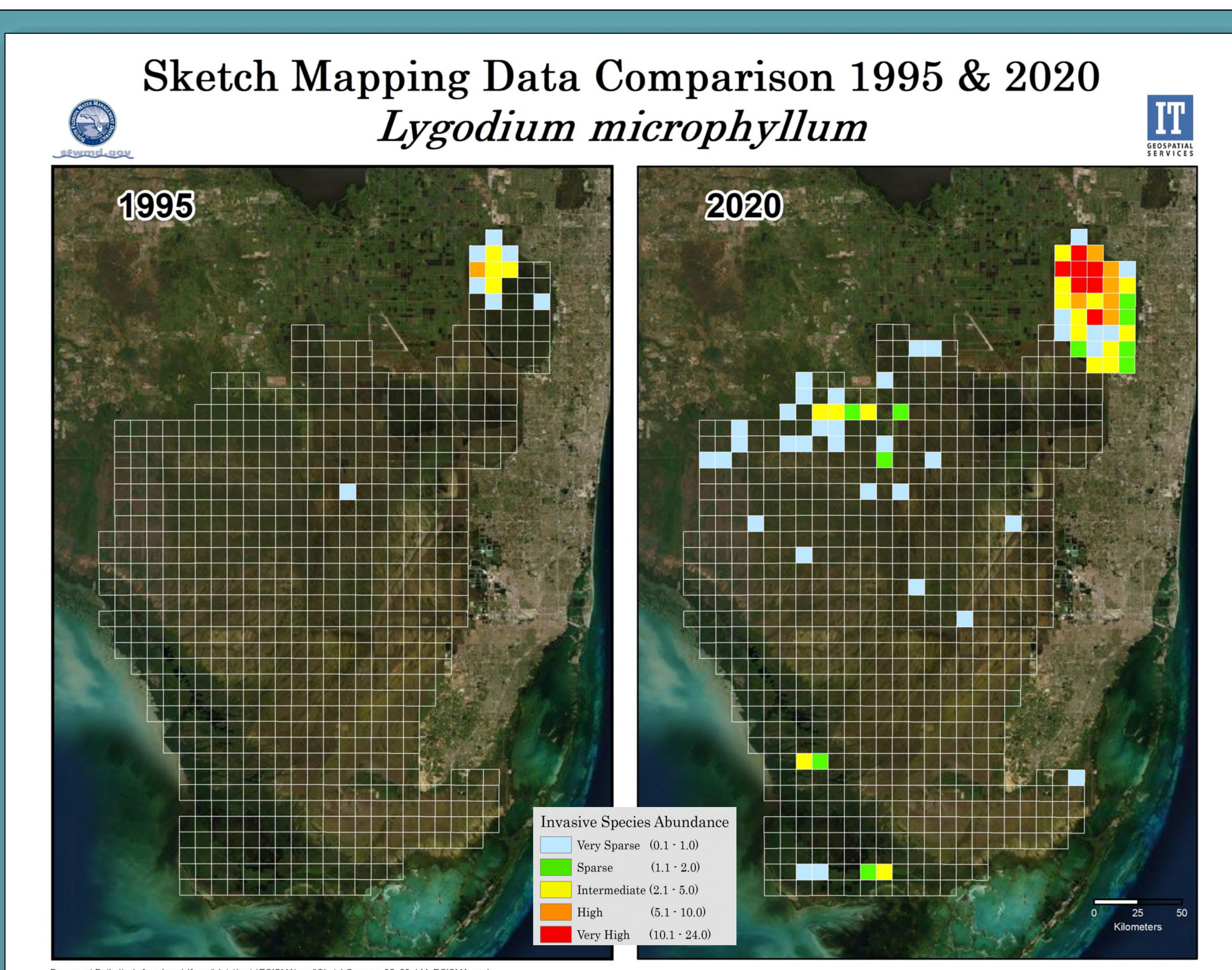
Observers visually estimate species cover within random plots from aircraft. Data are collected using specialized mapping software.

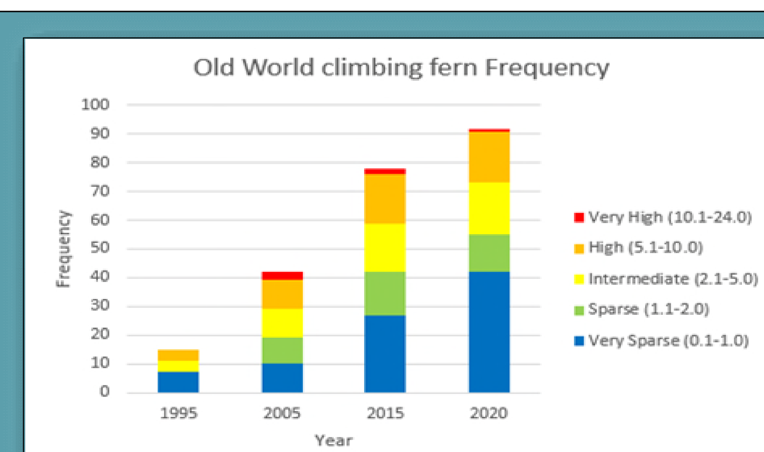
Maps show the distribution and abundance of three priority invasive species in 1995 and 2020 across the Everglades. Charts show the frequency of occurrence for each species during the 25-year study period.



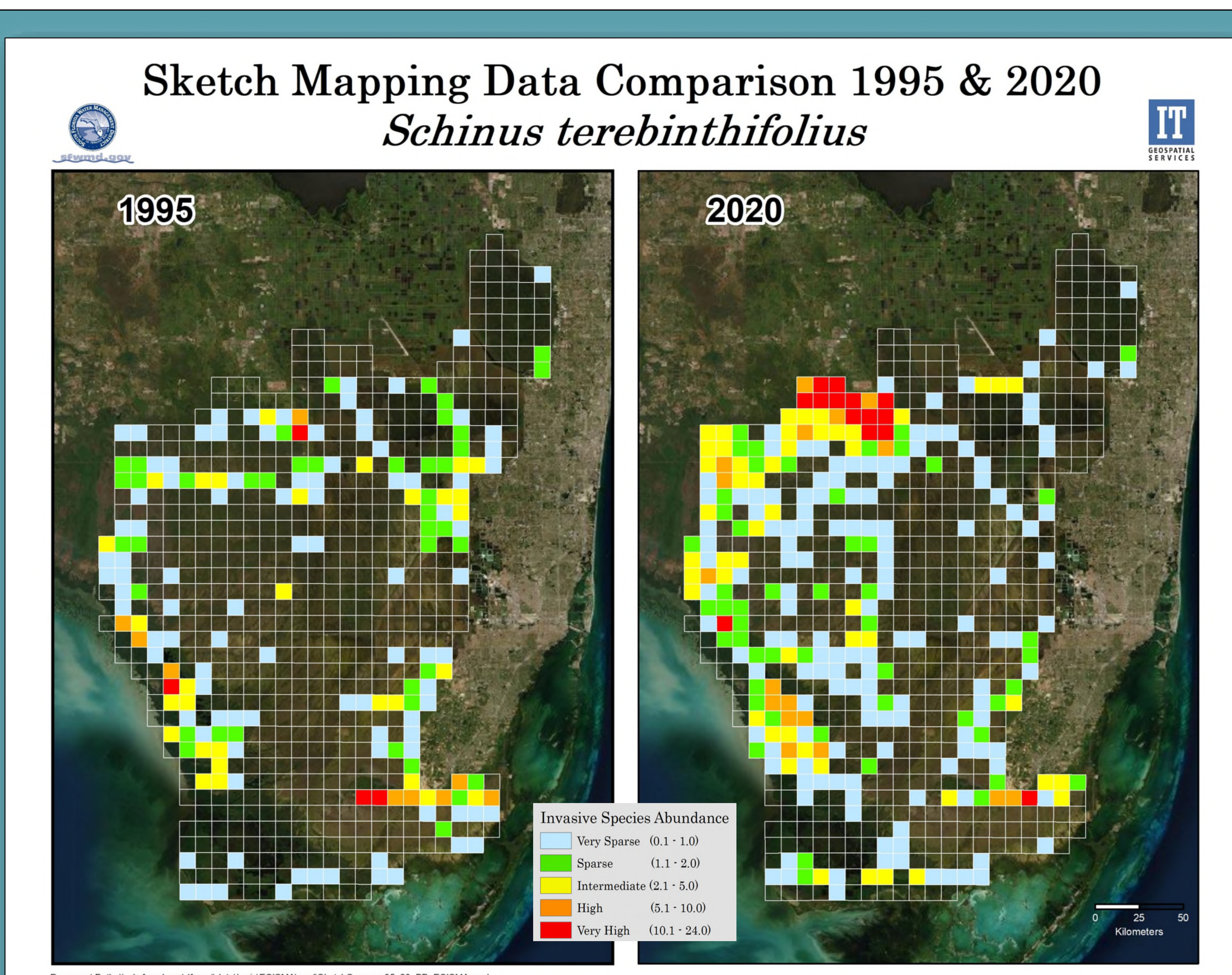


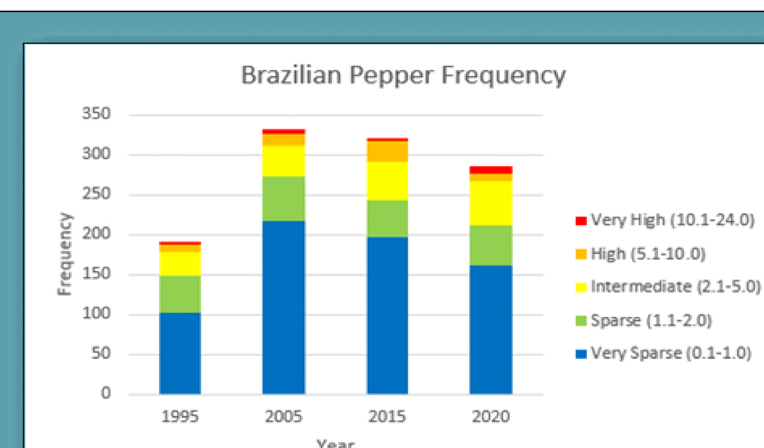
Melaleuca converts open wading bird foraging habitat to dense single species melaleuca swamps.

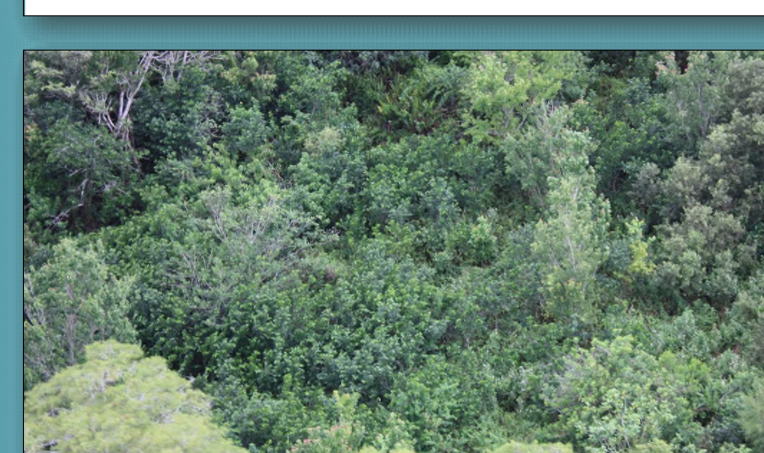




Uncontrolled Old World climbing fern leads to loss of Everglades tree islands.







Brazilian pepper displaces native species in Everglades tree islands, cypress swamps and mangroves.

Key Findings

Melaleuca

- An aggressive invader of multiple Everglades habitats, primarily marshes and sloughs.
- Integrated management has resulted in maintenance control in large areas (Water Conservation Area [WCA] 2 and 3).
- Melaleuca continues to expand across the landscape.
- Several regions have been experiencing abundance increases in the last five years.

Old World Climbing Fern

- This invasive "ecosystem engineer" is responsible for tree island collapse.
- Significant infestations still occur within A.R.M. Loxahatchee NWR (WCA 1).
- Infestations have expanded across the Everglades since 1995, but sustained control efforts have prevented heavy infestations.

Brazilian Pepper

- Most abundant and widespread invasive plant in the Everglades.
- Outcompetes native plants in disturbed areas, tree islands, and fringes of mangroves.
- Distribution across the Everglades has declined since 2005 due to expanded control efforts.

SCAN ME

Chapter 7: Protecting Everglades Restoration Investments through Invasive Animal Management

Edward F. Metzger III, Invasive Animal Biologist and Mike Kirkland, Sr. Invasive Animal Biologist
Land Resources Bureau

Everglades Restoration and Invasive Animals

Invasive animals threaten the Everglades restoration goal of protecting native species. One of the most destructive invasive animals is the Burmese python, a large constrictor (exceeding 18 ft. in length) native to southeast Asia (Figure 1). They prey upon South Florida's native birds, mammals, and alligators (Figure 2), which makes them a priority species for management.

Python Removal Contractors

The South Florida Water Management District (District) partners with the Florida Fish and Wildlife Conservation Commission (FWC) to manage 100 python removal contractors to reduce Burmese python numbers (Figure 3). Contractors conduct visual searches by vehicle, boat, and foot, throughout the Greater Everglades Ecosystem. Contractors have removed more than 11,000 pythons since 2017 (Figure 4).

Figure 1. Python removal contractors Kevin Pavlidis and Ryan Ausburn with an 18 foot, 9 inch Burmese python captured on the L-28 Tieback levee in 2020.

Figure 3. Members of the South Florida Water Management District Python Elimination Program.

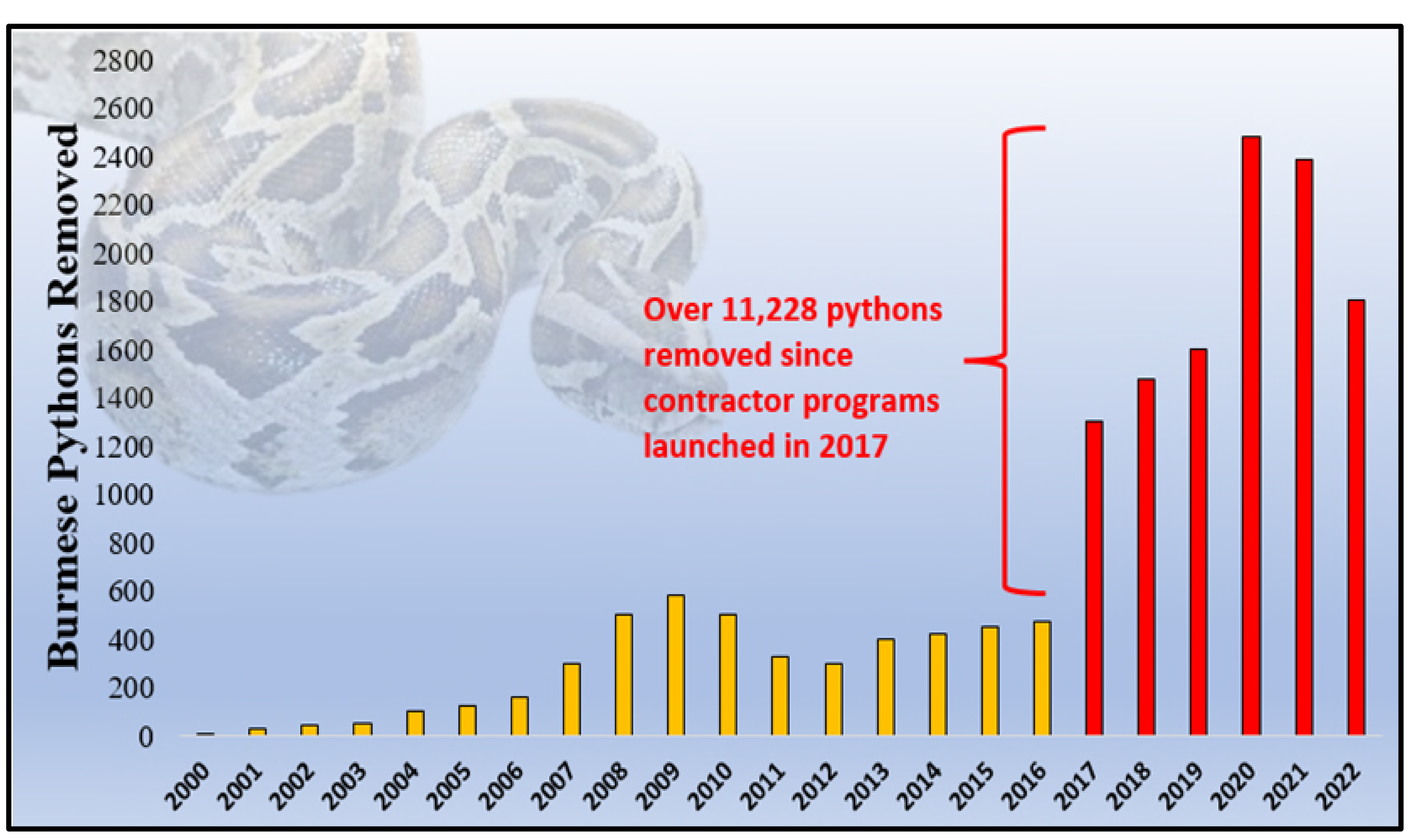


Figure 4. Number of Burmese pythons removed from Florida annually during 2000 to 2022. The dramatic increase in captures in 2017 represents the beginning of python contractor programs.

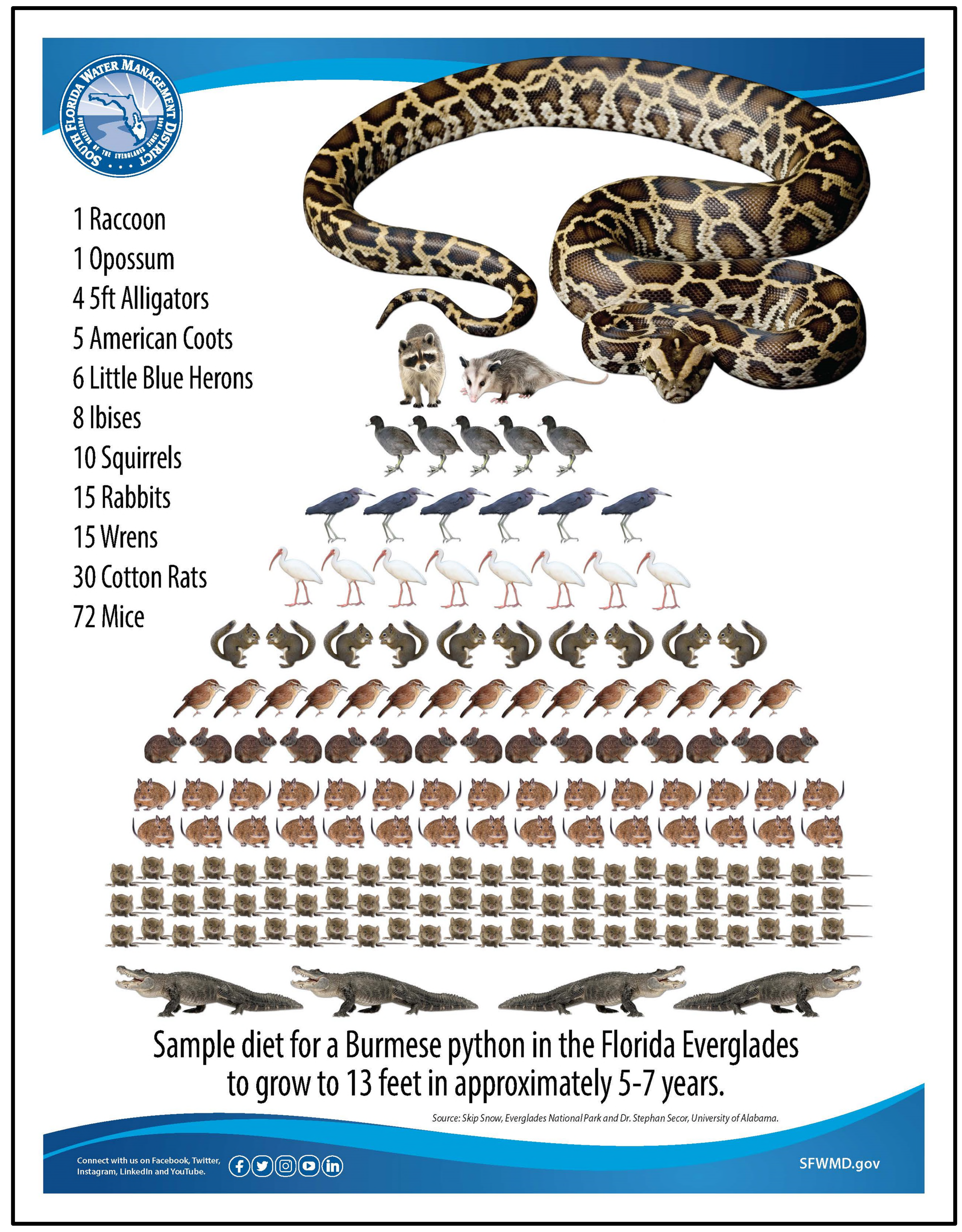


Figure 2. This hypothetical diet represents a fraction of the native species Burmese Pythons are known to prey upon. Each python that is removed may save hundreds of native animals.

Figure 5. Hatchling Burmese pythons tagged and ready for release to track their survival (CSWF photo).

Figure 6. University of Florida biologist Samantha Smith uses telemetry to track a radio-tagged Burmese python (UF/IFAS photo).

Research and Outreach supported by SFWMD

The most significant challenge in Burmese python management is detection. The District is investing in research and outreach projects to further understand python biology and increase python detection and reporting. Current collaborations with partner organizations include: (1) a python hatchling survival study with the Conservancy of Southwest Florida (CSWF; Figure 5), and (2) a python breeding ecology and habitat use in collaboration with the US Geological Survey, University of Florida, and FWC (Figure 6). To increase public participation and reporting, the District co-hosts the annual Florida Python Challenge® outreach event with FWC (Figures 7-8). Invasive animal management remains part of the District's core mission to ensure the success of Everglades restoration!

Figure 7. The annual Florida Python Challenge® event raises awareness and encourages public participation.

Figure 8. The IveGot1 smartphone app is a convenient way to report invasive species sightings from the field.

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Chapter 4: Everglades Agricultural Area Source Control Program Monitoring and Performance

Youchao Wang, Aubrey Frye, Mehrnoosh Mahmoudi, Christian Avila
Everglades and Estuaries Protection Bureau

Since 1996, a total of 4,431 metric tons of total phosphorus (TP) load has been prevented from being discharged directly from the Everglades Agricultural Area (EAA).

BEST MANAGEMENT PRACTICES

To reduce TP load at the source, permittees must obtain permits from SFWMD to implement Best Management Practices (BMP) plans consisting of nutrient management, water management, particulate matter, and sediment controls.

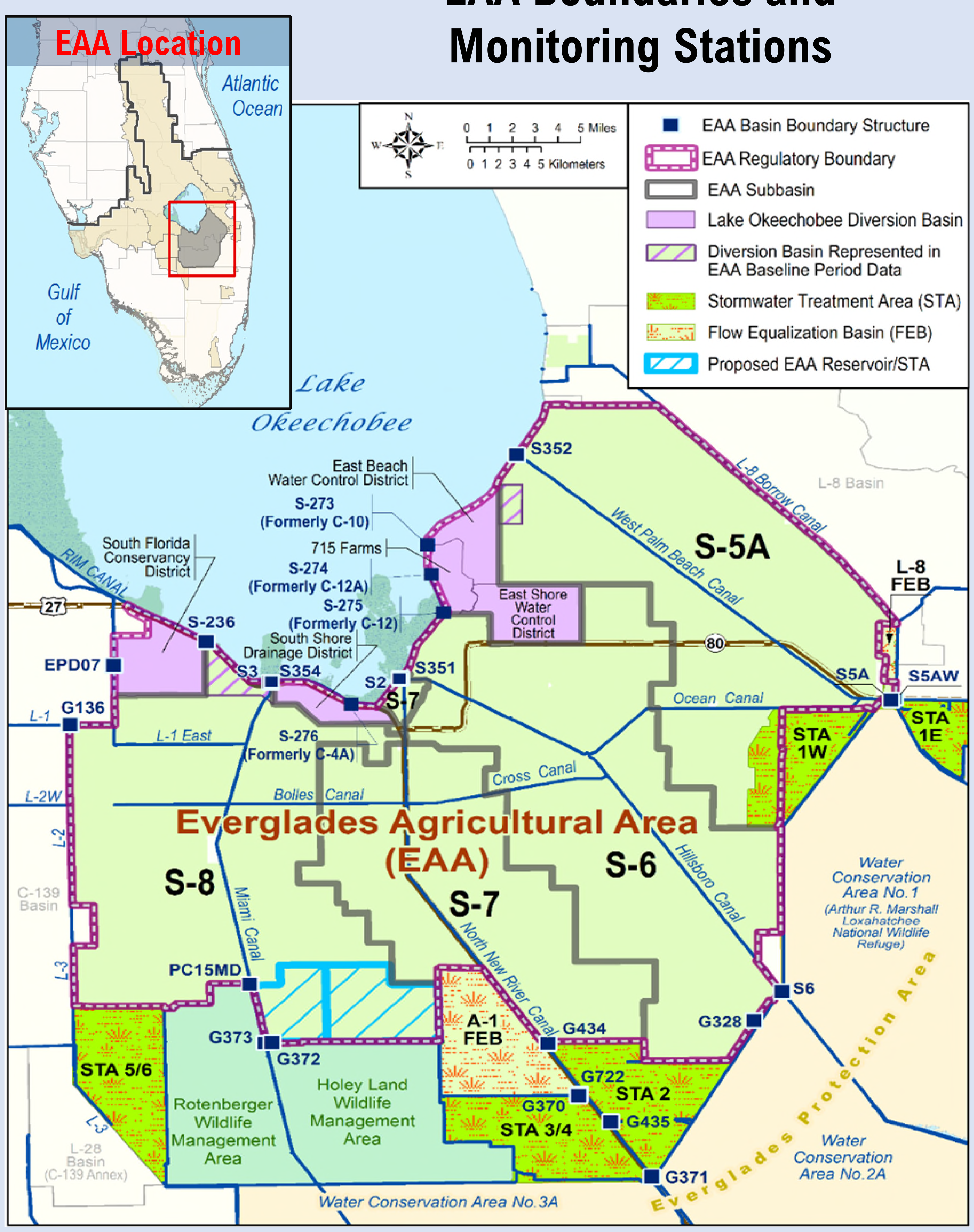
Nutrient Management

Water Management

Particulate Matter and Sediment Controls

The EAA Basin, approximately 474,000 acres, is located south of Lake Okeechobee and is the largest tributary basin of TP load to the Everglades. Because of historically high TP load from the EAA, the South Florida Water Management District (SFWMD) was directed under the Everglades Forever Act (373.4592 F.S.) to implement a regulatory source control program. **It requires permittees to achieve a 25% TP load reduction in their stormwater discharges to the Everglades.**

EAA Boundaries and Monitoring Stations

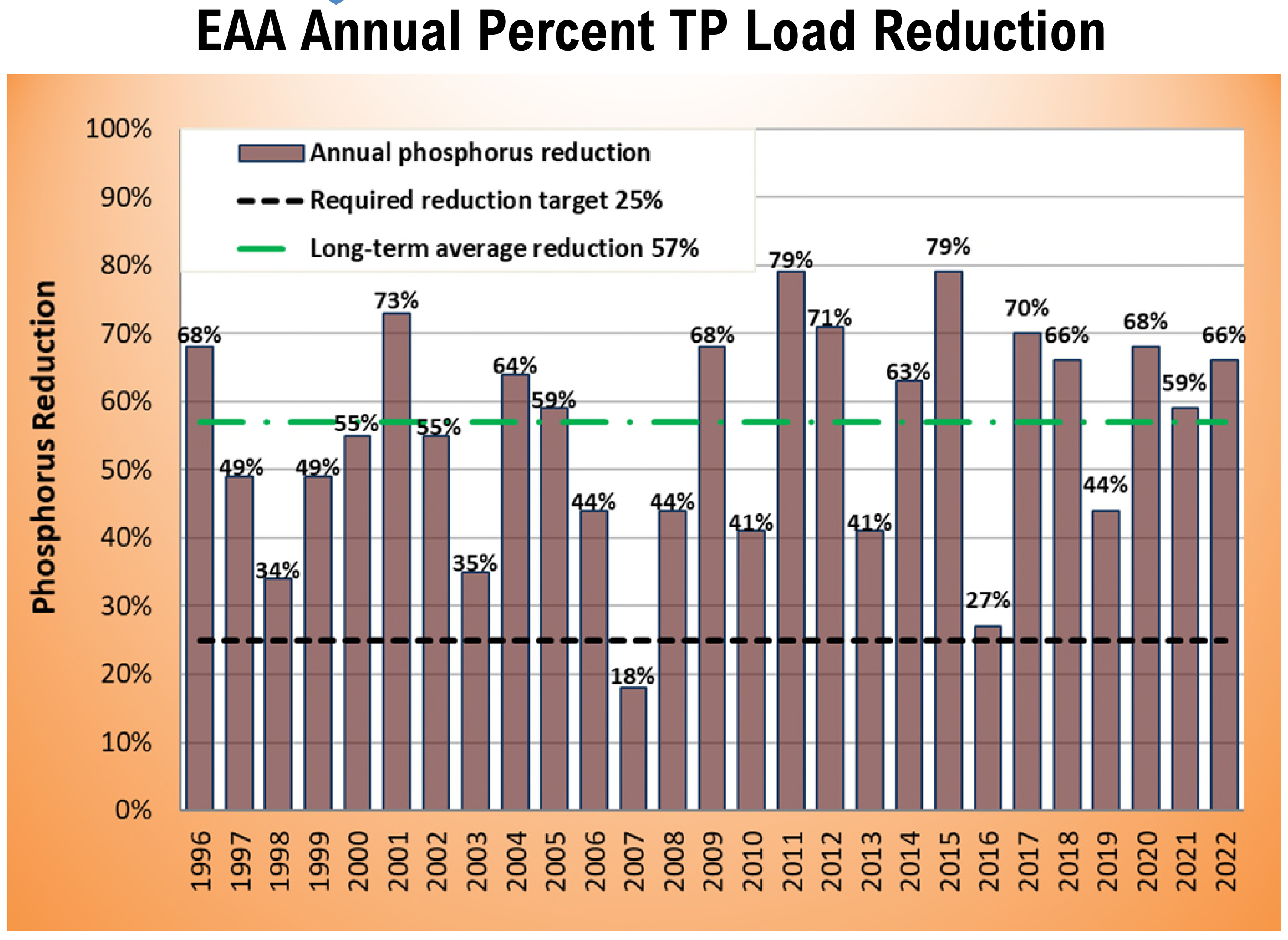


MONITORING & ASSESSMENT

- SFWMD collects samples of all EAA Basin discharges to determine the TP load discharged for the current water year.
- The TP load for the current water year is compared to a pre-BMP baseline period to determine compliance with the 25% reduction requirement.
- A regression model was developed to estimate the TP load during a historic pre-BMP baseline period (1979-1988).
- The model accounts for hydrologic variability between the current year and the baseline period to ensure an "apples to apples" comparison between the two periods.

Autosampler at S3 Pump Station

EAA Annual Percent TP Load Reduction



The EAA basin is determined to be out of compliance if the 25% TP load reduction target is not met for three consecutive years.

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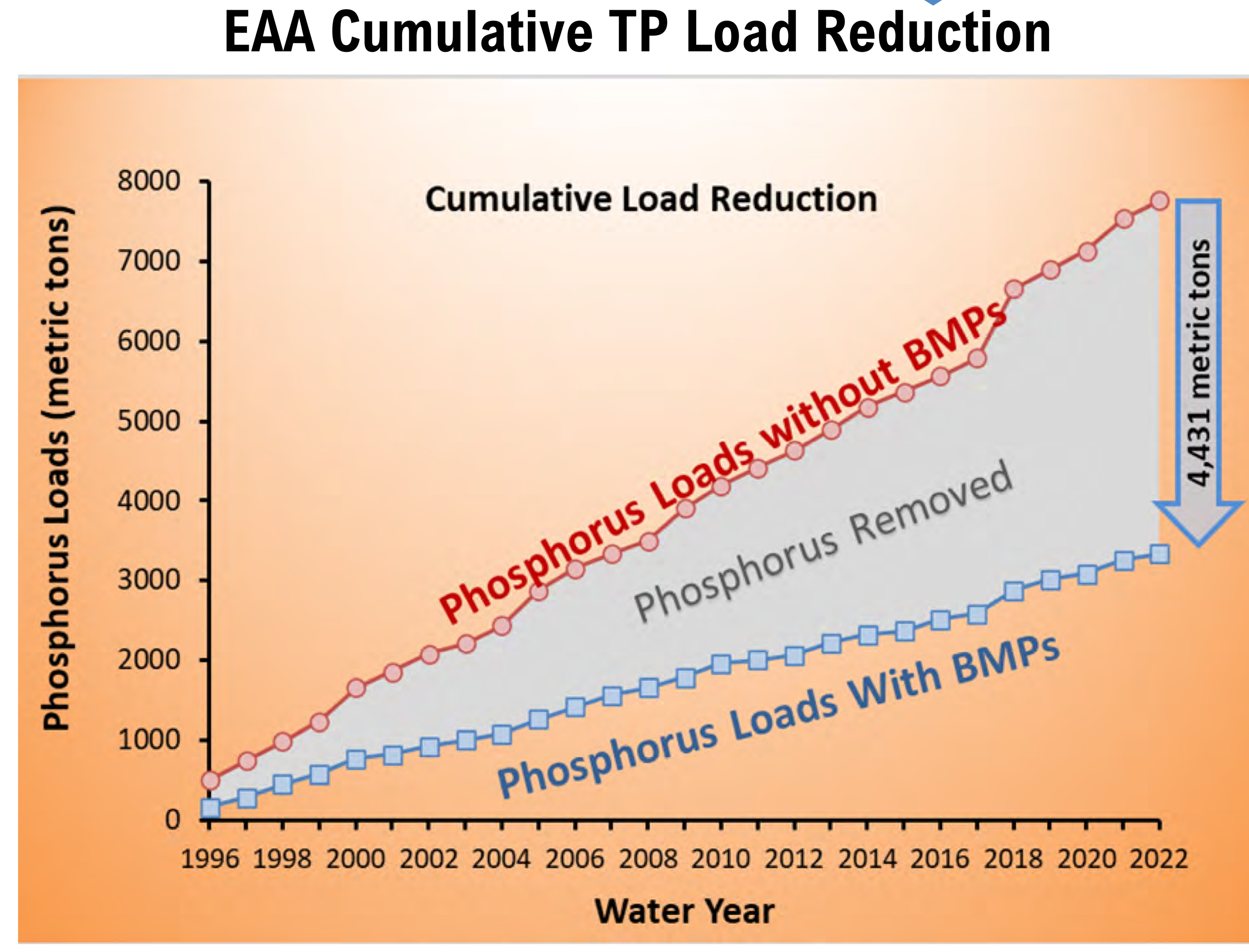
EAA Cumulative TP Load Reduction



CHAPTER 5A: RESTORATION STRATEGIES

Design and Construction Status of Water Quality Improvement Projects

Robert Shuford, Jose Otero, Tarana Solaiman, and Jennifer Smith

SCAN ME

Restoration Strategies (RS) Program

- Address water quality concerns associated with existing flows to the Everglades Protection Area (EPA).
- Consent orders and accompanying permits issued concurrently by the Florida Department of Environmental Protection.
- State's plan for expanding and improving stormwater treatment areas (STAs) within the Everglades Agricultural Area (EAA).
- Construct flow equalization basins (FEBs) to attenuate peak stormwater flows prior to delivery to STAs and provide dry season benefits.
- Build 13 projects in 13 years (2012–2025); 10 completed and 3 ongoing.
- Initial estimated cost is $880 Million.

Sample of Completed Projects

STA-1E Improvements
Southwest view of Cell 7. Cells 5 and 7 were regraded to repair differences in elevation

STA-1W Expansion #1
Southern view of Cell 6

A-1 FEB
G-370 PS and G-721 Inflow

EASTERN FLOW PATH

STA-1W Expansion #2 (100864)

Activity	Deadline	
Complete land acquisition	3/31/2018	✓
Initiate design	10/1/2018	✓
Submit state and federal permit applications	8/1/2019	✓
Complete design	7/31/2020	✓
Initiate construction	11/30/2020	✓
Construction status report	3/1/2021	✓
Construction status report	3/1/2022	✓
Complete construction	**12/31/2022**	
Initial flooding and optimization period complete	12/31/2024	

STA-1W Expansion #1 (100818) — COMPLETE

Activity	Deadline	
Complete land acquisition	9/30/2013	✓
Initiate design	9/30/2013	✓
Submit state and federal permit applications	7/30/2014	✓
Complete design	7/30/2015	✓
Initiate construction	1/31/2016	✓
Construction status report	3/1/2017	✓
Construction status report	3/1/2018	✓
Complete construction	12/31/2018	✓
Initial flooding and optimization period complete	12/31/2020	✓

STA-1E Repairs and Modifications — COMPLETE

Activity	Deadline	
PSTA Decommissioning complete	12/31/2022	✓
Culvert repairs complete	12/31/2022	✓
Cell 5 and 7 improvements complete	12/31/2022	✓

L-8 FEB (100813) — COMPLETE

Activity	Deadline	
Submit state and federal permit applications	1/31/2014	✓
Construction status report	3/1/2014	✓
Construction status report	3/1/2015	✓
Complete construction (begin multi-purpose ops)	12/31/2016	✓
Long term operations commence	12/31/2022	✓

G-341 Related Conveyance Improvements (100802)

Activity	Deadline	
Initiate design	10/1/2020	✓
Submit state and federal permit applications	8/1/2021	✓
Complete land acquisition (if required)	9/30/2021	✓
Complete design	7/31/2022	✓
Initiate construction	11/30/2022	✓
Construction status report	3/1/2023	✓
Construction status report	3/1/2024	✓
Complete construction	**12/31/2024**	

L-8 Divide Structure (100817) — COMPLETE

Activity	Deadline	
Initiate design	10/1/2012	✓
Complete design	9/30/2014	✓
Initiate construction	10/1/2016	✓
Complete construction	9/30/2018	✓

S-5AS Modifications (100822) — COMPLETE

Activity	Deadline	
Initiate design	10/1/2012	✓
Complete design	9/30/2014	✓
Initiate construction	10/1/2014	✓
Complete construction	9/30/2016	✓

S-375 Expansion (100819) — COMPLETE

Activity	Deadline	
Initiate design	9/30/2013	✓
Complete design	7/30/2015	✓
Initiate construction	1/31/2016	✓
Complete construction	12/31/2018	✓

LEGEND
- Flow Equalization Basin
- Stormwater Treatment Area
- Conveyance Improvement
- ✓ Complete

Projects Complete = 10 of 13
Activities Complete = 69 of 74
% Activities Complete = 93 %
% Time Complete = 79 %

CENTRAL FLOW PATH

STA-2 Expansion: Compartment B — COMPLETE

Activity	Deadline	
Initial flooding and optimization period complete	5/31/2014	✓

A-1 FEB (100706) — COMPLETE

Activity	Deadline	
Initiate design	4/1/2012	✓
Submit state and federal permit applications	12/1/2012	✓
Design status report	3/1/2013	✓
Complete design	8/1/2013	✓
Initiate construction	6/30/2014	✓
Construction status report	3/1/2015	✓
Construction status report	3/1/2016	✓
Complete construction	7/30/2016	✓
Operational monitoring and testing period complete	7/29/2018	✓

WESTERN FLOW PATH

STA-5/6 Internal Improvements (100868) — COMPLETE

Activity	Deadline	
Initiate design	10/31/2019	✓
Submit state and federal permit applications	8/30/2020	✓
Complete design	10/31/2021	✓
Initiate construction	1/31/2022	✓
Construction status report	3/1/2023	✓
Construction status report	3/1/2024	✓
Complete construction	12/31/2024	✓
Initial flooding and optimization period complete	12/31/2025	✓

STA-5/6 Expansion: Compartment C — COMPLETE

Activity	Deadline	
Initial flooding and optimization period complete	5/31/2014	✓

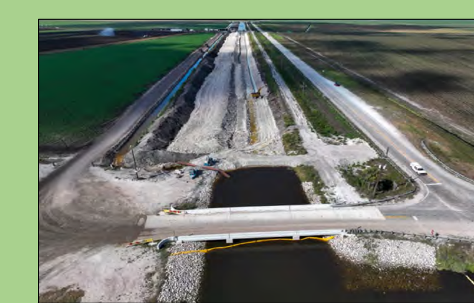
C-139 FEB (100867)

Activity	Deadline	
Initiate design	10/31/2018	✓
Submit state and federal permit applications	8/30/2019	✓
Complete design	10/31/2020	✓
Initiate construction	1/31/2021	✓
Construction status report	3/1/2021	✓
Construction status report	3/1/2022	✓
Construction status report	3/1/2023	✓
Complete construction	**12/31/2023**	
Operational monitoring and testing period complete	12/31/2024	

Note: PSTA – periphyton-based stormwater treatment area.

