SOUTH FLORIDA WATER MANAGEMENT DISTRICT

South Florida Environmental Report
VOLUME I: THE SOUTH FLORIDA ENVIRONMENT

KIMBERLY RICHER
Compliance Assessment and Reporting Section, Water Quality Bureau

Prepared by the South Florida Water Management District (SFWMD) in cooperation with the Florida Department of Environmental Protection (FDEP) & Florida Department of Agriculture & Consumer Services (FDACS), the 2024 South Florida Environmental Report (SFER) unifies dozens of individual mandated reports & plans into a single document for a "consolidated water management district annual report". The annual SFER updates key scientific results & findings for the reporting period. Overall, this information is the foundation for restoration, management, & protection activities associated with the Kissimmee Basin, Lake Okeechobee, the Everglades, & South Florida's coastal ecosystems.

2024 SFER Volume I

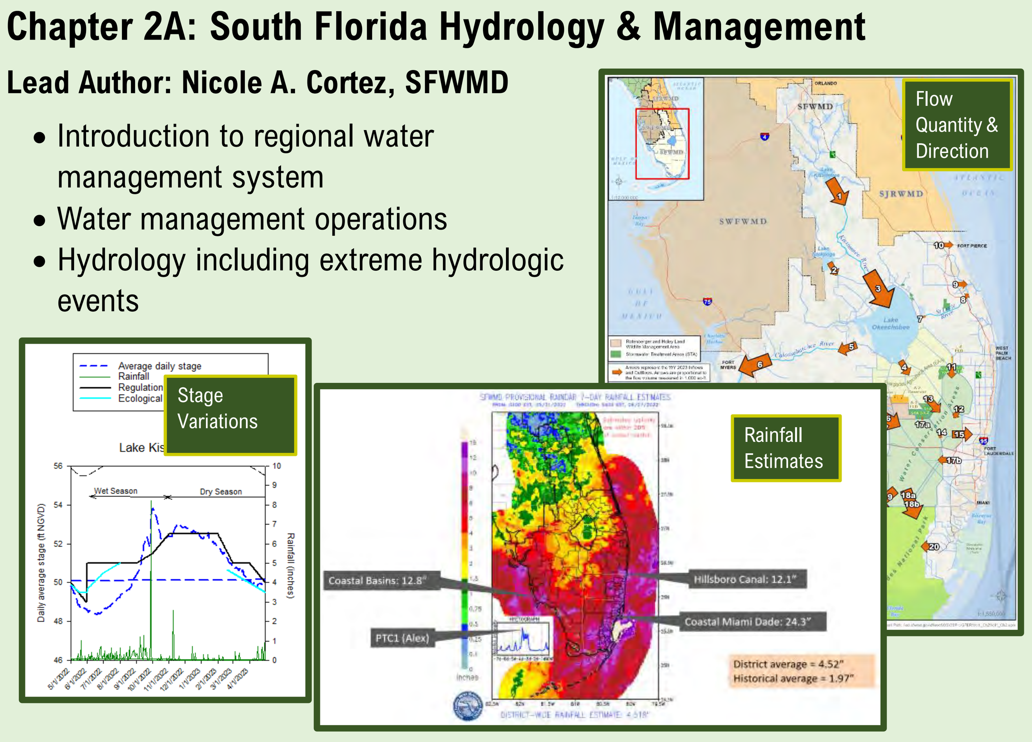
- Summarizes project science, status, & performance.
- Provides status updates & data summaries for various research & monitoring efforts during Water Year 2023 (WY2023; May 1, 2022–April 30, 2023).
- Mandated Peer Review: Chapters 3, 4, 5A, 5B, 5C, 6, and 7; Optional Peer Review: Chapters 8A, 8B, 8C, 8D, & 9.
- Public review is conducted concurrently with the peer review.
- Facilitated, edited, & produced by staff of the Compliance Assessment & Reporting Section of the Water Quality Bureau.

Major geographic features within SFWMD boundaries

Chapter 2A: South Florida Hydrology & Management

Lead Author: Nicole A. Cortez, SFWMD

- Introduction to regional water management system
- Water management operations
- Hydrology including extreme hydrologic events

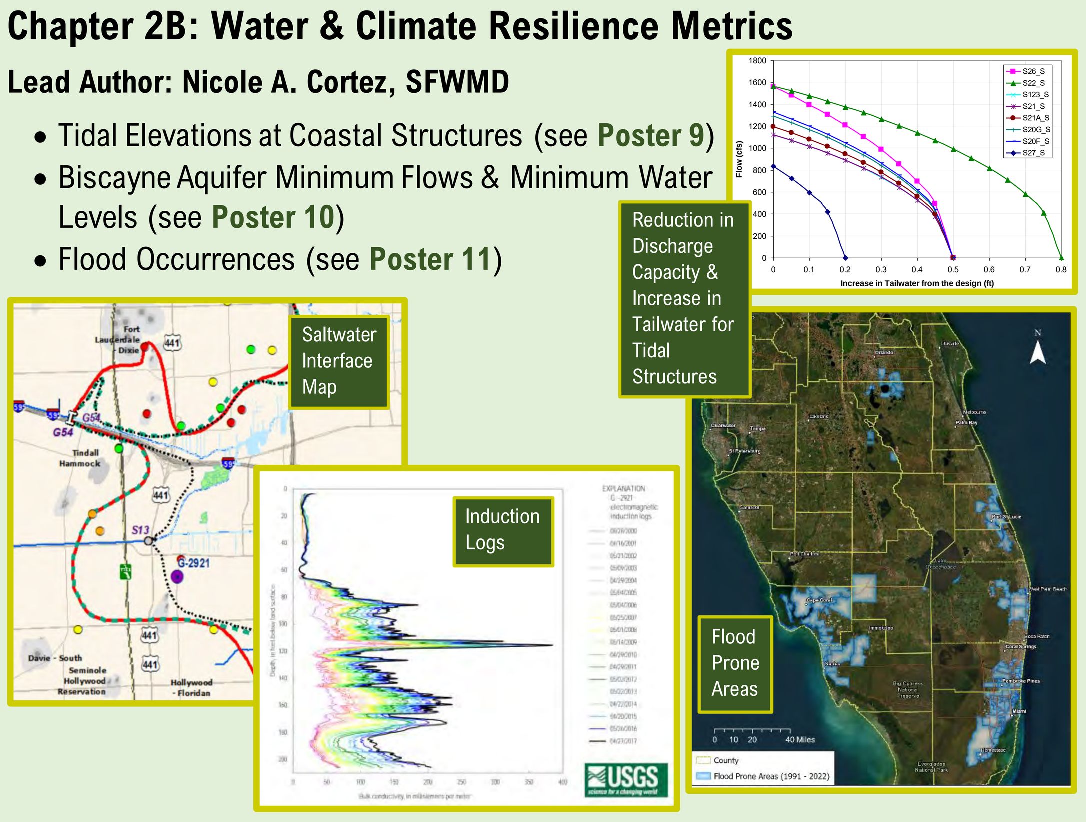


See Posters 7 & 8 for more information.

Chapter 2B: Water & Climate Resilience Metrics

Lead Author: Nicole A. Cortez, SFWMD

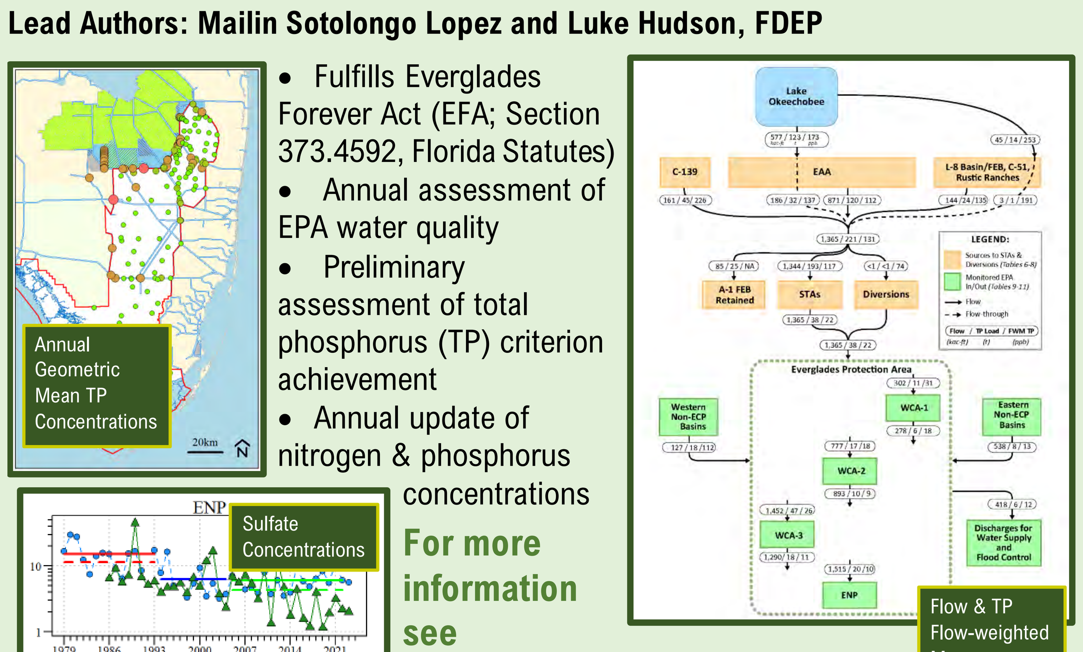
- Tidal Elevations at Coastal Structures (see Poster 9)
- Biscayne Aquifer Minimum Flows & Minimum Water Levels (see Poster 10)
- Flood Occurrences (see Poster 11)



Chapter 3: Water Quality in the Everglades Protection Area (EPA)

Lead Authors: Mailin Sotolongo Lopez and Luke Hudson, FDEP

- Fulfills Everglades Forever Act (EFA; Section 373.4592, Florida Statutes)
- Annual assessment of EPA water quality
- Preliminary assessment of total phosphorus (TP) criterion achievement
- Annual update of nitrogen & phosphorus concentrations

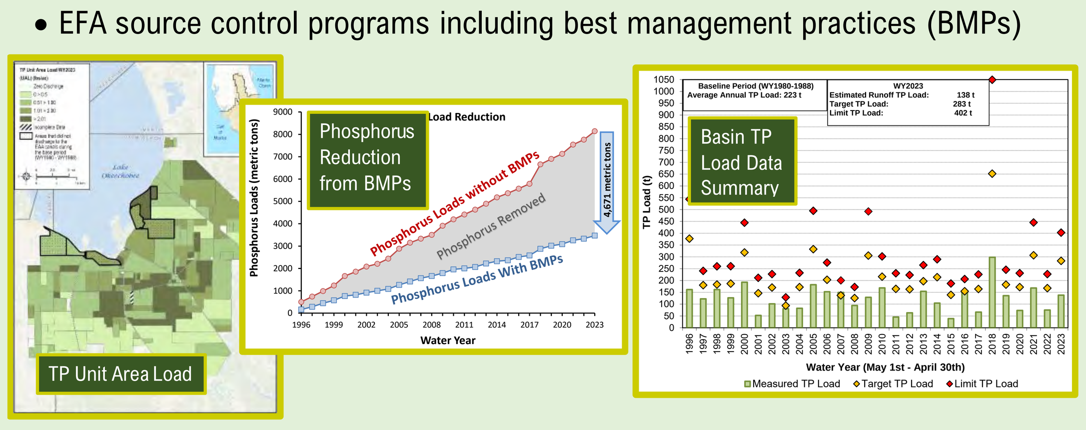


For more information see Poster 30.