Revised February 20, 2023

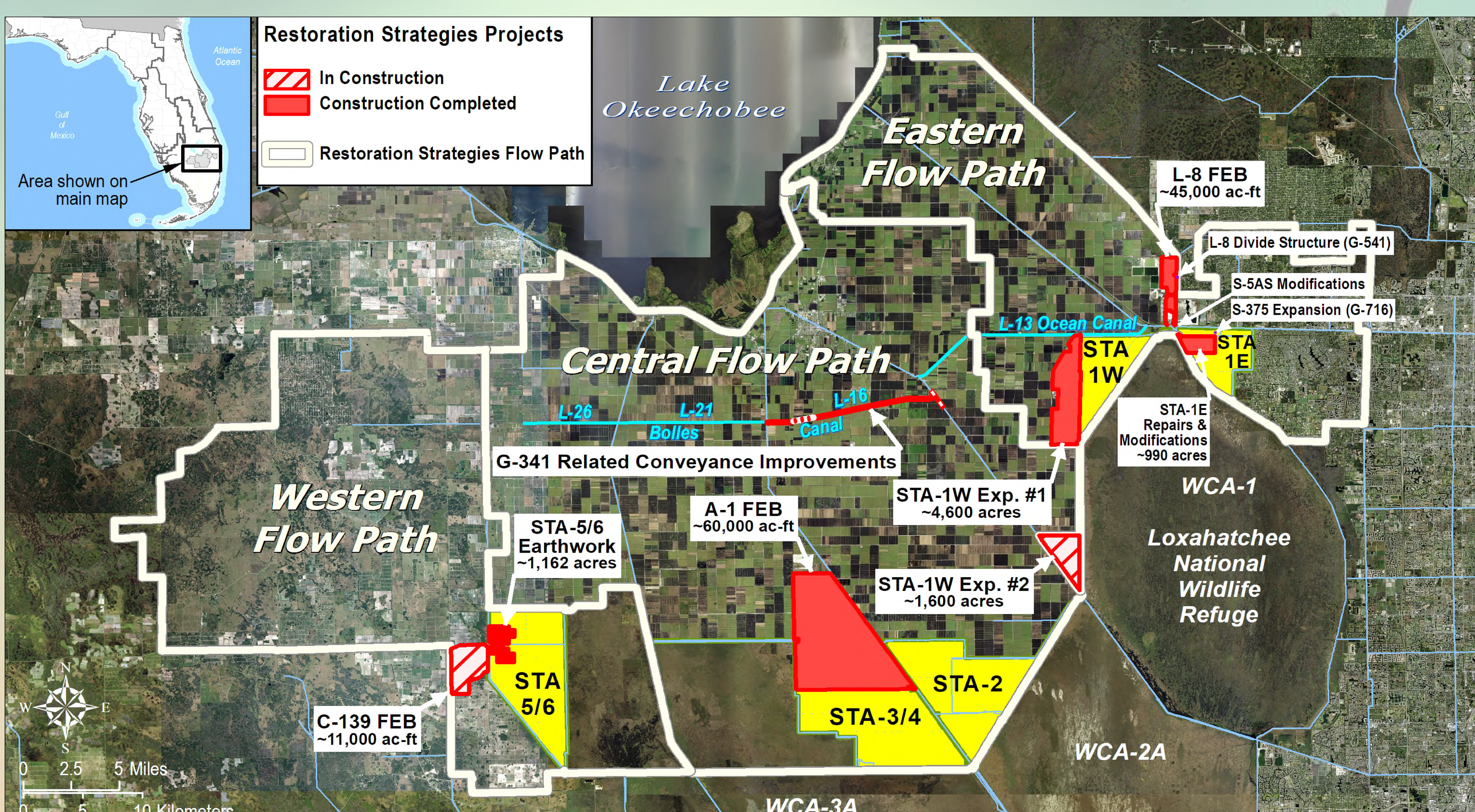
Ongoing Projects



G-341 Related Conveyance Improvements
Segment 5 in Bolles East Canal

STA-1W Expansion #2
Construction (with flow direction)

C-139 FEB
G-550 Construction



Note: ac-ft – acre-feet, Exp. – expansion, and WCA – Water Conservation Area.

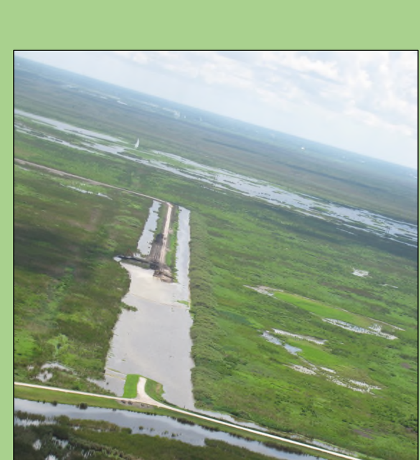
REFURBISHMENT PROJECTS

Going Above and Beyond Restoration Strategies

STA Refurbishments

- Refurbishments are projects to repair and improve function and efficiency within the STAs outside of the RS framework.
- 11 projects were conducted in all EAA STAs; 8 projects have been completed.
- Initial estimated cost is $100 Million.

STA-1E
Western view of the degraded east-west levee in Cell 6



STA-1W
East-west Levee removal to reshape Cells 2A and 5B

STA REFURBISHMENTS

STA-1E — COMPLETE

Activity		Status	Cell
1	Fill remnent ditches and remove berms to enhance sheet flow	✓	6

STA-1W — COMPLETE

Activity		Status	Cell
2	Build 1 mile levee and fill 1.5 miles of remnant farm ditch	✓	5B
2	Remove 1.6 miles section of north levee, extend distribution canal, and regrade 400 acres	✓	2A
3	Remove canals and match ground elevation	✓	3
4	Remove ENRP legacy structures	✓	2B & 4

Note: ENRP – Everglades Nutrient Removal Project.

STA-2

Activity		Status	Cell
5	Regrade 500-acre low area and remove 0.5-mile berm	✓	2
6	Remove 4 miles of remnant roads, fill	✓	3
5&6	Repair plugs	Ongoing	2 & 3

STA-3/4 — COMPLETE

Activity		Status	Cell
7	Install energy dissipators downstream of inflow structures	✓	1A, 2A, & 3A

STA-5/6

Activity		Status
8	Build conveyance connection from Lake Okeechobee	In Design

LEGEND
- Within RS Eastern Flow Path
- Within RS Central Flow Path
- Within RS Western Flow Path
- ✓ Complete

STA-2
Cut and fill project; raised ground elevation in 500-acre "lake"

STA-3/4
Energy dissipators located south of inflow structures; inset is a southern view at the G-377B structure

FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION
Everglades Protection Area
Total Phosphorus Criterion Assessment for WY 2022

Luke Hudson, Mailin Sotolongo-Lopez • Office of Water Policy and Ecosystems Restoration

The Everglades Protection Area (EPA) receives rainfall inputs and surface water inflows regulated by water control structures from agricultural tributaries, such as the Everglades Agricultural Area (EAA) to the north and the C-139 Basin to the west. Other surface water inflows include Lake Okeechobee to the north and urbanized areas to the east. The analyses presented provide a preliminary assessment of total phosphorus (TP) criterion achievement in the EPA on a regional scale. This evaluation was performed consistent with the four-part test specified in the TP Rule (Section 62-302.540, F.A.C.).

Total Phosphorus Rule (62-302.540, F.A.C.)

- **(4)(a).** "The numeric phosphorus criterion for Class III waters in the EPA shall be a long-term geometric mean of 10 ppb, but shall not be lower than the natural conditions of the EPA, and shall take into account spatial and temporal variability."
- **(4)(d).** Achievement of the Criterion in WCA-1, WCA-2 and WCA-3.
- **"4-Part Test"**
- Assesses impacted and unimpacted networks within each region (WCA-1, 2 and 3) separately.

Time	Applied to	Limit (µg/L)
5-Year Average	All Stations GM	≤10
3 of 5 Years	All Stations GM	≤10
Annual	All Stations GM	≤11
Annual	Individual GM	≤15

Table 1. 4-Part Test. (Note: GM – Geometric Mean)

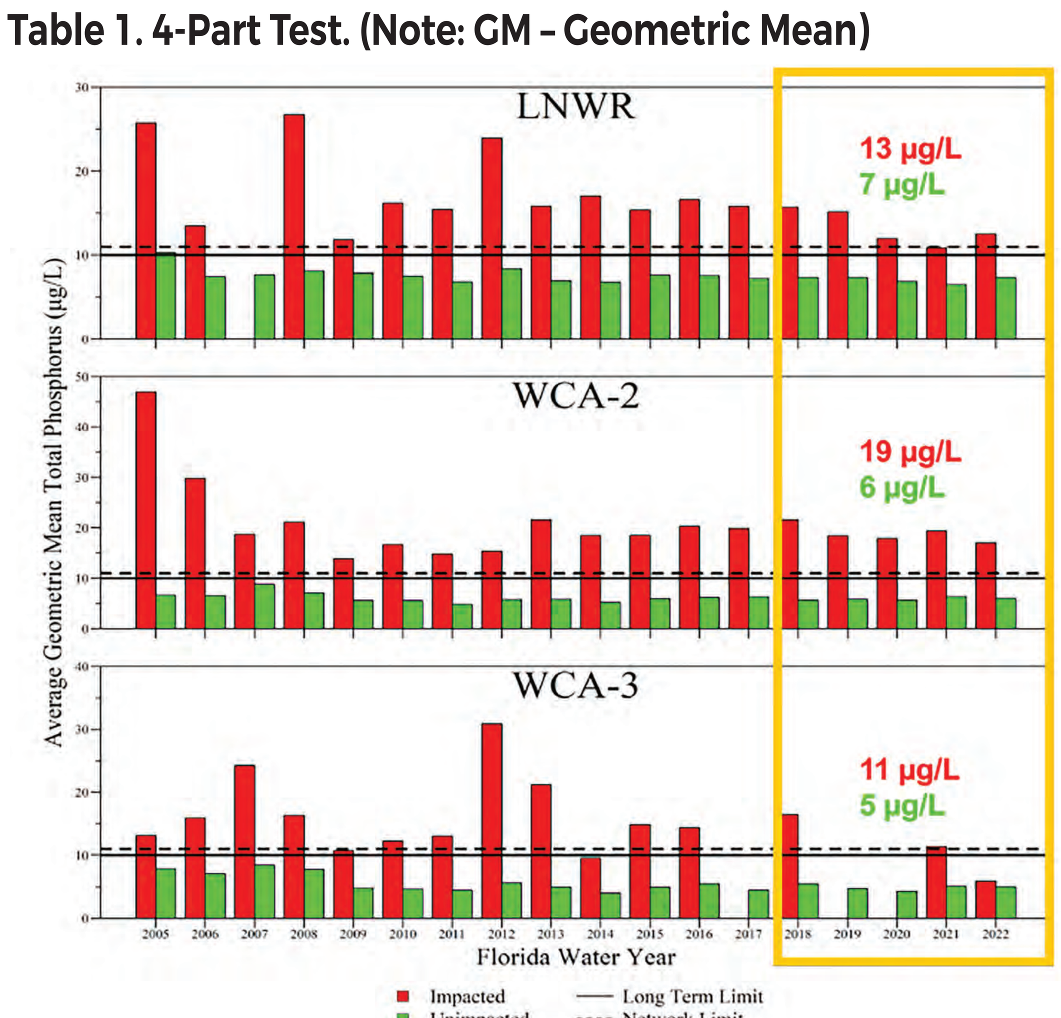


Figure 2. Network trends for LNWR, WCA-2, and WCA-3 during WY2005-2022 relative to the 10 µg/L long-term (five year) and the 11 µg/L annual network limits for TP. The yellow bracket highlights the five-year TP geometric mean average (WY2018-2022).

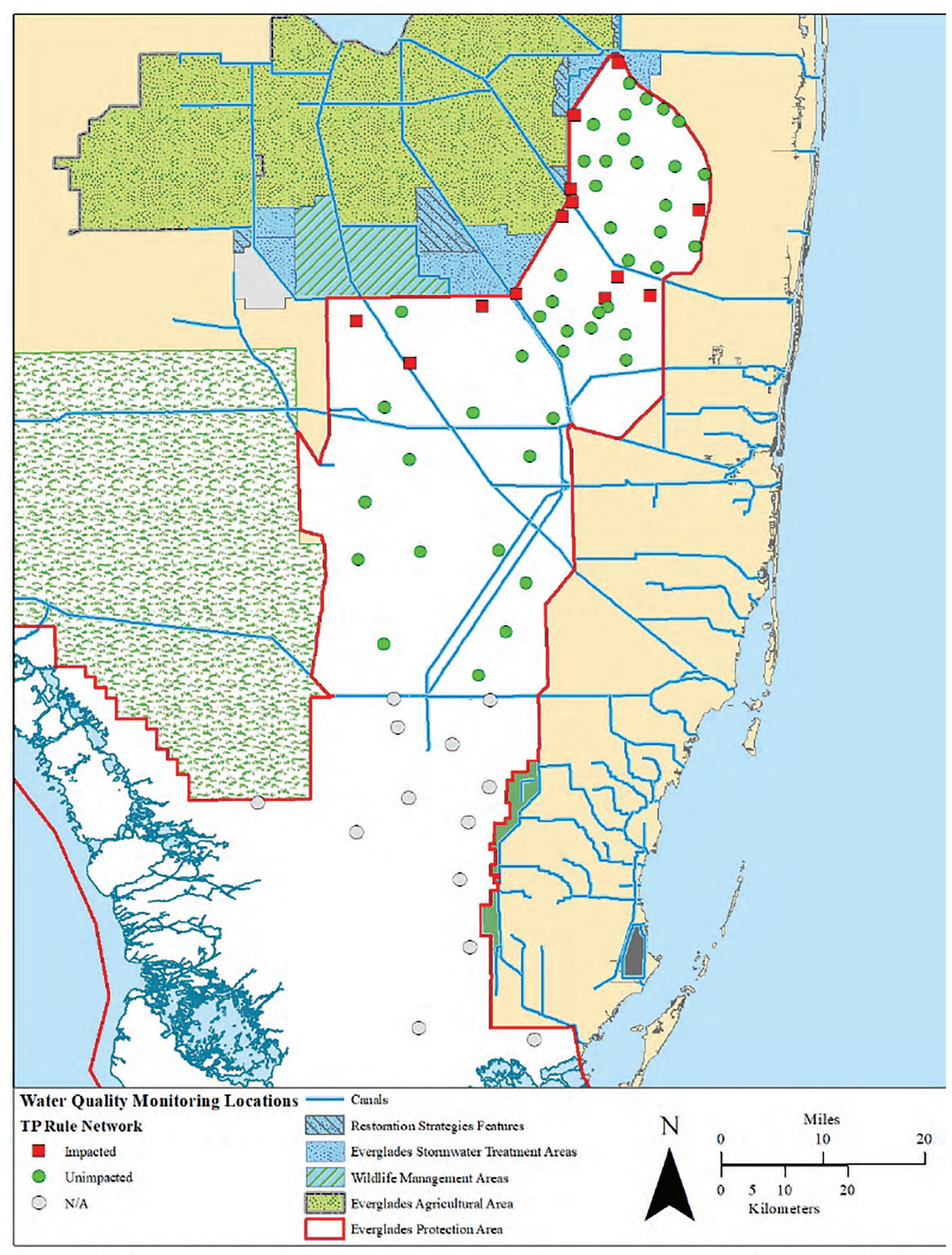


Figure 1. Location of TP criterion assessment monitoring stations and their respective classifications used in WY2018–WY2022 evaluations. (Note: N/A – not applicable)

Long-Term Geometric Mean for EPA

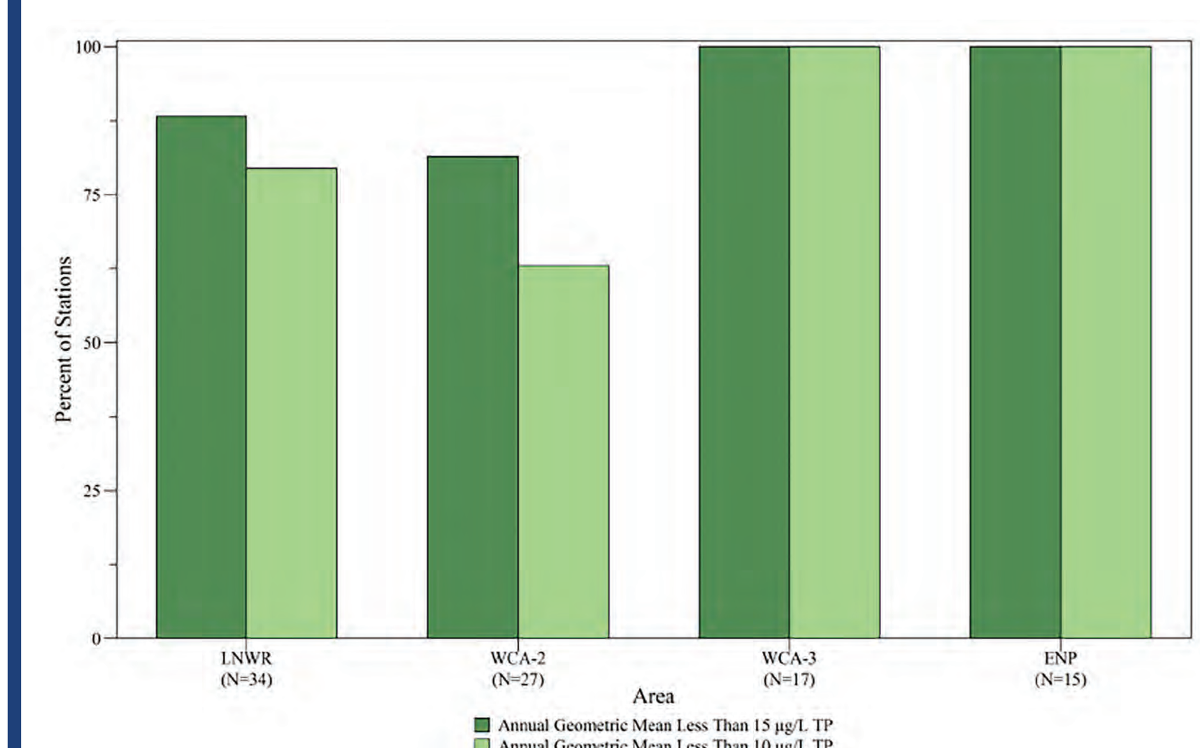


Figure 4. Percentage of stations within each region of the EPA with an annual geometric mean TP concentration less than 10 and 15 µg/L during WY2022. (Note: N – number of sites used in assessment with greater than six samples per year across the entire marsh monitoring network [TP Rule and ambient network]).

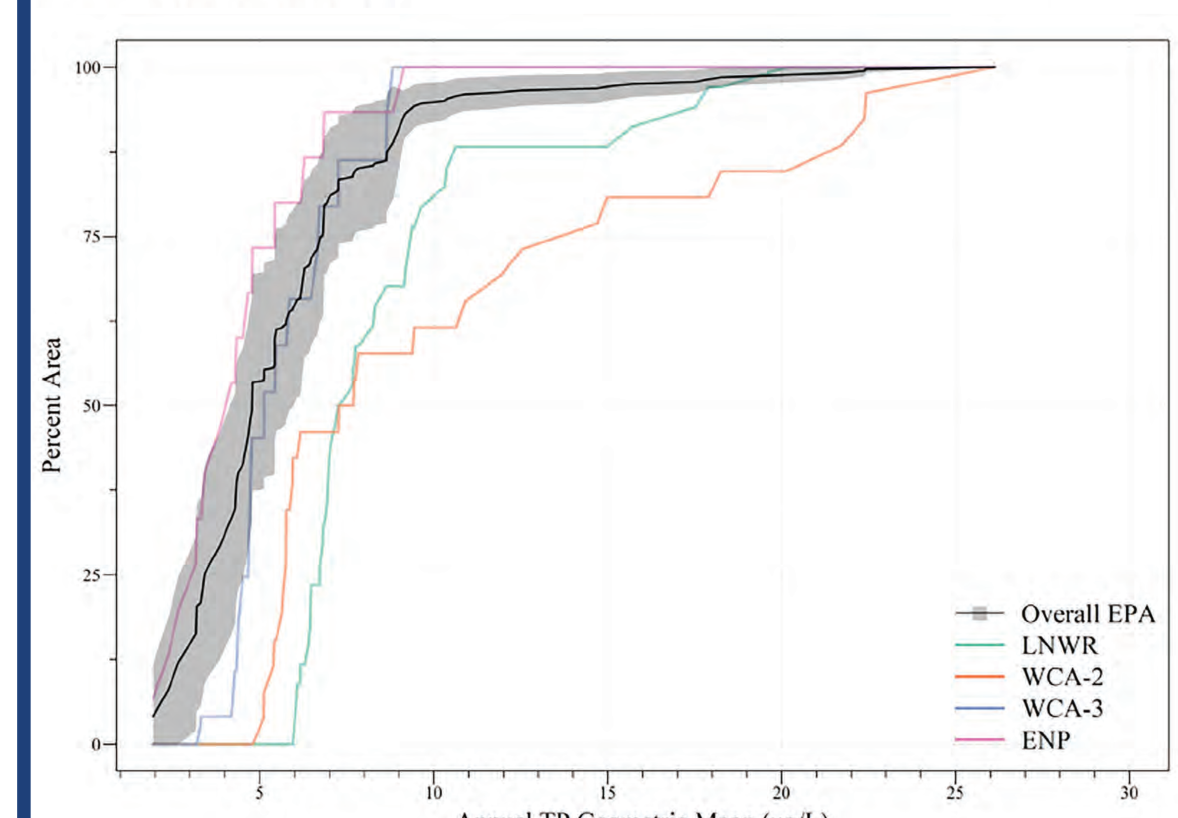


Figure 5. Cumulative distribution functions (CDFs) of annual geometric mean TP across the overall EPA and individual areas of the EPA in WY2022. Shaded region around the Overall EPA CDF represents the 95% confidence interval. (Note: CDF estimated for ENP is based on four monitoring locations within Shark River Slough and may not be representative of all the freshwater portions of ENP.)

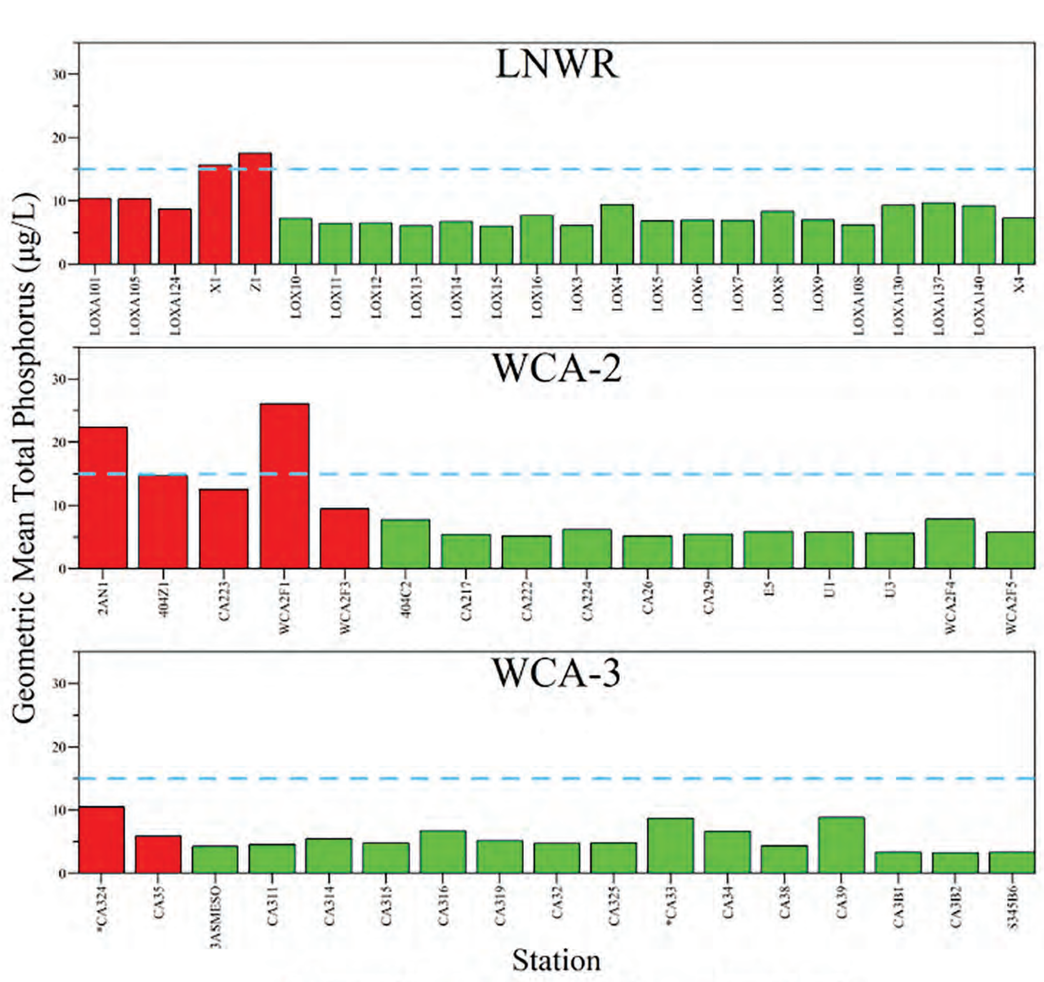


Figure 3. TP geometric mean concentration for each station during WY2022 for LNWR, WCA-2, and WCA-3 relative to the 15 µg/L annual limit. Stations with less than six samples are identified with an asterisk (*).

Total Phosphorus reduction progress from WY2005 to WY2022

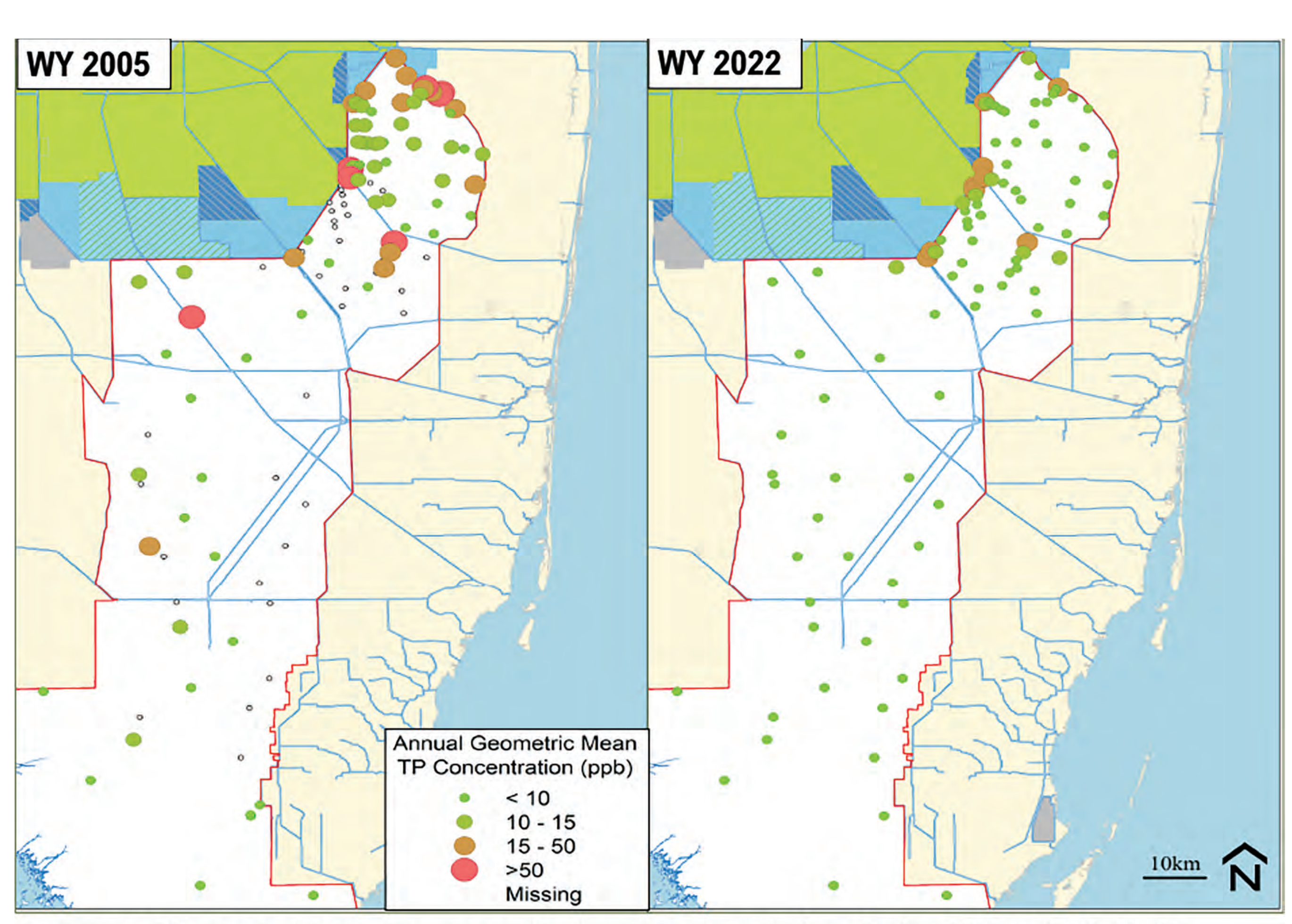


Figure 6. TP geometric mean concentration for each station during WY2005 (left) & WY2022 (right) for the EPA.

- Across the entire EPA, 90% of the interior sites had annual geometric mean TP concentrations of 15.0 µg/L or less, and 82% exhibited annual geometric mean TP concentrations of 10.0 µg/L or less during WY2022.
- Since the TP Rule came into effect in 2005, seven impacted stations across the EPA have transitioned from impacted to unimpacted.

Summary

- For WY2022, 55 of the 58 TP criterion monitoring network sites had sufficient data to be included in the TP criterion assessment.
- Unimpacted portions of each WCA passed all four parts of the compliance assessment. These areas are in compliance with the 10 µg/L criteria.
- Even though conditions within the impacted portions of the marsh have improved in recent years, impacted portions of each WCA failed one or more parts of the criterion assessment. These areas exceeded the criteria.
- Approximately 97% of the interior EPA is below 15 ppb and nearly 95% is below 10 ppb in WY2022. 100% of the ENP and WCA-3 is below 15 µg/L; 88% of LNWR is below 15 µg/L; and 80% of WCA-2 is below 15 µg/L.

SOUTH FLORIDA ENVIRONMENTAL REPORT
SCAN ME

Chapter 5C: Restoration Strategies Science Plan

R. Tom James, Principal Scientist, and Jill King, Section Administrator
Water Quality Treatment Technologies

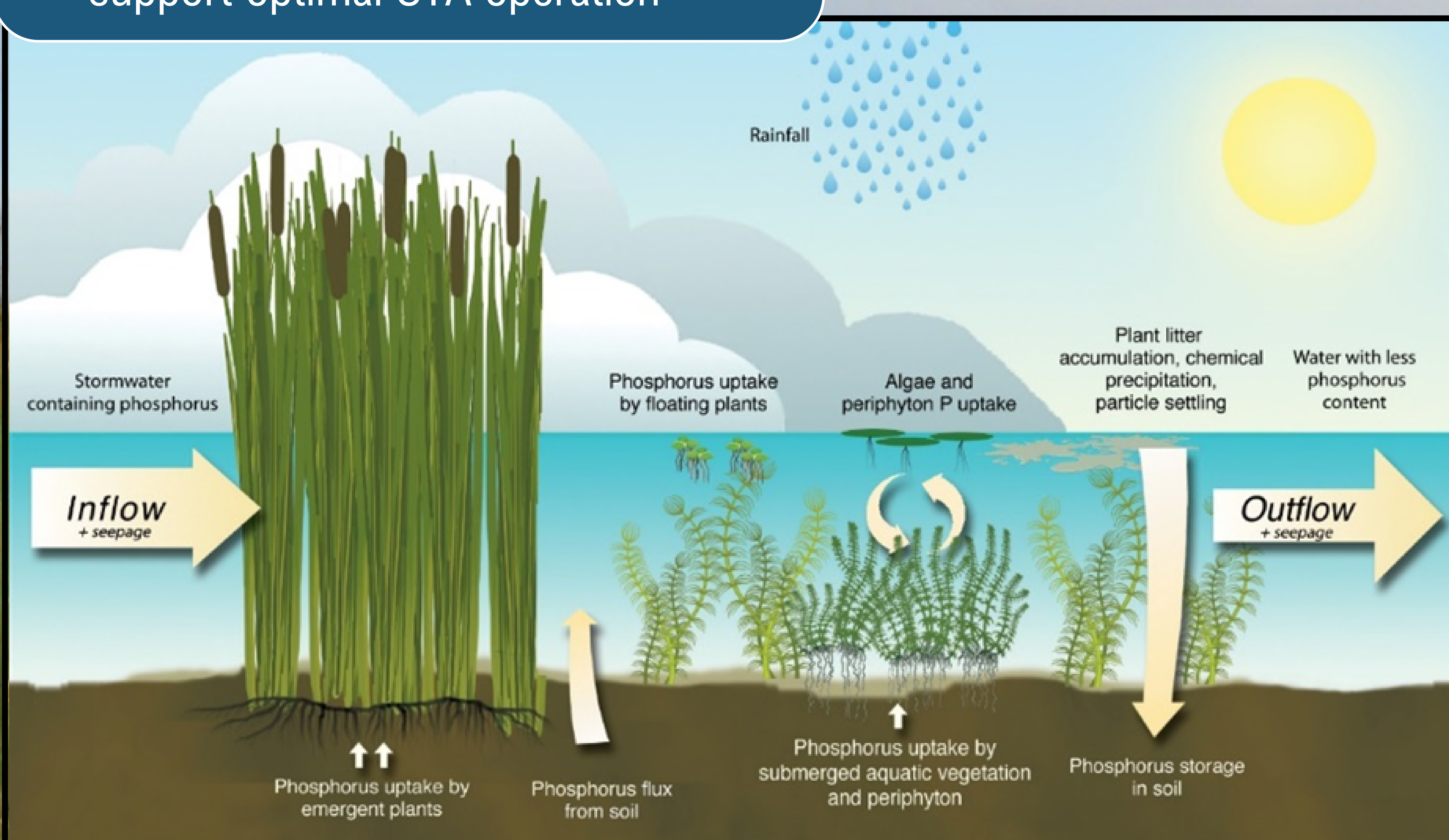
Introduction

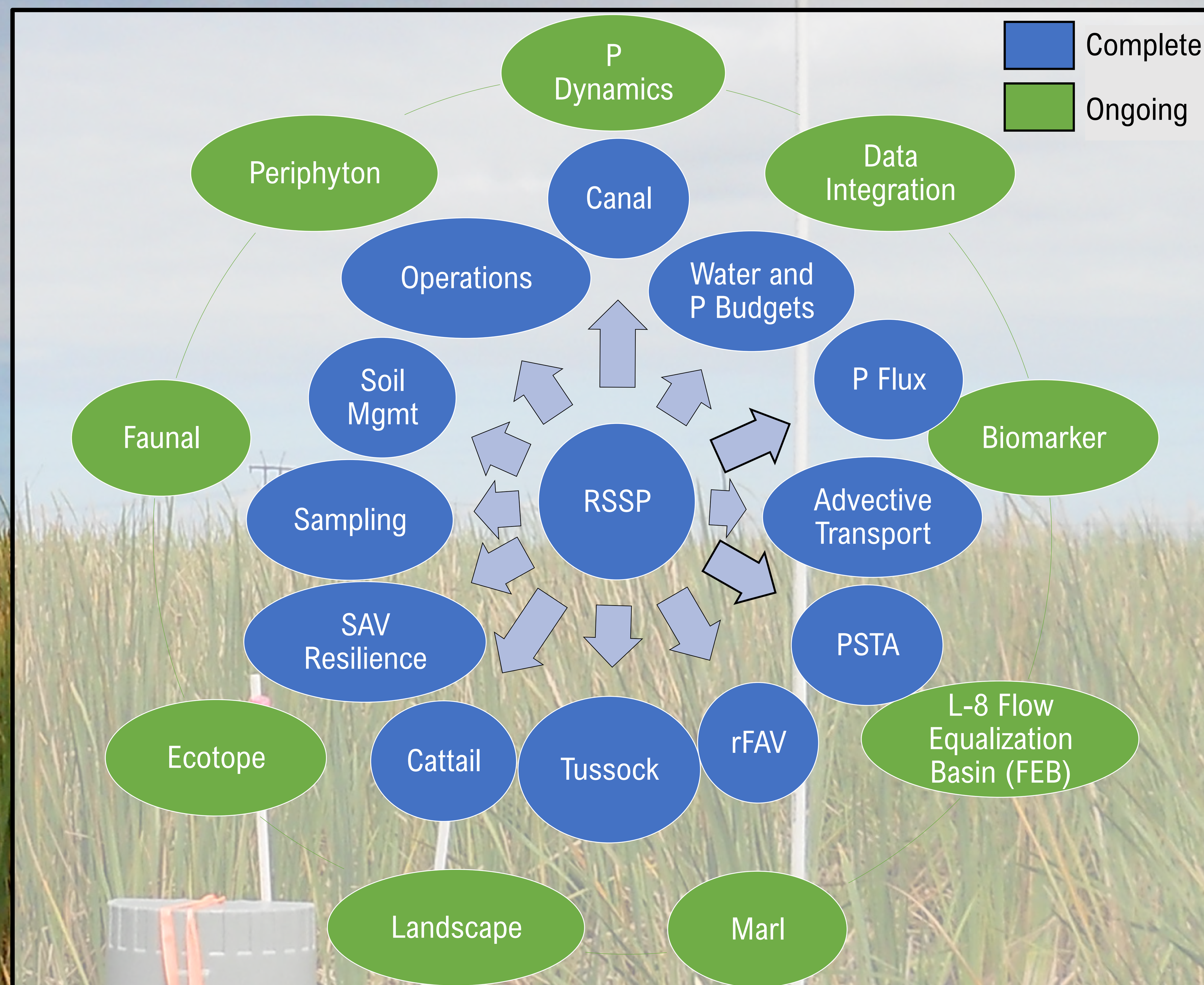
The Restoration Strategies Science Plan (RSSP), developed in 2013 and revised in 2018, is a framework for studies in the Everglades Stormwater Treatment Areas (STAs) to evaluate mechanisms and factors that affect phosphorus (P) treatment performance, particularly those that are key drivers of retention at low total P (TP) concentrations (< 20 micrograms per liter, or µg/L). RSSP is part of the Restoration Strategies for Clean Water for the Everglades developed to achieve the water quality based effluent limit (WQBEL) for STA discharges. The WQBEL was established to ensure that STA discharges do not cause or contribute to exceedances of the State of Florida's numeric P criterion for the Everglades Protection Area.

This poster highlights 8 studies that have increased our understanding of STA P dynamics the most out of 21 developed through the RSSP. As of 2023, 12 studies have been completed (blue) and nine are ongoing (green). Five studies consider data quality and operations that affect the STAs. Fifteen studies consider key aspects of STA ecological sustainability, including: P cycling, fauna and organic matter, soil/water interactions, and emergent (EAV) and submergent (SAV) aquatic vegetation and periphyton. The last study is the Data Integration study that incorporates information from all of the studies.