Chapter 4: Nutrient Source Controls Programs in the Southern Everglades

Lead Authors: Youchao Wang & Mehrnoosh Mahmoudi, SFWMD

- EFA source control programs including best management practices (BMPs)



Posters 31 & 32 provide additional information.

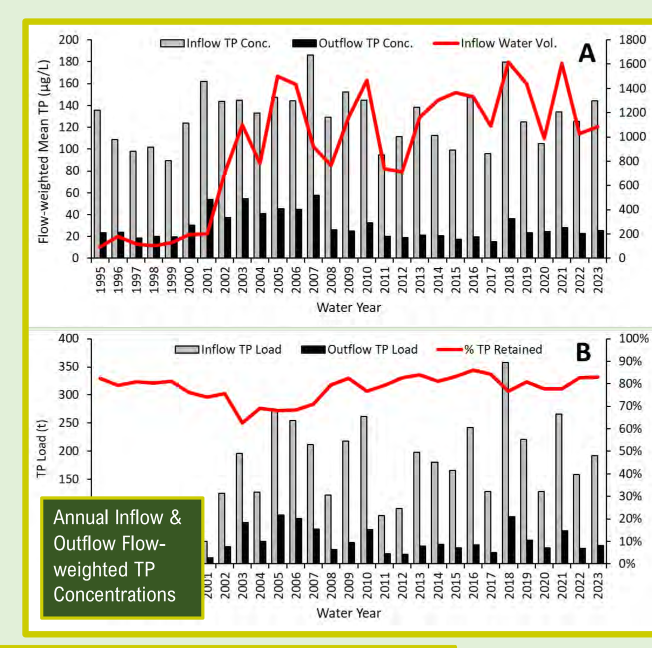
Chapters 5A, 5B, & 5C: Everglades STAs Performance, Restoration Strategies, and Science Plan

Lead Authors: 5A: Robert Shuford, 5B: Michael J. Chimney, and 5C: R. Thomas James, SFWMD

- Fulfills - EFA - National Pollution Discharge Elimination System (NPDES) permits - Everglades Construction Project (STAs) consent orders
- **Chapter 5A** – WY2023 status of Restoration Strategies projects

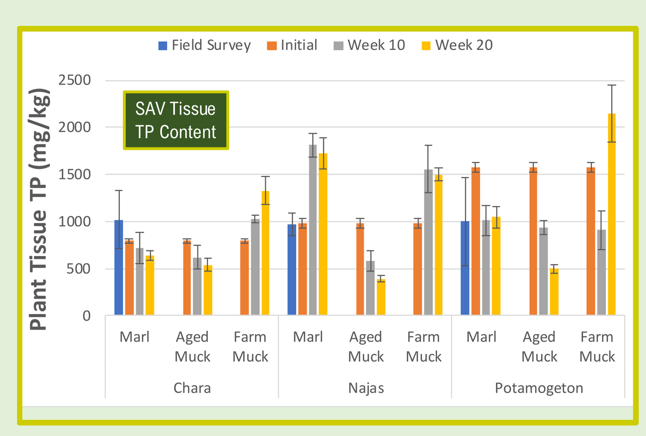
- **Chapter 5B** – WY2023 update on Everglades STAs:
  - Treatment performance - Facility status & operational issues - Vegetation surveys

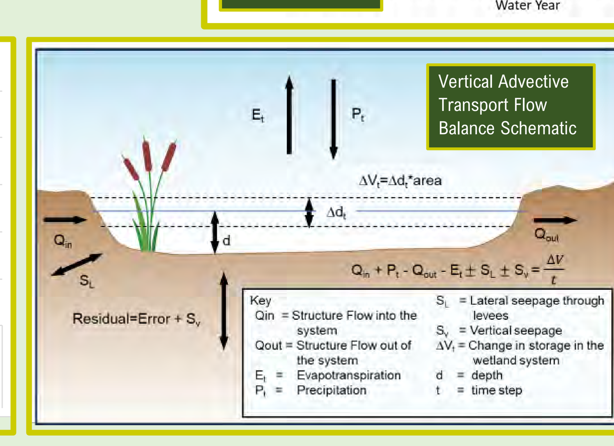
See Posters 33 & 34.



- **Chapter 5C** – Status & key findings of Science Plan studies
  - Science Plan studies focus:
    - Floating tussocks
    - Resilience of submerged aquatic vegetation (SAV)
    - Effect of vertical advective transport on TP concentrations

See Poster 35.

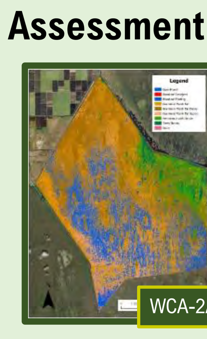


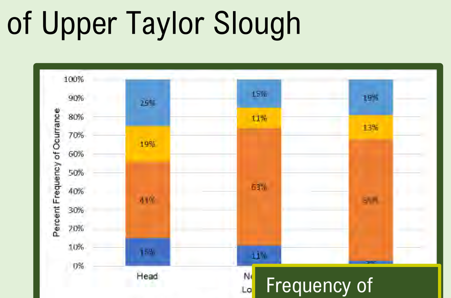


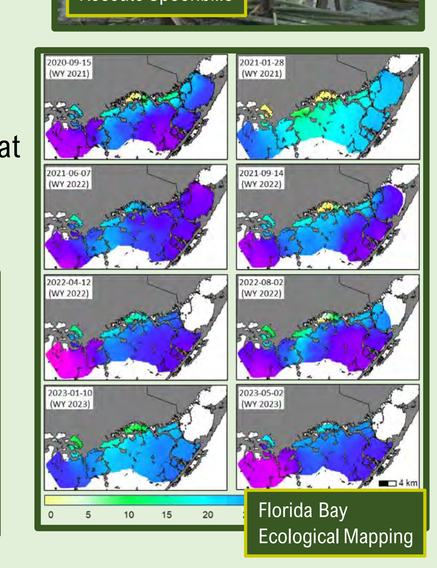
Chapter 6: Everglades Research & Assessment

Lead Authors: Fred Sklar, SFWMD

- Hydrology in the EPA & Florida Bay
- Wading Bird & Spoonbill Nesting
- Invasive Asian Swamp Eel Distribution
- Lygodium Infestation & Treatment in Water Conservation Area (WCA) 3
- Florida Bay Benthic Vegetation
- Vegetation Structure & Composition Cape Sable Seaside Sparrow Habitat
- Adaptive Foundational Resilience Performance Measure
- Periphyton & Vegetation Monitoring of Upper Taylor Slough
- Ecological Mapping in Florida Bay
- Implications from Decomp Physical Model (see Poster 36)
- Updated WCA-2A Vegetation & Topography







Chapters 8A, 8B, 8C, and 8D: Northern Everglades & Estuaries Protection Program (NEEPP) Annual Progress Report

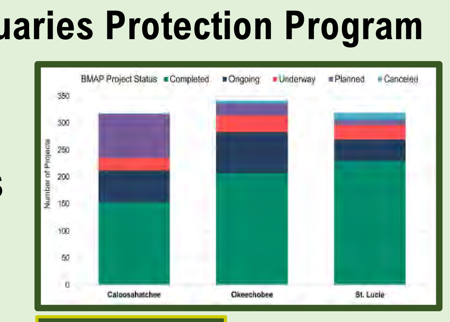
Lead Authors:

8A: Stacey Ollis, SFWMD, Diana Turner, FDEP, & Jennifer Thera, FDACS

8B: Anthony Betts, Zack Welch, & Paul Jones, SFWMD

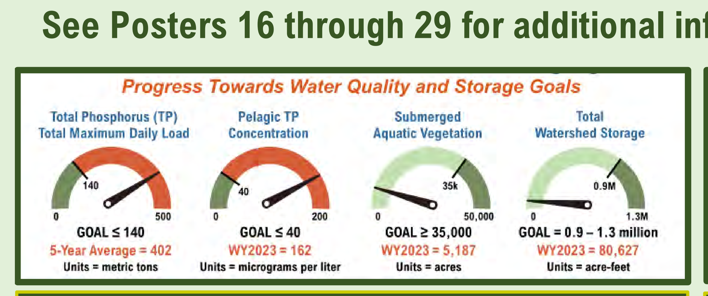
8C: Danielle Taylor, Melanie Parker, & Sara Ouly, SFWMD

8D: Danielle Taylor, Melanie Parker, & Jenna Bobsein, SFWMD

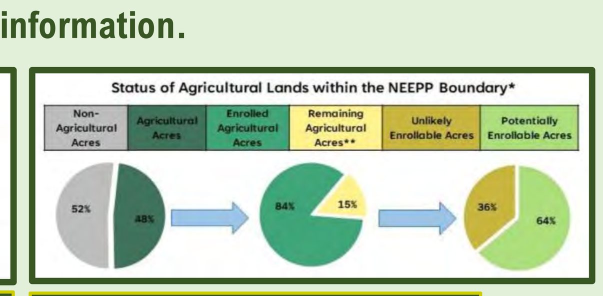


- Fulfills NEEPP legislation (Section 373.4505, F.S.) requirements
- SFWMD, FDEP, & FDACS coordinate efforts
- Chapter 8A provides updates on FDEP basin management action plans (BMAPs), SFWMD watershed construction projects, & FDACS BMP & Implementation Assurance programs
- Chapters 8B, 8C, & 8D provide ecological status & progress on implementing watershed protection plans for Lake Okeechobee, St. Lucie River, & Caloosahatchee River watersheds, respectively

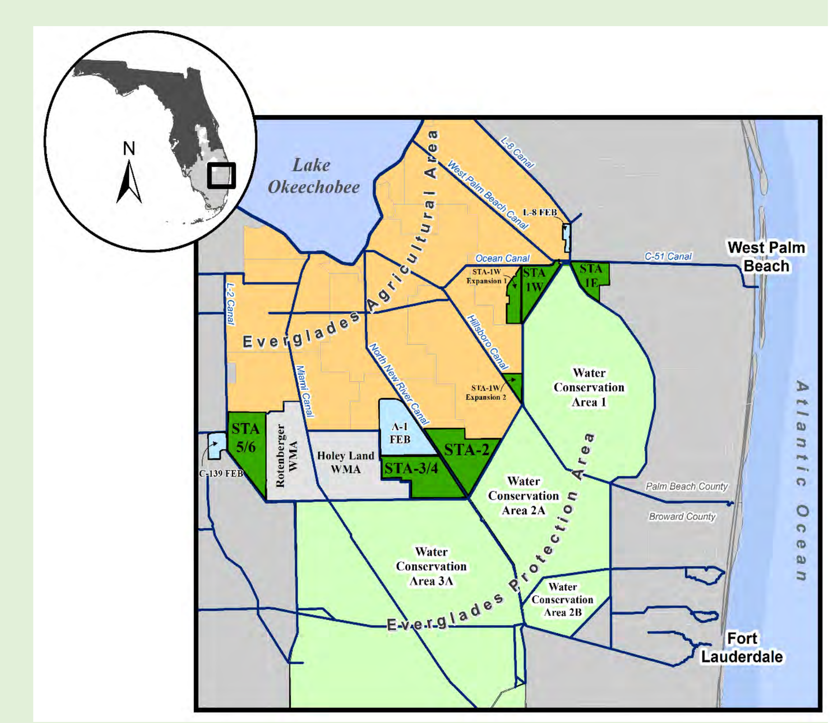
See Posters 16 through 29 for additional information.



Progress Towards Water Quality & Storage Goals for Lake Okeechobee



FDACS Agricultural Non-Point Source Program Status



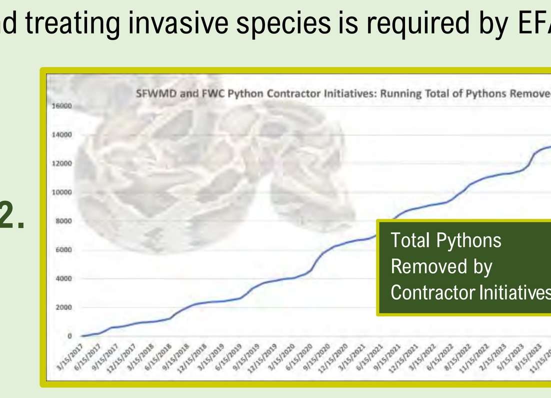
Everglades Stormwater Treatment Areas (STAs) region

Chapter 7: Status of Invasive Species

Lead Author: LeRoy Rodgers, SFWMD

- Invasive species in South Florida
- Programmatic overviews of regional invasive species initiatives
- Key issues linked to managing & preventing biological invasions
- Update & annotations for priority plant and animal species
- Summaries of new research findings
- Monitoring and treating invasive species is required by EFA & the NEEPP

For more information see Poster 12.

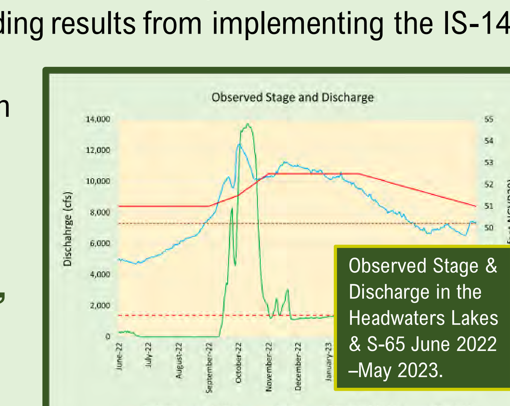


Chapter 9: Kissimmee River Restoration and Other Kissimmee Basin Initiatives

Lead Authors: Joseph Koebel & Stephan Bousquin, SFWMD

- Kissimmee River Restoration Evaluation Program (KRREP)
- Kissimmee Chain of Lakes projects
- Kissimmee River Restoration Project status
- Hydrology, including results from implementing the IS-14-50 Discharge Plan
- Dissolved oxygen
- Floodplain vegetation
- Wildlife

See Posters 13, 14, & 15.



To access statutes mandating reporting for Volume I, use these QR codes:

Consolidated Annual Report: SCAN ME EFA: SCAN ME NEEPP: SCAN ME

For more information: SCAN ME

S O U T H   F L O R I D A   W A T E R   M A N A G E M E N T   D I S T R I C T

South Florida Environmental Report
VOLUME II: DISTRICT ANNUAL PLANS & REPORTS

DIANA DE LA ROSA

Compliance Assessment and Reporting Section, Water Quality Bureau

Prepared by the South Florida Water Management District (SFWMD) in cooperation with Florida's five water management districts, Volume II comprises state-mandated reports that are required to be prepared annually. These reports document SFWMD's progress in implementing plans developed to address areas of responsibility on a regional or districtwide basis. Within this volume, SFWMD also exercises the option of completing an annual work plan report, currently referred to as the Fiscal Year 2022-2023 Annual Work Plan Performance (Chapter 2).

2024 SFER Volume II

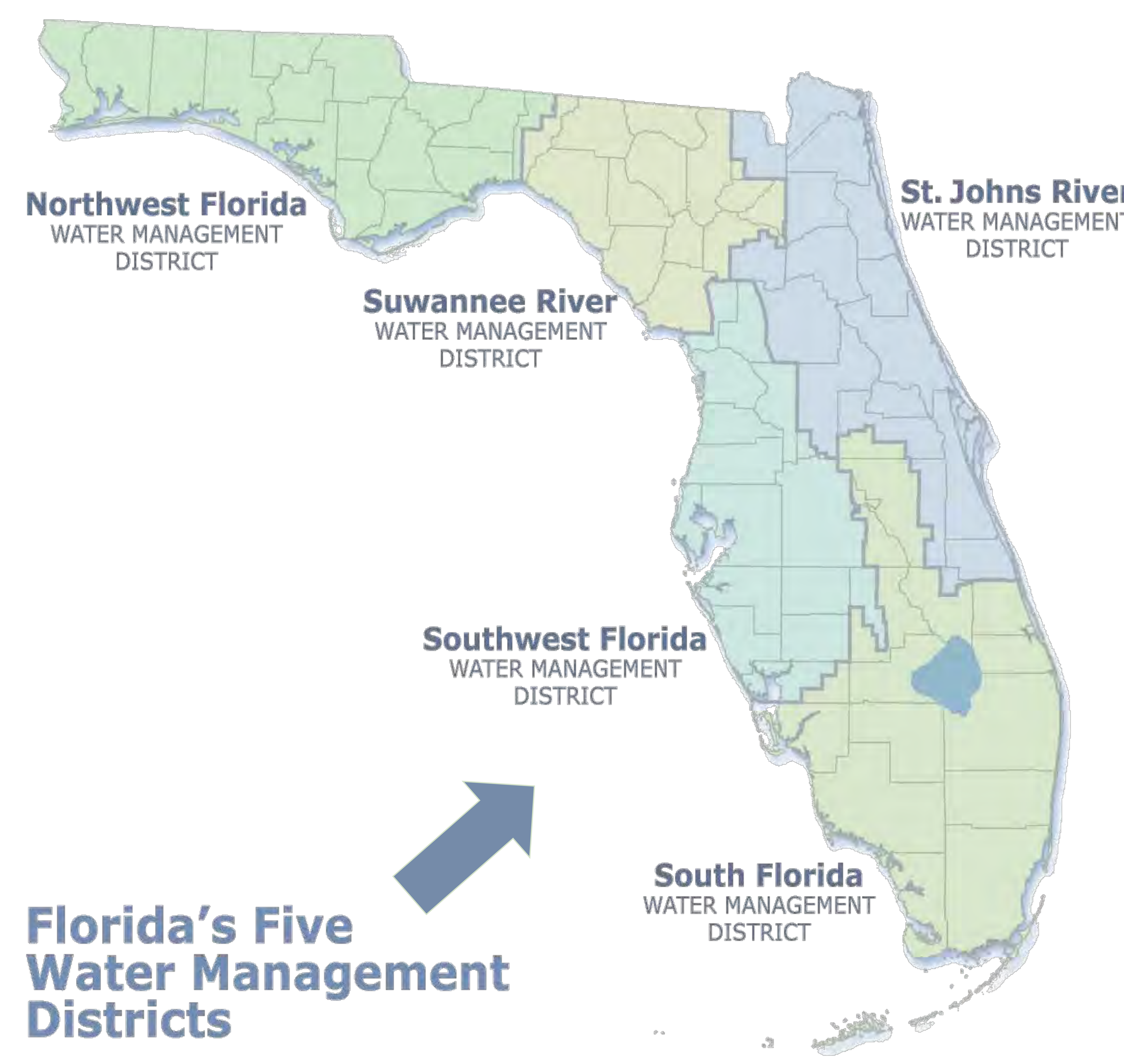
- Consolidated annual update of the implementation progress of plans developed to address areas of responsibility on a regional or districtwide basis.
- These updates are required by the Florida Legislature to keep them apprised of the status and progress of each program.
- Facilitated, edited, and produced by staff of the Compliance Assessment and Reporting Section of the Water Quality Bureau.

The **Consolidated Water Management District Annual Report (CAR)**, required by §373.036(7), F.S., reporting on the management of water resources and the Fiscal and Performance Accountability Report. 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 all Chapters and associated appendices.

The **Florida Forever Water Management District Work Plan (Florida Forever)** is required by §373.199, F.S., which was enacted in 1999 and amended in 2016.

- Required to present projects eligible for funding as well as projects eligible for state acquisition monies from the appropriate account or trust fund
- Reporting requirements for Florida Forever are provided in Chapters 2, 6A, 6B, and associated appendices.



For more information about CAR and Florida Forever scan the following QR codes:

SCAN ME SCAN ME

Chapter/Appendix Number	Chapter/Appendix Title	Reporting Requirements
Chapter 1	Introduction to Volume II	Consolidated Annual Report – §373.036(2)(f)4 and §373.036(7)(b)1, F.S. Florida Forever Water Management District Work Plan – §373.199(7)(c), F.S.
Chapter 2	Fiscal Year 2022-2023 Annual Work Plan Performance	Consolidated Annual Report – §373.036(2)(f)4 and §373.036(7)(b)1, F.S. Florida Forever Water Management District Work Plan – §373.199(7)(c), F.S.
Chapter 3 & Appendix	Priority Waterbodies List and Schedule	Consolidated Annual Report – §373.036(7)(b)2, F.S. Minimum Flows and Minimum Water Levels – §373.042, F.S. Establishment and Implementation of Minimum Flows and Minimum Water Levels – §373.0421, F.S. Authority to Establish Reservations – §373.223(4), F.S. Minimum Flows and Levels – Chapter 40E-8, F.A.C. Minimum Flows and Levels – Section 62-40.473(9), F.A.C. Reservations – Section 62-40.474(5), F.A.C.
Chapter 4	Five-Year Capital Improvements Plan	Consolidated Annual Report – §373.036(7)(b)3, F.S. District Budget – §373.536(6)(a)3 and §373.536(6)(a)4, F.S. Budgets for Fixed Capital Outlay – §216.043, F.S.
Chapter 5A	Five-Year Water Resource Development Work Program (contains Alternative Water Supply)	Consolidated Annual Report – §373.036(7)(b)4, §373.036(7)(b)5, and §373.036(7)(b)8, F.S. District Budget – §373.536(6)(a)4, F.S. Alternative Water Supply Development – §373.707, F.S.
Appendix 5A-1	Projects Associated with a Basin Management Action Plan	Consolidated Annual Report – §373.036(7)(b)8.a, F.S.
Chapter 5B	Projects in the Five-Year Work Program with Grading for each Watershed, Water Body, or Water Segment	Consolidated Annual Report – §373.036(7)(b)9, F.S.
Chapter 6A	Florida Forever Work Plan Annual Update	Consolidated Annual Report – §373.036(7)(b)6, F.S. Florida Forever Water Management District Work Plan – §373.199(7)(b), F.S. Florida Forever Act – §259.105(7)(b), F.S. Acquisition of Real Property – §373.139(3)(c), F.S.
Chapter 6B	Land Stewardship Annual Report	Consolidated Annual Report – §373.036(7)(b)6, F.S. Florida Preservation 2000 Act – §259.101, F.S. Florida Forever Water Management District Work Plan – §373.199(7)(a), F.S.
Chapter 7	Mitigation Donation Annual Report	Consolidated Annual Report – §373.036(7)(b)7, F.S. Additional Criteria for Activities in Surface Water and Wetlands – §373.414(1)(b)2, F.S.

For more information: SCAN ME

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

South Florida Environmental Report
VOLUME III: ANNUAL PERMIT REPORTS

CHRIS KING
Compliance Assessment and Reporting Section, Water Quality Bureau

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
- 2024 SFER Volume III comprises 5 chapters with a total of 23 appendices, each of which is a permit report for one or more projects

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 and Reporting Section of the Water Quality Bureau
- Individual reports are reviewed and approved by the Florida Department of Environmental Protection

WHEN IS IT PUBLISHED?