Data Integration Study - Ongoing

- Synthesize and combine all research efforts
- Continue model development and enhancement
- Develop a guidance document to support optimal STA operation

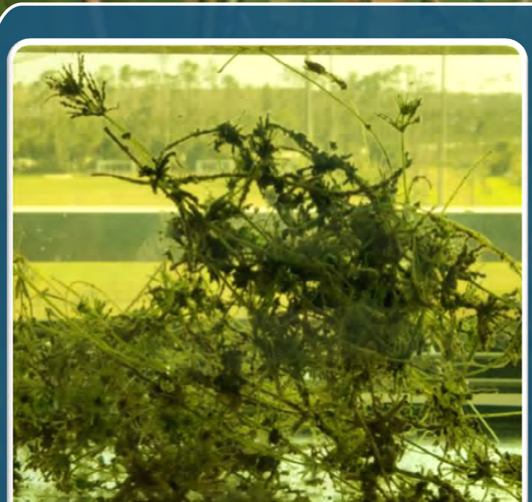




Tussock (Floating Wetland) Study - Completed

- Affected by water levels, soil quality and depth, and prior land activity
- Unmanned aerial vehicles equipped with cameras effectively located tussocks in the STAs

Periphyton Study - Ongoing



- Evaluate periphyton (microbial community) functions affecting P cycling and retention
- DNA analysis on periphyton
- Evaluate influence of plant communities P loading, water flow, and water depth on periphyton functions

P Dynamics Study - Ongoing

- Study underperforming flow-ways
- Underperformance related to disturbances of dryout, storm events, construction, and poor vegetation conditions

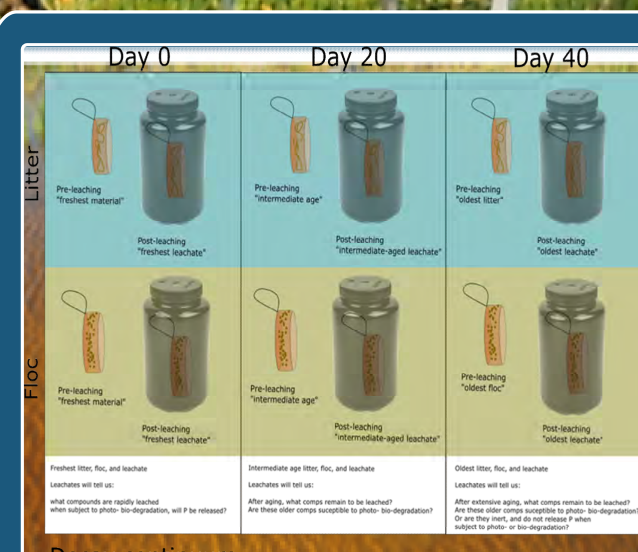
Cattail Study - Completed

- Evaluated effects of deep water inundation
- Leaves elongate
- Adult and juvenile plant densities decline
- Tussocks develop
- Plants collapse after rapid water reduction due to elongated leaves

PSTA Study - Completed

- Evaluated effect of muck removal and low inflow TP loads in 100-acre cell
- Achieved annual flow-weighted mean concentrations at or below 13 µg/L for 15 years
- Removal or capping of P-rich soils may be an appropriate management tool in some STA outflow regions

Biomarker Study - Ongoing



- Identify sources and turnover of P forms in soil and plant material to improve understanding of P cycling
- Use advanced methods to measure organic P components
- Compare to known materials for degradability and origins

Fauna Study - Ongoing

- Evaluate fauna effects in low P environment
- Biomass density and diversity is higher than in the Everglades
- Small fish contribute more P through excretion than large fish
- Excretion is higher than P loading to STA flow-way
- Bioturbation (fauna mixing soils into water column) is localized and species-specific (armored catfish and tilapia)

SCAN ME

Chapter 5B: Submerged Aquatic Vegetation Coverage in the Stormwater Treatment Areas

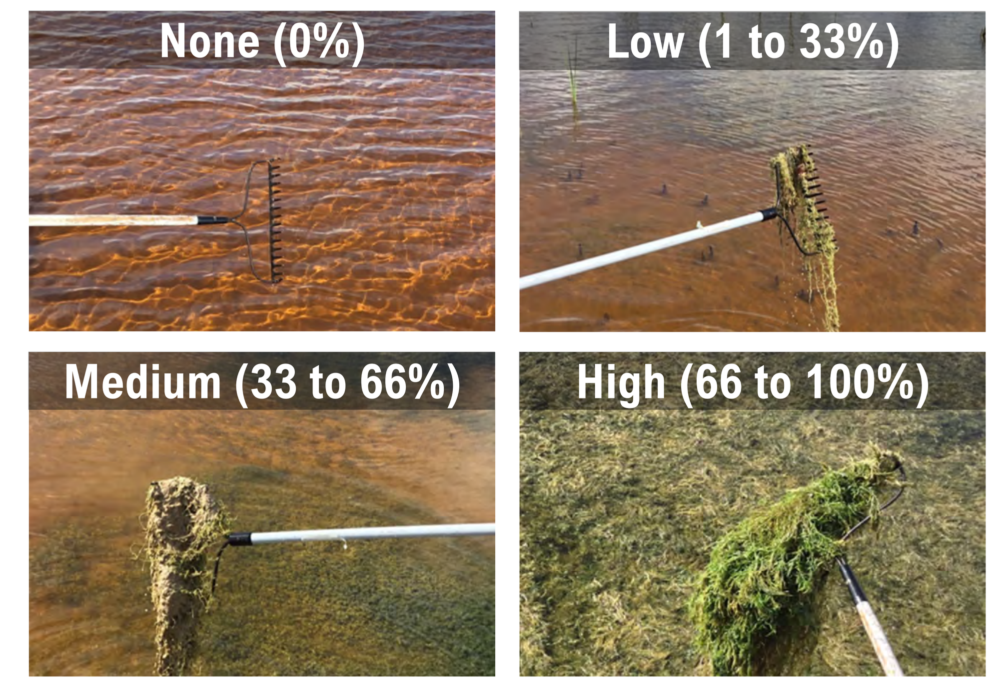
Ryan Goebel, Jacob Dombrowski, Camille Herteux, South Florida Water Management District, West Palm Beach, FL, USA

Introduction

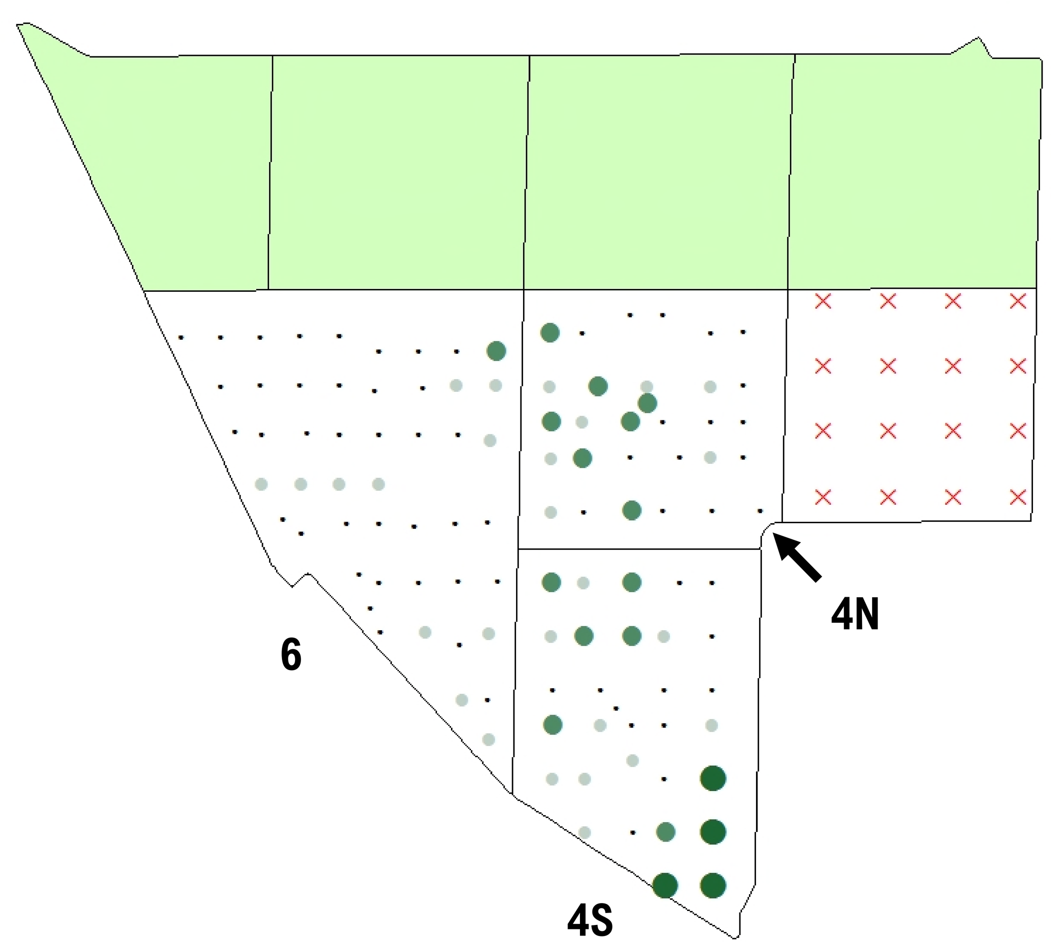
Stormwater treatment areas (STAs) are constructed wetlands designed to reduce phosphorus (P) concentrations entering the Everglades Protection Area. The STAs were constructed primarily on former agricultural lands and retain nutrients through plant and microbial uptake, particulate settling, retention in soil by sorption, and ultimately accretion of plant and microbial biomass to the sediments. The STAs are comprised of emergent aquatic vegetation (EAV) cells that provide an initial reduction in P concentrations followed by mixed emergent/submerged aquatic vegetation (EAV/SAV) cells that provide additional P removal. Ground surveys are conducted within EAV/SAV cells on a periodic basis to document current and long-term trends of SAV taxa aerial coverage. Data collected provide insight on STA marsh structure, vegetation health, and efficacy of management practices.

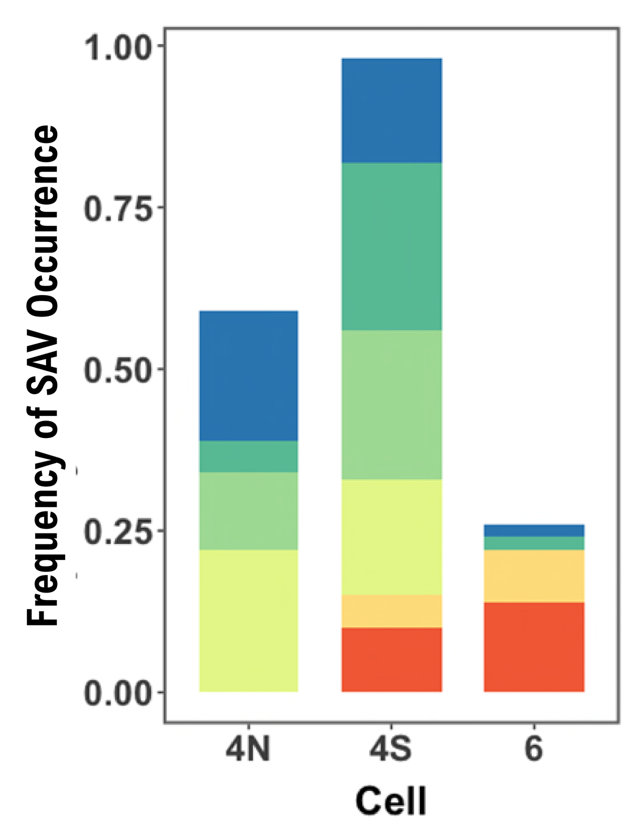
Methods

Ground surveys are conducted at geo-referenced sites arranged in a grid pattern within each EAV/SAV cell. The coverage of SAV taxa is evaluated based on the amount of visible SAV within 50 feet of the survey point. A garden rake is also dragged along the wetland bottom to collect plant material not directly visible to ensure SAV detection. Coverage assessments are made for total SAV and individual SAV taxa. Surveys use a 4-point ordinal scale to estimate coverage: *None* – no plants; *Low* – 1 to 33% coverage; *Medium* – 33 to 66% coverage; *High* – >66% coverage. The frequency of occurrence is calculated for each SAV taxon based on the number of SAV present survey sites relative to the total number of sites visited. Figures below correspond to data collected in Water Year 2022 (WY2022; May 1, 2021–April 30, 2022).

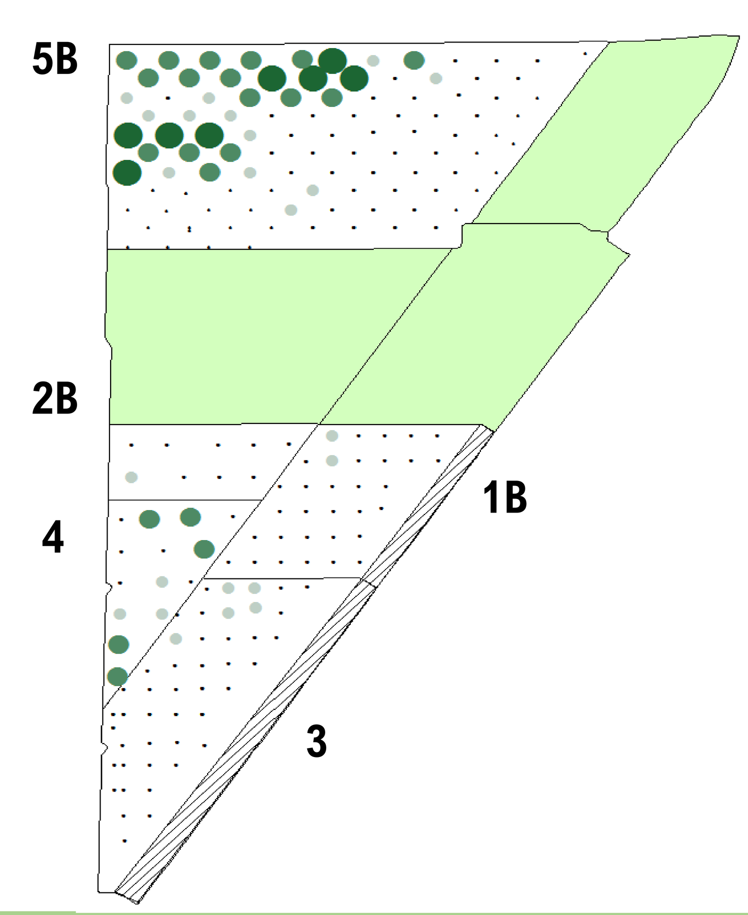


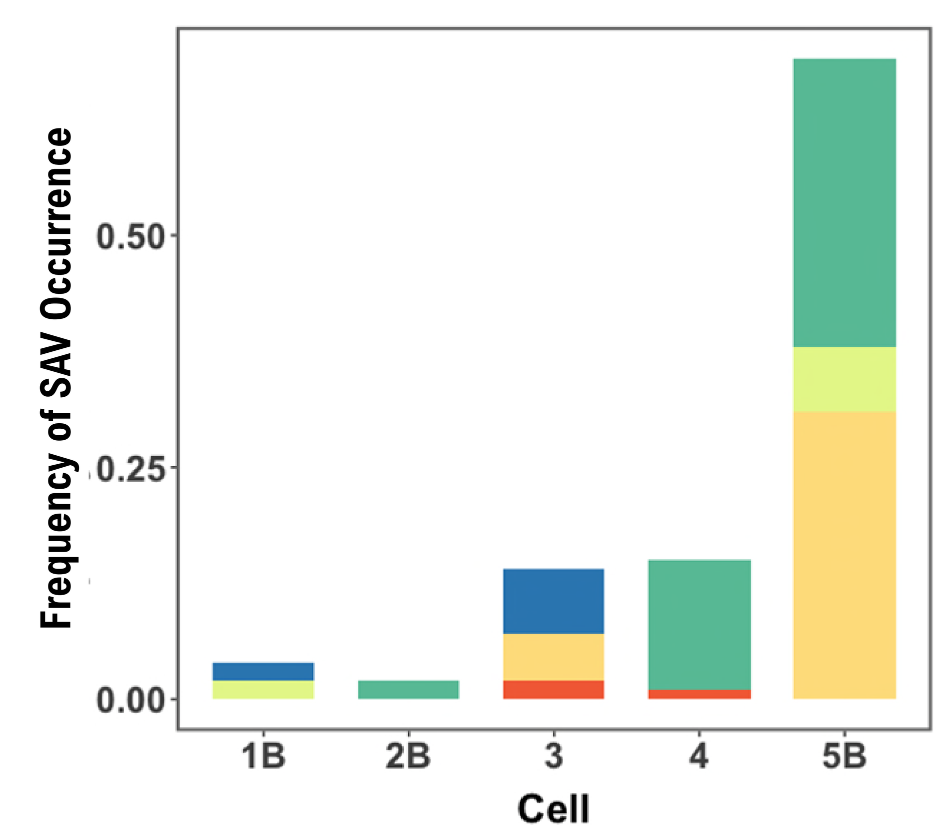
STA-1E



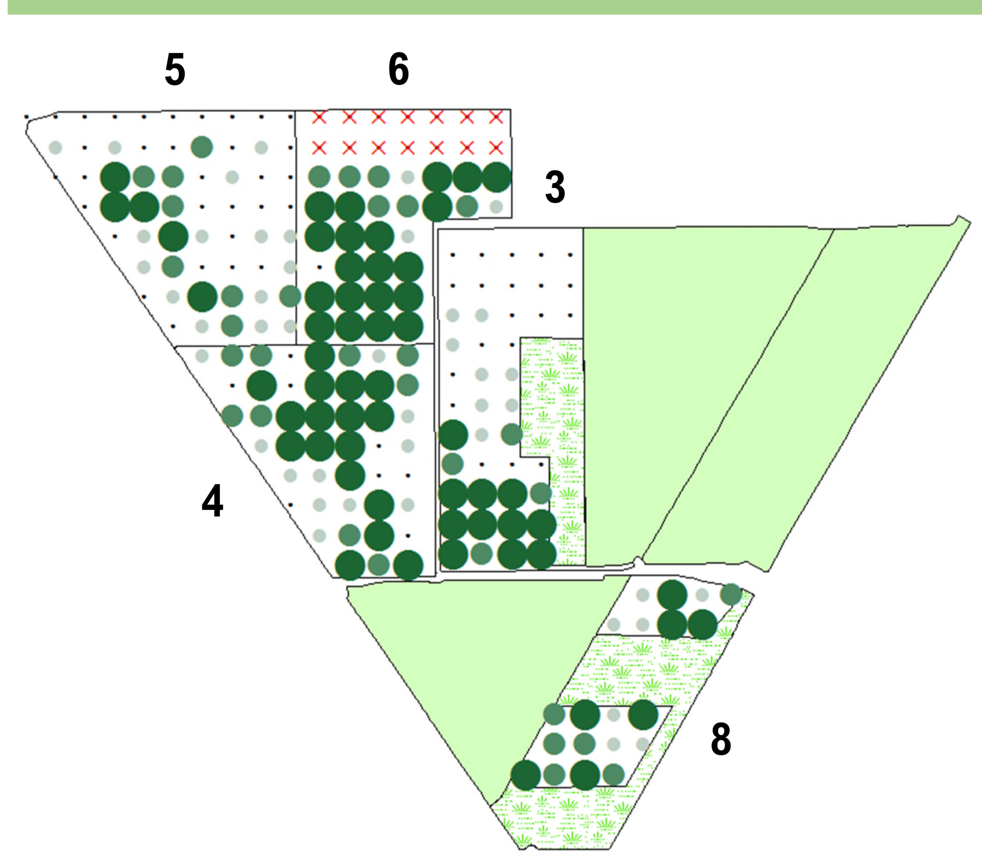


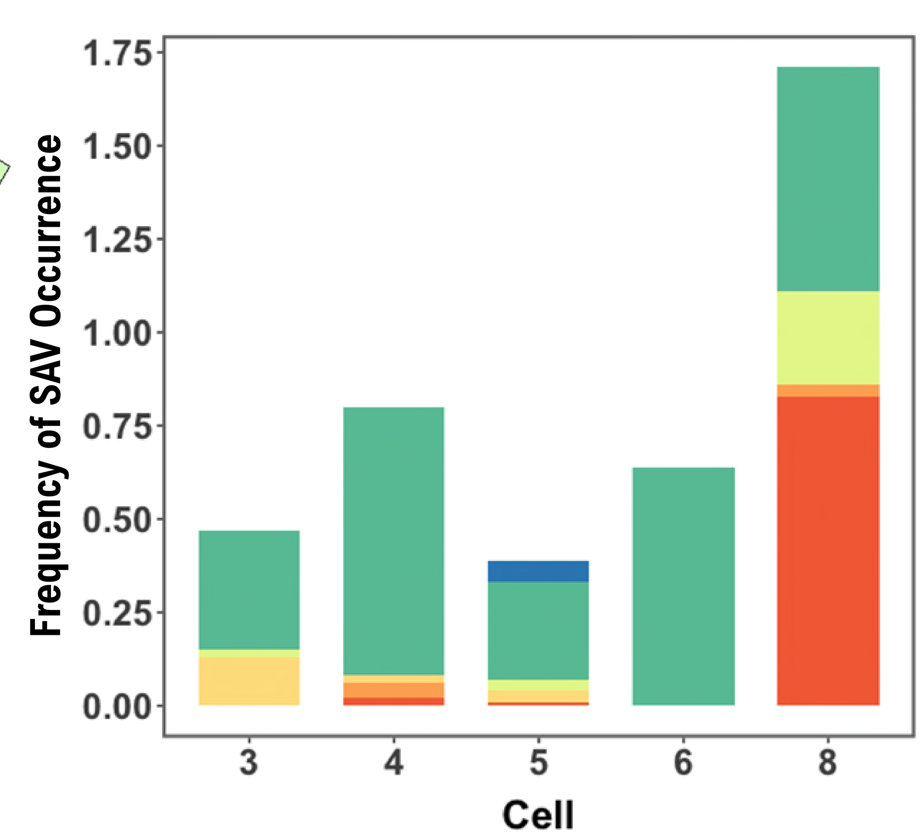
STA-1W



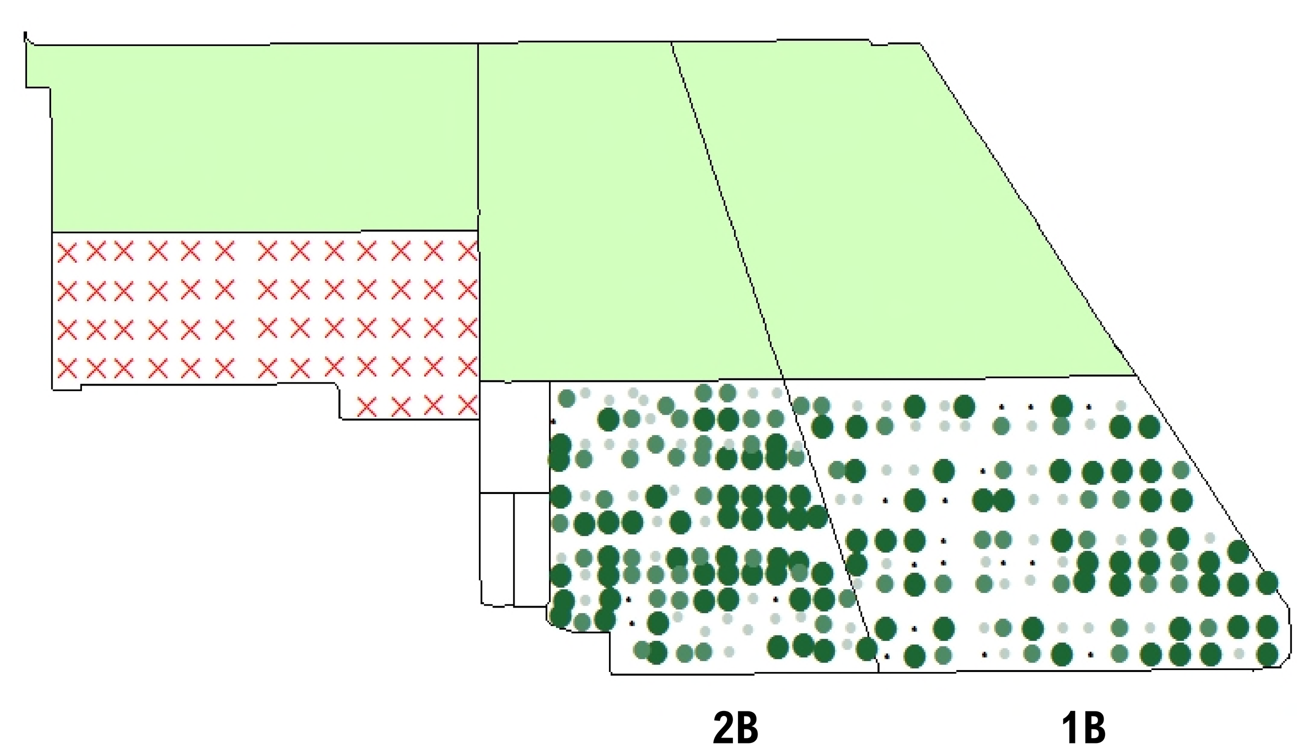


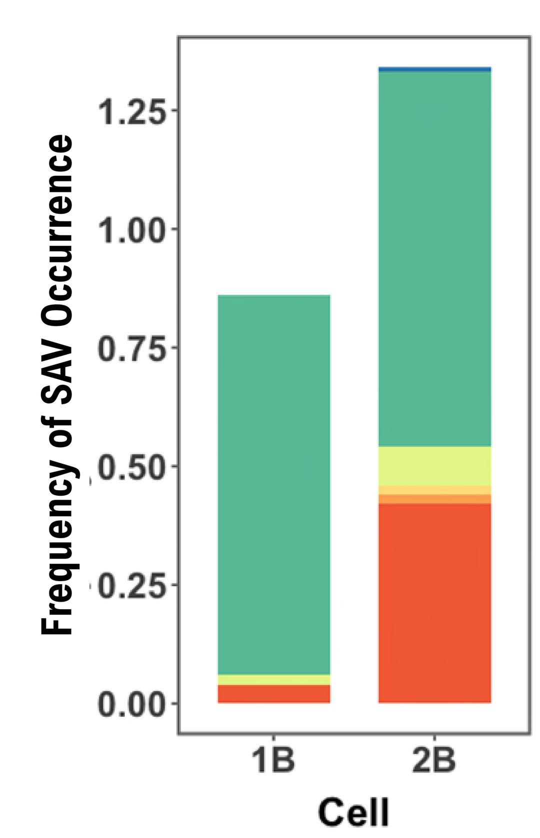
STA-2



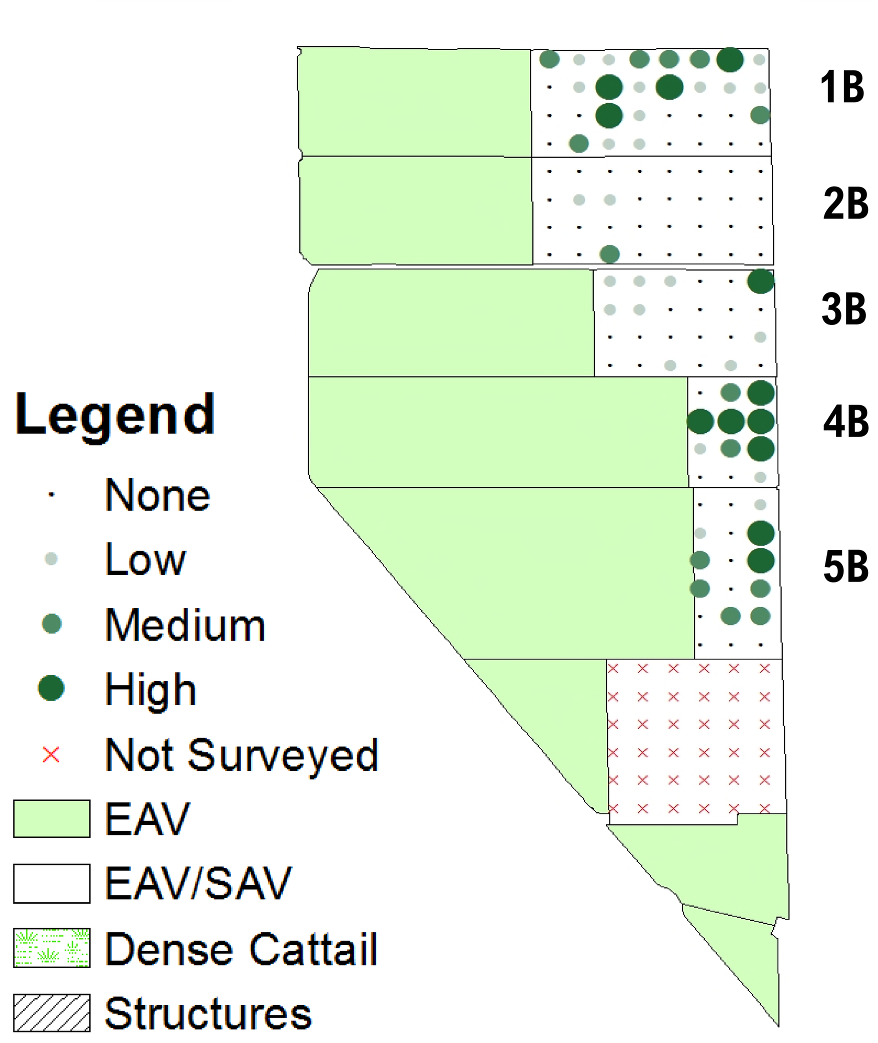


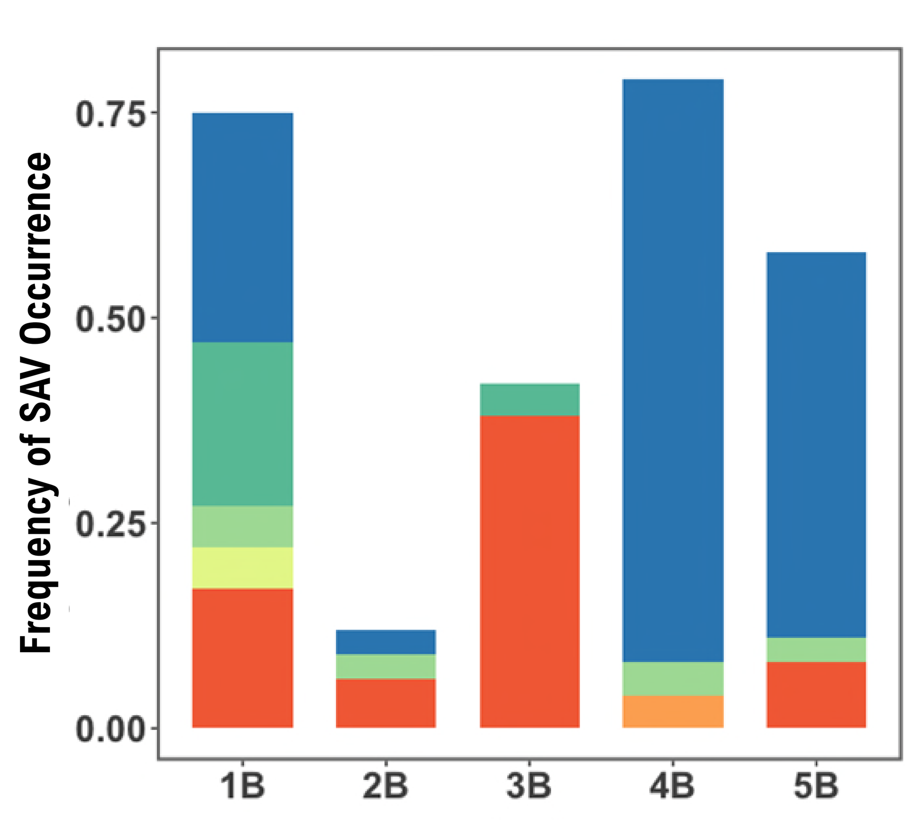
STA-3/4





STA-5/6





Water Year 2022 Trends

STA-1E
- Six SAV taxa identified in WY2022
- Well-distributed taxa occurrences within presence sites
- Surveys limited by Restoration Strategies construction in Western Flow-way
- Increased SAV from WY2021

STA-1W
- Five SAV taxa identified in WY2022
- Highest densities recorded in northern cell
- Multiple ongoing STA refurbishment projects
- Surveys not conducted in expansion cells (not depicted) as SAV begins to colonize
- Decreased SAV from WY2021

STA-2
- Five SAV taxa identified in WY2022
- Muskgrass most common taxa observed
- Surveys limited in dry season due to low water levels
- Increased SAV from WY2021

STA-3/4
- Six SAV taxa identified in WY2022
- Muskgrass most common taxa observed
- Dense cattail restricted surveys in Western ell
- Similar SAV to WY2021, with increased EAV

STA-5/6
- Five SAV taxa identified in WY2022
- Coontail and bladderwort most common taxa observed
- Surveys limited in dry season due to low water levels
- Similar SAV to WY2021, with notable EAV dominance

SCAN ME

Chapter 5B: Performance and Operation of the Everglades Stormwater Treatment Areas

Michael J. Chimney, Ph.D.

Applied Sciences Bureau, Water Quality Treatment Technologies Section

SCAN ME

INTRODUCTION

- The Everglades Stormwater Treatment Areas (STAs) are five large constructed wetlands located within, or adjacent to, the Everglades Agricultural Area (EAA; **Figure 1**) designed to reduce total phosphorus (TP) levels in stormwater runoff primarily from local drainage basins before this water enters the Everglades Protection Area (EPA). The STAs retain TP via biological, chemical and physical mechanisms with long-term P storage as accretion of new wetland soil in the STAs.
- The first prototype STA (the Everglades Nutrient Removal Project, ca. 3,800 ac) began flow-through operation in Water Year 1995 [WY = May 1, 1994 to April 30, 1995]. The five STAs now encompass ca. 62,000 ac (**Table 1**).
- Each STA is divided by internal levees into a number of treatment cells. STA flow-ways are comprised of 1 to 3 treatment cells. The five STAs collectively have 46 treatment cells arranged into 25 flow-ways.
- The goal is to balance inflow water volumes and TP loads among flow-ways within an STA to the extent possible, and make operational adjustments based on recent treatment performance.
- Flow-way status:
  - ∗ ***Online*** = no restrictions to operation
  - ∗ ***Online with Restrictions*** = flow or stage-limited, full operation only during emergencies
  - ∗ ***Offline*** = operation suspended entirely
- Challenges that can limit flow-way operation:
  - ∗ Construction/maintenance (e.g., Restoration Strategies, STA Refurbishments)
  - ∗ Vegetation management/rehabilitation
  - ∗ Migratory and endangered bird nesting
  - ∗ Major weather events (tropical cyclones, droughts)

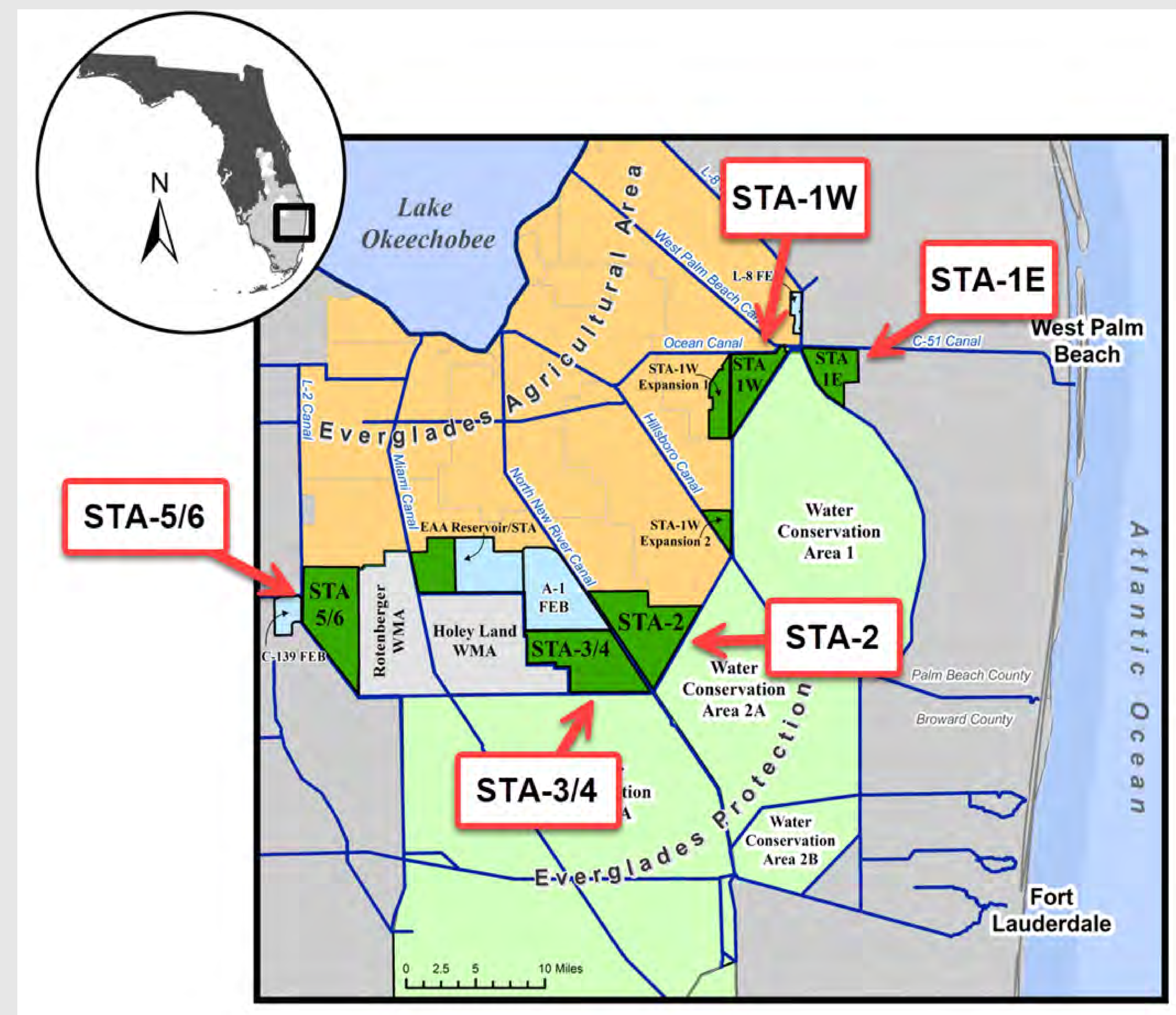


Figure 1. Location of the STAs in relation to the EAA, EPA, and flow equalization basins (FEBs).

Table 1. STA surface areas, start dates and the number of complete WYs.

STA	Area (ac)	Start Date	# WY*
STA-1E	4,994	Sep 2004	18
STA-1W	10,810	Oct 1993	28
STA-2	15,495	Jun 1999	21
STA-3/4	16,327	Oct 2003	19
STA-5/6	14,338	Dec 1997	25
All STAs	61,964		28

*complete District water years with flow-through operation

Table 2. Summary of treatment performance in each STA and all STAs combined during WY2022 for each STA and all STAs combined.

Parameter	STA-1E	STA-1W	STA-2	STA-3/4	STA-5/6	All STAs
WY2022						
Inflow Water Volume (ac-ft)	173,000	57,000	289,000	330,000	178,000	**1,027,000**
Mean Inflow TP (µg/L)	119	158	90	91	243	**125**
P Loading Rate (PLR) (g/m²/yr)	2.3	0.3	0.6	0.6	1.0	**0.7**
Mean Outflow TP (µg/L)	22	24	15	15	50	**23**
TP Load Reduction (%)	85%	86%	82%	84%	81%	**83%**

Note: g/m²/yr = grams per square meter per year.

SUMMARY

- Table 5B-2 in the 2023 South Florida Environmental Report summarizes the operational status of all 25 flow-ways for the 2022 water year.
- STA-2 and STA-3/4 usually have received the greatest annual inflow water volumes. Total STA inflow water volume increased markedly after WY2001 as additional STAs started treating runoff. Year-to-year differences in inflow water volumes for individual STAs, at times, have exceeded 50% (**Figure 2, Top Panels**).
- STA-3/4 had the lowest annual mean outflow TP concentration in many WYs (**Figure 2, Middle Panels**).
- Treatment performance in all the STAs generally improved after WY2011 (**Figure 2, Middle Panels**).
- The inflow-to-outflow TP load reduction often ranged from 75 to 85% after WY2011 in all the STAs (**Figure 2, Bottom Panels**).
- All STAs over the 28-yr period-of-record (POR):
  - ∗ Treated 25.2 million acre-feet (ac-ft) of runoff
  - ∗ Retained 3,221 metric tons of TP
  - ∗ TP load reduction = 77%
  - ∗ Outflow mean TP = 30 µg/L
- STA-3/4 over its 19-year POR:
  - ∗ Treated the most water = 8.3 million ac-ft
  - ∗ Retained the most TP load = 875 metric tons
  - ∗ Highest inflow-to-outflow TP load reduction = 85%
  - ∗ Lowest mean outflow TP conc. = 15 µg/L

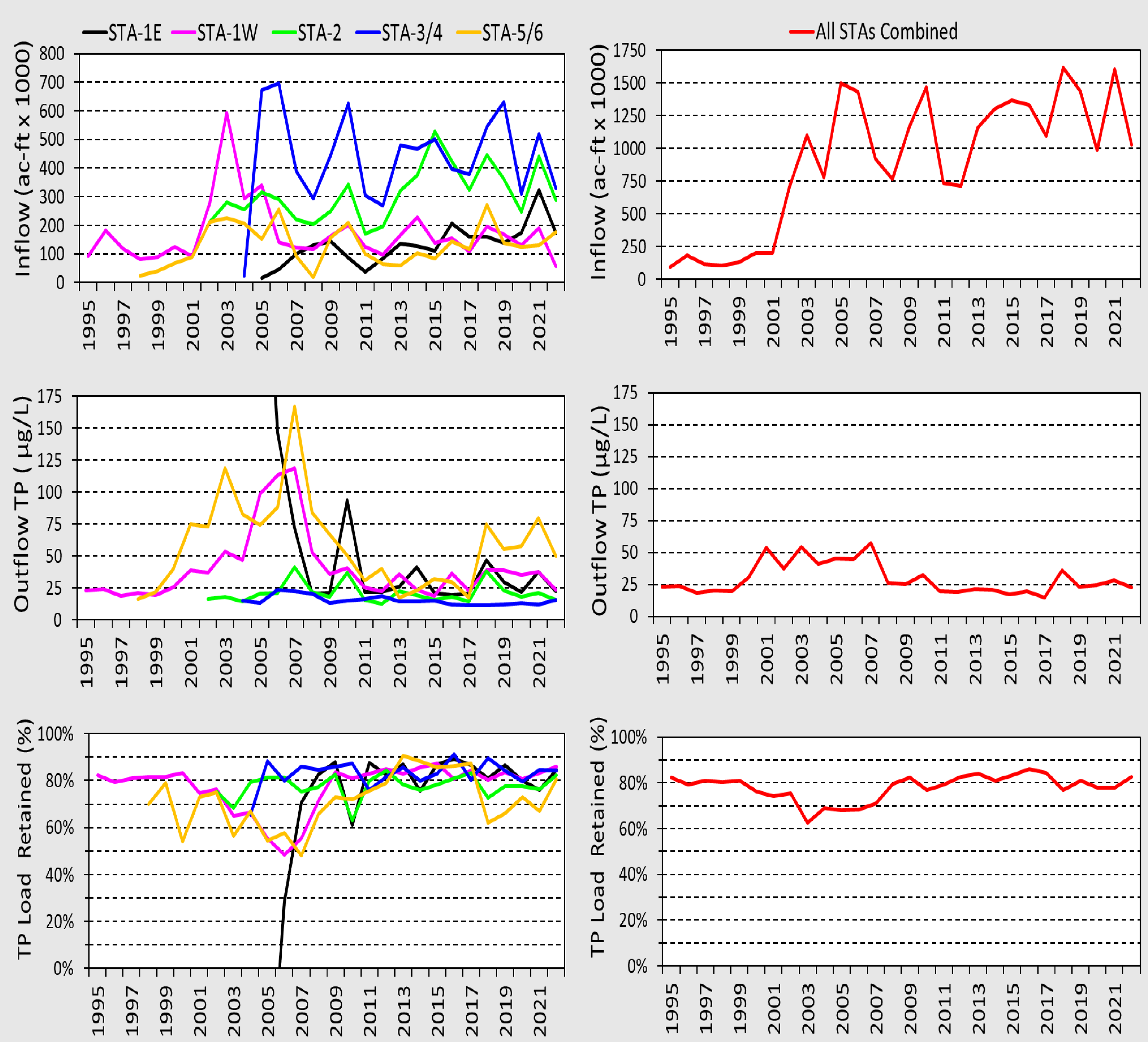


Figure 2. Annual time-series plots (WY1995—WY2022) for each STA and all STAs combined. **Top Panels** = total inflow water volume; **Middle Panels** = mean outflow TP concentration; **Bottom Panels** = percent inflow-to-outflow TP load reduction.