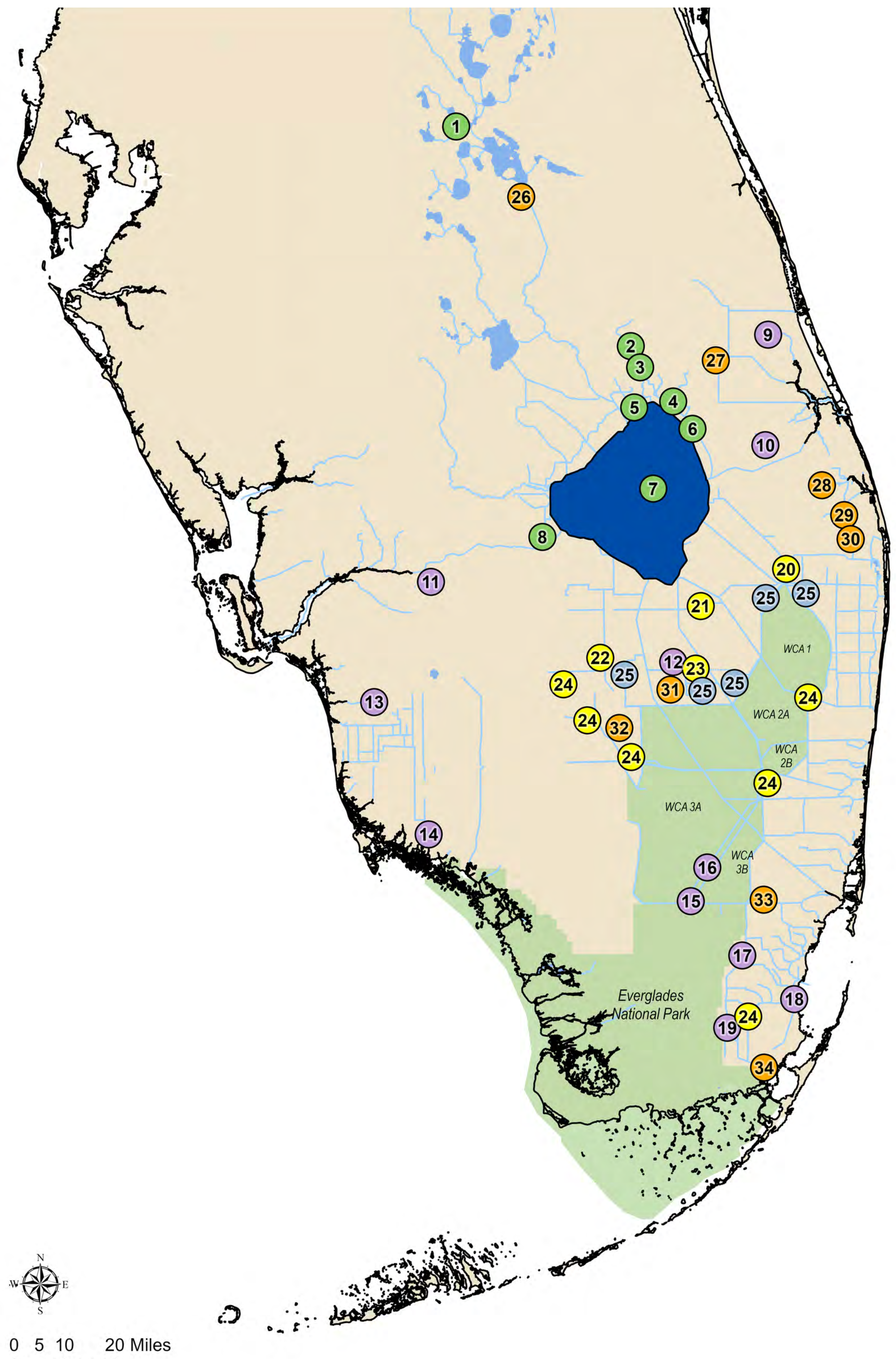
- Volume III is published online in the SFER annually on March 1

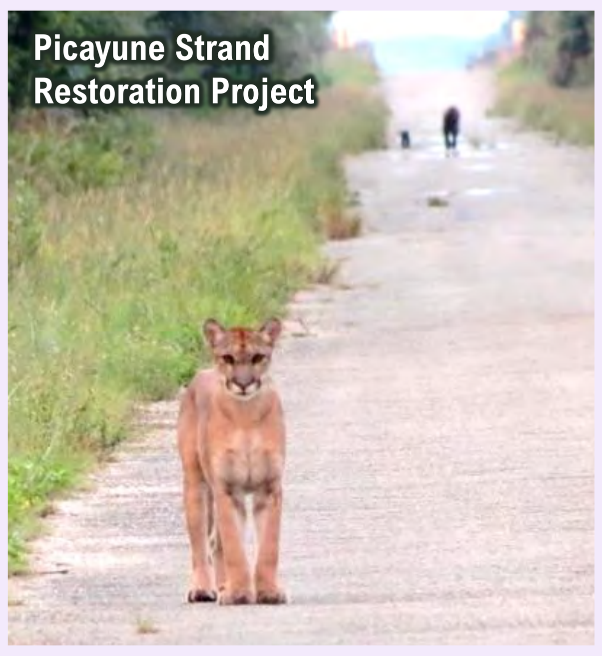
PERMITTED PROJECTS COVERED IN SFER VOLUME III:

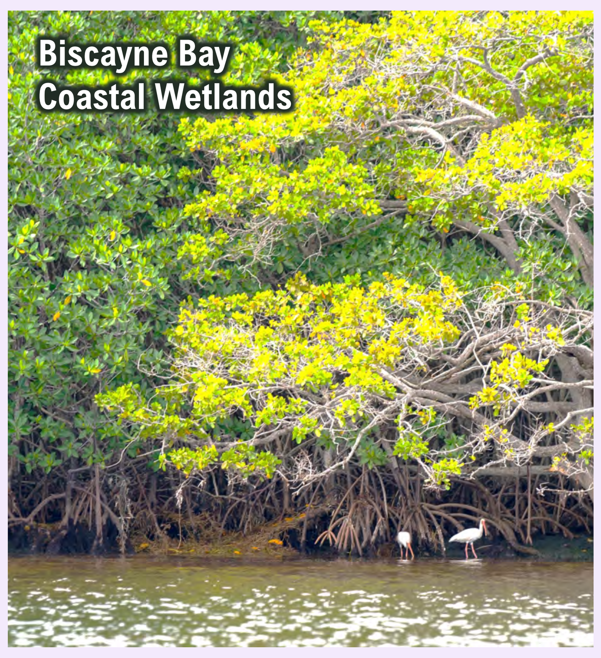
#	PROJECT	PERMIT TYPE*	IN VOLUME III
1	Rolling Meadows Restoration	NEEPP	Appendix 4-5
2	Grassy Island Hybrid Wetland Treatment Technology Project	NEEPP	Chapter 1
3	Taylor Creek Stormwater Treatment Area	NEEPP	Chapter 5
4	Nubbin Slough Stormwater Treatment Area	NEEPP	Appendix 4-4
5	Lemkin Creek Hybrid 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	C-43 West Basin Storage Reservoir Project	CERPRA	Chapter 2
12	Everglades Agricultural Area A-2 Reservoir and Stormwater Treatment Area	CERPRA	Chapter 2
13	Southern Corkscrew Regional Ecosystem Watershed (CREW) Restoration	CERPRA	Chapter 1
14	Picayune Strand Restoration Project	CERPRA	Appendix 2-5
15	Central Everglades Planning Project S-333N Gated Spillway	CERPRA	Appendix 2-9
16	Water Conservation Area 3 Decompartmentalization and Sheetflow Enhancement Physical Model (DPM Test Project)	CERPRA	Appendix 2-7
17	Modified Water Deliveries to Everglades National Park and the C-111 South Dade Project	CERPRA	Appendix 2-1
18	Biscayne Bay Coastal Wetlands Project	CERPRA	Appendix 2-3
19	C-111 Spreader Canal	CERPRA	Appendix 2-4
20	L-8 Flow Equalization Basin	EFA	Appendix 3-4
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
31	Buttermilk/Packingham Slough, G-700 Pump Station Bypass Removal	ERP	Appendix 5-5
32	C-4 Emergency Detention Basin	ERP	Appendix 5-4
33	C-18 Canal Control Structure (G-160)	ERP	Appendix 5-3
34	G-161 Water Control Structure	ERP	Appendix 5-3

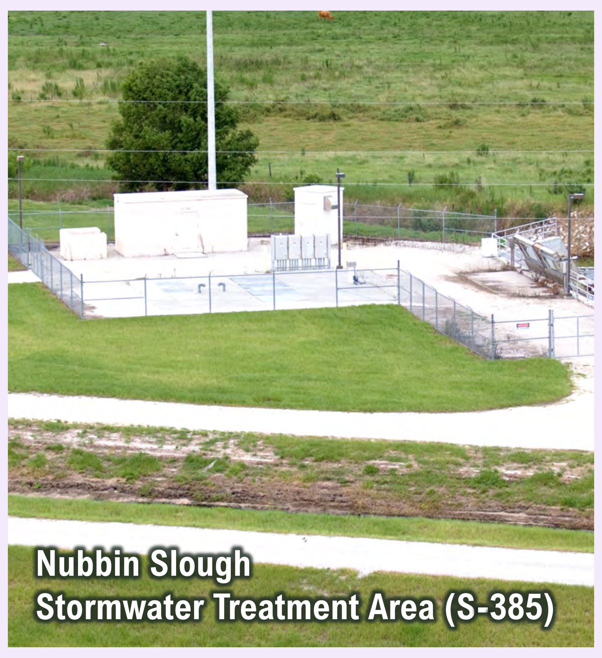
***Permit Types:** CERPRA – Comprehensive Everglades Restoration Plan Regulation Act, EFA – Everglades Forever Act, ERP – Environmental Resource Permit, NEEPP – Northern Everglades and Estuaries Protection Program, and NPDES – National Pollutant Discharge Elimination System.

PROJECT LOCATIONS FOR MOST PERMIT REPORTING IN SFER VOLUME III:









Rolling Meadows
Restoration Project

For more information:
SCAN ME

Water Quality Sample Collection, Methods, and Equipment

Mark Hinz, Danielle Tharin
Water Quality Monitoring Section, Water Quality Bureau

Water Quality Monitoring Workflow:

Monitoring Plan Development, Permit Coordination, Environmental Monitoring Review Team Approval → Site Reconnaissance, Station Installation, and Registration → Start-Up and Routine Sample Collection → Sample Collection, Audits, and Quality Assurance → Field Data Validation

Sample Collection and Processing

WHY DO WE MONITOR?
- Restoration projects
- Science studies
- Tracking progress towards meeting water quality standards

Site Access

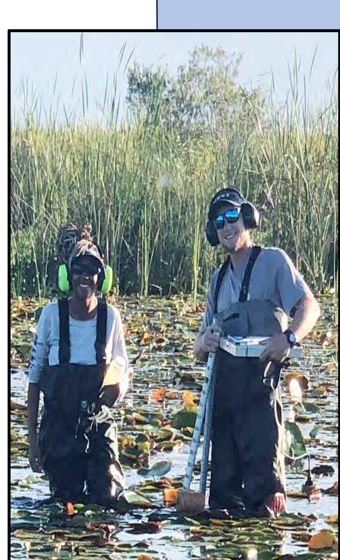
AIRBOAT
Station PC34 on the Kissimmee River floodplain. Collection of surface water samples and multi-parameter sonde data.

HELICOPTER
Station CA217 in Water Conservation Area (WCA) 2A. Preparing to take depth readings in the marsh using a "Paluga pole".

TRUCK
S5A-E on the C-51 Canal. Collection of samples upstream of the gates using a Van Dorn.

BOAT
Station A03 in East Lake Tohopekaliga. Collection of surface water samples and multi-parameter sonde data.

Methods



GRAB
Station LOXAZ2 in WCA-1. Surface water collection in the marsh.

GRAB
L001 water quality station on Lake Okeechobee. Collecting a water quality sample using a Van Dorn.

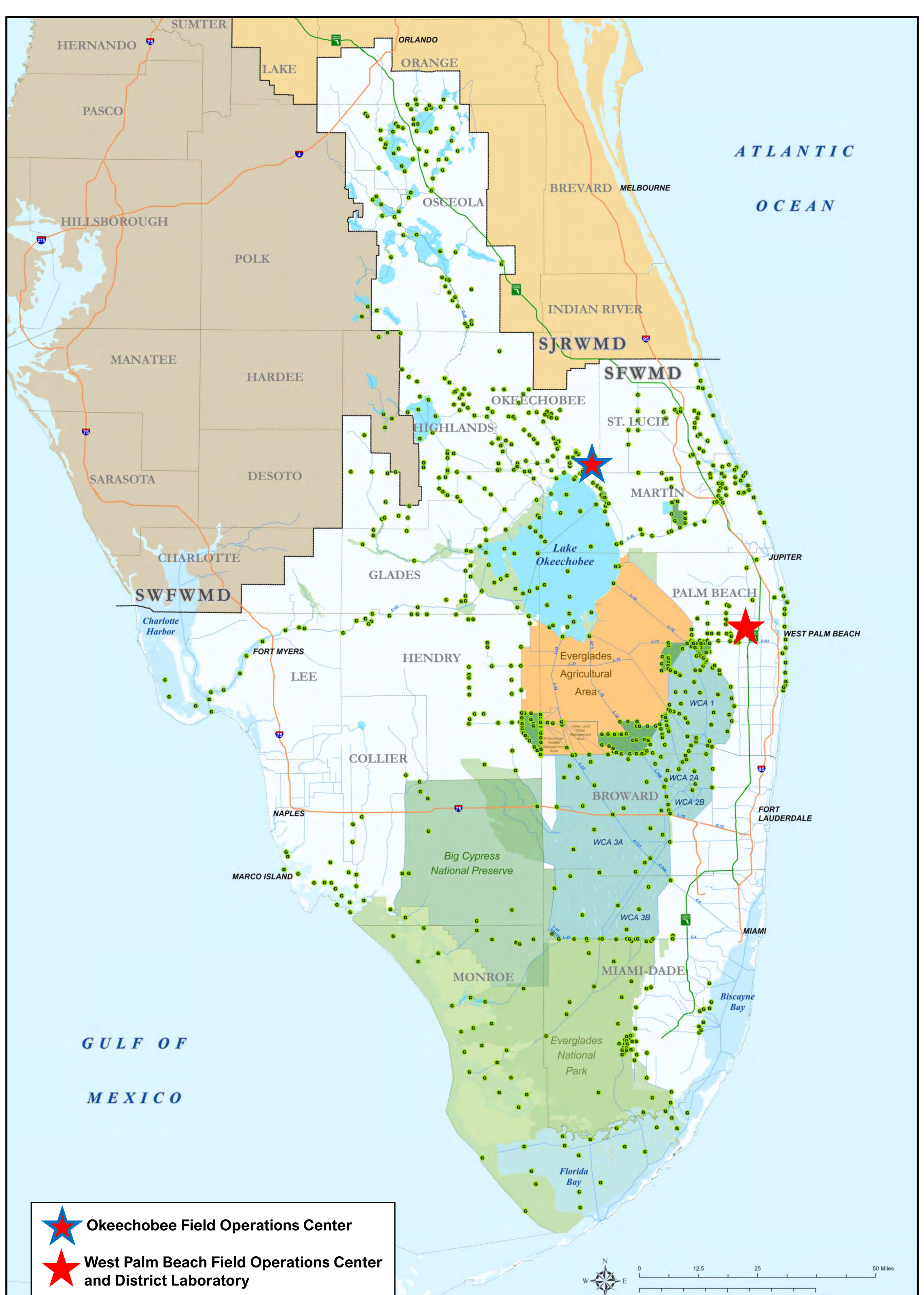
IN-SITU
Field instruments measure pH, dissolved oxygen, temperature, specific conductance, and more.

AUTOSAMPLER
Station S332DX of the Everglades National Park Inflow North project. Autosampler retrieval and system setup for the next week's sampling.

SEDIMENT
FS transect in WCA-2A. Processing a sediment sample from a coring tube for laboratory submission.

CONTINUOUS MONITORING
Station SGT5W1 in Collier County. One of the 43 continuous monitoring locations transmitting data back to District servers.

FISH COLLECTION
G-734 in Stormwater Treatment Area (STA) 1W Expansion 1. Mosquitofish collection for mercury analysis.



DBHYDRO Water Quality Monitoring: Active Surface Water Grab Stations

Monitoring Site Type	Instrumentation Used	Site Visits				Total Annual Site Visits	Total Annual Site Visits Combined	Average Weekly Site Visits
		Helicopter	Boat	Truck	Total Sites			
Surface Water		83	224	676	1,086	21,935	22,451	432
Autosampler		0	0	103				
Continuous Monitoring (e.g., In-situ field data measurement)		0	36	7	43	516		

Sample Processing

Station L001 on Lake Okeechobee. Processing routine surface water sample for laboratory submission.

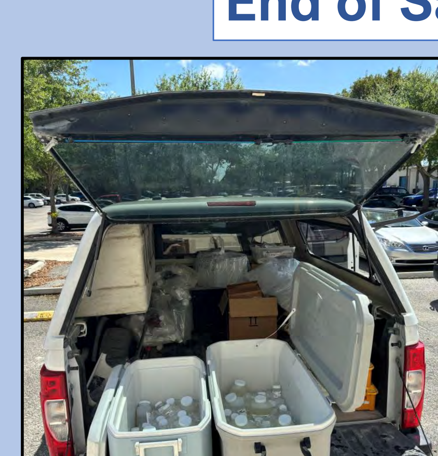
Station IRL06 in the Indian River Lagoon. Processing samples into bottles for specific lab analyses.

Station CA39 in WCA-3A. Adding acid needed for proper sample preservation.

Field Technology

Station G390B in STA-3/4. Field observations and instrument data are entered directly into the computer in the field. This maximizes efficiency and minimizes errors through an abundance of built-in cross-checks. The data and information are uploaded directly into the Laboratory Information Management System (LIMS).

End of Sampling Day

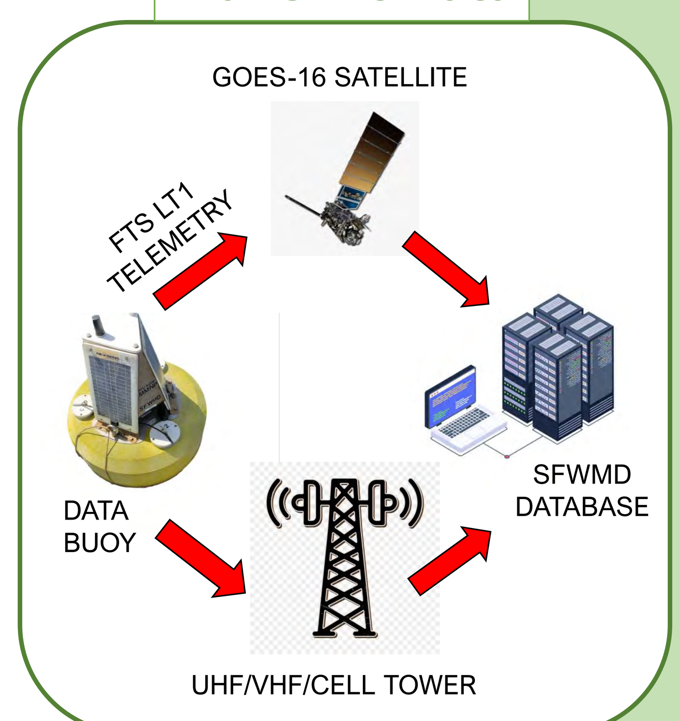


Samples are preserved (filtered, acidified, or chilled) in the field and submitted to the laboratory.

Samples are delivered to the District laboratory or shipped to an external laboratory for analysis.

Continuous Data Monitoring

Two Ways to Transmit Data



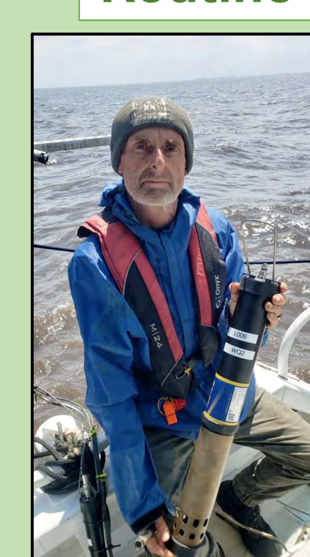
Calibration

Continuous monitoring instrument calibration at the District's Field Operations Center.

Station Installation

S-308C channel marker on Lake Okeechobee. Installing solar panels to power the deployed continuous monitoring equipment.

Routine Maintenance

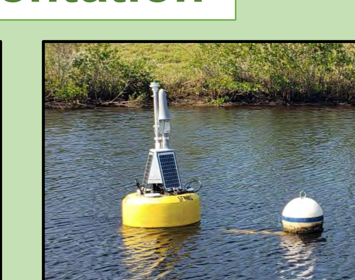


KBRN Platform in the Kissimmee River. Swapping out continuous monitoring instruments.

L006 water quality station on Lake Okeechobee. Interchanging continuous monitoring instruments.

Instrumentation

Lake Okeechobee instrumentation platform and telemetry tower.



Manatee Mitigation Feature – North Pool Instrumentation buoy. Continuous Monitoring of temperature and specific conductance data.

In-Situ data collection and telemetry equipment for upload.

Post-Calibration / Data Processing

Monthly Continuous Monitoring instrument calibration and review at the District's Field Operations Center.

Data Validation

Chemistry Laboratory

For more information:

Compliance Monitoring Plans — SCAN ME

Operational Monitoring Plans — SCAN ME

Quality First: The Environmental Laboratory Workflow, Analytical Methods, Techniques, and Applications

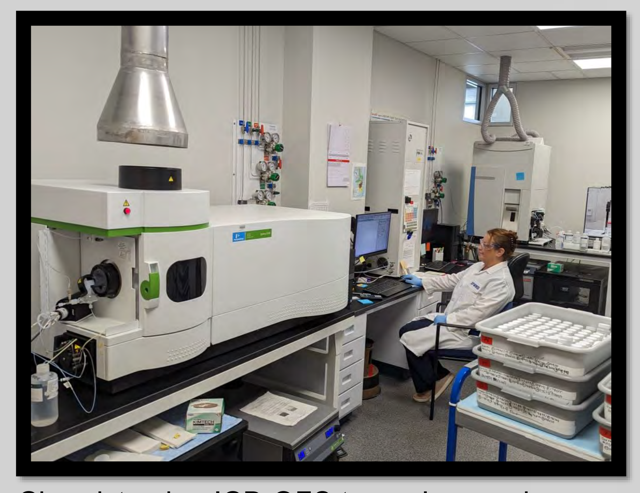
Thomas Boccio, Leidy Cruz, Anthony DeNardo, Kieth Herring, Josh Labrum, Lucrecia Poveda-Lee
Analytical Services Section, Water Quality Bureau

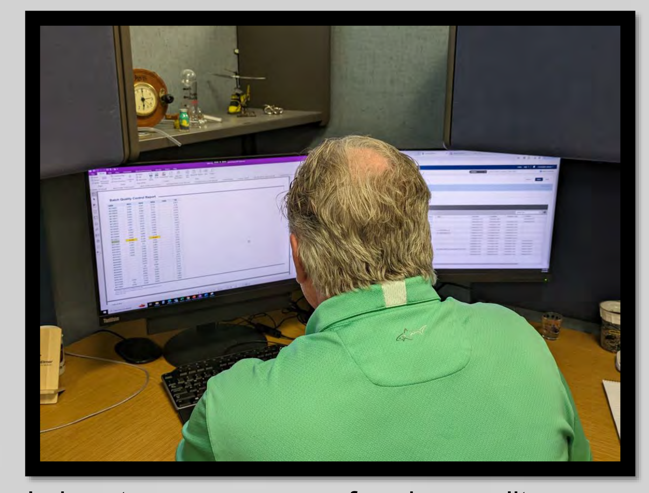
Path from Sample to Data:

Laboratory Client Services → Sample Receiving → Laboratory Analysis → Quality Assurance/ Quality Control Review → Data Validation → Database Loading → Data Accessible in DBHYDRO Insights and DataOne

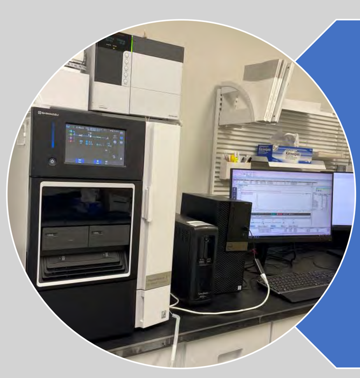

Login analyst verifying number of samples and sample pH during sample receiving.