CHAPTER 9:

Kissimmee River Restoration and Other Kissimmee Basin Initiatives

Steve Bousquin, Kissimmee River Restoration Evaluation Program (KRREP)

THE PURPOSE OF CHAPTER 9

Chapter 9 reports progress toward the hydrologic and ecological goals of the Kissimmee River Restoration (KRR) Project

- **Components of the KRR include:**
  - **Construction (USACE)**
  - **Engineering (USACE)**
  - **Land acquisition (SFWMD)**
  - **Restoration evaluation (SFWMD)**

THE KISSIMMEE RIVER RESTORATION EVALUATION PROGRAM (KRREP)

The District's Kissimmee River Restoration Evaluation Program (KRREP):

- **Conducts scientific monitoring and evaluations of the success of KRR**
- **Reports findings in SFER and peer-reviewed publications**
- **Develops strategies for improvement**
- **Will conduct final project success evaluations after HRS is fully implemented**
- **Restoration evaluation is a mandated component of KRR**

SUMMARY OF ECOLOGICAL RESPONSES TO DATE

- **Success to date has been limited to river channel metrics, while ecological response on the floodplain needs improvement in hydrology**
- **This is because flow has been nearly continuous in the Phase I area since 2001, while floodplain inundation has been inadequate**
- **Future success is dependent on the following:**
  - **The additional storage that will be provided by phased implementation of HRS**
  - **Our ability to put water on the Kissimmee River floodplain at historic durations and frequencies**

RECENT KRR MILESTONES

KRR construction was completed in 2021

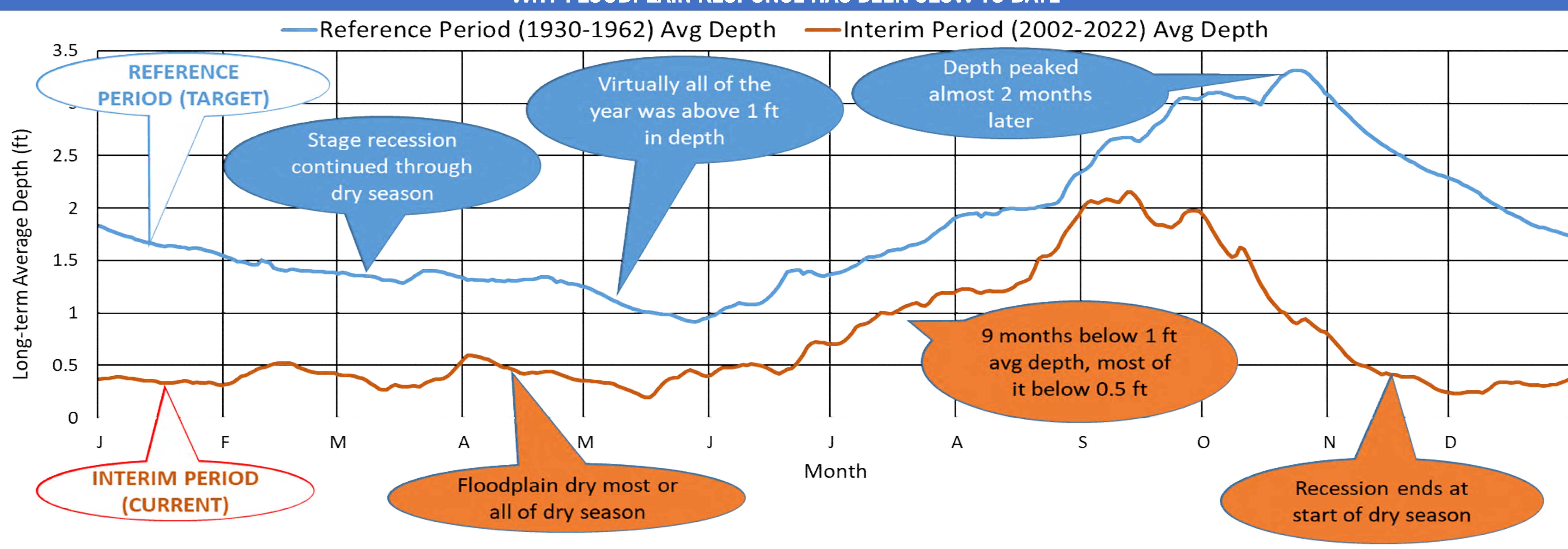
- **Repairs are ongoing**
- **Completion of construction sets the stage for:**
  - **Gradual implementation of the Headwaters Revitalization Schedule (HRS) starting in 2023**
  - **Improved water management for river and floodplain restoration**

Treatment of invasive vegetation to control incursions of invasive grasses begins in 2023

- **Monitoring of herbicide effects will be ongoing to determine the most effective methods**

RECOVERY STATUS (General Summary of Performance Measures)	**AREA**	**METRIC CLASS**
Good	River Channel	Hydrology
		Invertebrate Communities
		Vegetation
		Geomorphology
Needs Improvement	Floodplain	Bass Populations
		Wading Bird Abundance
		Waterfowl Abundance
		Dissolved Oxygen
		Hydrology
		Vegetation
	River Channel	Bass Populations
Not Currently Sampled	Floodplain	Invertebrate Communities
		Herpetofaunal Communities

WHY FLOODPLAIN RESPONSE HAS BEEN SLOW TO DATE



SOLUTIONS

- **In addition to continuous flow, sustained periods of higher flow are needed to restore a recurring annual flood pulse to the floodplain**
- **More and longer floodplain inundation are needed, with slower transitions to a dry floodplain**
- **A completely inundated floodplain is not necessary every year, but when rainfall presents opportunities, we must take advantage of it to ultimately achieve floodplain restoration**

SCAN ME

The photo sequence below illustrates the approximate annual cycle of drying and flooding comprising a flood pulse: (a) Floodplain drying down with a "drying pool" attracting wading birds; (b) flow contained in river channel; (c) floodplain fully inundated

Chapter 9: Response of Largemouth Bass and Other Sunfish (Centrarchids) to Environmental Conditions in the Kissimmee River

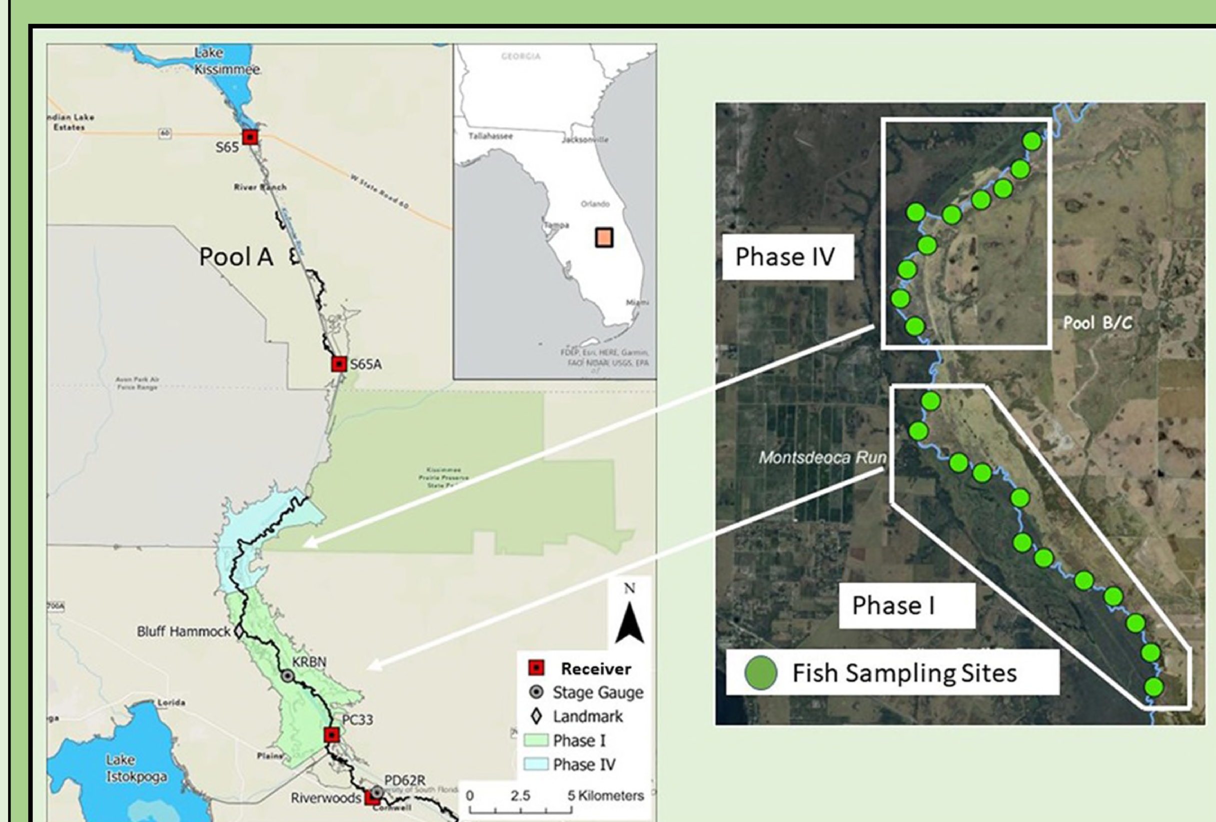
Chuck Hanlon, Senior Scientist
Lake and River Ecosystems Section
South Florida Water Management District

INTRODUCTION

The primary goal of the Kissimmee River Restoration Project (KRRP) is to restore ecological integrity to the river-floodplain system. Phase I and Phase IV of the restoration were completed in 2001 and 2009, respectively. In total, flow has been reestablished in over 40 miles of continuous and historic river channel, and the floodplain wetland was enlarged by over 12,398 acres. Since completion of these restoration projects, dissolved oxygen (DO) concentrations in the river have generally improved, but prolonged periods of anoxic (DO < 1 milligram per liter [mg/L]) and hypoxic (DO < 2 mg/L) conditions do continue to occur in the wet season. The impact that anoxic and hypoxic conditions have on largemouth bass (LMB) and other centrarchid sunfish is being evaluated.

STUDY AREA AND METHODS

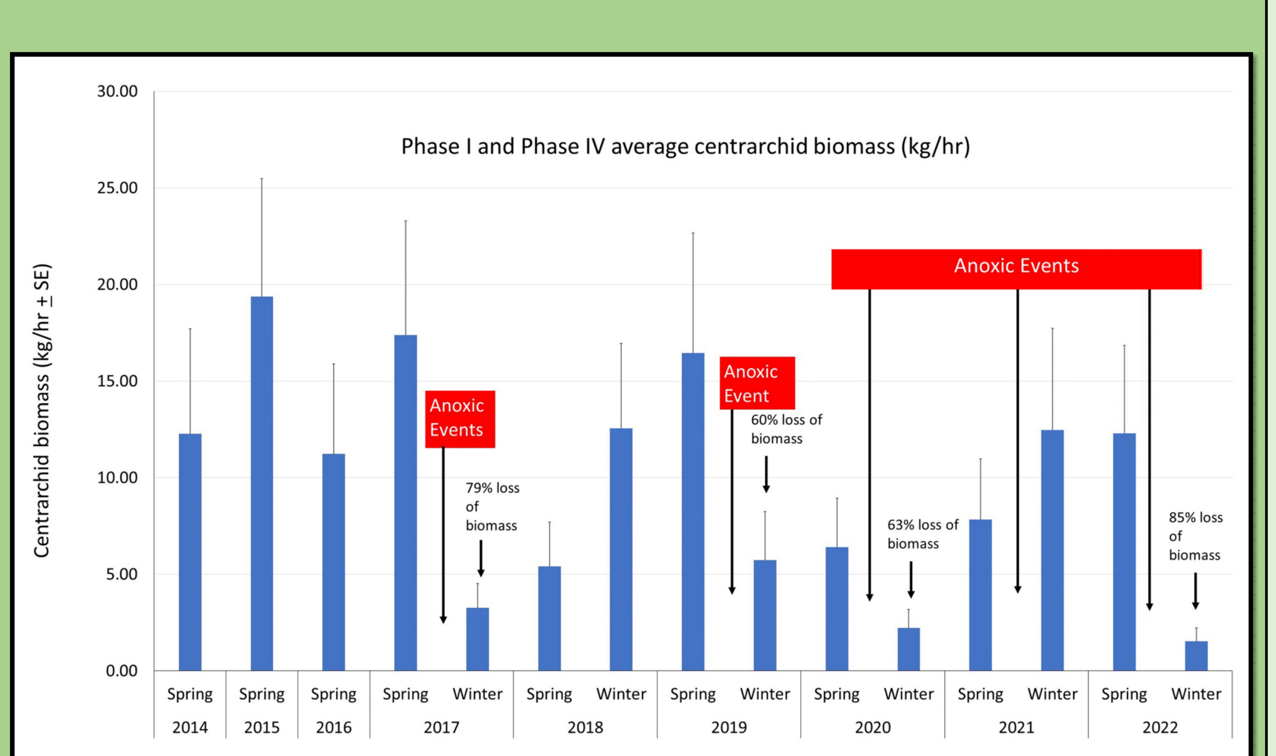
Fish abundance in the restored of the river has been monitored annually (spring) or bi-annually (spring/winter) since 2014. Fish are sampled at 22 fixed locations (165 yards [yd] of shoreline) using standardized electrofishing techniques. Each site is sampled for 15 minutes and catch per unit effort (CPUE – number of fish per minute) is used to estimate fish abundance.

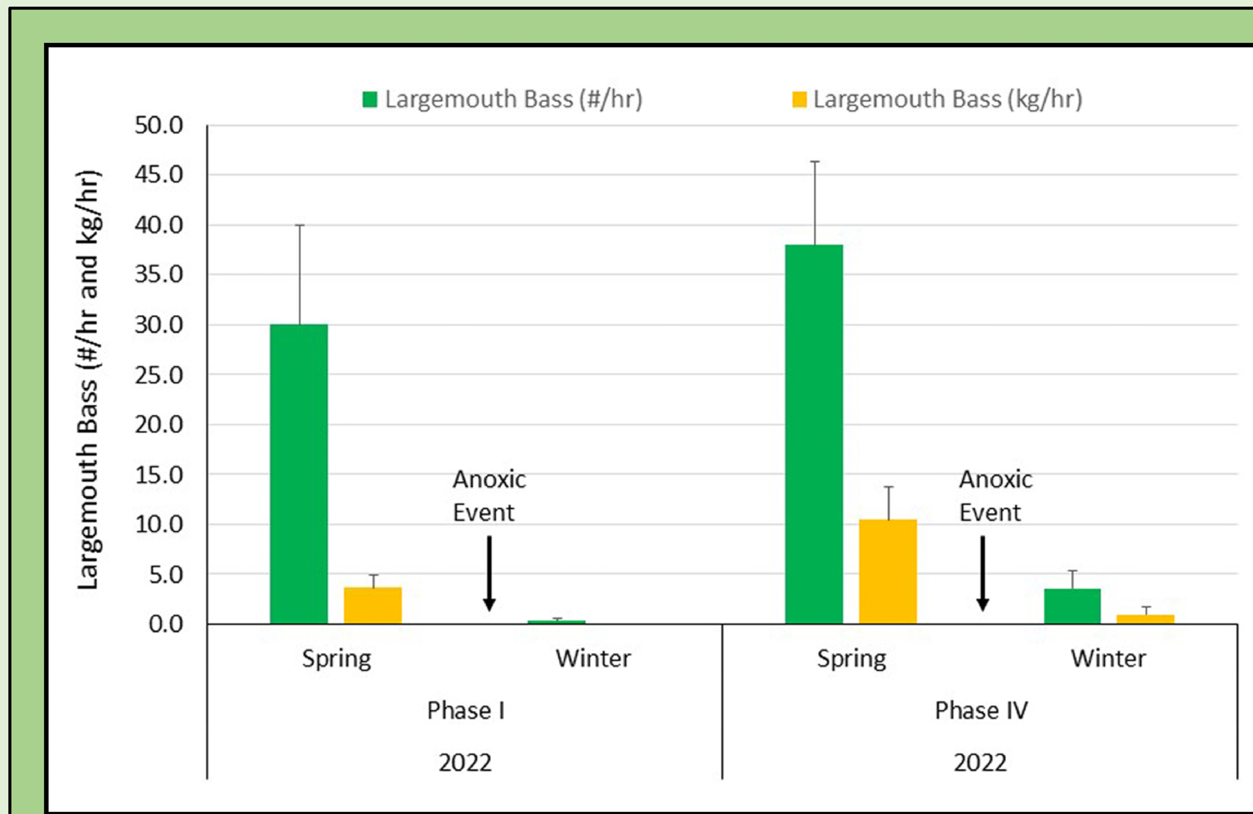


In 2020, we partnered with the Florida Fish and Wildlife Conservation Commission (FWC) and conducted a two-year (2020-2021) telemetry study to determine in real time how LMB respond to changing environmental conditions (e.g., DO and flow). Radio transmitters were surgically implanted into 50 LMB in 2020 and again in 2021. Each year, 10 LMB were tagged in Lake Kissimmee, 10 in Pool A (C-38), and 30 in the restored area of the river. Passive receivers that recorded fish movement upstream or downstream were set up at four locations between S-65 and the Riverwoods Field Lab, and supplemental active tracking by boat was conducted weekly to determine LMB movement and location.

RESULTS

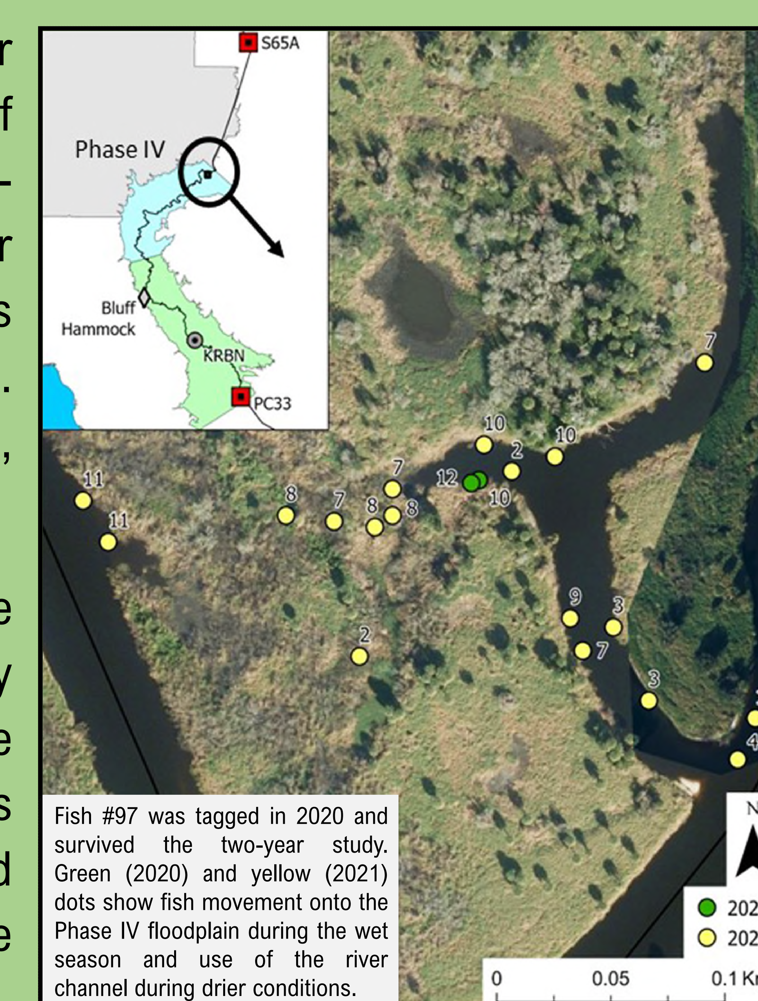
In most years, a summer anoxic event was followed by a 60% to 85% reduction in winter centrarchid (LMB and other sunfish) biomass.





LMB abundance and biomass often declined by more than 90% following an anoxic event.

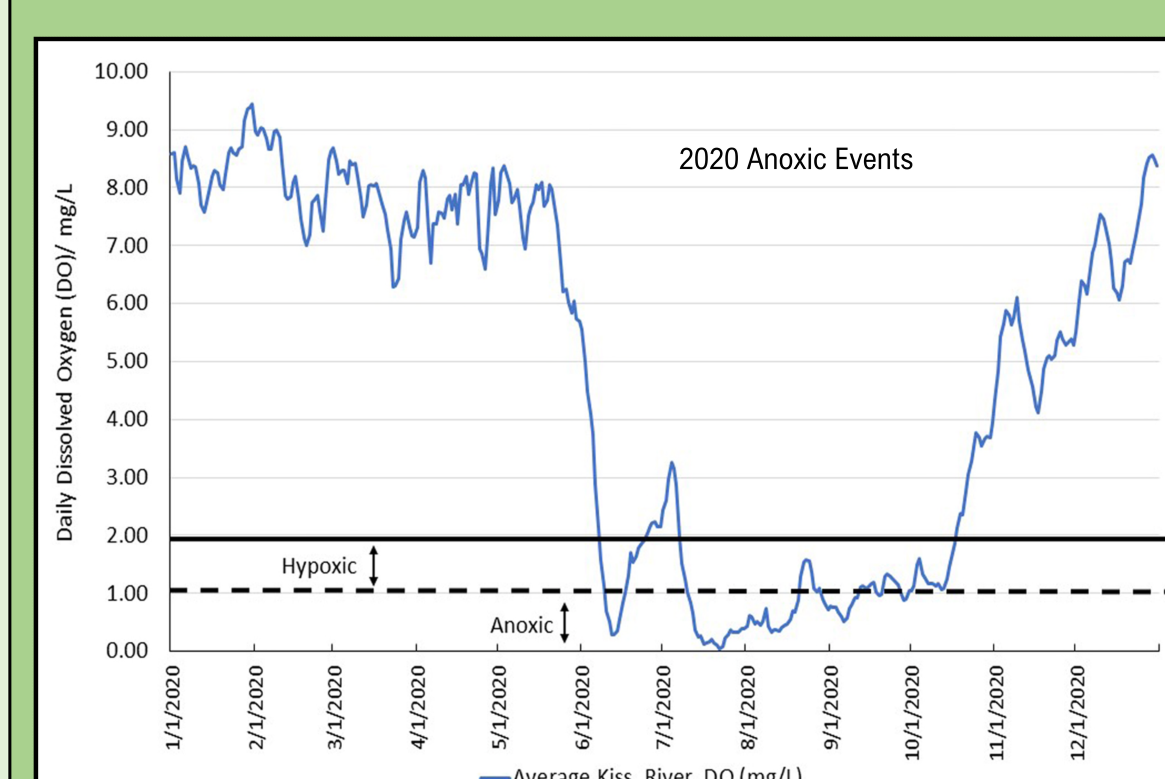
Movement – Most fish moved less than 220 yd per day on average, with occasional large movements of 1,100 yd or more per day. LMB increasingly used off-channel habitats (sloughs and side channels) as water stage increased. Utilization of these habitats was particularly apparent during spring (spawning season). LMB tended to stay within 100 yd of the river channel, and no fish made long excursions onto the floodplain.



Fish #97 was tagged in 2020 and survived the two-year study. Green (2020) and yellow (2021) dots show fish movement onto the Phase IV floodplain during the wet season and use of the river channel during drier conditions.

The oxygen stress response showed that avoidance behavior was evident below 2 mg/L, with daily movements increasing as fish actively sought more favorable conditions. However, when conditions became anoxic, the fish had very little movement, and large-scale mortality events occurred when the duration of anoxia was too long or the onset too fast.

Mortality – A large local basin rainfall event at the beginning of June 2020 caused systemwide declines in DO below 1 mg/L by June 8. Over half (17) of the study fish tagged in Phase I and IV died within two weeks. A second anoxic event in July led to the death of seven additional study fish.



Water discharge increases from S-65A were moderate in 2021 compared to 2020 and hypoxia was of much shorter duration. Four study fish tagged in 2021 were lost to predation prior to the wet season. Only six of the remaining 26 LMB tagged in Phase I and IV died during a low DO event in August 2021. Total annual mortality was estimated at 89% and 33% in 2020 and 2021, respectively.

CONCLUSIONS

1. There was net migration of tagged LMB out of Phase I and Phase IV in 2020 and 2021.
2. No LMB were observed migrating into the restored section of the river from Lake Kissimmee.
3. Two of four LMB that moved south out of the study area during summer 2020 returned in the fall when DO conditions improved.
4. In some areas, access to floodplain habitat is impeded by dense stands of exotic grasses.
5. It will be difficult for the river's fishery to show long-term improvement until DO conditions improve and proper floodplain inundation depths and frequencies that allow access to floodplain habitat during breeding season (winter-spring) are established. In 2020, the river was anoxic or hypoxic for 121 days. Conditions improved somewhat in 2021 (64 days) and 2022 (56 days). The District and its partners continue to work on reducing the severity and duration of Kissimmee River hypoxic/anoxic events to the extent possible.

SCAN ME

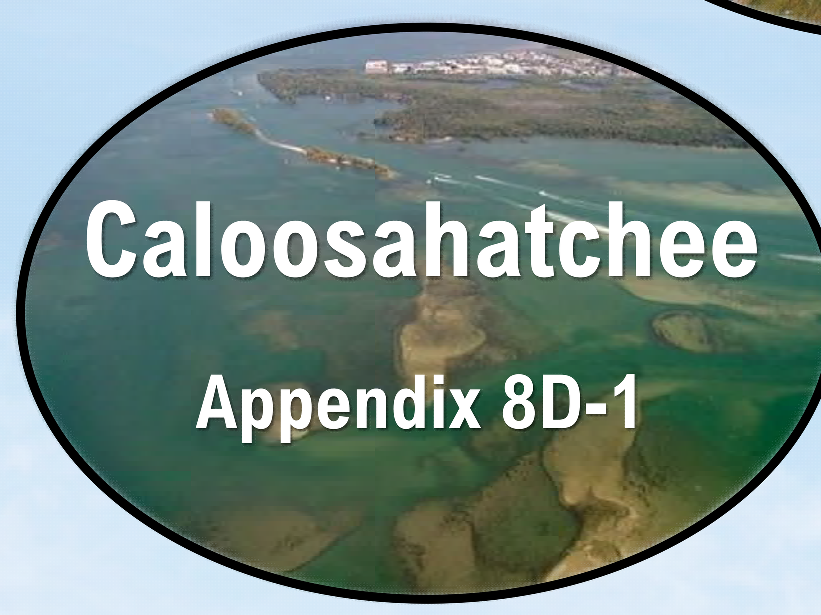
SOUTH FLORIDA WATER MANAGEMENT DISTRICT

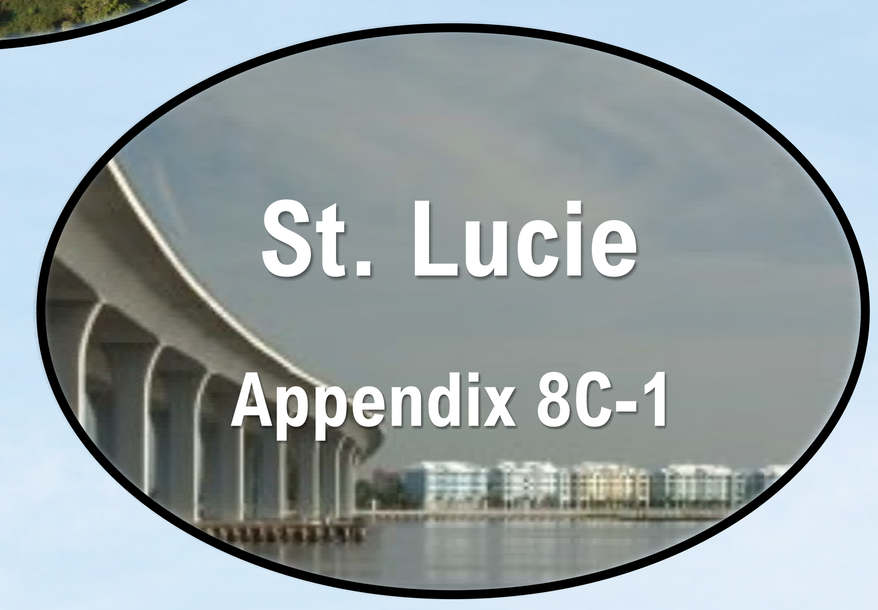
Northern Everglades Upstream Water Quality Monitoring Network

2023 SFER - Volume I, Appendices 8B-1, 8C-1, and 8D-1

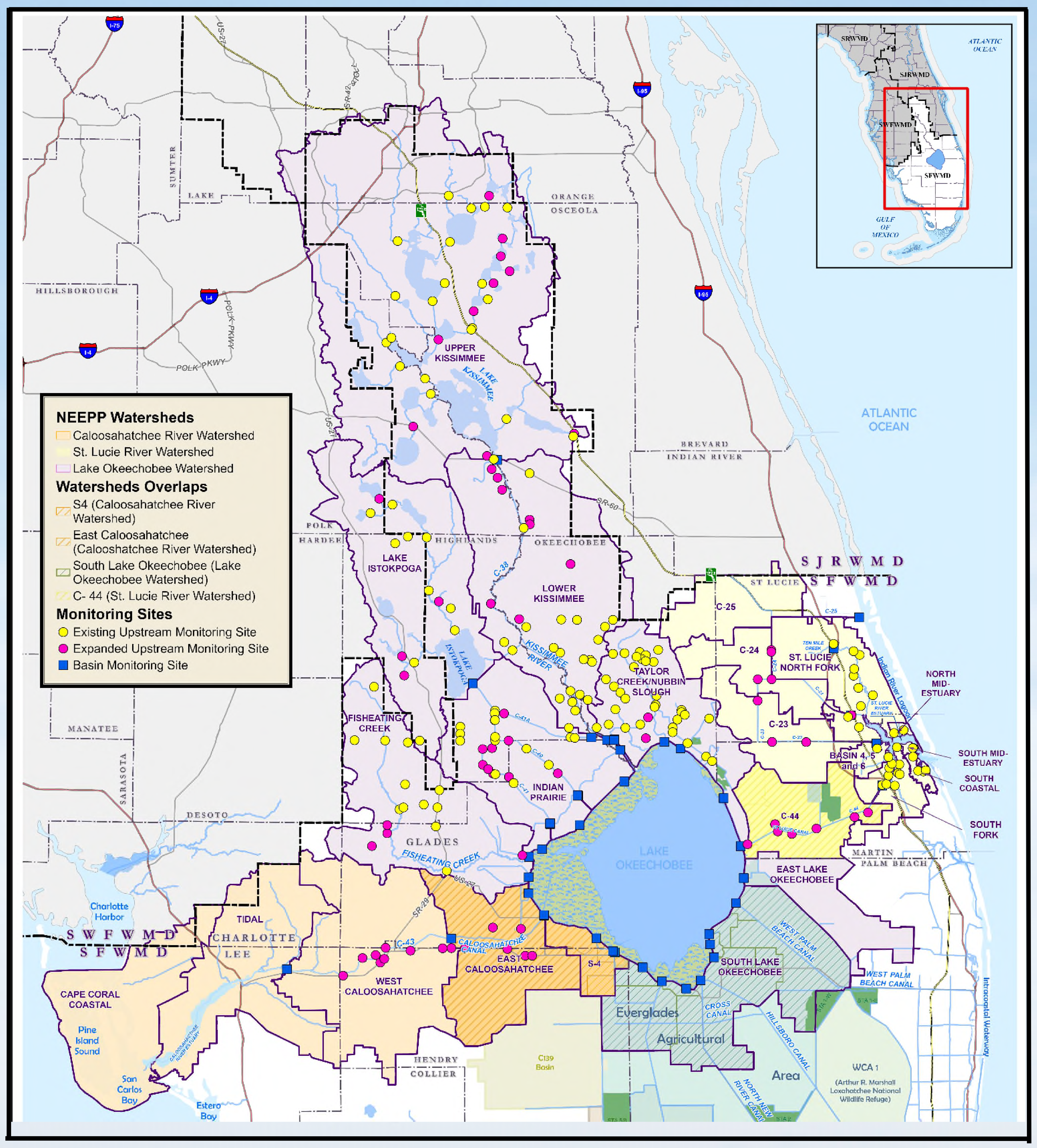
Steffany Olson, Amanda McDonald, Aubrey Frye, and Megan Junod

Purpose of Upstream Monitoring: ➢highlight areas of concern ➢prioritize resources ➢track progress





Water Quality Monitoring Network



Governing Board Expansion of Upstream Network

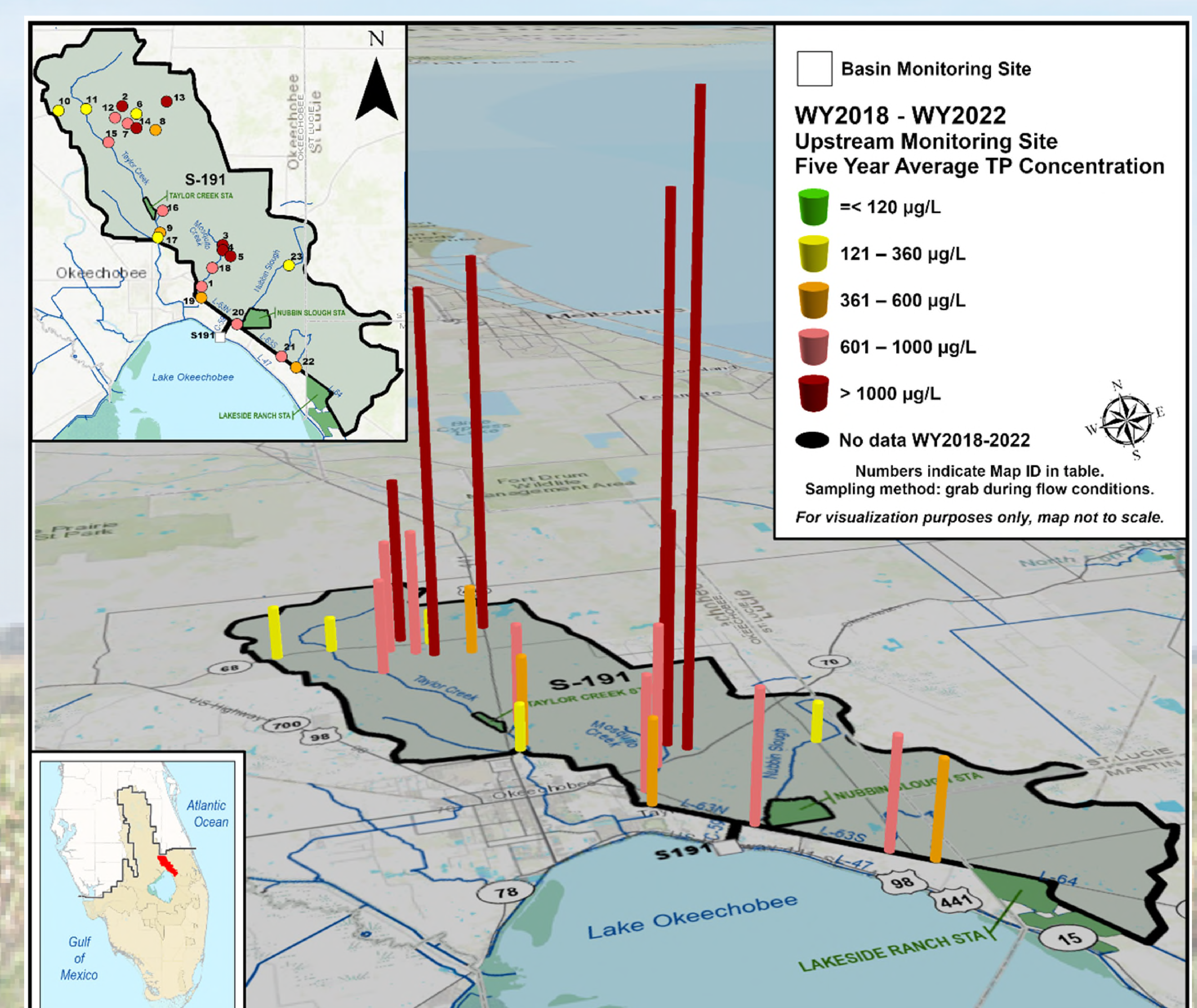
➢Increased:

- number of sites
- collection frequency to bi-weekly
- parameters collected

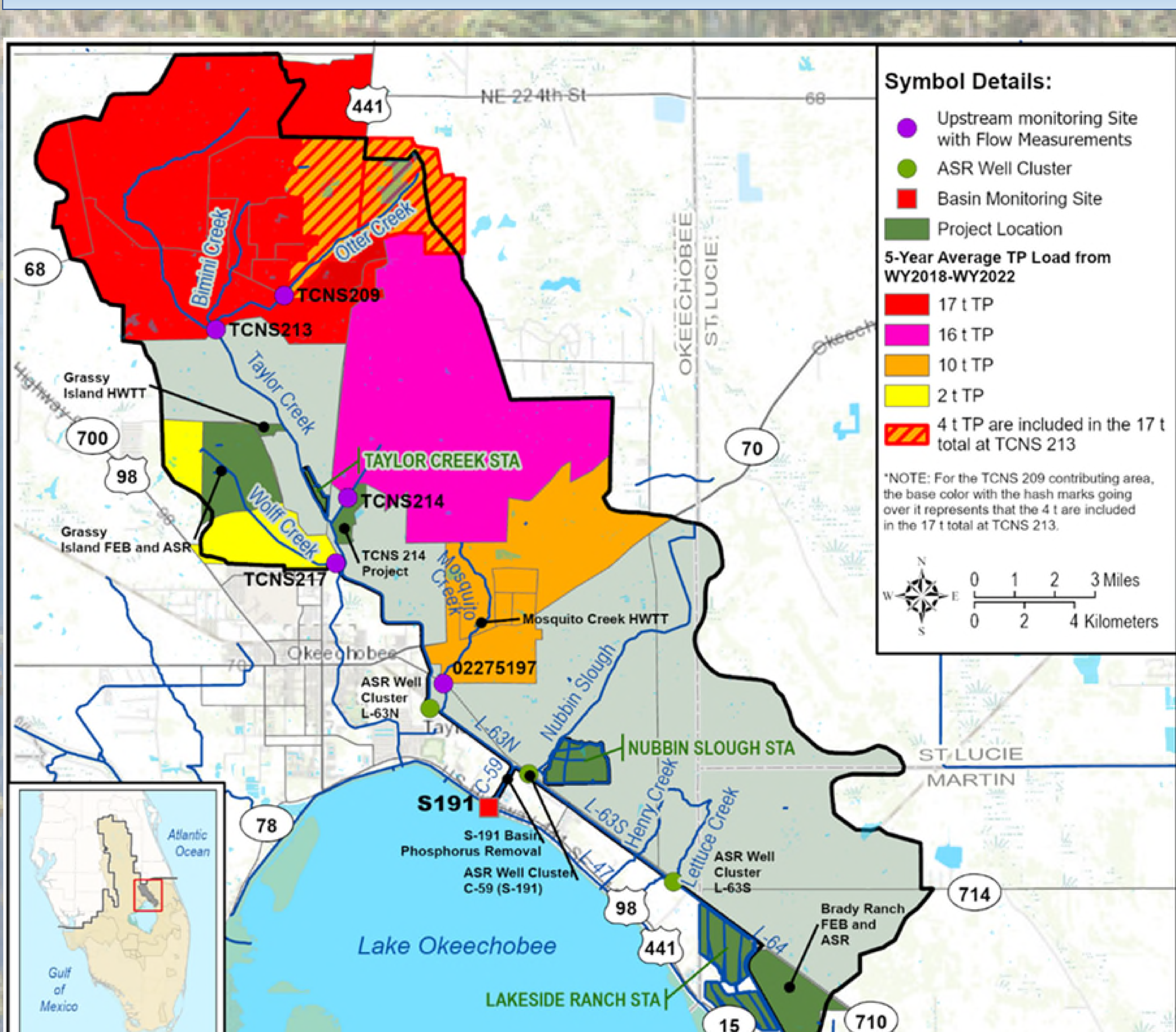
Total Number of Sites

Monitoring Level	Lake Okeechobee Watershed	Caloosahatchee River Watershed	St. Lucie River Watershed
Basin	37	5	6
Upstream	150	15	46
Upstream Monitoring Plan			
Frequency	Biweekly when flowing (some weekly)		
Parameters	TP, OPO4, TN, NH3-N, NOx, pH, Temp, DO, Conductivity		

Total Phosphorus Concentrations (App. 8B-1)



Total Phosphorus Loads (App. 8B-1)



Dissolved Inorganic Nutrient Concentrations Water Year 2022 (App. 8B-1)

S-191	Orthophosphorous OPO4 (µg/L)		Ammonia NH3-N (mg/L)		Nitrate-Nitrite NOx (mg/L)	
Map ID	Samples	Avg.	Samples	Avg.	Samples	Avg.
1	12	*328*	11	0.08	12	0.36
2	0	-	0	-	0	-
3	2	*2,698*	2	1.18	2	0.84
4	1	*2,337*	1	0.76	1	0.03
5	2	*3,686*	2	*1.84*	2	0.01
6	1	71	1	0.26	1	0.01
7	2	*468*	2	*2.94*	2	1.15
8	2	16	2	0.75	2	0.02
9	1	*382*	1	0.15	1	0.08
10	0	-	0	-	0	-
11	6	*148*	6	0.15	6	0.22
12	3	*469*	3	0.54	3	1.11
13	0	-	0	-	0	-
14	6	*3,178*	6	*20.61*	5	0.85
15	17	*881*	17	*4.64*	16	0.38
16	20	*381*	20	0.15	20	0.15
17	12	*182*	12	0.11	12	0.14
18	9	*376*	9	0.32	9	0.15
19	17	*281*	17	0.55	17	0.46
20	0	-	0	-	0	-
21	1	*366*	1	0.11	1	0.05
22	5	*429*	5	0.14	5	0.07
23	1	99	1	0.07	1	0.01

➢ Data bars are included to help the viewer spot highest and lowers numbers at a glance.