Login analyst storing received samples in walk-in cooler for future analysis. The lab has one cooler for water samples and another for sediment and tissue samples.


Chemist using ICP-OES to analyze various metals in the sample. See below for a list of the analytical instrumentation and associated procedures.

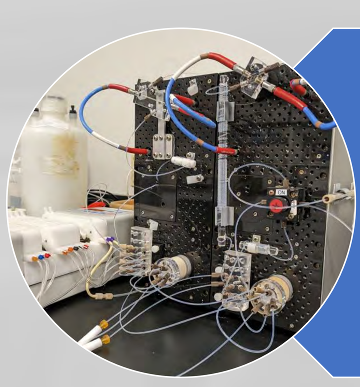

Laboratory manager performing quality review of data using the laboratory information management system (LIMS).


Quality assurance supervisor performing data validation review of LIMS data for approval to upload to the SFWMD DBHYDRO database.



High Performance Liquid Chromatography (HPLC)
- Chlorophyl a and b
- Pheophytin

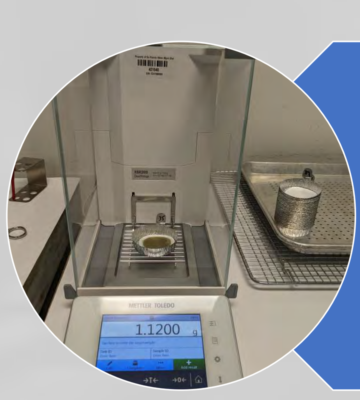
Inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES)
- Total Metals (Aqueous and Sediment/Tissue)
- Cations (Ca, K, Mg, Na, etc.)



Flow Injection Analysis (FIA/Colorimetric)
- Total Phosphorus
- Total Nitrogen
- Orthophosphate
- Nitrate/Nitrite
- Ammonia
- Silica

Titration
- Alkalinity
- pH

Combustion Analysis
- Total Organic Carbon (Aqueous)
- Total Carbon (Sediment/Tissue)
- Total Organic Carbon (Sediment/Tissue)
- Total Nitrogen (Sediment/Tissue)



Physical
- Total Suspended Solids
- Volatile Suspended Solids
- Total Dissolved Solids
- Ash Free Dry Weight
- Conductivity
- pH

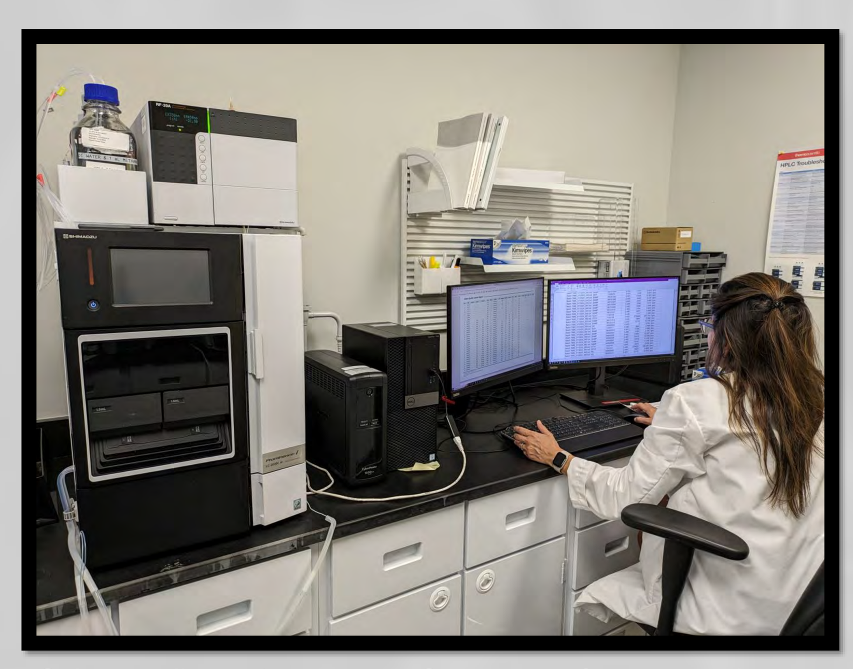
Laboratory Production, Water Year 2023 (5/1/2022 through 4/30/2023)

Laboratory Customer	Sampling Trips	Stations Visited	Field Tests Conducted	Parameters Collected (Laboratory Tests)	Total Parameters Collected (Field and Laboratory)
Water Quality Monitoring	2,621	902	49,870	114,966	164,836
Hydrology, Research and Coop Agreement	493	472	2,783	24,957	27,740

Additional Laboratory Production Metrics, Water Year 2023

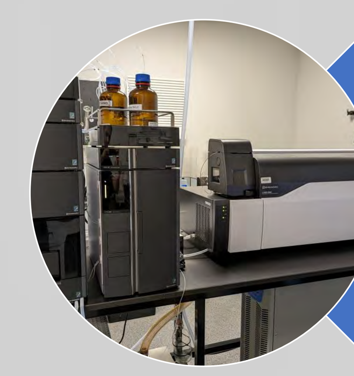
	Total
Laboratory Tests Performed (All Projects)	139,923
Field and Laboratory Total Parameters Collected (All Projects)	192,576
Projects Completed (Work Orders)	3,365
DBHYDRO Records Loaded	227,043
Watershed Information Network (WIN) Florida Department of Environmental Protection (FDEP) Database Records Loaded	96,724


Total Nitrogen: Chemist performs analysis using the FIALab FIAlyzer FLEX instrument. This instrument is versatile and is used by SFWMD laboratory analysts to perform a wide variety of inorganic nutrient analysis (TP, TN, OPO_4/NO_2, NH_4, SiO_2, etc.).


Chlorophyll and Pheophytin: Chemist performing analysis using a Shimadzu LC-2030C (High Performance Liquid Chromatography).


Total Suspended Solids: Chemist performing gravimetric analysis, a labor-intensive physical analysis to determine the amount of suspended matter in a fixed volume of a sample of surface water.

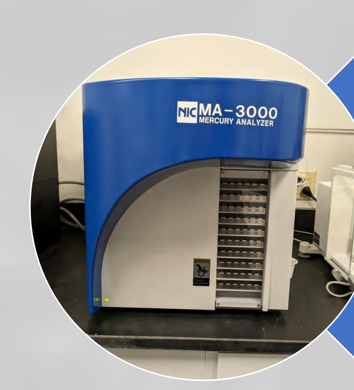

Algal Toxins: Chemist performing maintenance on a new LC MS/MS instrument used by SFWMD to analyze algal toxins.



Liquid Chromatography Tandem Mass Spectrometry (LC MS/MS)
- Algal Toxins
- Research and Development

Inductively Couple Plasma-Mass Spectrometry (ICP-MS)
- Total Metals (Aqueous & Sediment/Tissue)

Ion Chromatography (IC)
- Anions (Chloride and Sulfate)

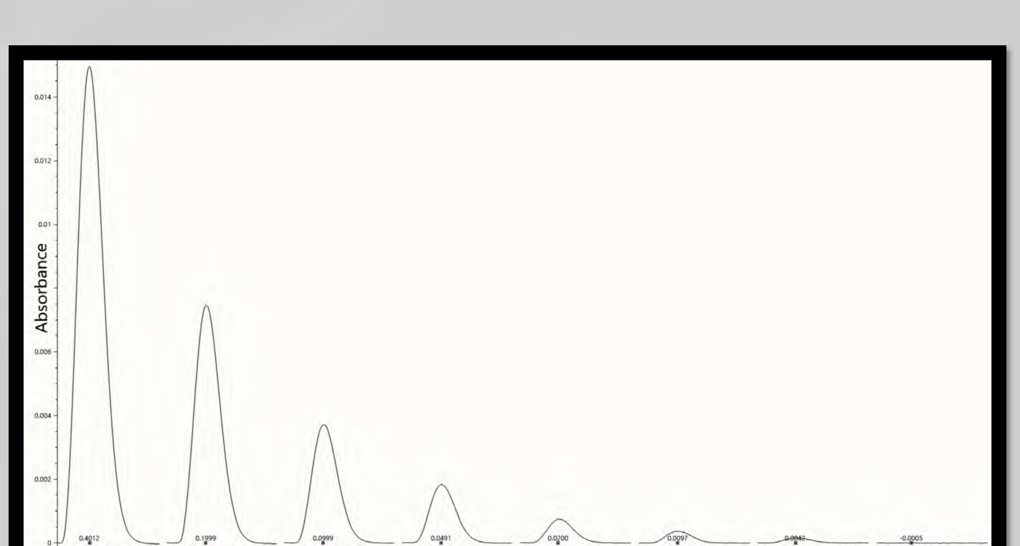


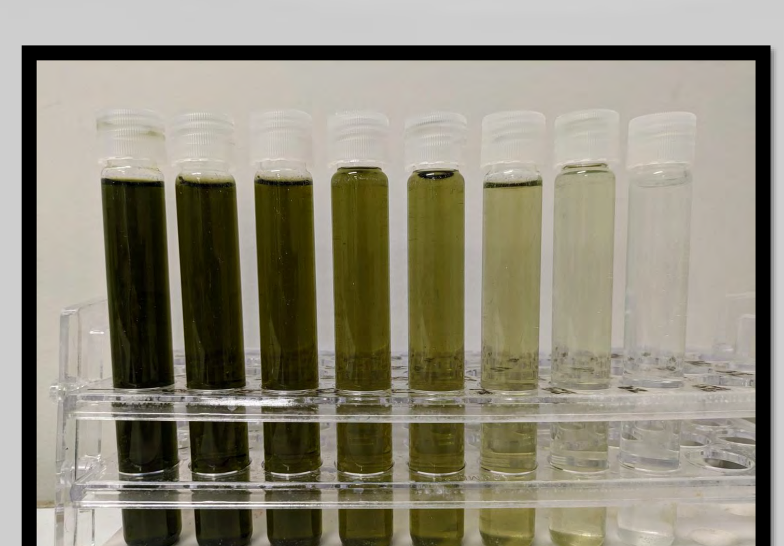
Thermal Decomposition and Atomic Absorption
- Total Mercury in Sediment and Tissue

Turbidimeter
- Turbidity

Lyophilization
- Freeze drying soil/sediment/biological tissue

The SFWMD Environmental Laboratory is accredited by the Florida Department of Health (FDOH) through the National Environmental Laboratory Accreditation Program following F.A.C 64E-1 (Certification for Environmental Testing Laboratories) and adheres to F.A.C 62-160 (Quality Assurance) to maintain the highest quality data possible.


Graphical representation of the standard curve and quality control samples produced while analyzing total phosphorus using flow injection analysis on the FIALab FIAlyzer FLEX instrumentation.


Visual representation of instrument calibration curve. Samples above range from the high concentration (left) to non-detectable concentrations (right).

For more information:

DBHYDRO Insights — SCAN ME

SFWMD DataOne Portal — SCAN ME

Chapter 2A: South Florida Hydrology and Water Management

Nicole A. Cortez, Office of District Resiliency

Mark Nissenbaum, Shi Xue, and Allison Lamb contributed to the content of this poster.

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 other events.

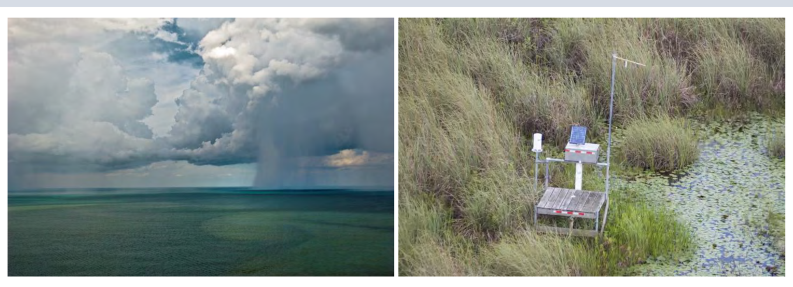
CONNECTION TO RESILIENCY

- The data presented in this chapter captures a static moment in time, reflecting the conditions during the water year. However, when interpreted alongside long-term norms, trends, and future projections, it offers insight into the variabilities over time.
- The annual cycle of analysis, documentation, and reporting facilitates the identification of evolving conditions as they unfold. This process helps pinpoint problem areas, validate modeled system deficiencies, and inform planning, enhancements, and investments for resiliency.

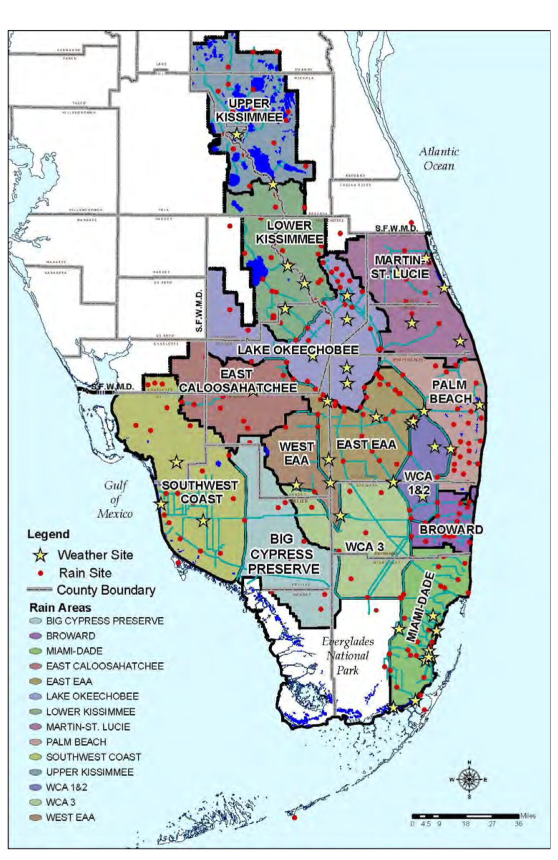
WY2023 HYDROLOGY AND WATER MANAGEMENT

- The 2024 South Florida Environmental Report (SFER) presented a large-scale overview of South Florida hydrology and water management system operations during Water Year 2023 (WY2023; May 1, 2022-April 30, 2023).
- It provided a brief introduction of the regional water management system, highlights of extreme hydrologic events, summaries of rainfall, evapotranspiration, and groundwater levels by area, a summary of wildfires, overall water management operations, and stage variations of major water bodies and surface flow across the region within the South Florida Water Management District (SFWMD) boundaries.

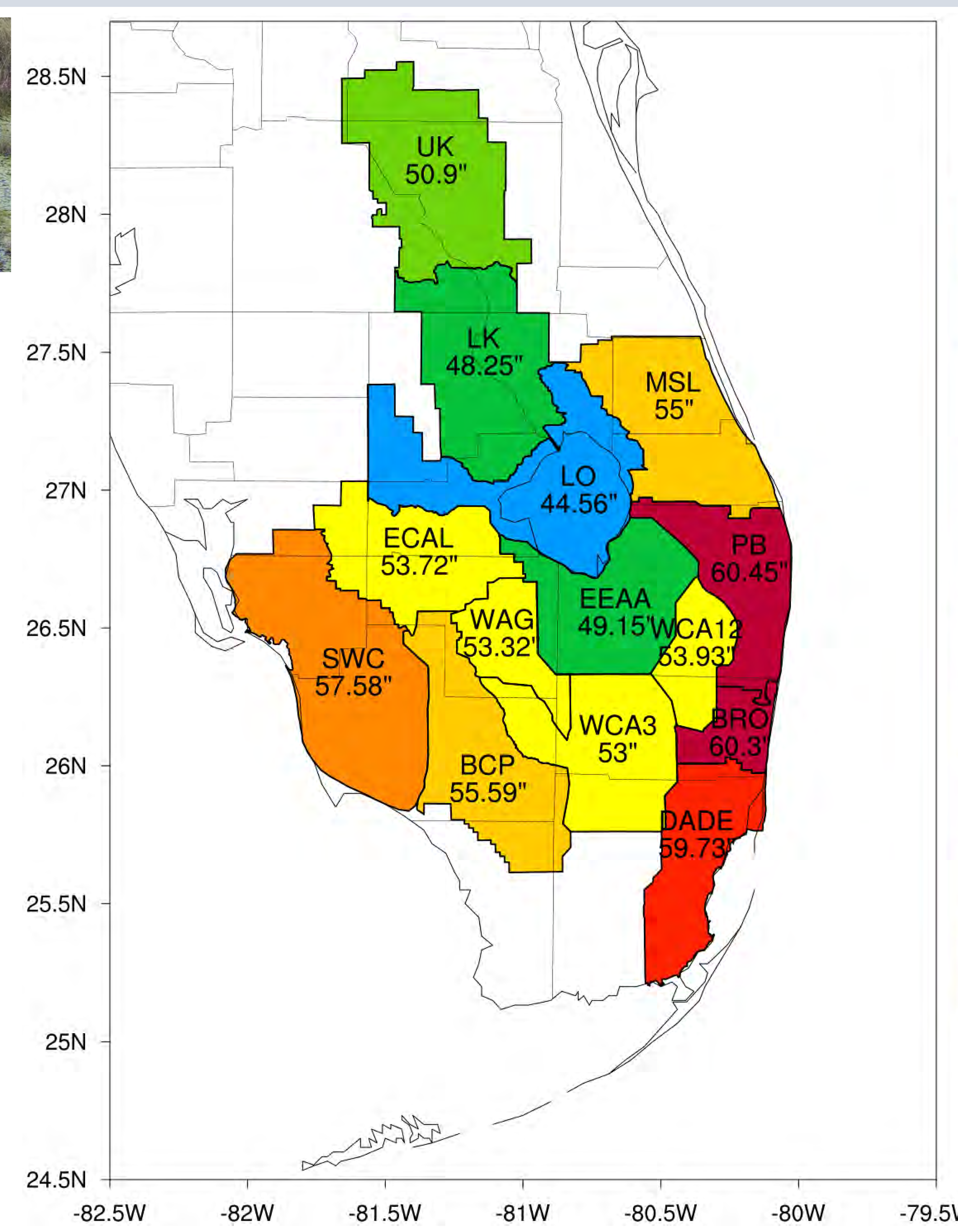
RAINFALL



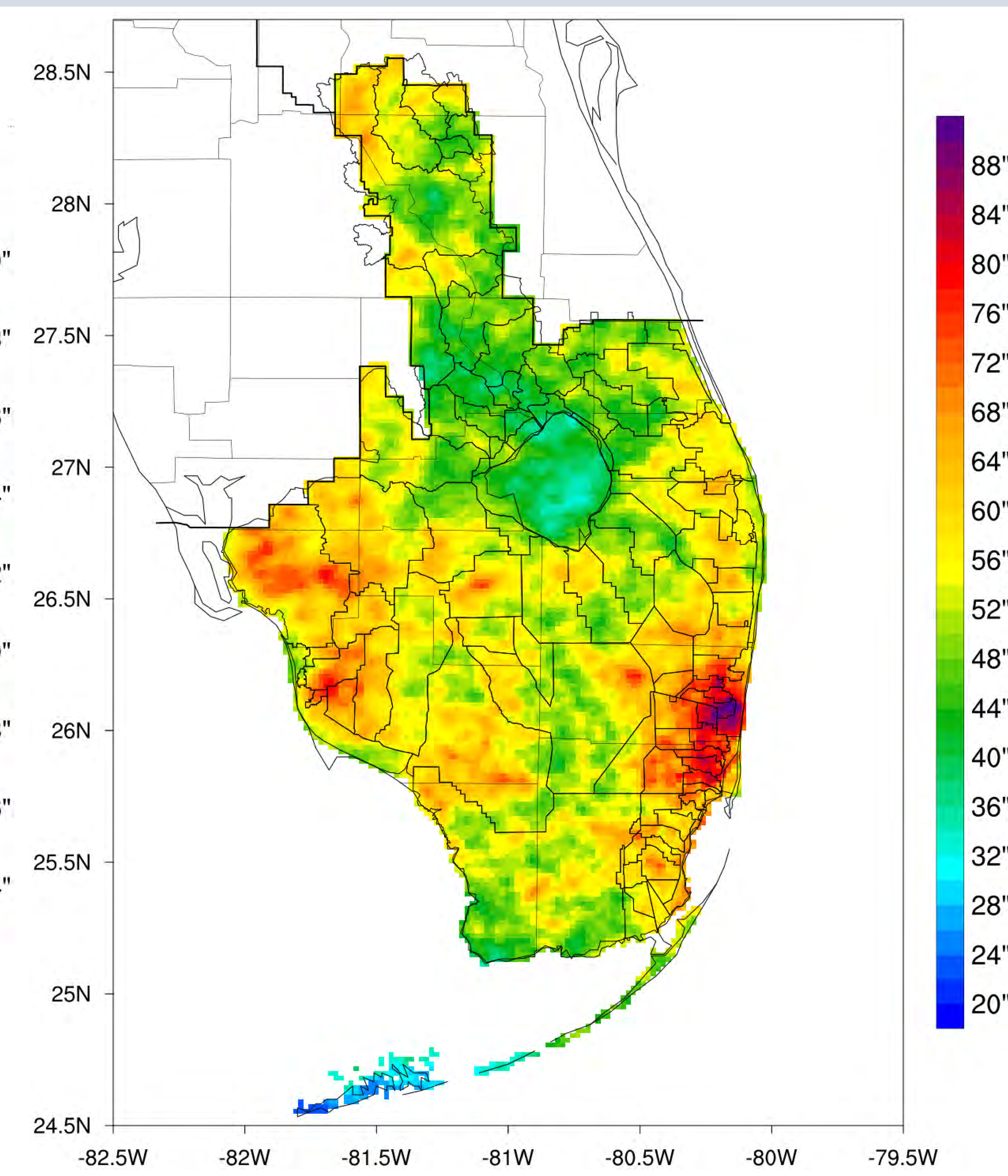
Rainfall over Atlantic Ocean east of Port St. Lucie (left). Groundwater and rainfall monitoring station in Water Conservation Area (WCA) 3 (right).