➢ Red italicized numbers indicate concentrations above the numeric nutrient criteria (NNC) values for total phosphorus and total nitrogen. Note that this is presented for reference and is not an assessment of NNC compliance.

App. 8B-1 SCAN ME

App. 8C-1 SCAN ME

App. 8D-1 SCAN ME

Chapter 8C: St. Lucie River Watershed Protection Plan Annual Progress Report
Part III: St. Lucie River Watershed Construction Project

Aubrey Frye

SCAN ME

The Northern Everglades and Estuaries Protection Program (NEEPP) promotes a comprehensive approach to protect the St. Lucie River Watershed (SLRW). Using a combination of research, monitoring, source controls and construction projects, the NEEPP will restore and protect surface water resources by addressing water quality and storage in the natural system. The following are the key accomplishments and successes during Water Year 2022 (WY2022; May 1, 2021 – April 30, 2022).

Operational Projects in WY2022 provided:

- **> 63,098 acre-feet per year** (ac-ft/yr) of water storage
- **> 29 metric tons per year** (t/yr) total phosphorus (TP) removal
- **> 307 metric tons per year** (t/yr) total nitrogen (TN) removal

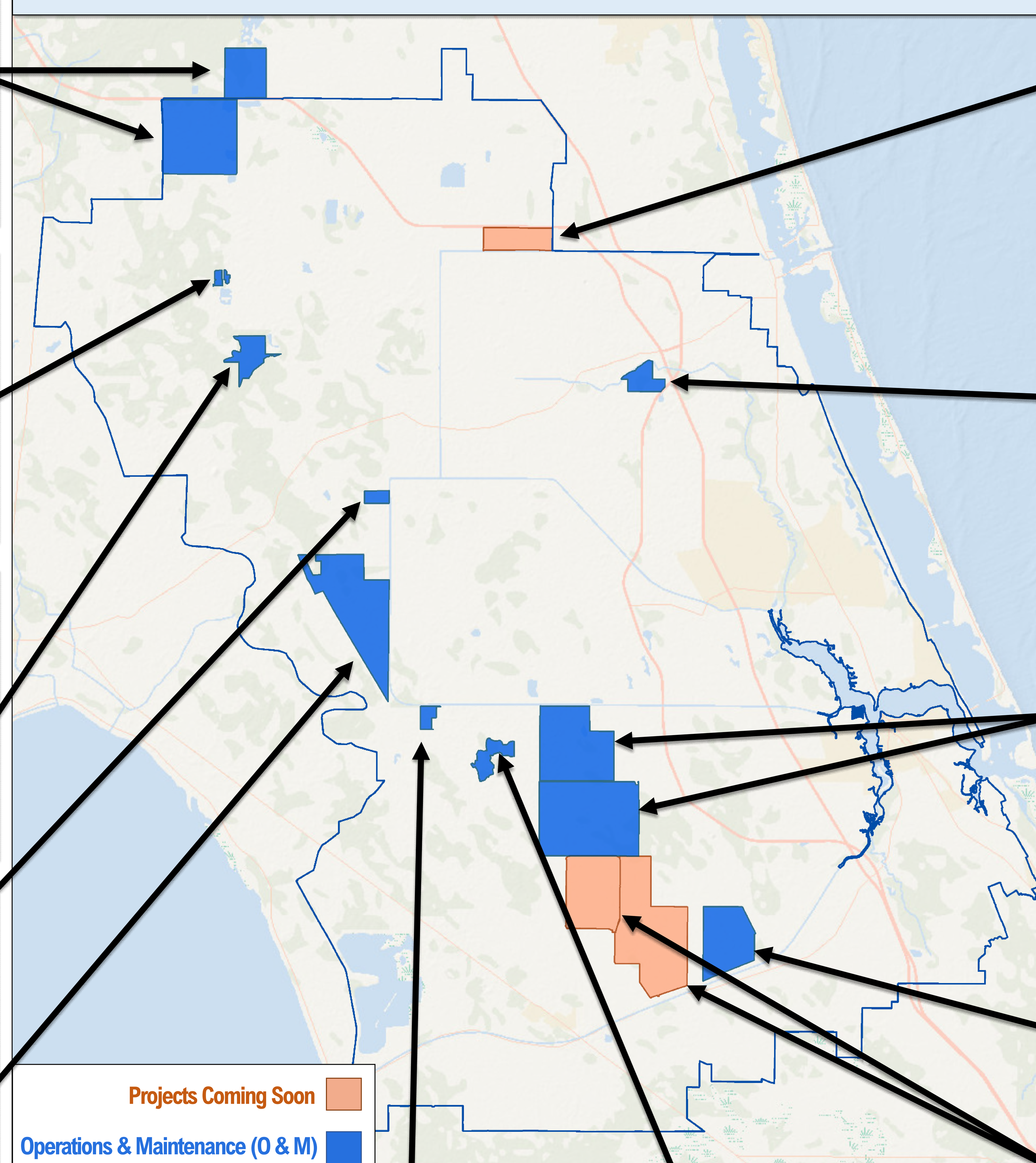
Northern Everglades Request for Proposals:

In May 2022, the District Governing Board authorized staff to negotiate up to **four** water retention and nutrient load reduction projects in the St. Lucie River Watershed.

- **Two** 10-year contract renewals were executed.
- **Two** new projects are in development in the C-24 and C-25 basins.

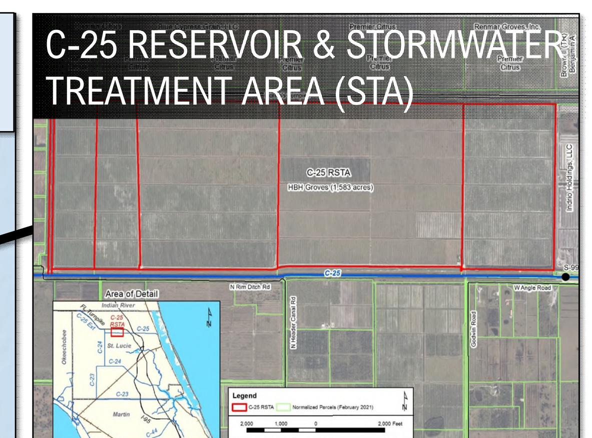
Advancing Watershed Construction Projects

Watershed Construction Projects with Storage Benefits



Status: **O & M**
Basin: **C-25**
Project Area: **7,444 ac**
Storage: **5,595 ac-ft/yr** [a]
TP Removed: **1.4 t/yr** [a]
TN Removed: **10.8 t/yr** [a]


SCOTT WATER FARM


C-25 RESERVOIR & STORMWATER TREATMENT AREA (STA)

Status: **COMING SOON!**
Basin: **C-25**
Project Area: **1,583 ac**
Est. Storage: **5,392 ac-ft/yr**
Est. TP Removed: **8.9 t/yr**
Est. TN Removed: **35.6 t/yr**


ALDERMAN-DELONEY RANCH

Status: **O & M**
Basin: **C-25**
Project Area: **170 ac**
Storage: **73 ac-ft/yr**
TP Removed: **0.01 t/yr**
TN Removed: **0.1 t/yr**

Status: **O & M**
Basin: **Ten Mile Creek**
Project Area: **658 ac**
Storage: **2,240 ac-ft/yr**
TP Removed: **2.6 t/yr**
TN Removed: **4.8 t/yr**


TEN MILE CREEK WATER PRESERVE AREA

Status: **O & M**
Basin: **C-24**
Project Area: **1,000 ac**
Storage: **444 ac-ft/yr**
TP Removed: **0.1 t/yr**
TN Removed: **0.7 t/yr**


ADAMS-RUSSAIKIS RANCH


ALLAPATTAH PARCELS A & B

Status: **O & M**
Basin: **C-23**
Project Area: **12,724 ac**
Storage: **11,687 ac-ft/yr**
TP Removed: **N/A** [b]
TN Removed: **N/A** [b]


C23/C24 INTERIM STORAGE SECTION C

Status: **O & M**
Basin: **C-24**
Project Area: **297 ac**
Storage: **2,008 ac-ft/yr**
TP Removed: **0.3 t/yr**
TN Removed: **2.7 t/yr**

Status: **O & M**
Basin: **C-44**
Project Area: **3,275 ac**
Storage: **20,211 ac-ft/yr**
TP Removed: **3.6 t/yr**
TN Removed: **26.1 t/yr**


CAULKINS WATER FARM

Status: **O & M**
Basin: **C-23**
Project Area: **6,104 ac**
Storage: **18,573 ac-ft/yr** [a]
TP Removed: **5.2 t/yr** [a]
TN Removed: **27 t/yr** [a]


BLUEFIELD GROVES

Status: **O & M**
Basin: **C-23**
Project Area: **210 ac**
Storage: **1,420 ac-ft/yr**
TP Removed: **0.9 t/yr**
TN Removed: **3.6 t/yr**


SPUR LAND & CATTLE


BULL HAMMOCK RANCH

Status: **O & M**
Basin: **C-23**
Project Area: **608 ac**
Storage: **847 ac-ft/yr**
TP Removed: **0.3 t/yr**
TN Removed: **1.2 t/yr**


C-44 RESERVOIR & STA

Status: **COMING SOON!**
Basin: **C-44**
Project Area: **9,300 ac**
Est. Storage: **60,050 ac-ft/yr**
Est. TP Removed: **23 t/yr**
Est. TN Removed: **77 t/yr**

a. Project was completed construction mid-water year and, therefore, was not operational for the full water year.
b. N/A – not applicable. Nutrient reduction is not associated with the project's primary objective.

Progress Towards Water Quality and Storage Goals

Protection Plan and BMAP Targets

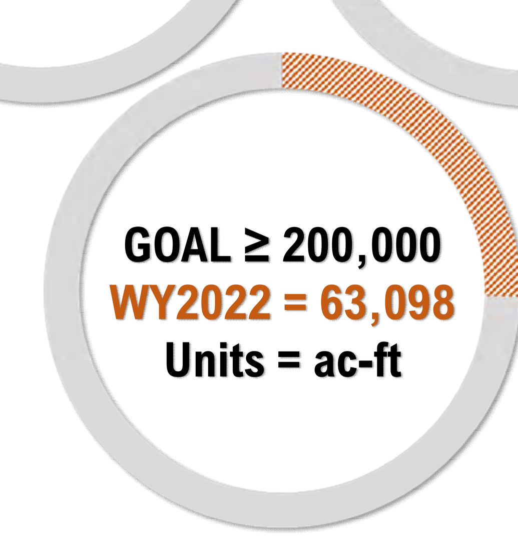
Storage Volume:
200,000 ac-ft

Estuary TMDL Concentrations:
TP: **0.08 milligrams per liter (mg/L)**
TN: **0.72 mg/L**

Estimated Nutrient Removal Needed:
TP: **184 t/yr**
TN: **566 t/yr**

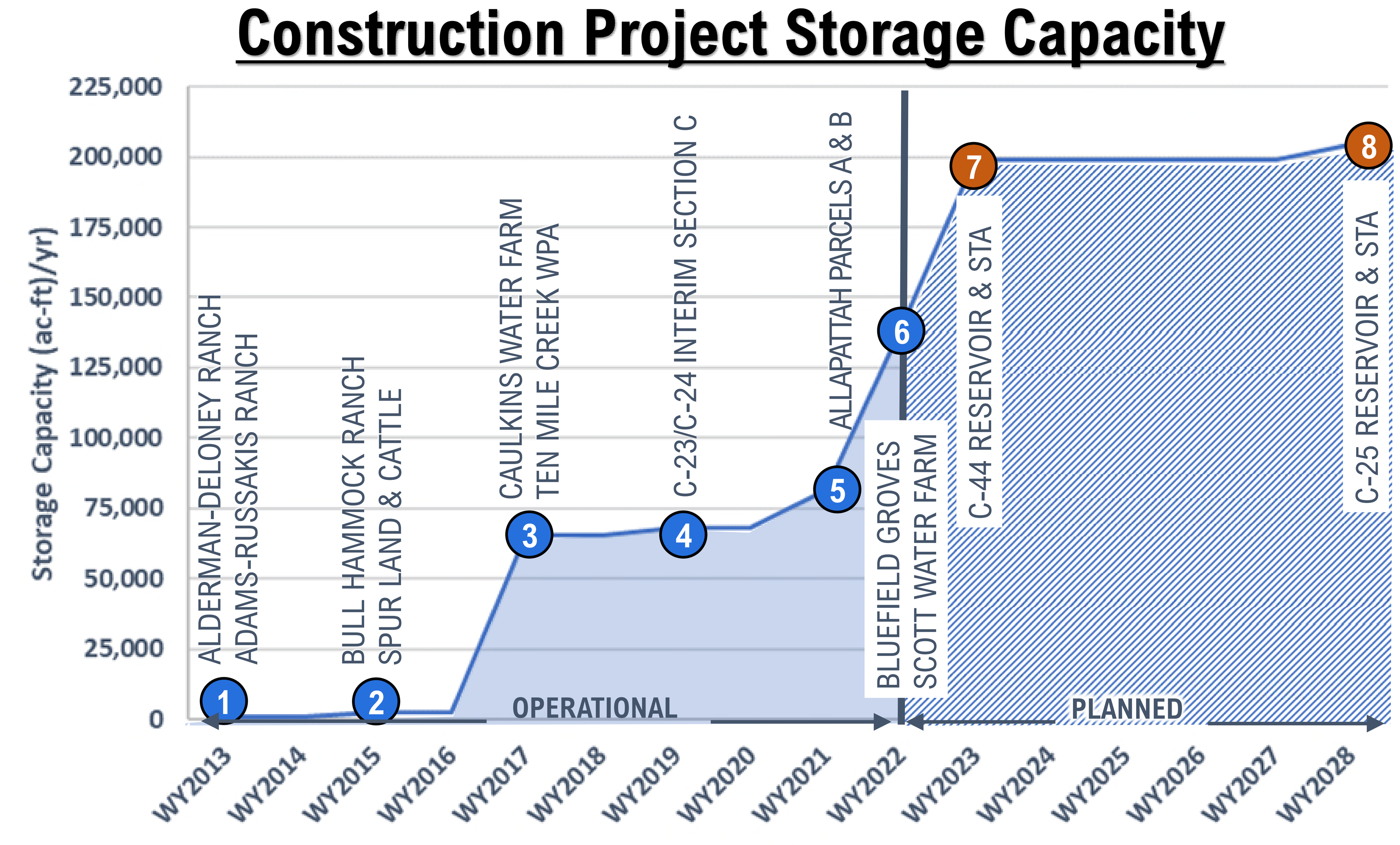
TP Removal

TN Removal



Project Storage

Construction Project Storage Capacity



Future planned projects that will further increase storage include the IRL-South C-23/C-24 North Reservoir and South Reservoir.

Chapter 8B: Lake Okeechobee Watershed Protection Plan Annual Progress Report

Part III: Lake Okeechobee Watershed Construction Project

Anthony Betts

Twenty operational projects in Water Year (WY) 2022 provided approximately:

- > **65,000 acre-feet** (ac-ft) of storage
- > **67 metric tons** (t) total phosphorus (TP) retention
- > **143 t** total nitrogen (TN) retention
- > **50,000 acres** of hydrated wetlands

Northern Everglades Request for Proposals:

In 2022, the South Florida Water Management District Governing Board authorized staff to negotiate up to **eight** projects in the Lake Okeechobee Watershed.

- **Four** 10-year contract extensions were executed for existing projects.
- **Two** new projects in the Lake Istokpoga and Upper Kissimmee subwatersheds.

Advancing Watershed Construction Projects

Partin Family Ranch

Basin: **Upper Kissimmee**
Project Area: **3,000 ac**
Storage: **To be determined (TBD)**
TP Retention: **TBD**
TN Retention: **TBD**

Basin: **C-41 & C-41A**
Project Area: **8,142 ac**
Est. Storage: **11,552 ac-ft/yr**
Est. TP Retention: **3.2 t/yr**
Est. TN Retention: **27.3 t/yr**

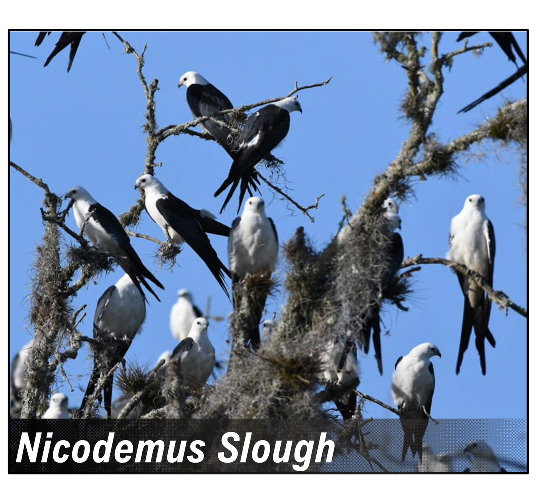

Brighton Valley


XL Ranch

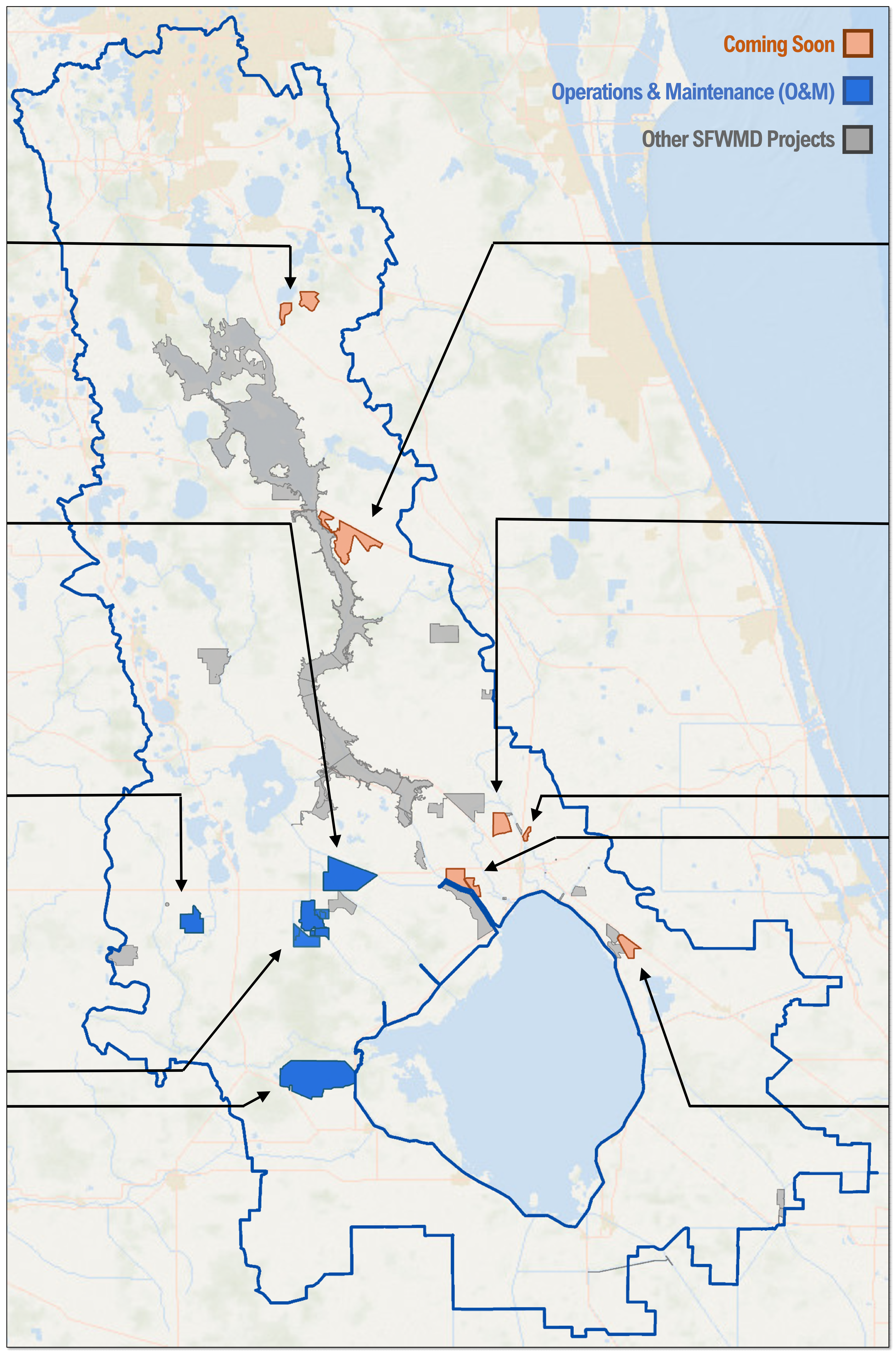
Basin: **Fisheating Creek**
Project Area: **765 ac**
Storage: **847 ac-ft/yr**
TP Retention: **0.1 t/yr**
TN Retention: **1.5 t/yr**

Basin: **C-41**
Project Area: **4,796 ac**
Storage: **2,741 ac-ft/yr**
TP Retained: **2.4 t/yr**
TN Retained: **13.2 t/yr**


Buck Island Ranch


Nicodemus Slough

Basin: **Nicodemus Slough North**
Project Area: **15,858 ac**
Storage: **21,062 ac-ft/yr**
TP Retention: **2.3 t/yr**
TN Retained: **47.2 t/yr**



Basin: **Lower Kissimmee**
Project Area: **7,030 ac**
Storage: **2,500 ac-ft per year (yr)**
TP Retention: **2.4 t/yr**
TN Retention: **7.0 t/yr**

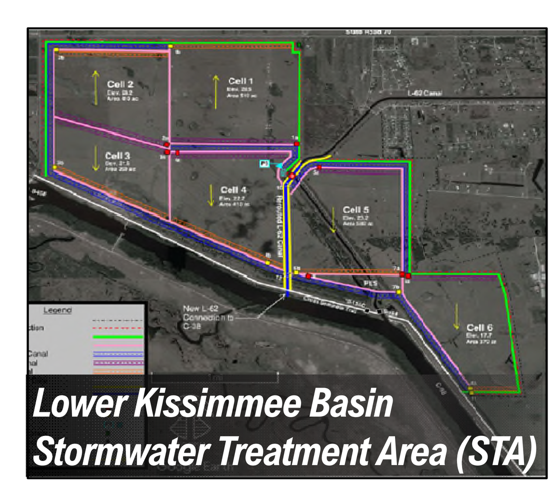
El Maximo Ranch


Grassy Island Flow Equalization Basin (FEB)

Basin: **S-191**
Project Area: **2,400 ac**
Storage: **3,200 ac-ft/yr**
TP Retention: **0.8 t/yr**
TN Retention: **TBD**

Basin: **S-191**
Project Area: **410 ac**
Storage: **312 ac-ft/yr**
TP Retention: **1.0 t/yr**
TN Retention: **4.0 t/yr**

TCNS 214 Storage & Treatment


Lower Kissimmee Basin Stormwater Treatment Area (STA)

Basin: **S-154C**
Project Area: **3,350 ac**
Est. Storage: **3,600 ac-ft/yr**
Est. TP Retention: **TBD**
Est. TN Retention: **TBD**

Basin: **S-191**
Project Area: **1,800 ac**
Storage: **7,200 ac-ft/yr**
TP Retention: **4.0 t/yr**
TN Retention: **TBD**

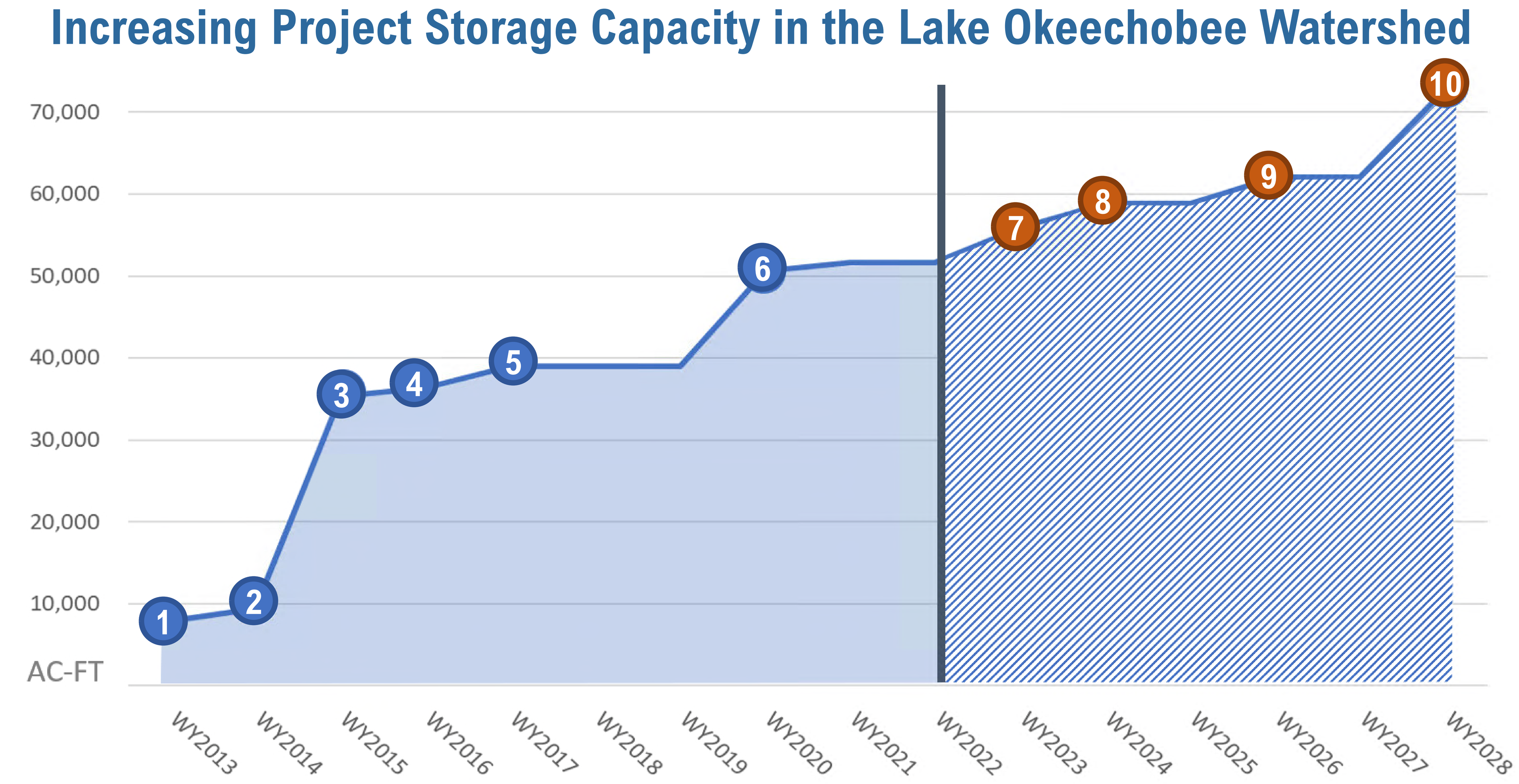
Brady Ranch FEB

Progress Towards Water Quality and Storage Goals

TP Annual Load

Total Watershed Storage

Increasing Project Storage Capacity in the Lake Okeechobee Watershed



1. BUCK ISLAND RANCH, DIXIE RANCH, DIXIE WEST
2. EAGLE HAVEN RANCH, XL RANCH
3. NICODEMUS SLOUGH, RAFTER T RANCH
4. ABINGTON PRESERVE
5. LLANO RANCHES
6. BRIGHTON VALLEY
7. PARTIN FAMILY RANCH
8. EL MAXIMO RANCH, TCNS 214 STORAGE AND TREATMENT
9. GRASSY ISLAND FEB
10. BRADY RANCH FEB, LOWER KISSIMMEE BASIN STA

* Long-term storage estimates (shown here) may vary from actual water year storage.

SCAN ME

Chapter 8D: Caloosahatchee River Watershed Protection Plan Annual Progress Report

Part III: Caloosahatchee River Watershed Construction Project

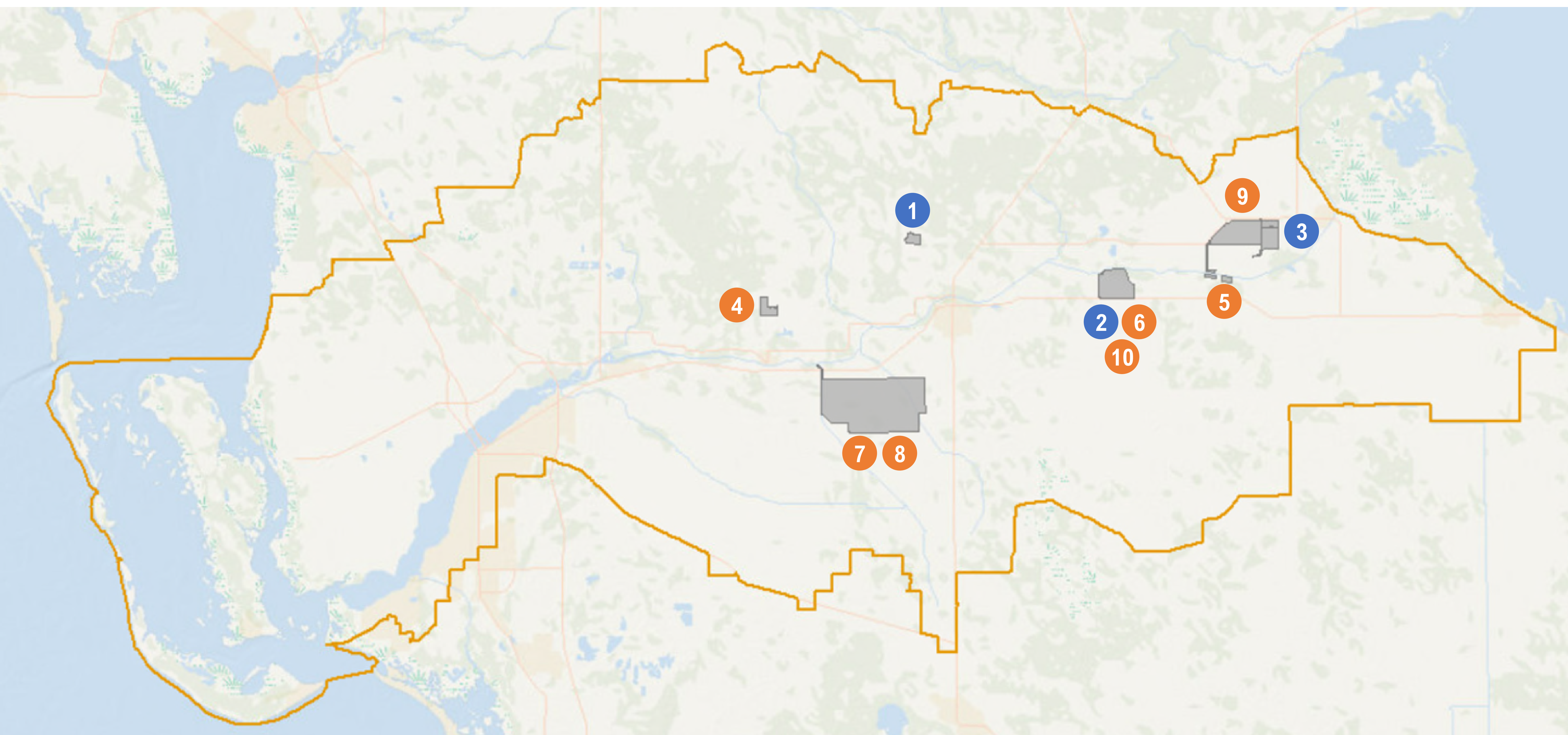
Jenna Bobsein

Three operational projects in WY2022 provided approximately:

- 8,800 acre-feet of storage
- 2 metric tons total phosphorus (TP) retention
- 27 metric tons total nitrogen (TN) retention

Northern Everglades Request for Proposals:
In 2022, the SFWMD Governing Board authorized staff to negotiate up to **two new projects** in the Caloosahatchee River Watershed.

Advancing Watershed Construction Projects



Operational Projects


Inspection at Mudge Ranch

1. Mudge Ranch

- Dispersed water management (DWM) public-private partnership
- Passive storage on 304 acres
- Operational since 2014


Pump at Boma Interim Storage Project

2. Boma Interim Storage Project

- Temporary storage until construction begins for the Boma Flow Equalization Basin (FEB) in 2023
- Operational since 2019


Pump Station G-725 at LHHEP Phase I

3. Lake Hicpochee Hydrologic Enhancement Project (LHHEP) Phase I

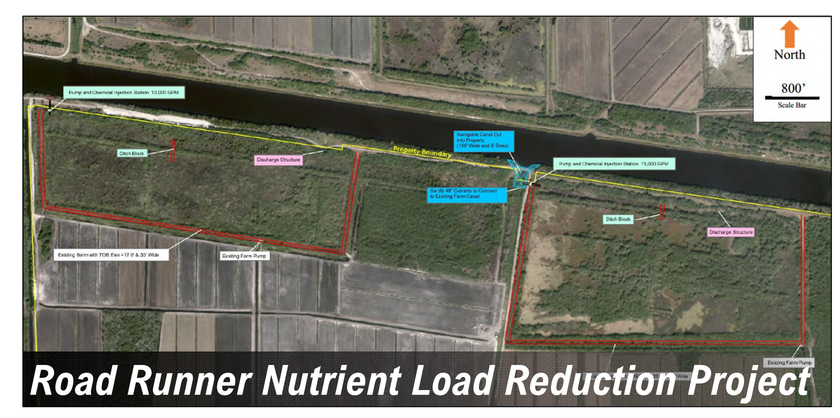
- Enhance hydration of the historic Lake Hicpochee
- Phase I captures excess surface water from the C-19 canal
- Operational since 2021

Planned Projects


Four Corners Rapid Infiltration Project

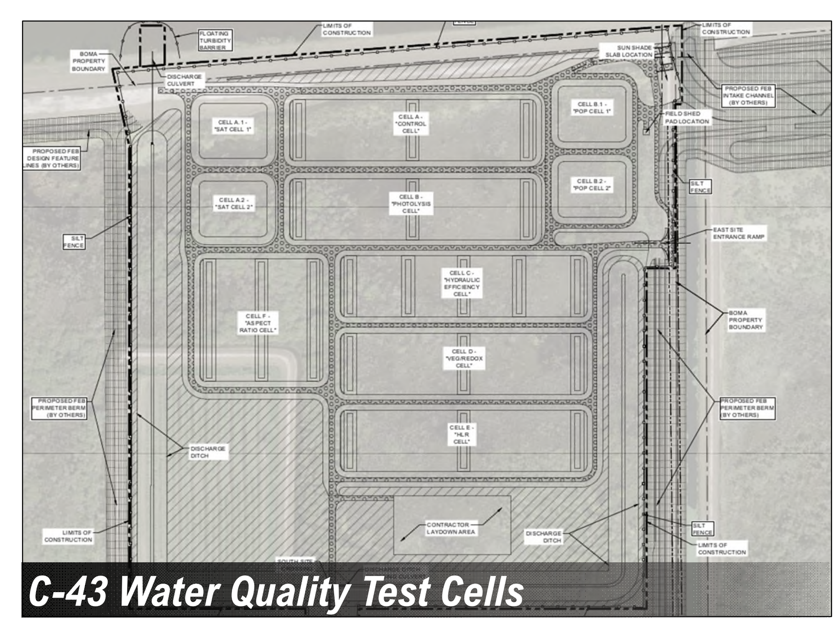
4. Four Corners Rapid Infiltration Project

- 366-acre above ground impoundment (AGI), including a 22-acre rapid infiltration area
- Status: Construction
- Expected to be operational in 2023


Road Runner Nutrient Load Reduction Project

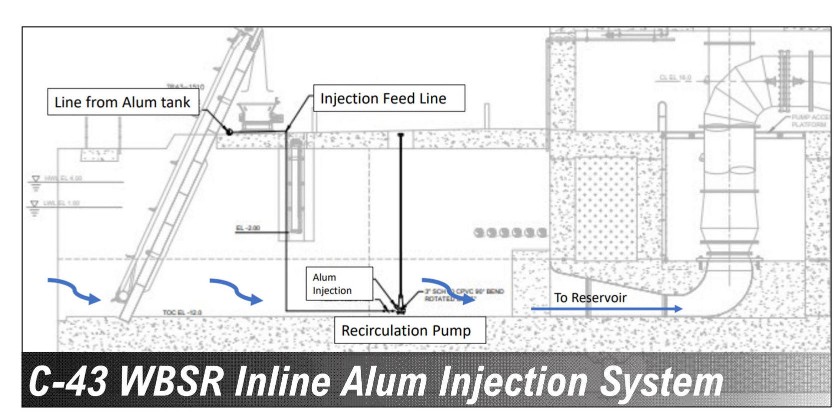
5. Road Runner C-43 Nutrient Load Reduction Project

- Alum treatment for water diverted from the C-43 canal for nutrient load reduction
- Status: Design
- Expected to be operational by 2024


C-43 Water Quality Test Cells

6. C-43 Water Quality Treatment and Testing Project – Phase II (Test Cells)

- Study evaluating the effectiveness of constructed wetland treatment systems in reducing nitrogen at a test scale
- Status: Construction
- Expected to be operational by 2025



C-43 WBSR Inline Alum Injection System

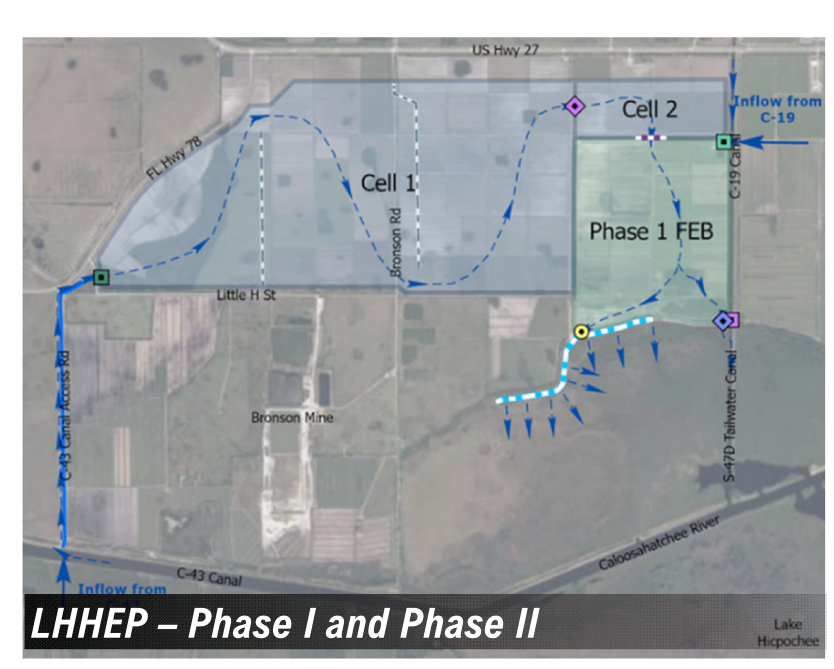
7. C-43 West Basin Storage Reservoir (WBSR) – Water Quality Component

- Inline alum injection system at the C-43 WBSR project
- Status: Design
- Expected to be operational by 2025


C-43 West Basin Storage Reservoir

8. C-43 West Basin Storage Reservoir

- Provide storage to reduce harmful discharges to the Caloosahatchee River Estuary during the wet season and provide freshwater flow during the dry season
- Status: Construction
- Expected to be operational by 2025



LHHEP – Phase I and Phase II

9. LHHEP Phase II

- Phase II includes a new 2,200 acre FEB and a pump station to withdraw water from the C-43 canal
- Status: Design
- Construction will begin in 2023
- Expected to be operational by 2026

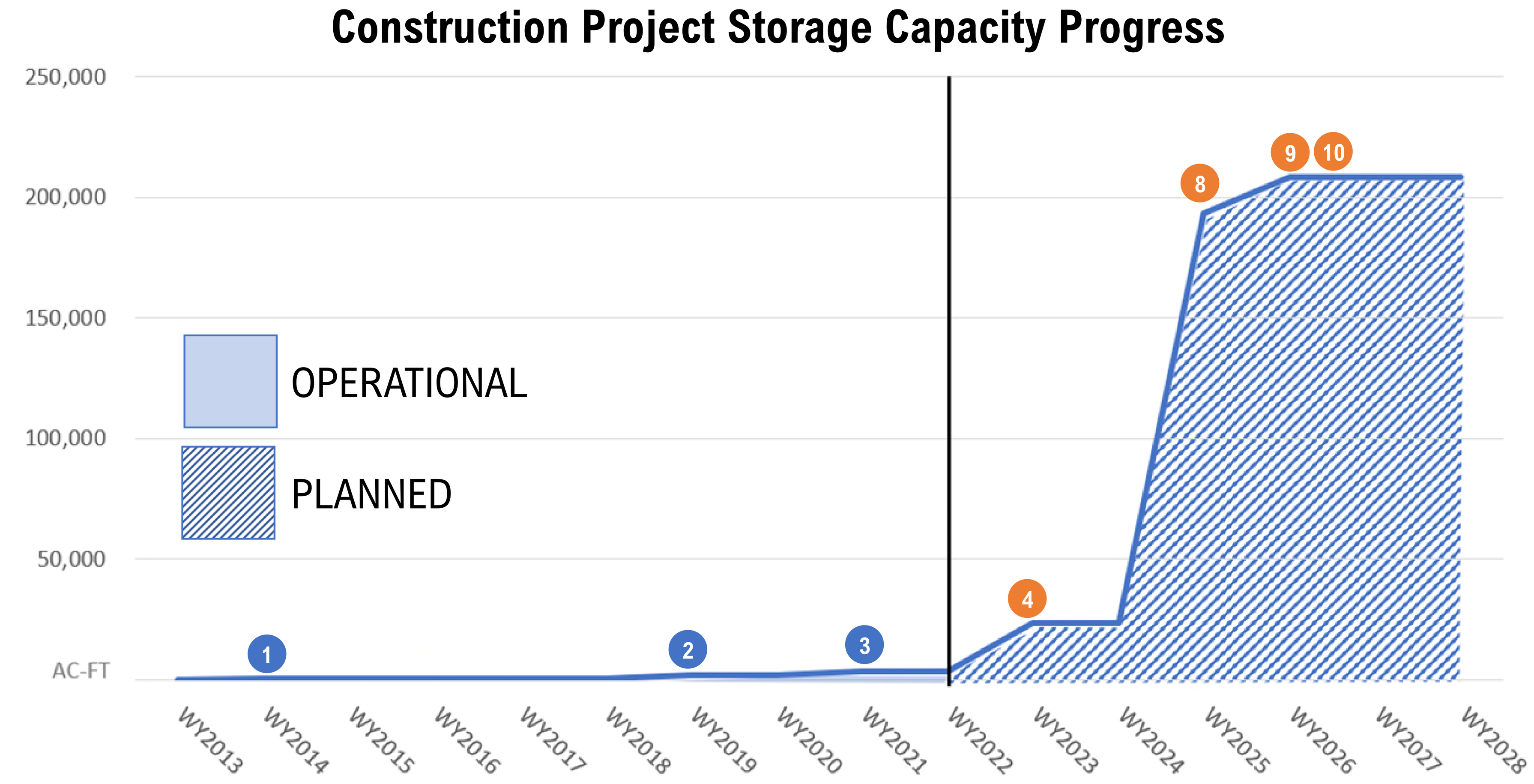
Boma FEB

10. Boma FEB

- Provide storage to reduce harmful discharges to the Caloosahatchee River Estuary
- Status: Design
- Construction will begin in 2023
- Expected to be operational by 2026

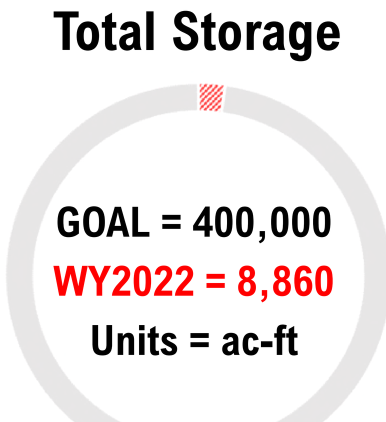
Progress Towards Water Quality and Storage Goals

Construction Project Storage Capacity Progress

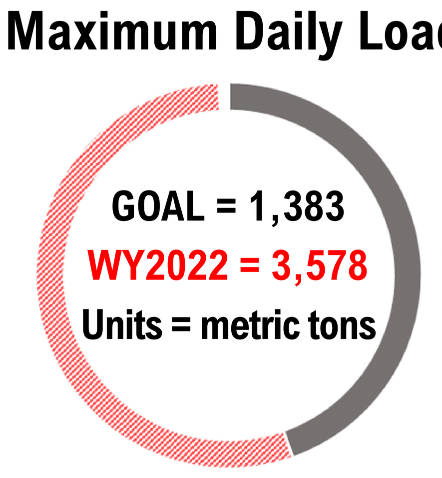


* WY – water year (May 1 to April 30); long-term average storage estimates (shown here) may vary from actual water year storage.

Total Storage



TN Total Maximum Daily Load (TMDL)



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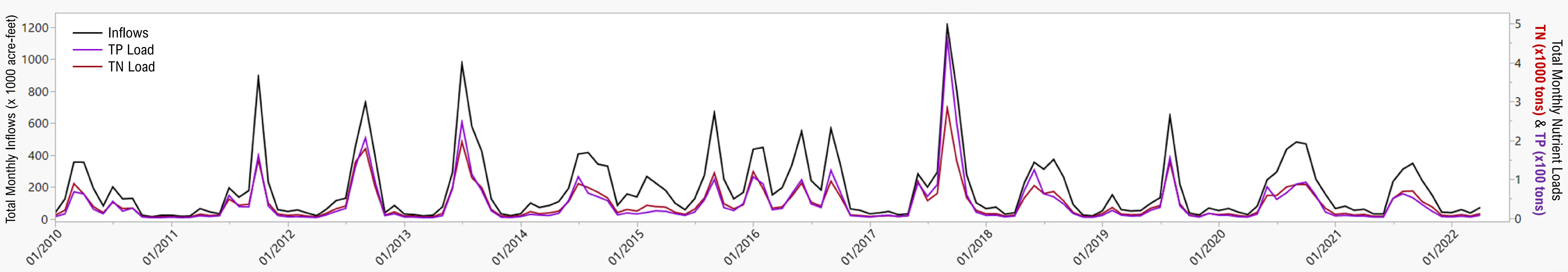
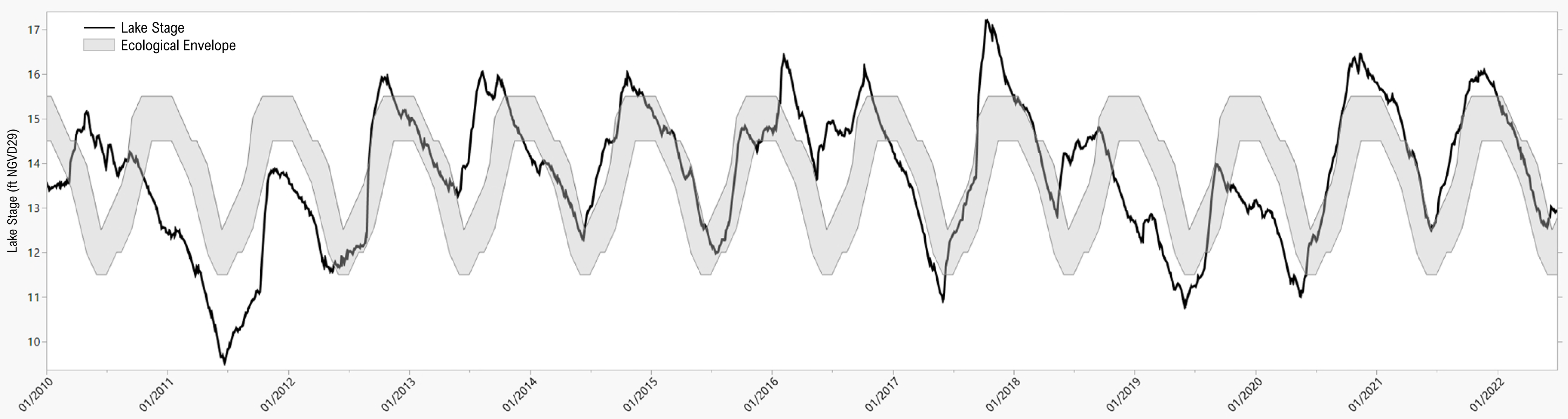
Chapter 8B: Lake Okeechobee Hydrology, Water Quality, and the Ecological Envelope

Paul Jones
Applied Sciences Bureau

Flows & Loads

Nutrient loads (total nitrogen [TN] and total phosphorus [TP]) to Lake Okeechobee are determined primarily by the quantity of surface water inflows. Elevated inflows are also the main driver of rapid rises in lake stage. With milder weather and lower inflows, Water Year 2022 (WY2022; May 1, 2021–April 30, 2022) had relatively low TN and TP loads.





Lake Stage Ecological Envelope

Lake Okeechobee stages (in feet National Geodetic Vertical Datum of 1929 [ft NGVD29], black line) fluctuate in response to variations in inflows, outflows, rainfall, and evaporation.

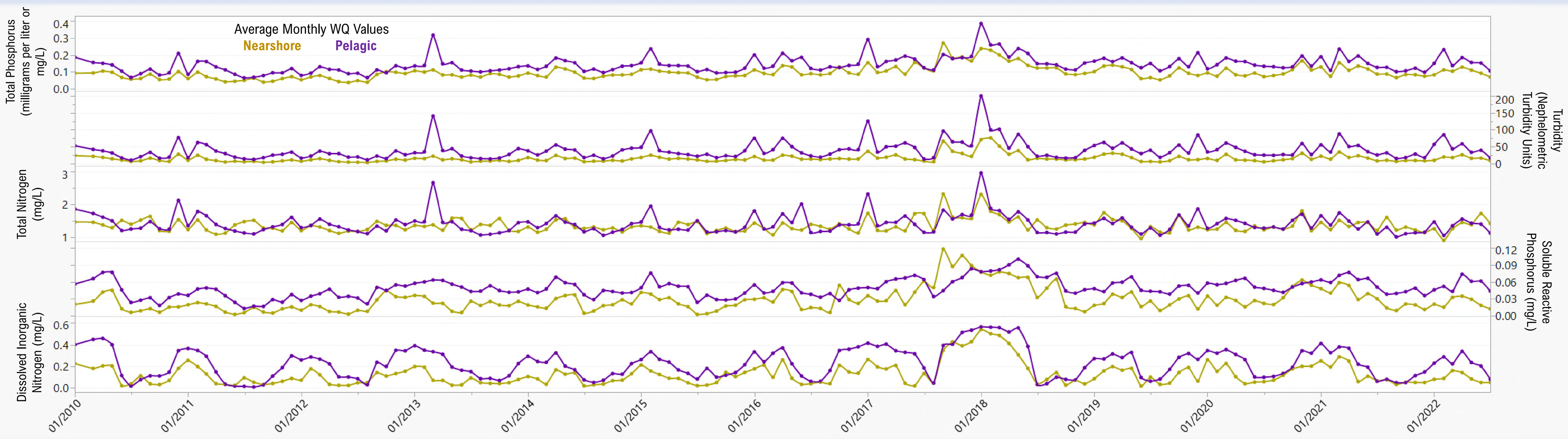
The ecological envelope (gray band) defines the ideal lake stages. It is a range of water levels that represents a compromise of optimal conditions across seasons, habitats, flora, and fauna

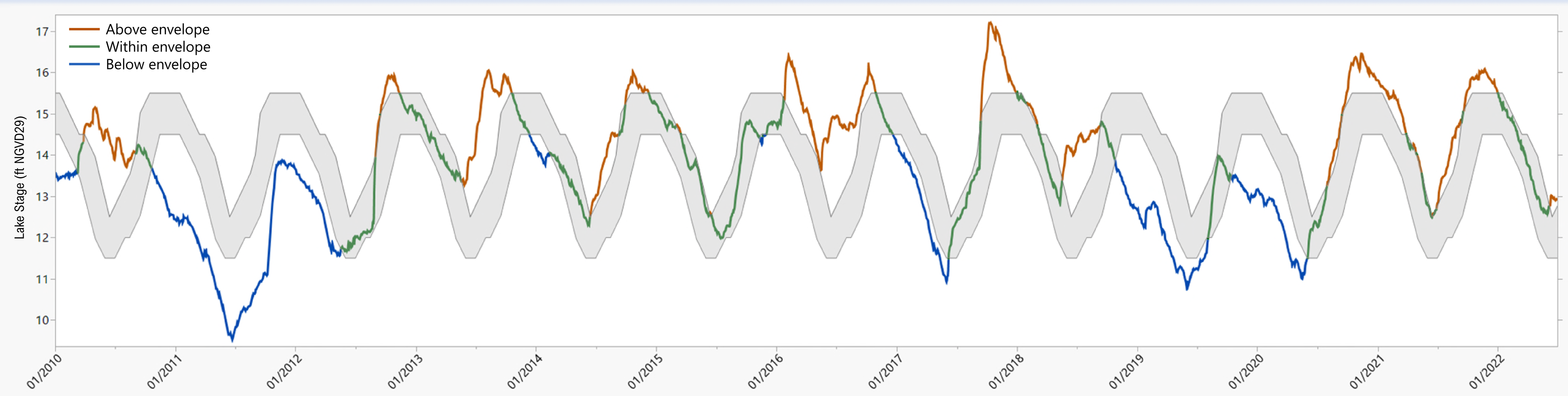
In-lake Water Quality

Due to the large volume of water, in-lake nutrient concentrations are not as governed by inflows.

Particulate associated nutrients (e.g., turbidity, TP, and TN) are influenced by strong winds, especially in the **Pelagic** region.

Dissolved nutrients (e.g., dissolved inorganic nitrogen [DIN] and soluble reactive phosphorus [SRP]) are more indicative of biological activity, and elevated levels suggest an increase risk of phytoplankton blooms.



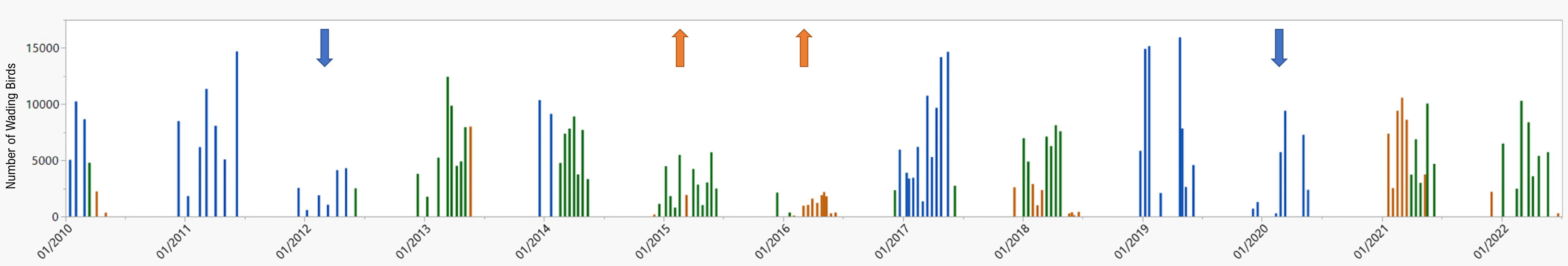


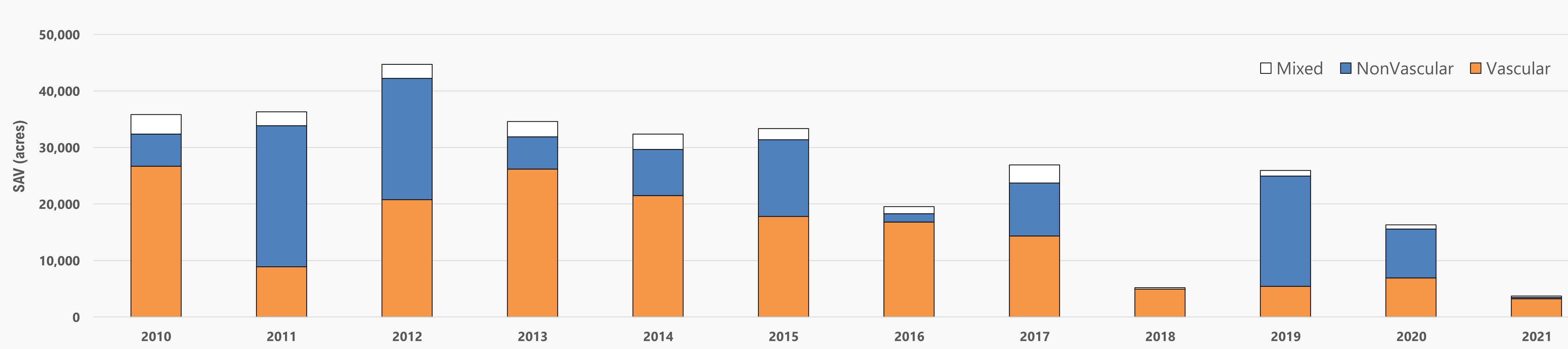
Deviations from the Ecological Envelope

Short periods **above** or **below** the envelope are not always ecologically harmful, but rapid and extreme variations in water levels within or between years is unnatural and a function of the highly channelized watershed. Balance and slow rates of change are desirable.

Wading Bird Foraging

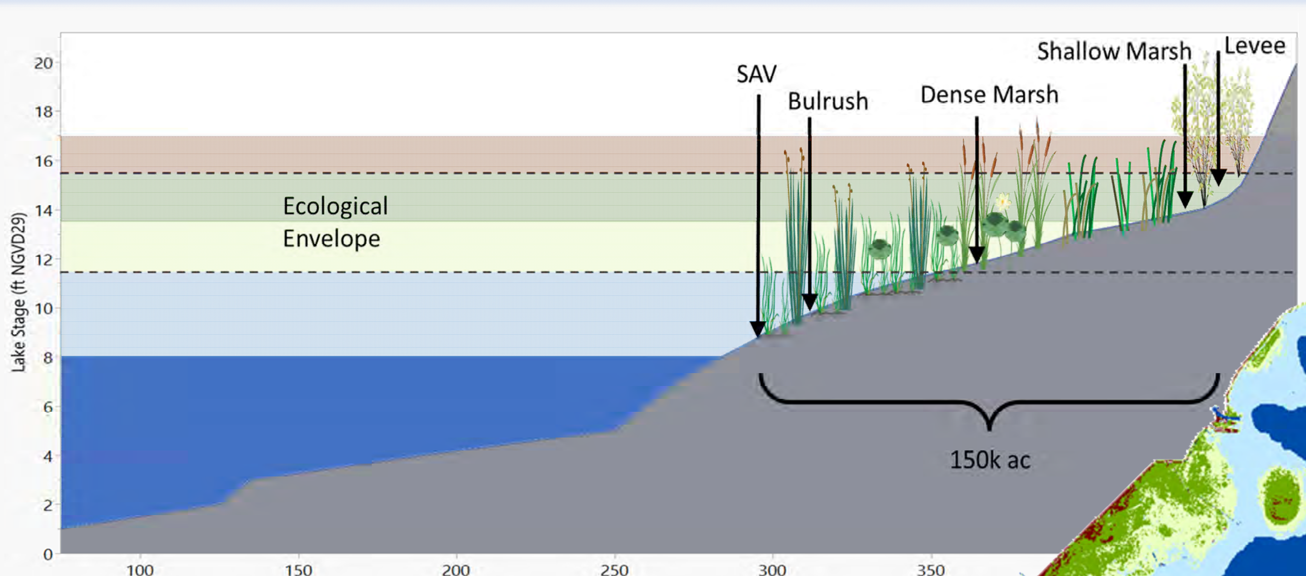
Higher lake levels promote prey production in the upper marshes. As lake levels recede and the marshes dry, prey are more concentrated and easier to catch. If lake levels are too low prior to nesting season (e.g.,⬇), or too high during (e.g.,⬆), then foraging numbers are usually lower.

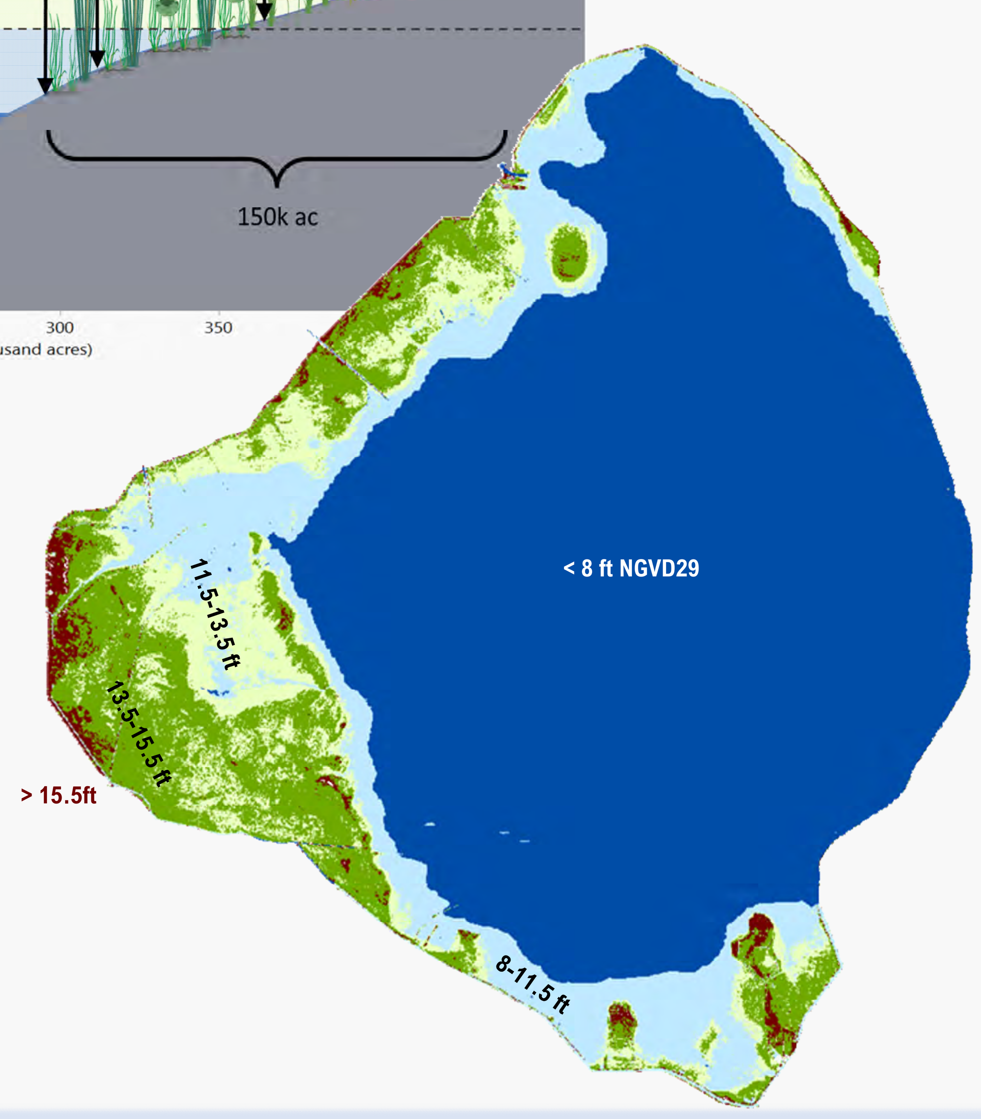


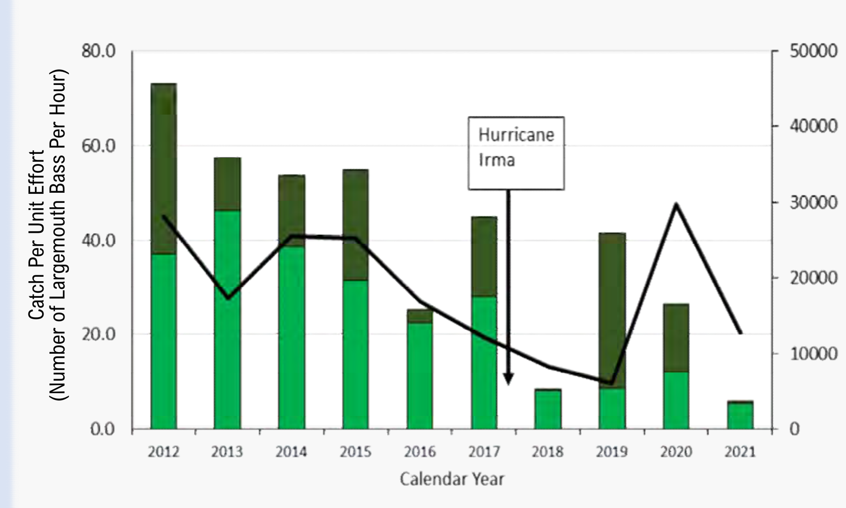


Submerged Aquatic Vegetation (SAV)

Lower lake stages increase the amount of light reaching young/seedling SAV and promote growth. If stages stay too low, SAV beds may dry out and become dominated by emergent plants. Similarly, if lake stages stay too high, only tall and well established SAV remains. The impacts of Hurricane Irma (September 2017) and high stages in 2021 and 2022 on the vascular SAV are still evident.

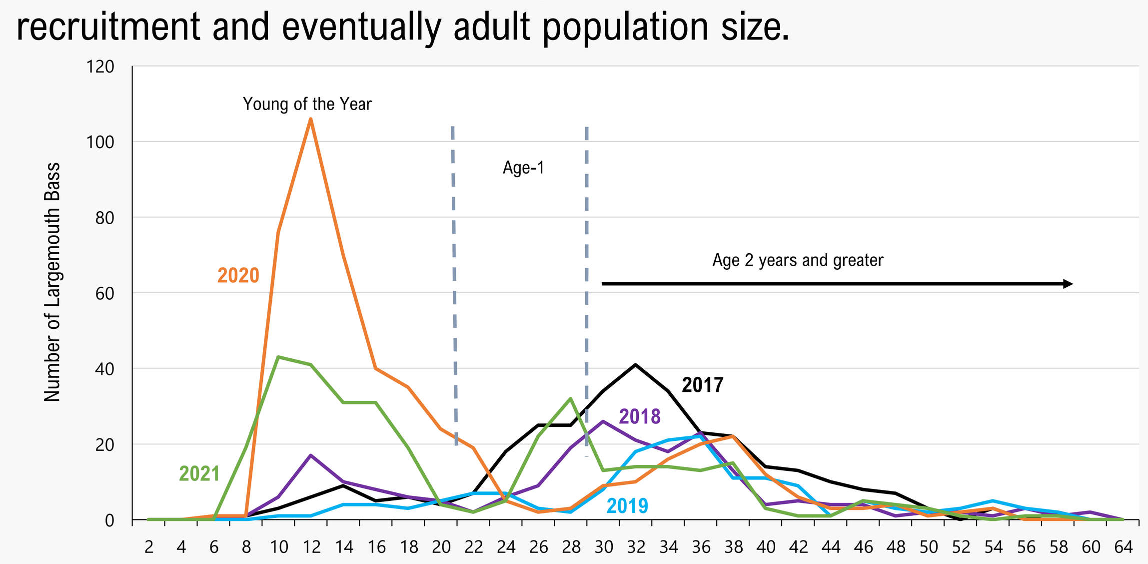


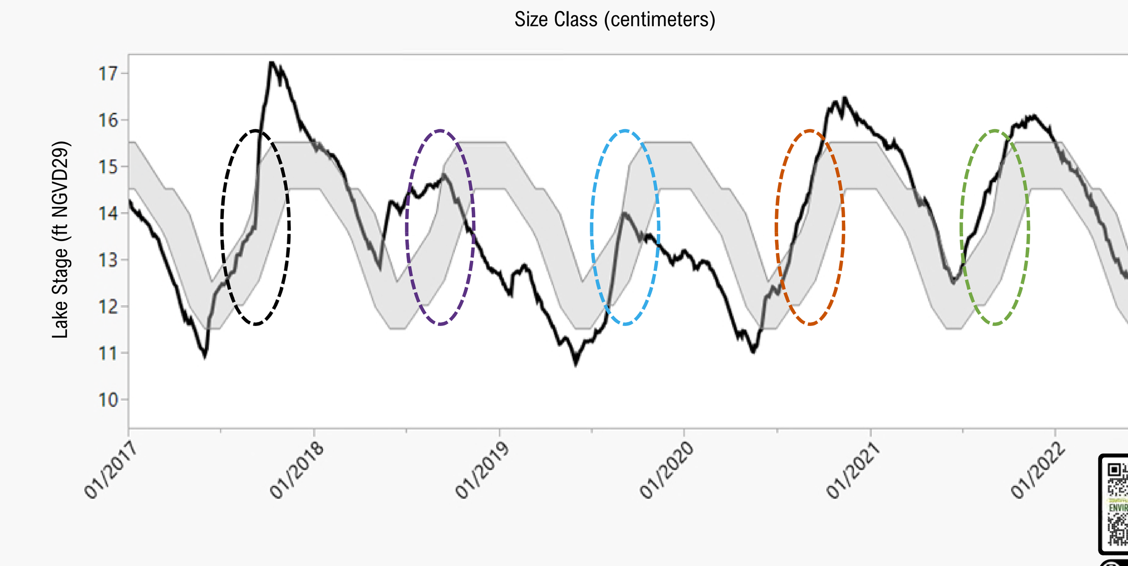




Largemouth Bass

Storms and prolonged deviations from the ecological envelope can have a delayed impact on fisheries by reducing spawning habitat and available food and cover for juveniles, which in turn may reduce recruitment and eventually adult population size.



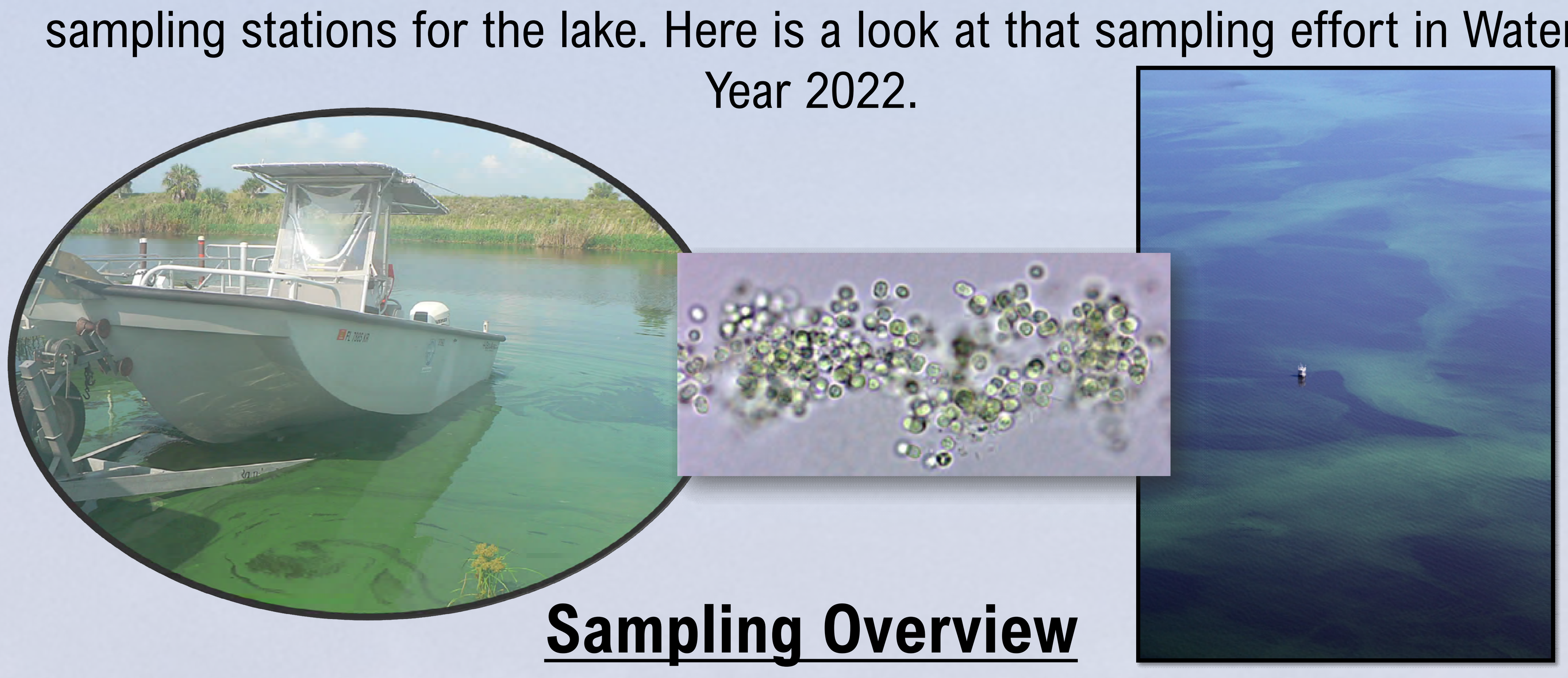


Chapter 8B: Lake Okeechobee Phytoplankton Monitoring in Water Year 2022

Anna Swigris, Environmental Scientist
Lake and River Ecosystems Section, South Florida Water Management District, West Palm Beach, FL

The Challenge

The South Florida Water Management District (SFWMD) aims to understand the prevalence and distribution of phytoplankton blooms and their associated toxins in Lake Okeechobee. To accomplish this, SFWMD monitors 19 historic sampling stations for the lake. Here is a look at that sampling effort in Water Year 2022.



Sampling Overview

- Water Year 2022 (WY2022) = May 2021 through April 2022
- Dry season = November through April
- Wet (Bloom) Season = May through October
- Monthly at 19 stations (**Figure 1**)
- Chlorophyll *a* (chl-*a*), as a proxy for phytoplankton biomass, is measured at all sites.
- Algal identification and microcystin-LR toxin concentrations are measured at 6 sites.
- Surface water quality is measured at all sites.

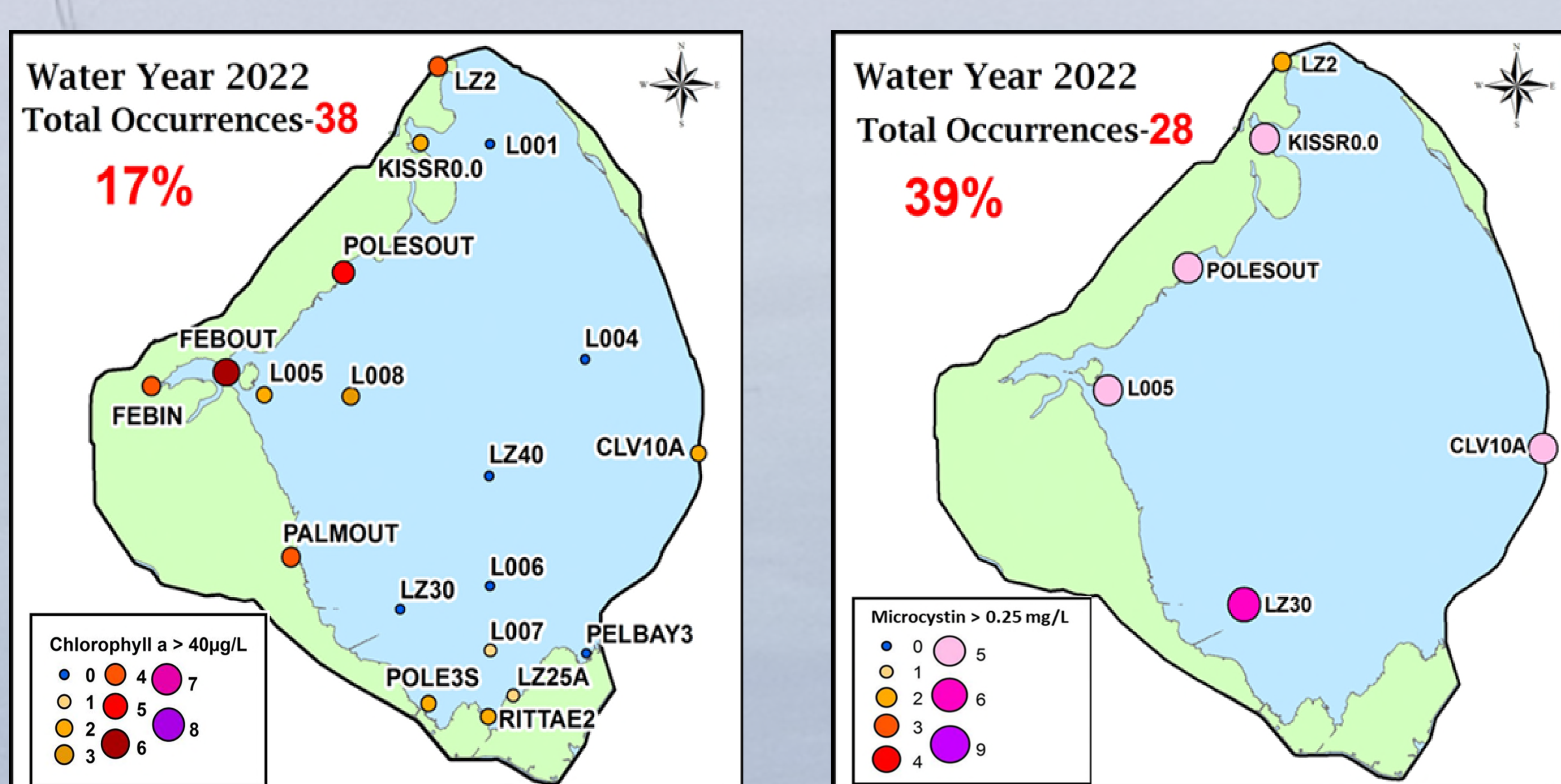


Figure 2. Frequency of algal blooms (left) and detectable microcystin-LR toxin levels (right) from Water Year 2022. The number of occurrences is depicted by the size of the dot.

Under or Over?

SFWMD scientists use several phytoplankton thresholds to define blooms and microcystin-LR toxin levels in Lake Okeechobee. Here is how phytoplankton in Water Year 2022 compares to those standards.

1. Bloom Event Threshold = 40 µg chl-*a*/L. This level was exceeded in 17% of samples (**Figure 4**).
2. Microcystin-LR Toxin Detection Level = 0.25 µg/L. This level was exceeded in 39% of samples (**Figure 4**).
3. United States Environmental Protection Agency (USEPA) Standard for Recreational Waters = 8 µg microcystin-LR/L. This level was exceeded in 4% of samples.
4. World Health Organization (WHO) Guideline for Recreational Waters = 24 µg microcystin-LR/L. This level was exceeded in 3% of samples.
5. Restoration Coordination and Verification (RECOVER) Program Target = Less than 5% of samples exceeding the Bloom Event Threshold. This target was exceeded this year, with 17% of samples being blooms.

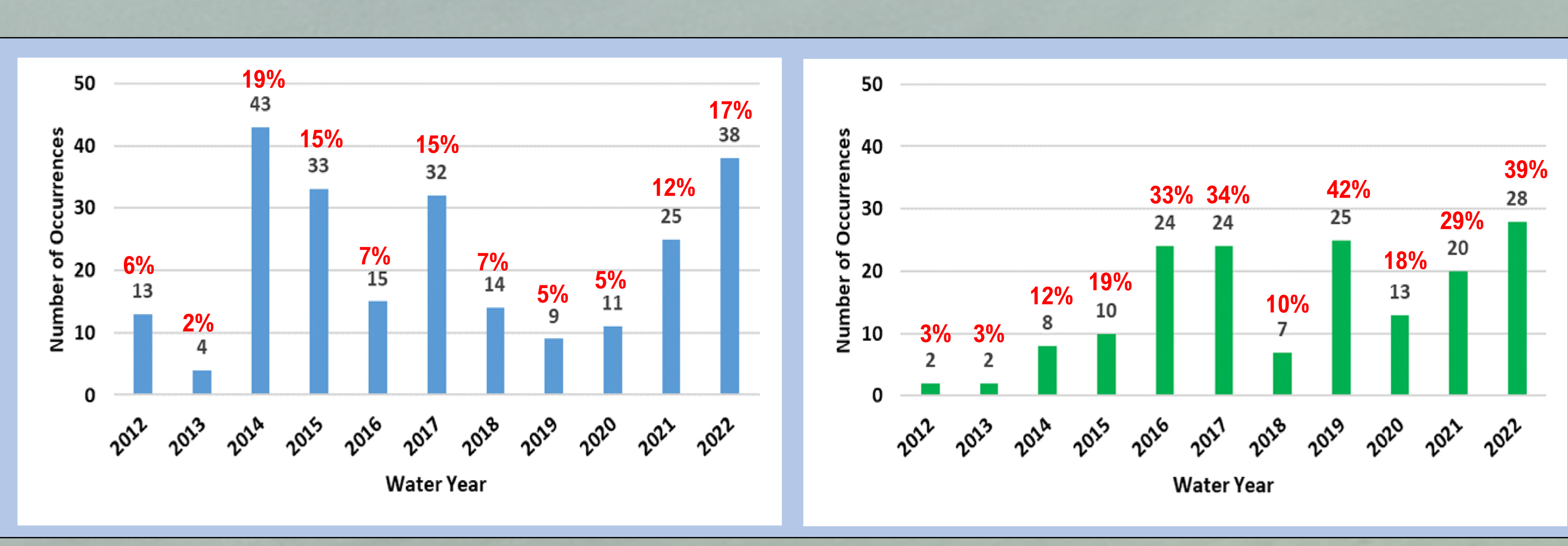


Figure 4. Frequency of algal blooms (left) and detectable microcystin toxin levels (right) from Water Year 2012 through Water Year 2022.

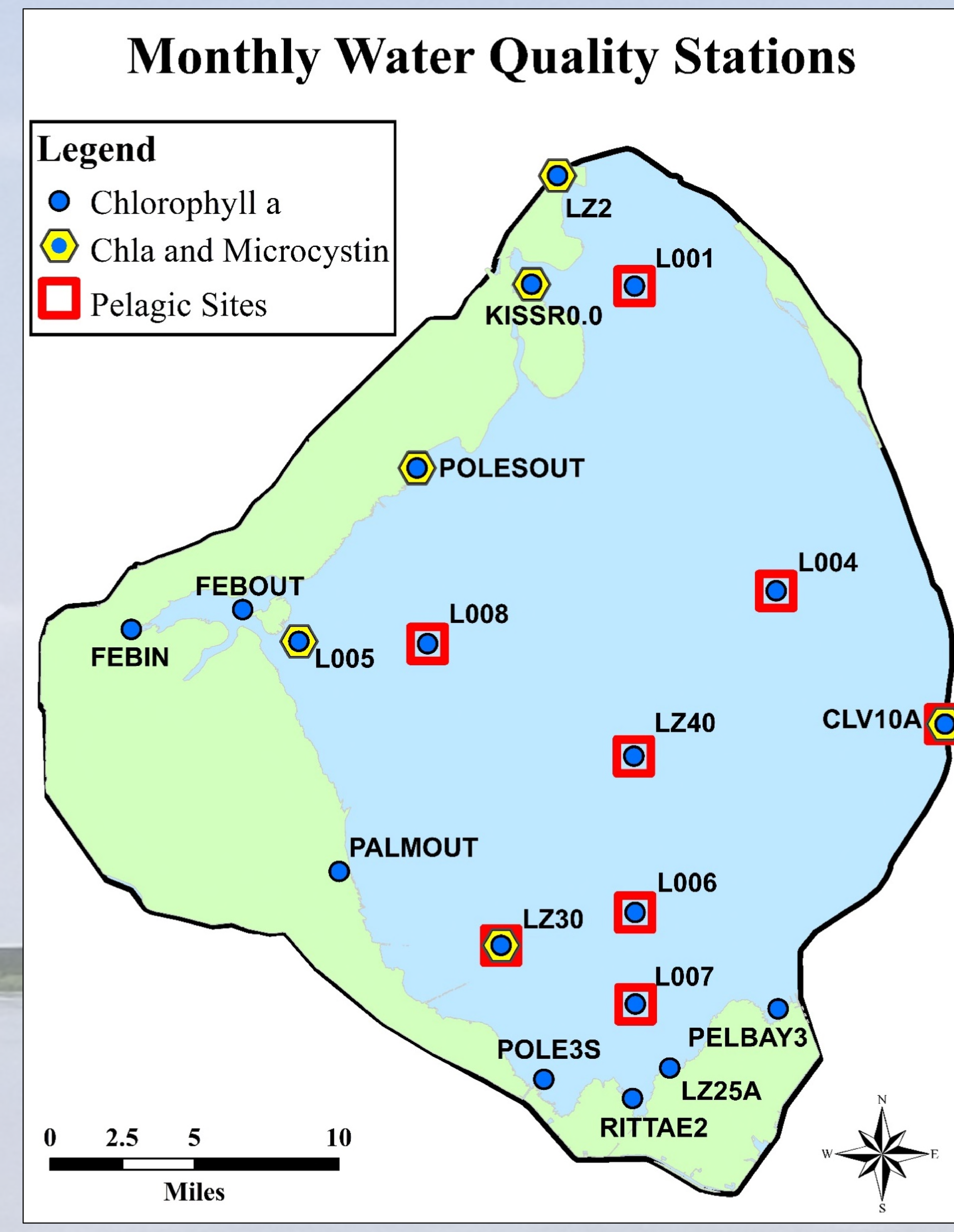


Figure 1. Long-term monitoring stations for chlorophyll *a* (19) sites (blue circles), and microcystin-LR levels and algal identification (6) sites (yellow outline). These sites have been sampled monthly since WY2012 in Lake Okeechobee. Pelagic stations are outlined with red squares.

Past vs. Present

Phytoplankton biomass, bloom events, and toxin levels vary in response to a multitude of environmental variables. Here is how Water Year 2022 compares to data from the prior ten water years.

Water Year 2022

May 2021-April 2022

- 17% of samples exceeded the bloom threshold
- 39% of samples exceeded the microcystin-LR toxin detection level
- Average microcystin-LR concentration of 1.8 µg/L, the highest of the eleven water years
- Average chl-*a* concentration of 24.5 µg/L, the highest of the eleven water years

Water Years 2012 - 2021

May 2011-April 2021

- 9.3% of samples exceeded the bloom threshold
- 20.1% of samples exceeded the microcystin-LR toxin detection level
- Average microcystin-LR concentration of 0.5 µg/L
- Average chl-*a* concentration of 18.2 ug/L

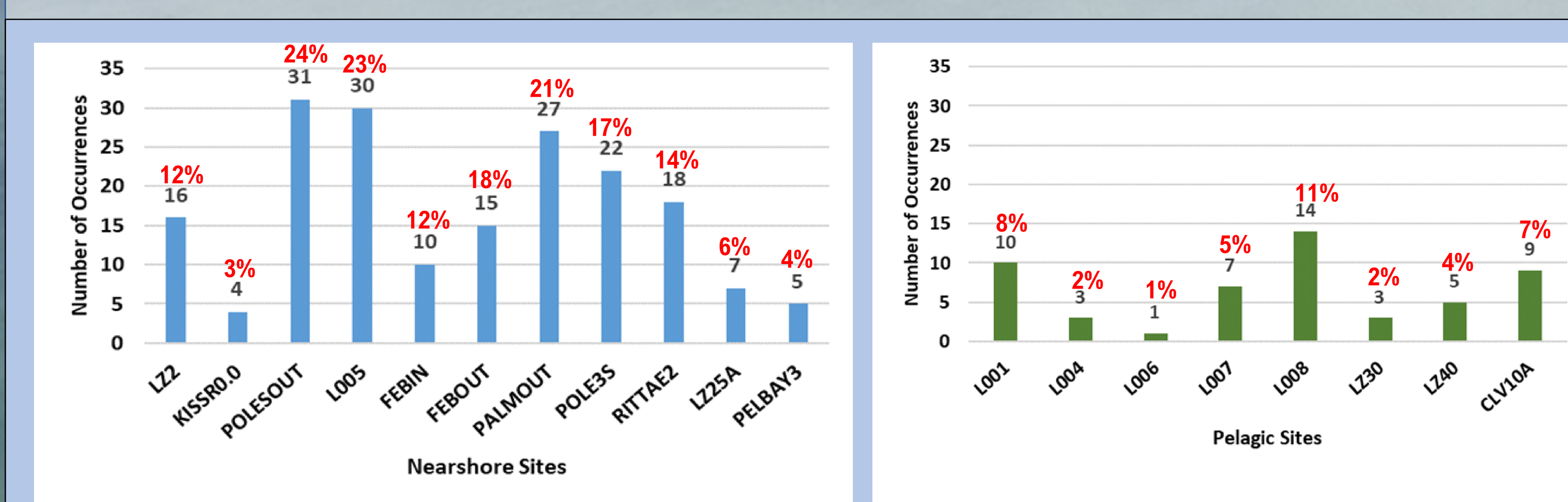


Figure 3. Frequency of blooms (chl-*a* concentrations of 40 µg/L or greater) for 11 nearshore (left panel) and 8 pelagic (right panel) sites in Lake Okeechobee over the past eleven water years (WY2012-WY2022).

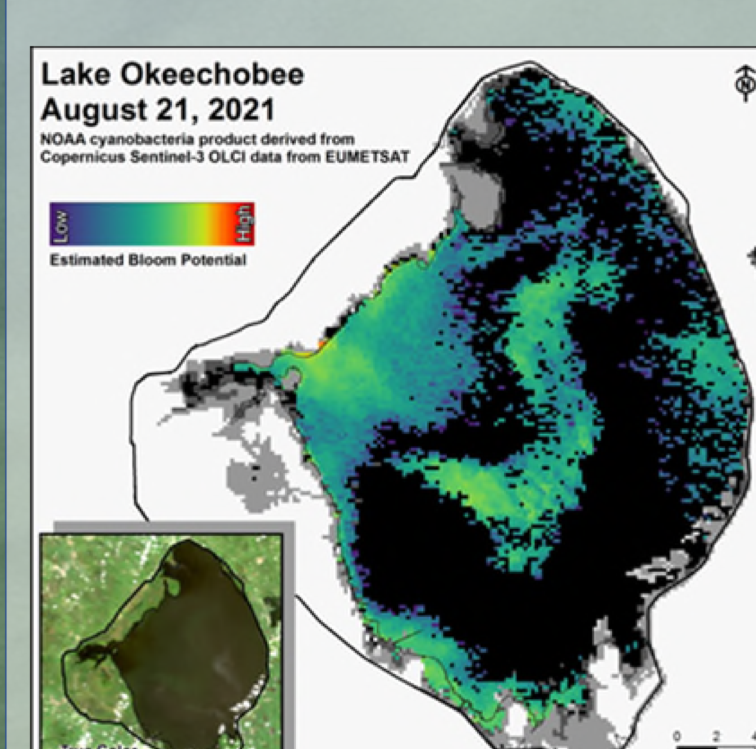


Figure 5. Satellite imagery showing bloom potential in Lake Okeechobee during a day in WY2022's bloom season.

It's a Shore Thing.

Over the last eleven water years, the highest frequency of algal blooms occurred in the western nearshore areas in Lake Okeechobee. Of the 237 total blooms recorded from WY2012 through WY2022, 78.1% occurred at nearshore sites and 21.9% occurred at offshore sites (**Figure 3**). However, when looking at microcystin-LR concentrations, the opposite trend is seen, with nine out of the ten samples exceeding the USEPA recreational water standard of 8 µg/L occurring at offshore sites.

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Chapter 8B: The Current State of Submerged Aquatic Vegetation in Lake Okeechobee

Daniel Marchio, Environmental Scientist

Lake and River Ecosystems Section

Submerged Aquatic Vegetation (SAV) is a key indicator of overall ecological health and benefits the lake ecosystem in a multitude of ways, such as :

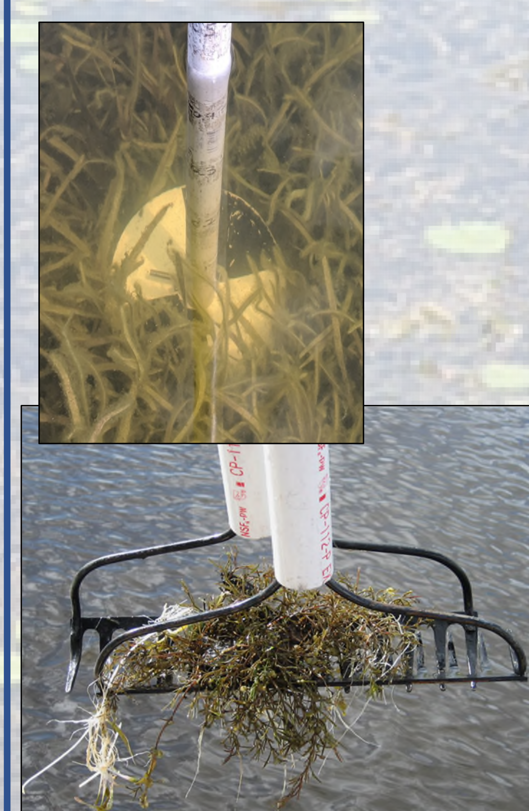
- increased water clarity
- improved water quality
- stabilization of substrate
- increased mammalian and invertebrate species richness

SAV distribution and abundance is principally governed by light availability and water depth in Lake Okeechobee.

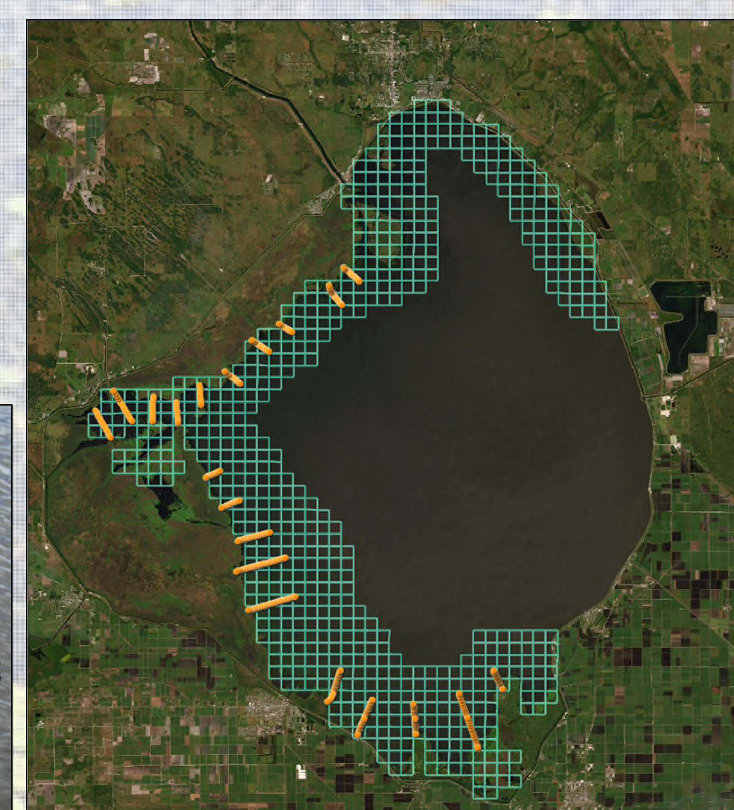
SAV coverage has varied dramatically over the period of record, coincident with hydrology:

- SAV coverage generally peaks 1-2 years after low lake stage and increased underwater irradiance.
- SAV coverage generally decreases after major hurricanes.

SAV is monitored by two methods to track responses to environmental conditions at different scales in time and space using a combination of methods. Each fall (August to September) the entire nearshore region of the lake is mapped to determine the total area of each SAV species using a systematic grid and biomass of SAV species is measured twice a year on transects.



Secchi disk (upper left) and modified-rake SAV sampler.

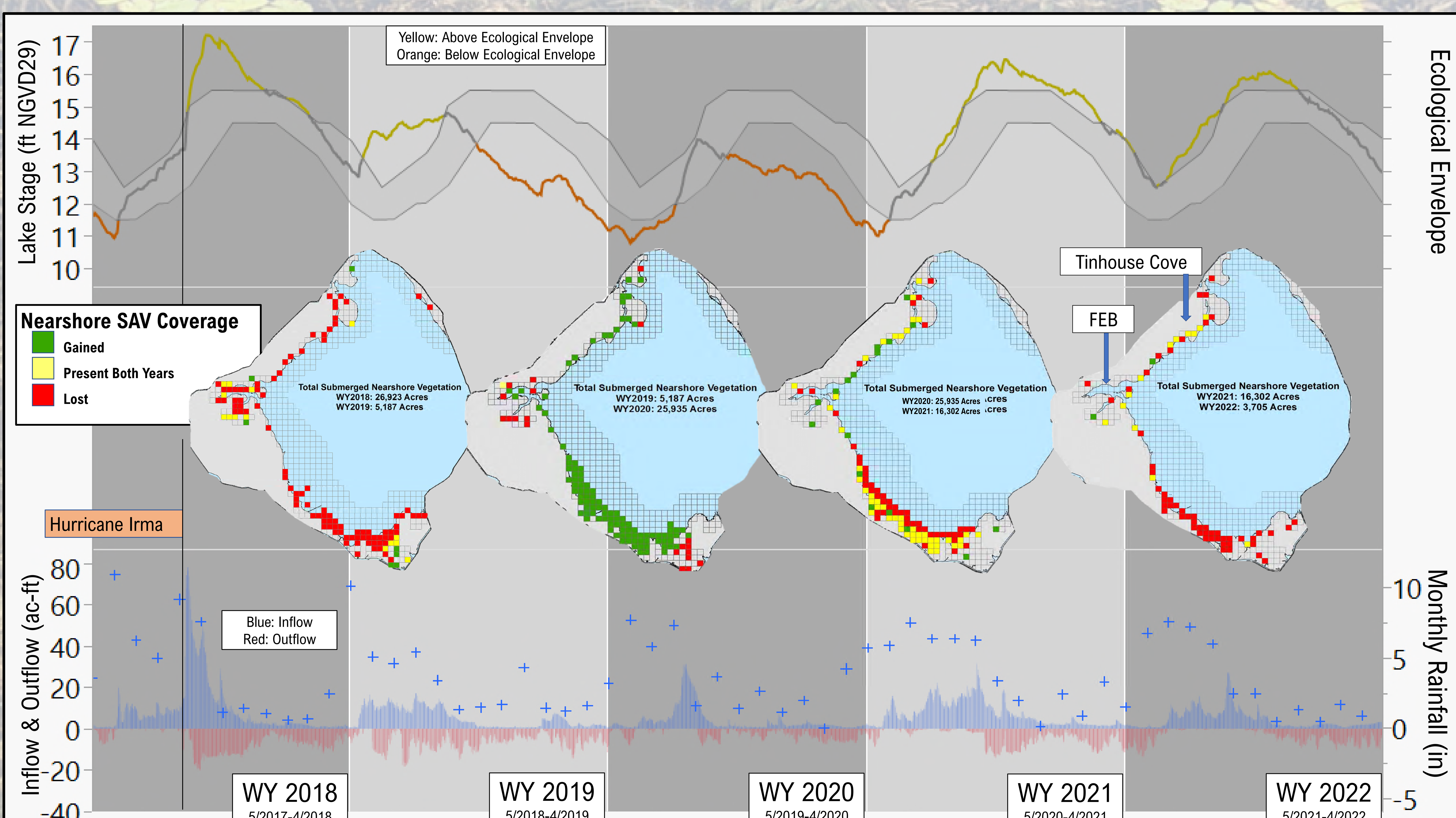


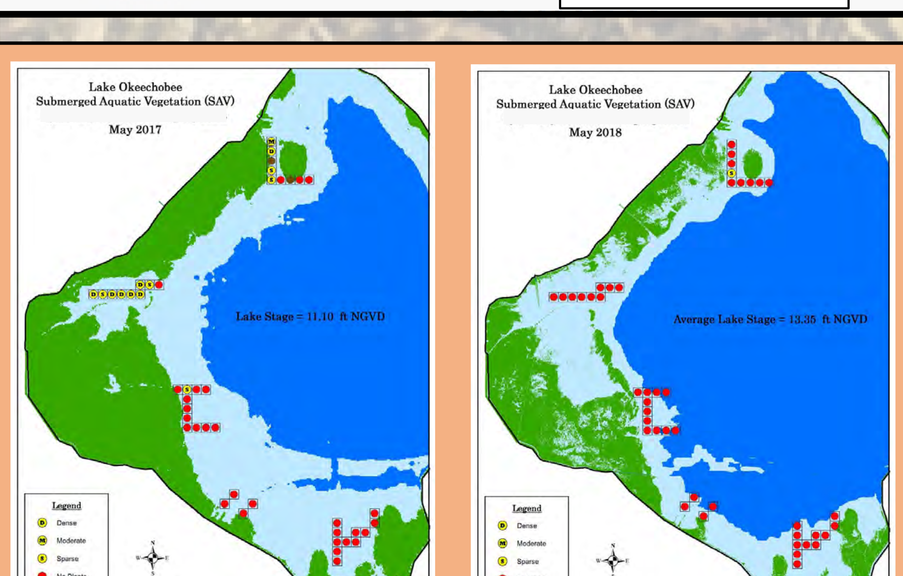
Combined SAV grid (blue boxes) projection and transects (orange dots) on Lake Okeechobee.

Ongoing research dealing with SAV may allow identification of an optimal range of water levels, and in turn could be used to maximize ecological benefits from regional hydrologic restoration programs (i.e., the Comprehensive Everglades Restoration Plan).

Current research is investigating underwater light availability, seedbank dynamics and near real-time water quality, to gain a better understanding of environmental stresses imposed on SAV.

Photosynthetic Active Radiation sensor* (left) and water quality buoy (right). *not to scale





A year after Hurricane Irma passed near the lake the coverage of SAV reached its lowest level in 12 years.

Low water levels and sediment covered SAV (May 2019)

Low lake stages in WY2020 assisted the SAV recovery from lingering impacts of Hurricane Irma. Coverage of SAV increased from 5,187 acres to 25,935 acres, the vast majority was from, *Chara*, the non-vascular species (macroalgae).
SW Shore Lake Okeechobee, 2020

Vallisneria sprouts found during transect sampling (September 22, 2022 at location FEB)

SAV at Tinhouse Cove, Lake Okeechobee. (March 23,2022)

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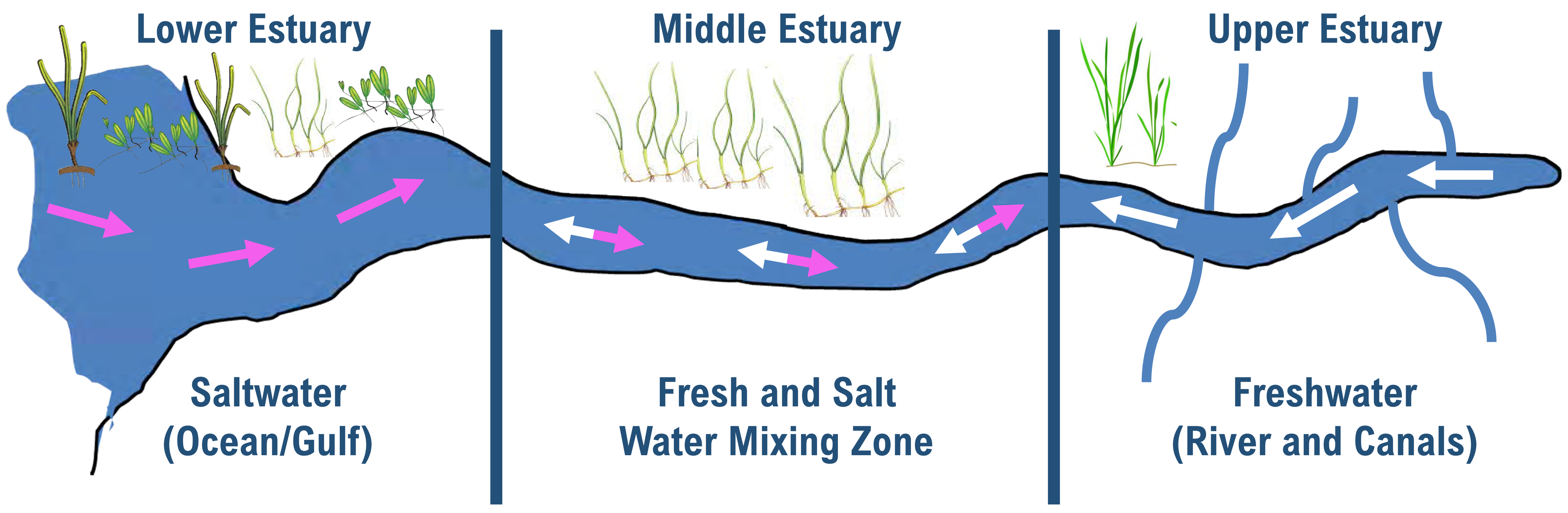
Chapters 8C and 8D: Submerged Aquatic Vegetation in the St. Lucie and Caloosahatchee Estuaries

Danielle Taylor and Melanie Parker

Chapter 8C SCAN ME

Chapter 8D SCAN ME



*Arrows indicate flow of saltwater (pink) and freshwater (white).

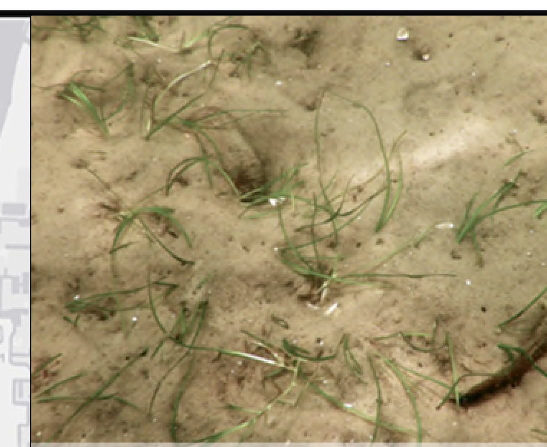
Importance of Submerged Aquatic Vegetation

- Submerged aquatic vegetation (SAV) includes freshwater, estuarine, and marine species (seagrass), each with a unique salinity tolerance range
- Provide habitat, food source, sediment stabilization, improved water quality, and serve as indicator species for estuarine health
- Light availability, temperature, and salinity affect SAV health and distribution

Ecosystem-Scale SAV Monitoring

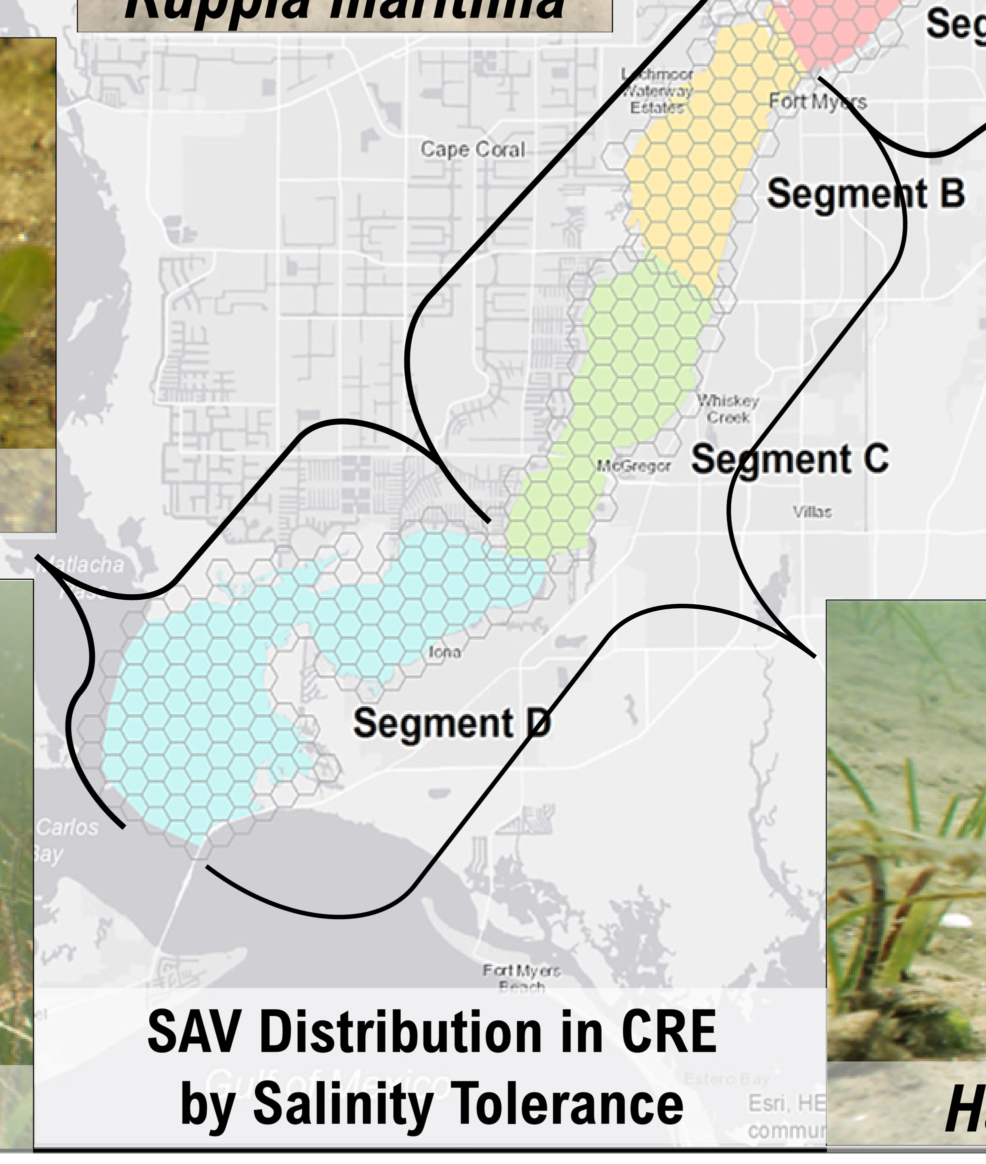
H. wrightii and *H. johnsonii*

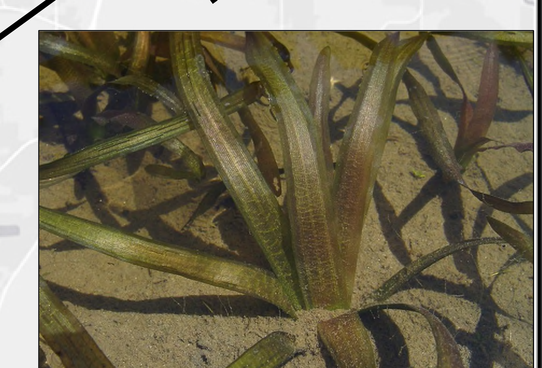
Quadrat Sampling



Ruppia maritima

Halophila decipiens





Vallisneria americana

Thalassia testudinum

SAV Distribution in CRE by Salinity Tolerance

Halodule wrightii

Ecosystem-Scale SAV Monitoring	Spatial Extent			Abundance		
	WY2022 Results	Change from WY2021		WY2022 Results	Change from WY2021	
St. Lucie Estuary	0.04	↓	14%	0.27	↑	30%
CRE – Segment A	0.12	↑	36%	0.31	↑	24%
CRE – Segment B	0.20	↓	13%	0.29	↑	32%
CRE – Segment C	0.19	↑	2%	0.24	↑	32%
CRE – Segment D	0.65	↑	43%	0.40	↓	14%

Community-Scale SAV Monitoring

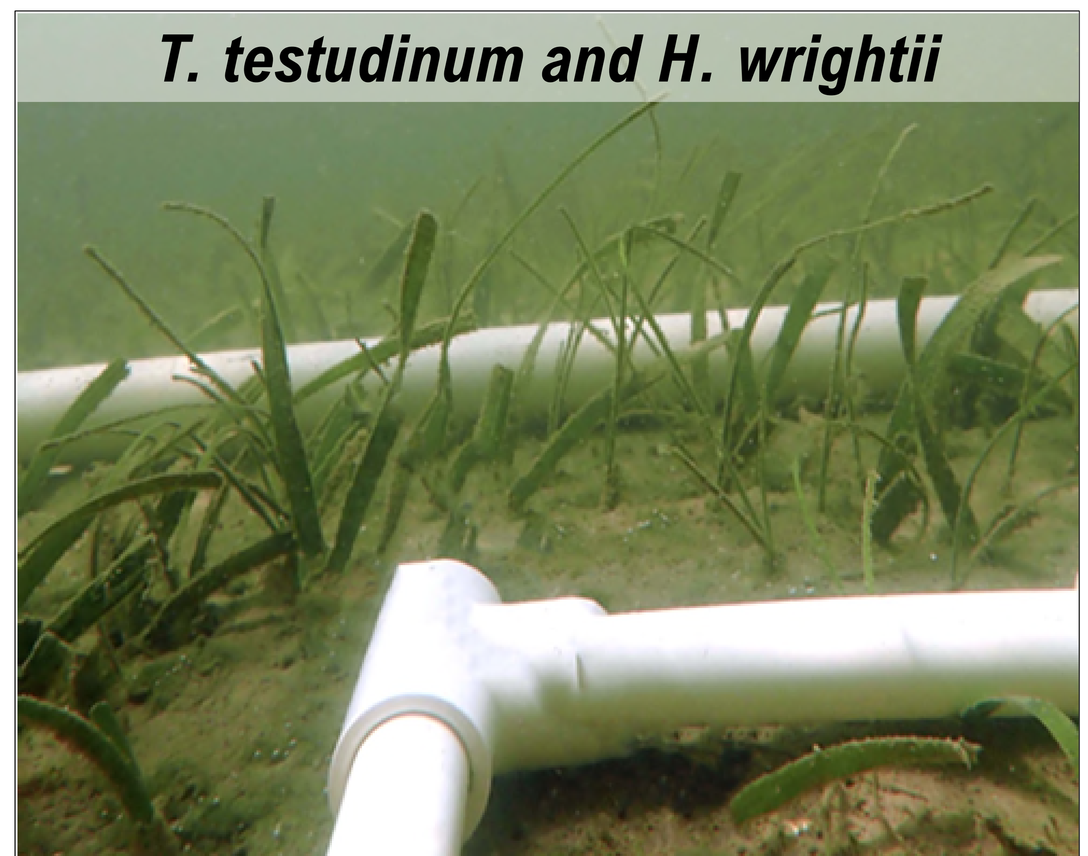
St. Lucie Inlet Transect Site

Sand Dollar and SAV

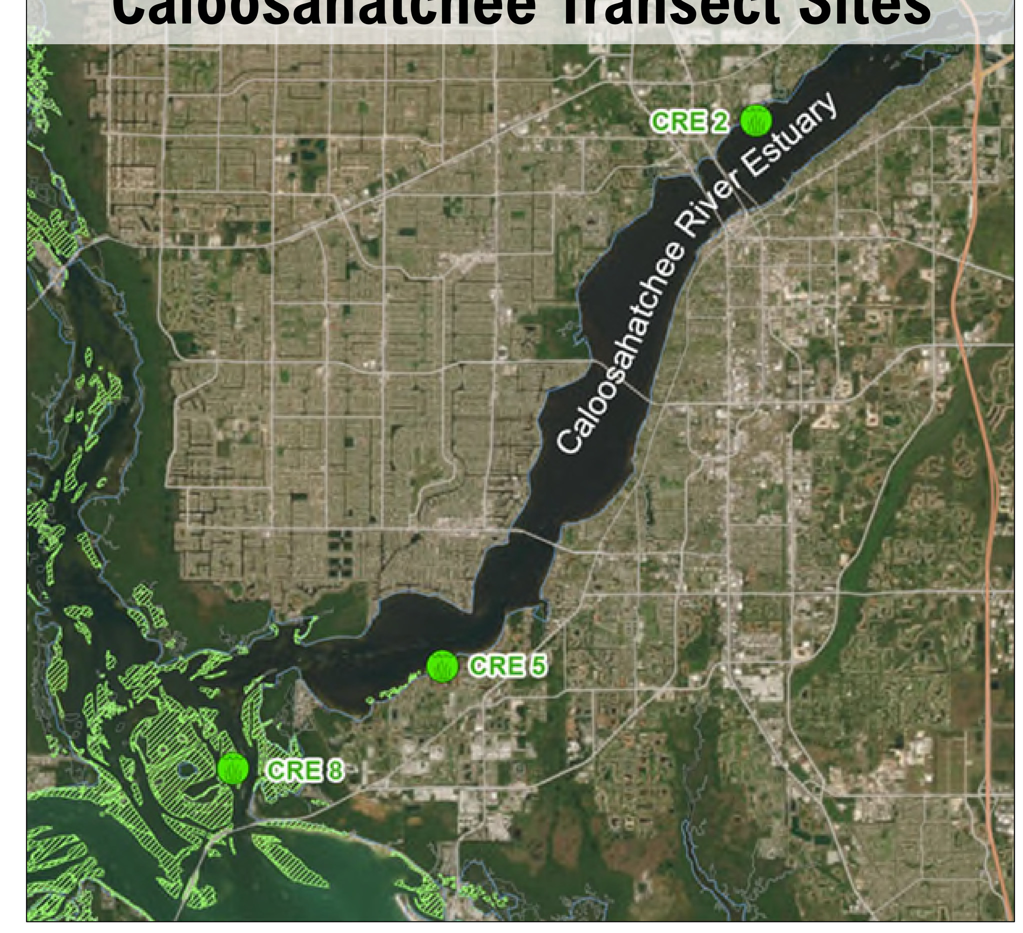
Halodule wrightii on transect

Community-Scale SAV Monitoring	Percent Cover		
	WY2022 Results	Change from WY2021	
SLE – Willoughby Creek	1.9	↑	186%
SLE – St. Lucie Inlet	17.5	↓	21%
CRE 2	0.8	↓	22%
CRE 5	10.4	↑	3%
CRE 8	32.2	↓	2%

T. testudinum and H. wrightii



Caloosahatchee Transect Sites



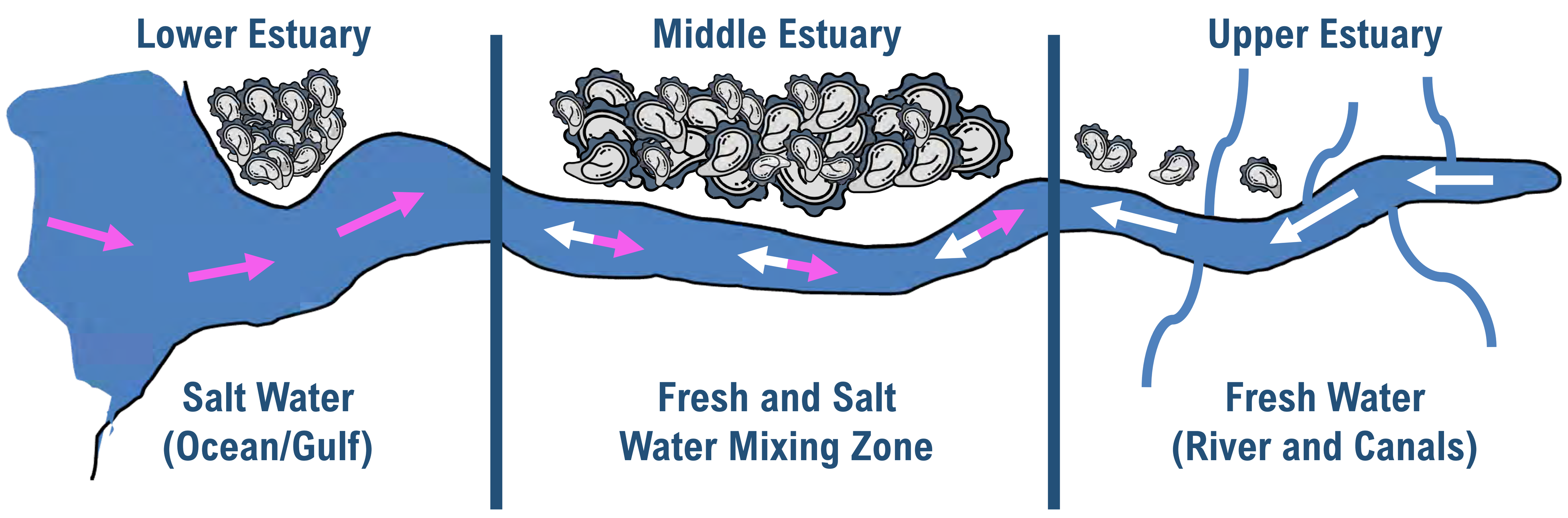
Halophila decipiens

Note: CRE – Caloosahatchee Rive Estuary, SLE – St. Lucie Estuary, and WY – Water Year (May 1–April 30).

Chapters 8C and 8D: Oysters in the St. Lucie and Caloosahatchee Estuaries

Melanie Parker and Danielle Taylor

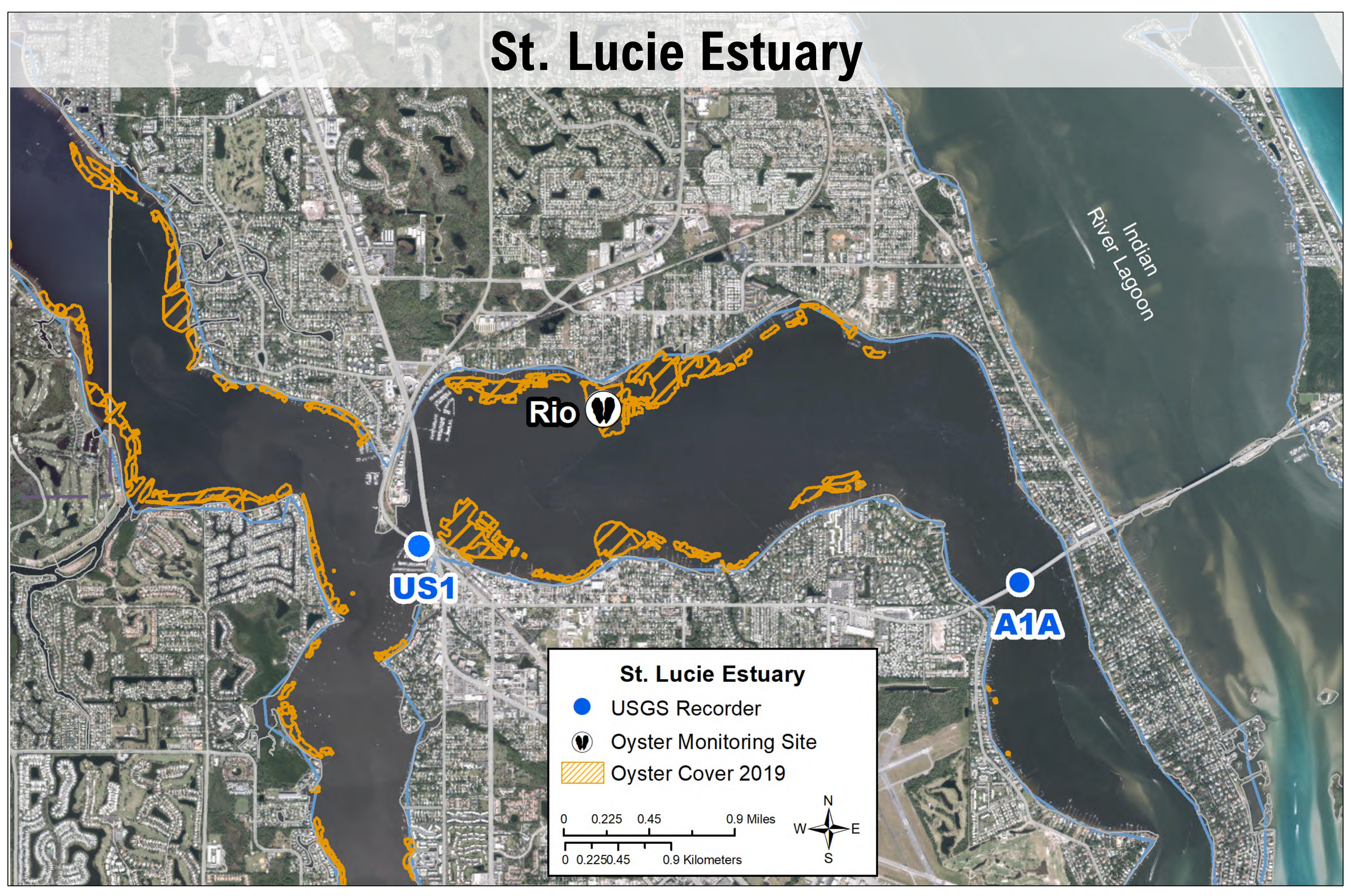
Chapter 8C SCAN ME
Chapter 8D SCAN ME



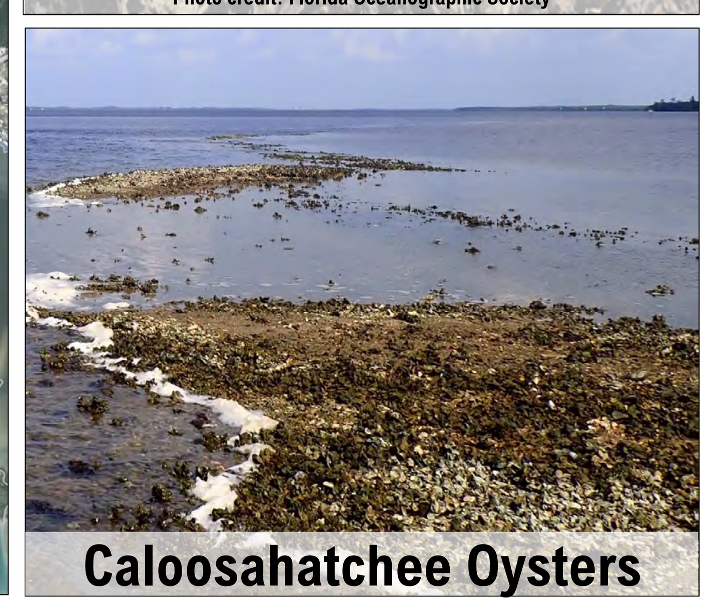
*Arrows indicate flow of salt water (pink) and fresh water (white).

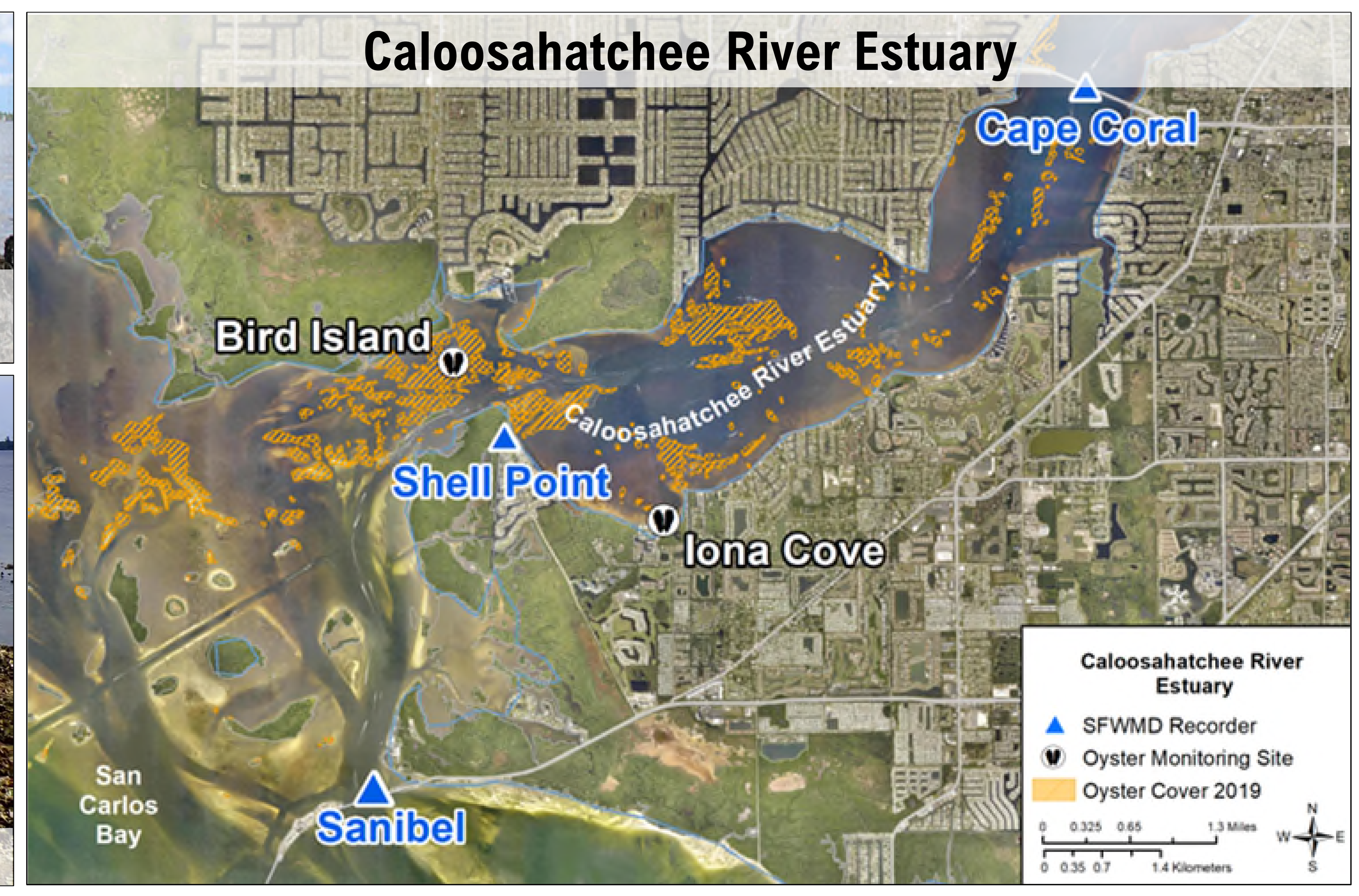
Importance of Oysters

- Oysters are monitored by the Fish and Wildlife Research Institute for RECOVER (Restoration Coordination & Verification) as an indicator species for estuarine health
- Provide habitat, food source, sediment stabilization and improve water quality
- Respond more quickly to changes in water quality than seagrass




St. Lucie Oysters
Photo credit: Florida Oceanographic Society


Caloosahatchee Oysters



Salinity and Oysters

- Salinity is the most important factor determining distribution and health of oyster populations
  - **Low salinity** → acute physiological stress and death
  - **High salinity** → high disease and predation rates
- Oysters weakened by disease are more susceptible to predators
- Short-term salinity decreases can benefit oysters by decreasing parasite and predator densities

# of Days in Optimal Salinity Range for Oysters (10-25)	WY2022 Results	Change from WY2021	
St. Lucie Estuary	288	↑	24%
Caloosahatchee River Estuary Cape Coral	230	↑	3%
Caloosahatchee River Estuary Shell Point	245	↑	9%


Blue crab

Settled Oyster Density

- Density reflects abundance of all sizes of settled oysters
- Low salinity events cause oyster die-offs
- Greater densities at CRE-Bird Island = higher recruitment rates

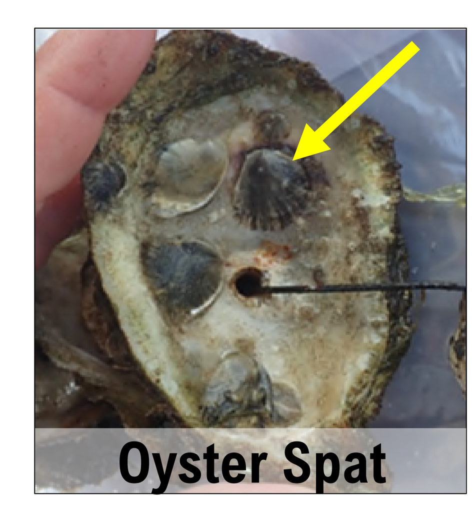
Settled Oyster Density (Oysters/m^2)	WY2022 Results	Change from WY2021	
St. Lucie Estuary	277	↓	9%
Caloosahatchee River Estuary Iona Cove	241	↑	92%
Caloosahatchee River Estuary Bird Island	770	↑	162%

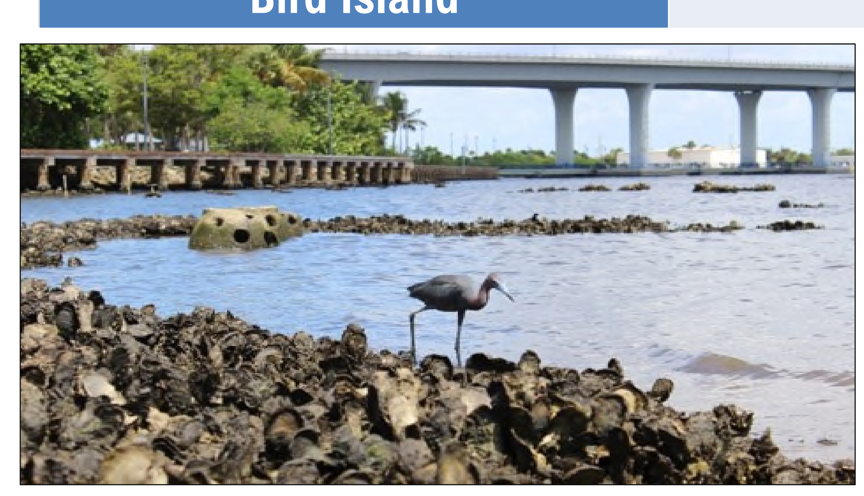

Survey Quadrat

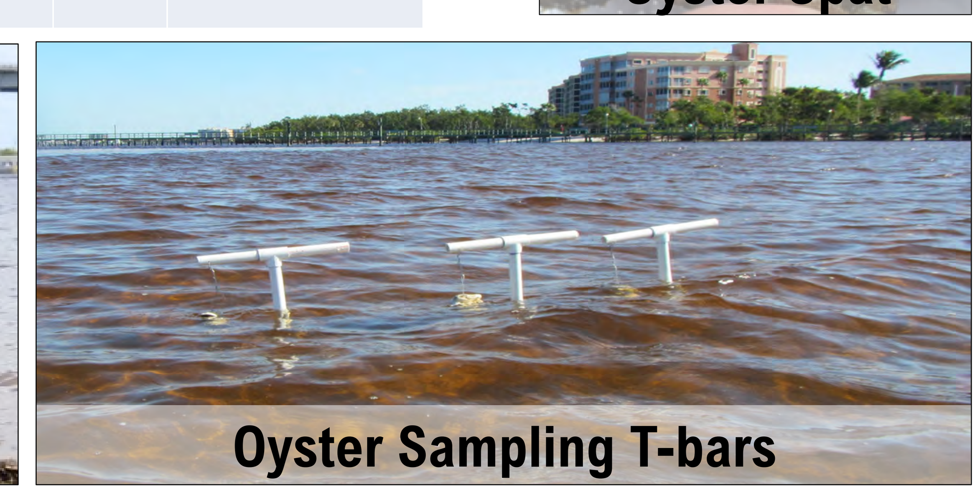
Juvenile Oyster Recruitment

- Spat recruitment occurs in spring through late fall in Florida
- Peak recruitment in the spring and fall if salinities remain optimal
- Low salinity events disrupt spawning season: WY2021 Hurricane Eta
- Salinities usually within or above optimal at Caloosahatchee River Estuary Bird Island, generally result in higher recruitment rates

Juvenile Oyster Recruitment (Spat/Shell/Month)	WY2022 Results	Change from WY2021	
St. Lucie Estuary	4.5	↑	179%
Caloosahatchee River Estuary Iona Cove	1.8	↓	27%
Caloosahatchee River Estuary Bird Island	8.9	↑	89%


Oyster Spat

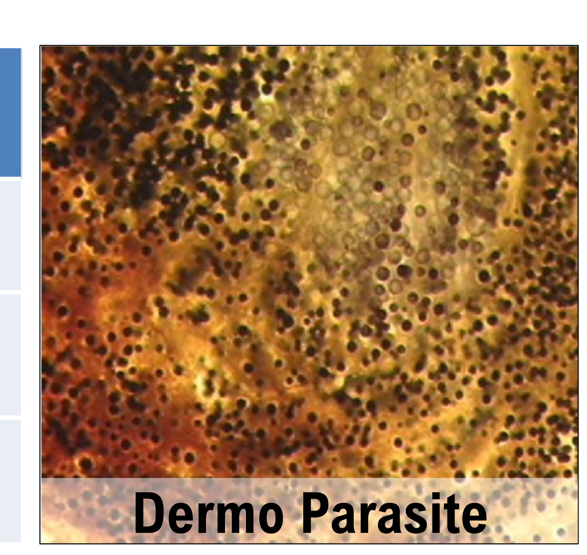



Oyster Sampling T-bars

Oyster Disease

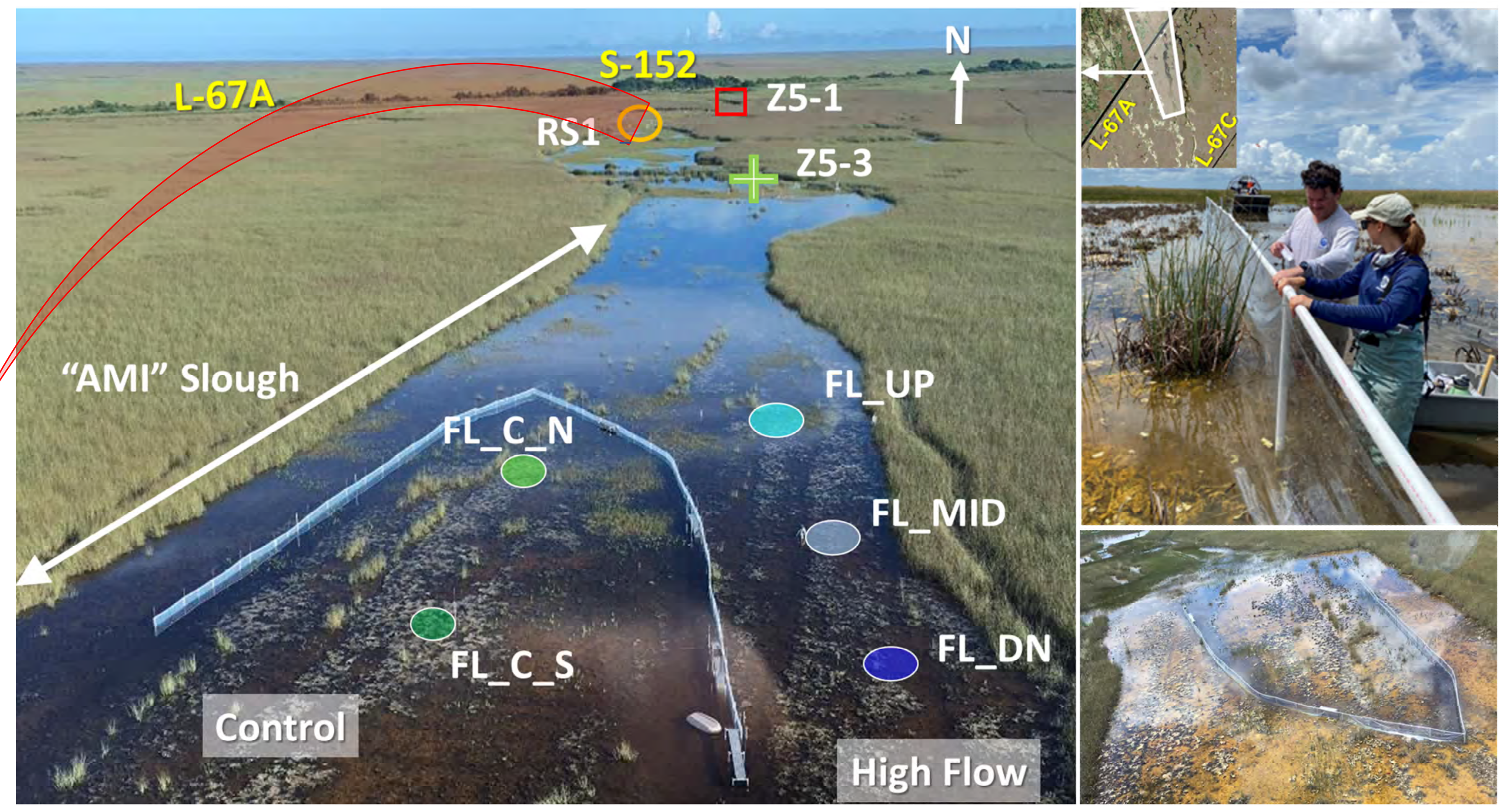
- Dermo is a protozoan parasite (*Perkinus marinus*) that prefers warm, salty waters
- Low salinity events decrease parasite numbers and infection rates (WY2021 Hurricane Eta)
- Prolonged periods of high salinity increase infection rates
- Much higher infection rates in CRE oysters since salinities frequently exceed the optimal range

Oysters with Dermo Infections (%)	WY2022 Results	Change from WY2021	
St. Lucie Estuary	17	↑	97%
Caloosahatchee River Estuary Iona Cove	57	↓	3%
Caloosahatchee River Estuary Bird Island	57	↑	20%


Dermo Parasite

Note: CRE Caloosahatchee River Estuary, m^2 – square meter, SFWMD – South Florida Water Management District, USGS – United States Geological Survey, and WY – Water Year (May 1–April 30).

EXPERIMENTAL DETERMINATION OF FLOW AND LOAD RESPONSES IN THE DECOMP PHYSICAL MODEL



View of the flume study (facing north) showing 3 high flow and 2 control sites and location relative to Water Conservation Area (WCA) 3 Decompartmentalization and Sheetflow Enhancement Physical Model (DPM) sentinel sites (left panel). Photos show construction of the flume (top right panel) and view from a helicopter (bottom right panel, facing south). Approximately 1 kilometer (km) south of the S-152 structure, the flume is located within a slough that was restored using Active Marsh Improvement (AMI) to its historic (based on 1940s imagery) length and width.

Cattail invasions at Z5-1

Results: High flows combined with "clean" water, 9 to 10 parts per billion (ppb) still causes natural sloughs to become invaded by cattail.

Implications: Restoring flow may also require water total phosphorus (TP) lower than 10 ppb, or changes in the way we operate flow structures (e.g., switching, partial openings, spreader swales to minimize extreme flows).

The flume creates elevated flows, but in areas with much lower water TP. The flume will provide the "Goldilocks of Flow" that maximizes ecosystem benefits and minimizes ecological costs.

Chapter 6: Everglades Research and Evaluation

Edited by Fred Sklar

SCAN ME

Projects	Findings
Hydrology	
Hydrologic Patterns for WY2022	Both annual rainfall totals and annual mean stages in the Everglades during Water Year 2022 (WY2022; May 1, 2021–April 30, 2022) were below average historical conditions.
Florida Bay Hydrology	Despite low rainfall, water depths in northern Taylor Slough have been consistently higher in the dry season since WY2018.
Wildlife Ecology	
Wading Bird Monitoring	The 2022 nesting season was characterized by relatively late nesting, a low nesting effort at the historical coastal colonies, and poor nesting success.
Florida Bay Consumers Expand Their Trophic Niche in Enriched Areas	The sub-watershed differences in hydrological connectivity and nutrient regimes can influence the niche space, food webs, and foraging decisions by higher order consumers.
Plant Ecology	
Florida Bay Benthic Vegetation	As the long-term successional recovery of Florida Bay seagrass is ongoing, factors that affect this vegetation, such as water clarity in central and western Florida Bay, should remain important concerns.
Mechanisms of Seagrass Die-off in Florida Bay	When hydrogen sulfide is present in the sediments due to anoxic reducing conditions, lethality occurs when sediment sulfide gains entry to the rhizomes and especially the meristem.
Ecosystem Ecology	
Effect of Natural Disturbances on Tree Islands	Generally, forest structure reflected the long-term effects of the hydrology and natural disturbances, such as fires and hurricanes.
Experimental Determination of Load Responses in the DPM	The objective flume is to improve the DPM "response surface" of velocity, water TP, and phosphorous-loading conditions, and in doing so, identify the envelope of those factors that maximize ecosystem benefits and minimize ecological costs.
Landscape Ecology	
Florida Bay Water Quality and Status	Late season rains helped buffer low freshwater flows in the dry season of WY2022 by pre-hydrating the wetlands and helping keep bay salinity near the historic median.
Active Marsh Improvement	Using a combination of water levels and conductivity, a spatially extensive datalogger network documented the role of an interior berm on water movement into WCA-2A and highlighted a distinct west-east distribution of higher to lower conductivity water.
Synoptic Mapping in Florida Bay	At this time, chlorophyll *a*, colored dissolved organic matter, and phycocyanin were found to be elevated in Rankin Lake in the western survey area, suggesting the presence of a localized algal bloom.

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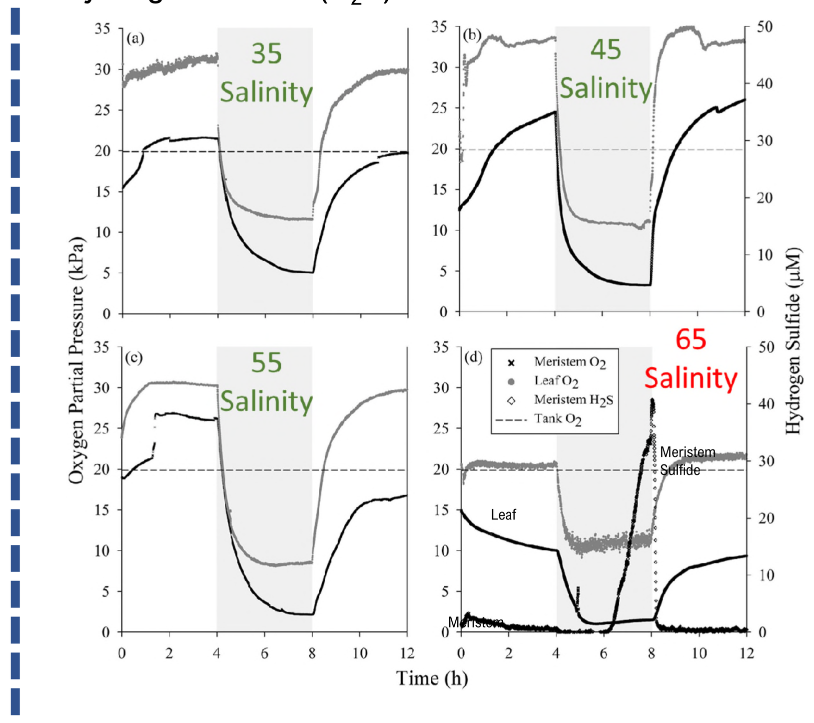
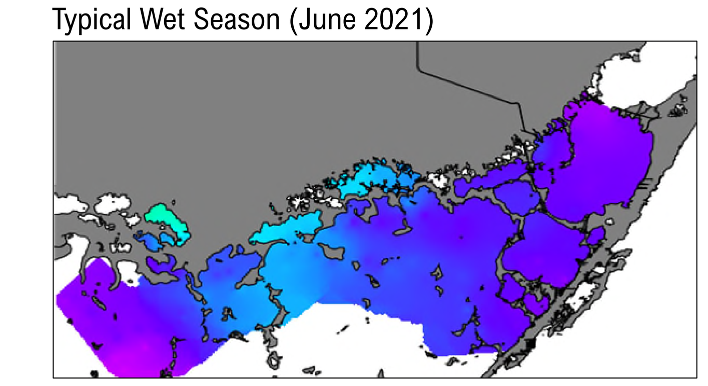
Note: FAU – Florida Atlantic University, FIU – Florida International University, FWRI – Fish and Wildlife Research Institute, SFWMD – South Florida Water Management District, and UF – University of Florida.

MAPPING FLORIDA BAY & MECHANISMS OF SEAGRASS DIE-OFF

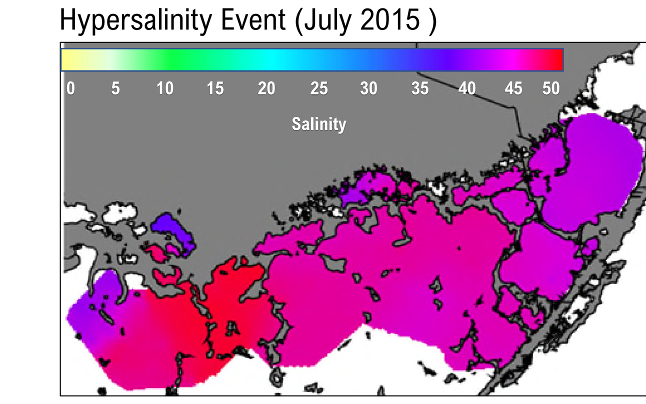
Lab Experiments: Salinity Limits Oxidation and Hydrogen Sulfide (H_2S) Intrusion Occurs in the Dark

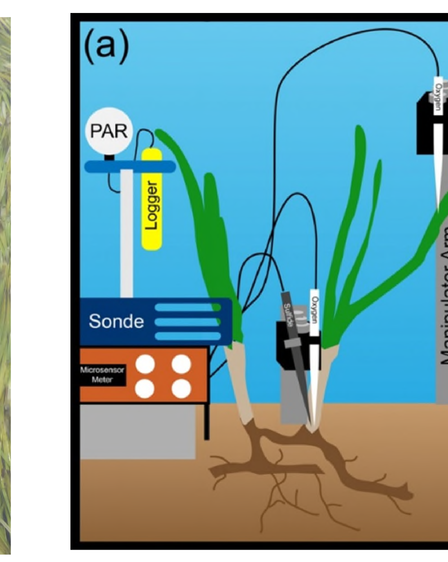


Typical Wet Season (June 2021)



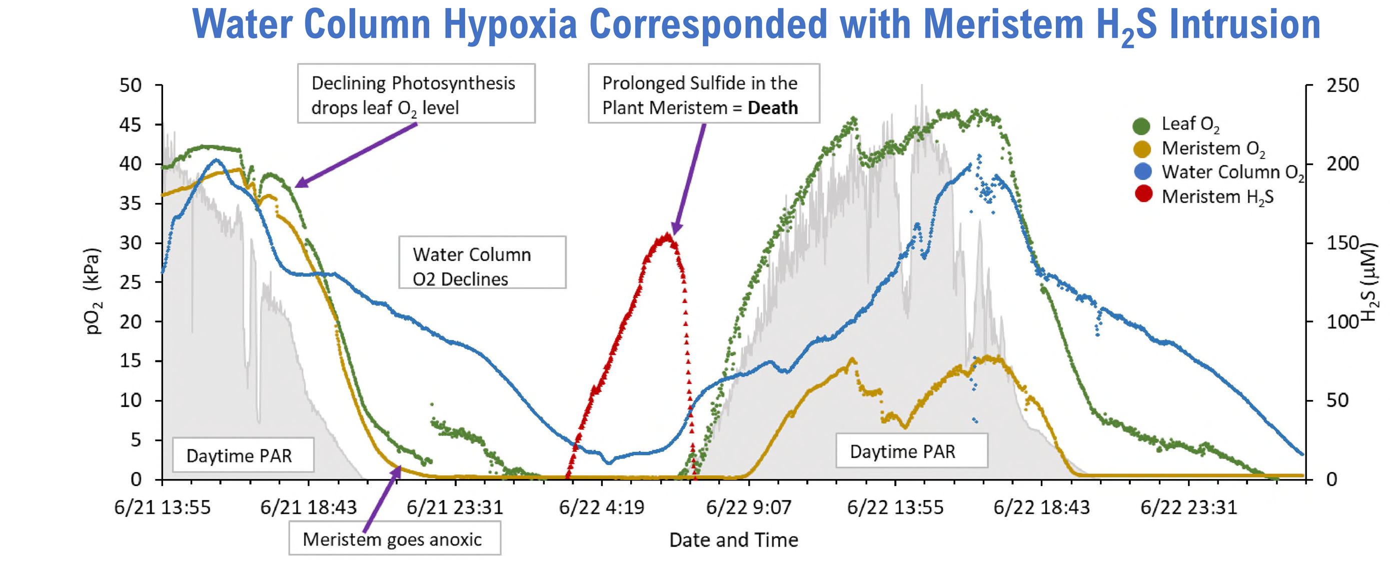
Hypersalinity Event (July 2015)





Schematic of microsensor deployment in the field showing data sonde, micromanipulator, microsensors, and light meter.

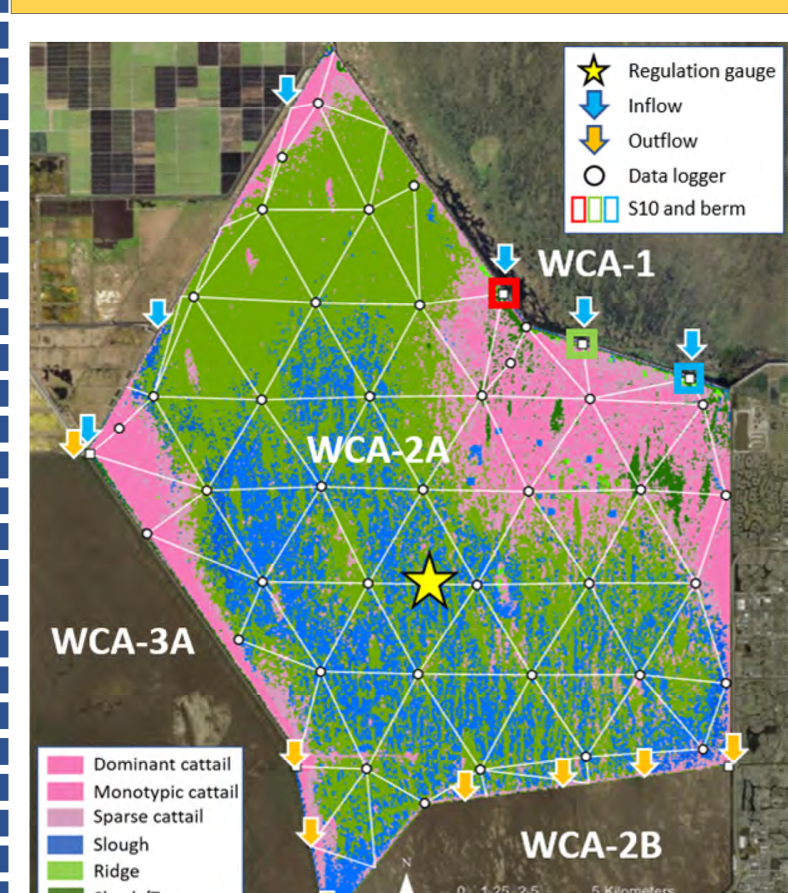
Water Column Hypoxia Corresponded with Meristem H_2S Intrusion



Results: High temperature/salinity are important factors that lower water column potential to "buffer" tissues from hypoxia and H_2S intrusion.

Implications: Greater freshwater flows, low salinity, and low ecosystem oxygen (O_2)-demand may become important strategies to buffer climate change harm to seagrass communities.

WATER CONSERVATION AREA 2A: POTENTIAL FOR NUTRIENT AND HYDROLOGIC RESTORATION



Top: Distribution map of the vegetation/landscape, flow structures, regulation gauge, and the hydrologic network in WCA-2A. **Bottom:** Interior berm (yellow dashed line) downstream of each S-10 gated spillway. Estimate of the berm ground elevation is 14 to 15 feet (ft) National Geodetic Vertical Datum of 1929 (NGVD29).

Figure A. Seasonal spatial distribution of water depth

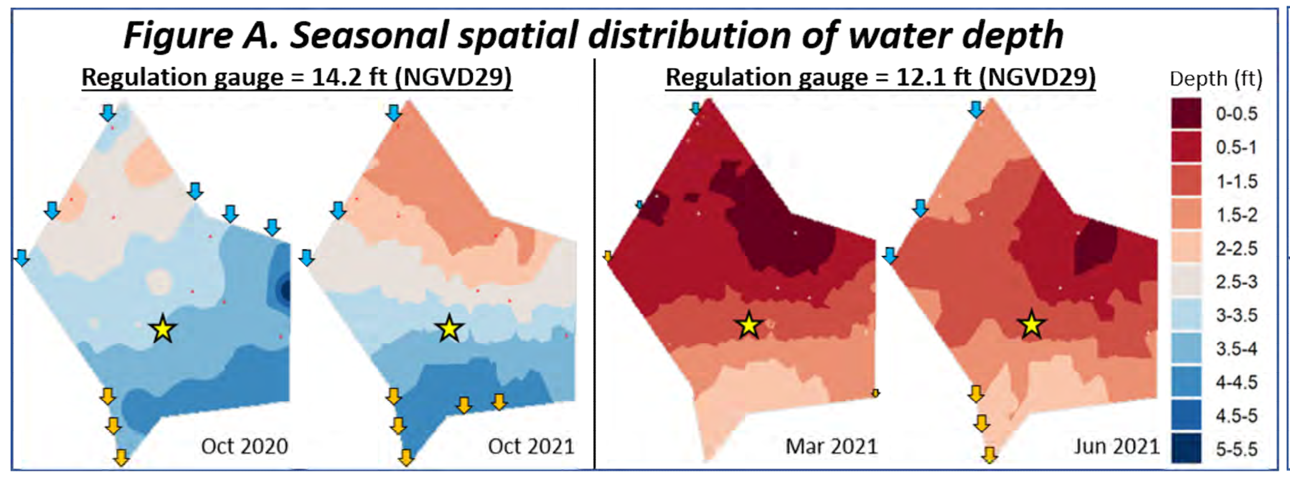


Figure B. Water depth change

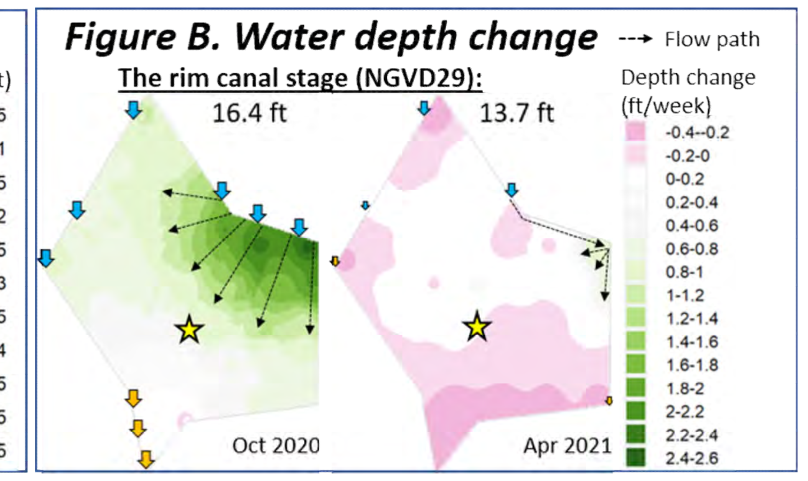
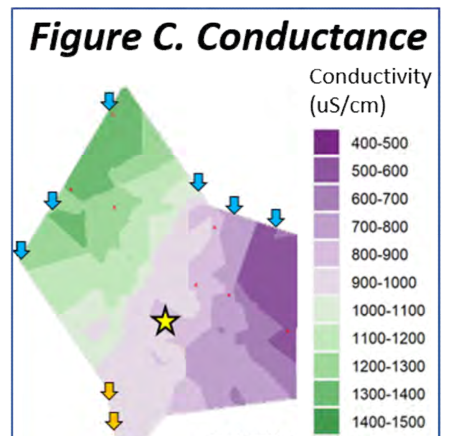


Figure C. Conductance



Results: Distribution of water depth is driven by climate conditions, ground elevation, and operations.

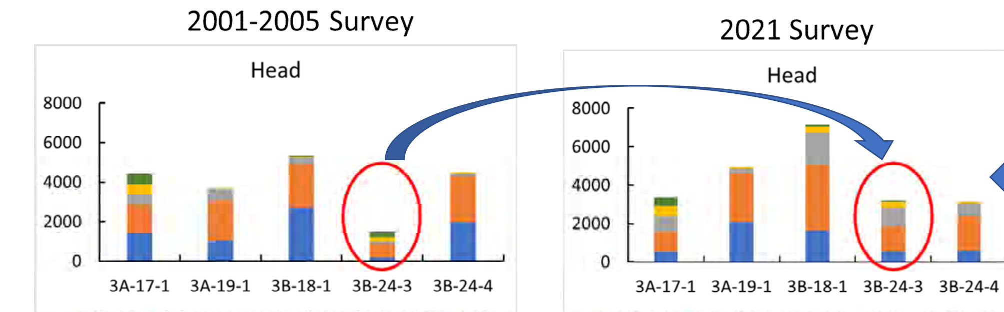
- **Figure A:** The WCA-2A regulation schedule is currently based on one gauge. The 2-17 gauge does not reflect spatial dynamics.
- **Figure B:** An interior berm downstream of the S-10s acts as a barrier to water movement from the canal into the marsh and causes a preferential flow path.
- **Figure C:** A west-to-east conductivity gradient highlights the influence of operations on surface water chemistry throughout the landscape.

Implications: High spatial water depth variability under the same regulation stage conditions highlight that a greater understanding of water movement in response to operations is essential for developing a revised regulation schedule and supports a need for a schedule that, similar to WCA-1 and WCA-3A, should use more than one regulation gauge.

EFFECT OF HYDROLOGY AND NATURAL DISTURBANCES ON FOREST STRUCTURE OF TREE ISLANDS IN WCA-3A AND WCA-3B

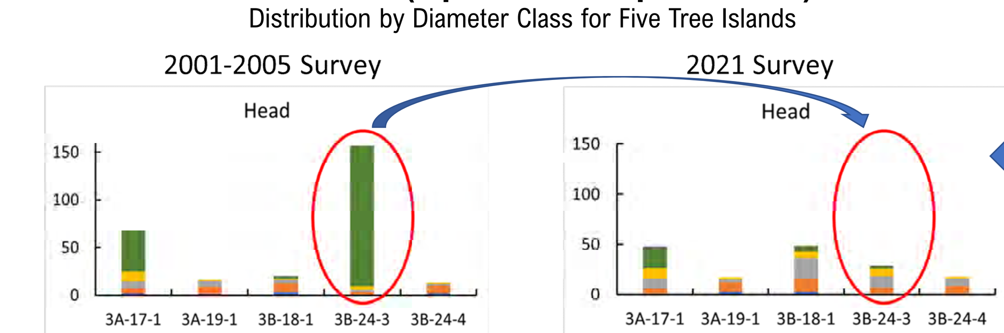
Tree Density (stems per hectare)

Distribution by Diameter-Class for Five Tree Islands



Basal Area (square meters per hectare)

Distribution by Diameter Class for Five Tree Islands

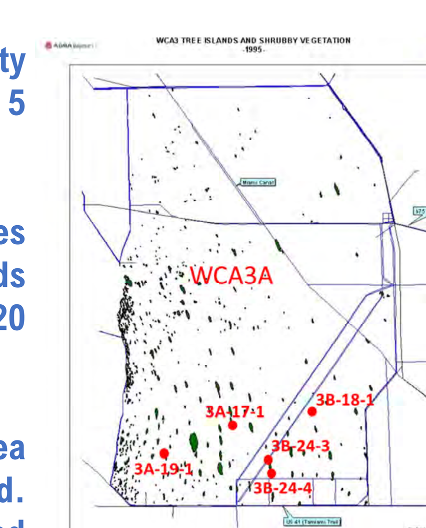


Tree Island 3A-19-1 **before** Hurricane Wilma

Tree Island 3A-19-1 **after** Hurricane Wilma

Results:

- In 15+ years, tree density increased for 4 out of 5 islands.
- Forest structure and species composition on tree islands has changed over the last 20 years.
- In 15+ years, tree basal area increased on only one island. The other 4 either decreased or did not change.



Implications:

- Forest structure and species composition changes are related not only to hydrology, but also to the effects of disturbances (e.g., hurricanes). They generate openings in the canopy, creating forest gaps that are conducive for natural tree recruitment.
- Water management decisions should promote natural hydroperiods and seasonal lower water levels to encourage maintenance and maturation of tree islands.