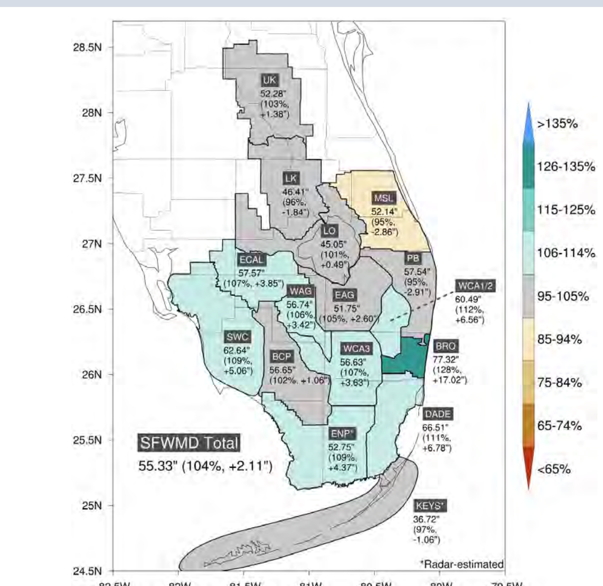
SFWMD's 14 rainfall areas.



30-Year (1991-2020) historical annual average rainfall in each rainfall area, in inches. SFWMD annual average = 53.22 inches.



WY2023 rainfall throughout the region, in inches. SFWMD WY2023 total = 54.65 inches.

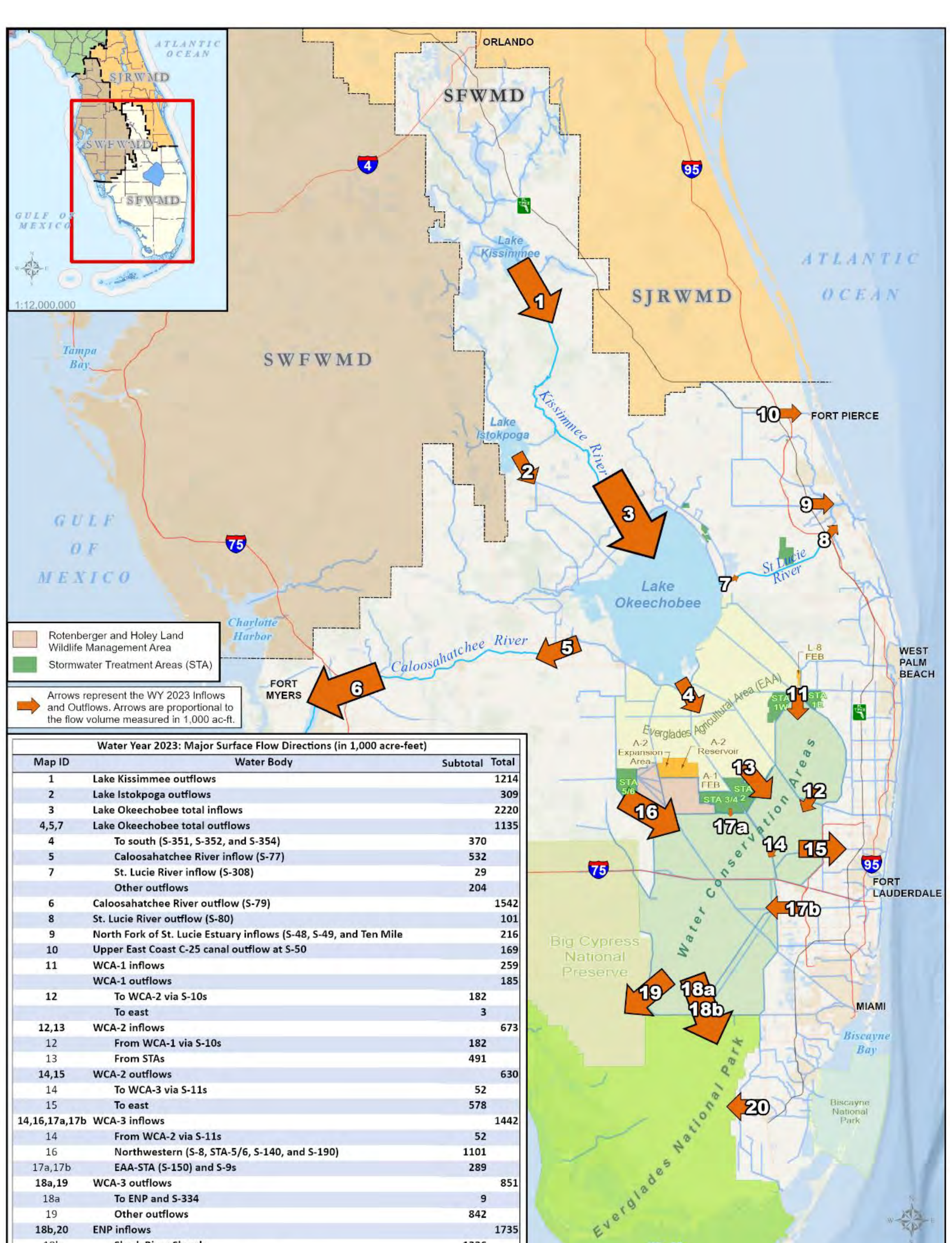


WY2023 rainfall in inches, percent of normal, and deviation from normal.

WY2023 total, historical average rainfall, WY2023 rainfall deviation from historical average, and WY2023 ETp for each rainfall area, in inches.

Rainfall Area	WY2023 Rainfall	Historical Average Rainfall	Historical Period	WY2023 Rainfall Deviation	WY2023 ETp
Upper Kissimmee	52.28	50.90	1991–2020	1.38	50.70
Lower Kissimmee	46.41	48.25	1991–2020	-1.84	53.23
Lake Okeechobee	45.05	44.56	1991–2020	0.49	57.37
East EAA	51.75	49.15	1991–2020	2.60	53.86
West EAA	56.74	53.32	1991–2020	3.42	52.41
WCA-1 & WCA-2	60.49	53.93	1991–2020	6.56	56.25
WCA-3	56.63	53.00	1991–2020	3.63	54.56
Martin/St. Lucie	52.14	55.00	1991–2020	-2.86	53.86
Palm Beach	57.54	60.45	1991–2020	-2.91	55.03
Broward	77.32	60.30	1991–2020	17.02	55.03
Miami-Dade	66.51	59.73	1991–2020	6.78	53.35
East Caloosahatchee	57.57	53.72	1991–2020	3.85	52.17
Big Cypress Preserve	56.65	55.59	1991–2020	1.06	55.03
Southwest Coast	62.64	57.58	1991–2020	5.06	53.67
SFWMD Average	**55.33**	**53.22**	**1991–2020**	**2.11**	**54.04**
Wet Season (June–September)	35.27	31.19	1991–2020	4.08	305.68
Dry Season (November–April)	13.66	13.51	1991–2020	0.15	354.59
ENP	43.90	55.00	1942–2022	-0.35	53.35

FLOWS



Water Year 2023: Major Surface Flow Directions (in 1,000 acre-feet)

Map ID	Water Body	Subtotal	Total
1	Lake Kissimmee outflows		1214
2	Lake Istokpoga outflows		309
3	Lake Okeechobee total inflows		2220
4,5,7	Lake Okeechobee total outflows		1135
4	To south (S-351, S-352, and S-354)	370	
5	Caloosahatchee River inflow (S-77)	532	
7	St. Lucie River inflow (S-308)	29	
	Other outflows	204	
6	Caloosahatchee River outflow (S-79)		1542
8	St. Lucie River outflow (S-80)		101
9	North Fork of St. Lucie Estuary inflows (S-48, S-49, and Ten Mile		216
10	Upper East Coast C-25 canal outflow at S-50		169
11	WCA-1 inflows		259
	WCA-1 outflows		185
12	To WCA-2 via S-10s	182	
	To east	3	
12,13	WCA-2 inflows		673
12	From WCA-1 via S-10s	182	
13	From STAs	491	
14,15	WCA-2 outflows		630
14	To WCA-3 via S-11s	52	
15	To east	578	
14,16,17a,17b	WCA-3 inflows		1442
14	From WCA-2 via S-11s	52	
16	Northwestern (S-8, STA-5/6, S-140, and S-190)	1101	
17a,17b	EAA-STA (S-150) and S-9s	289	
18a,19	WCA-3 outflows		851
18a	To ENP and S-334	9	
19	Other outflows	842	
18b,20	ENP inflows		1735
18b	Shark River Slough	1336	
20	Taylor Slough and Eastern Panhandle	399	

EAA - Everglades Agricultural Area, **ENP –** Everglades National Park, **STA –** Stormwater Treatment Area

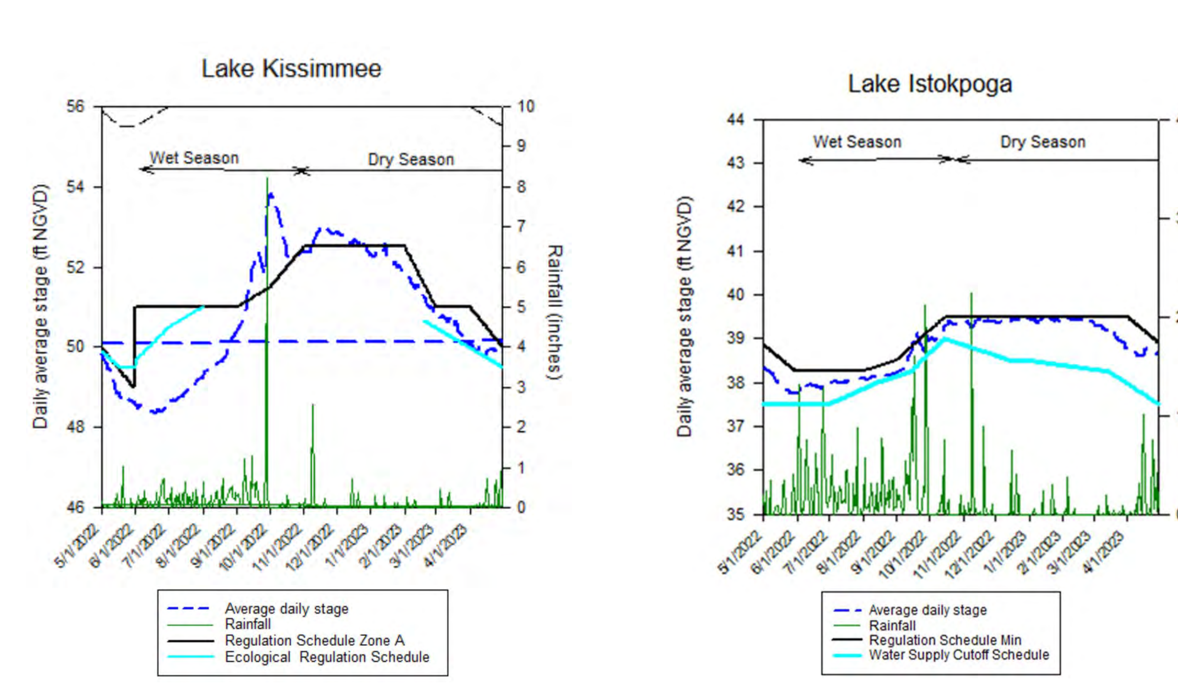
WY2023 major surface flow directions.

STAGES

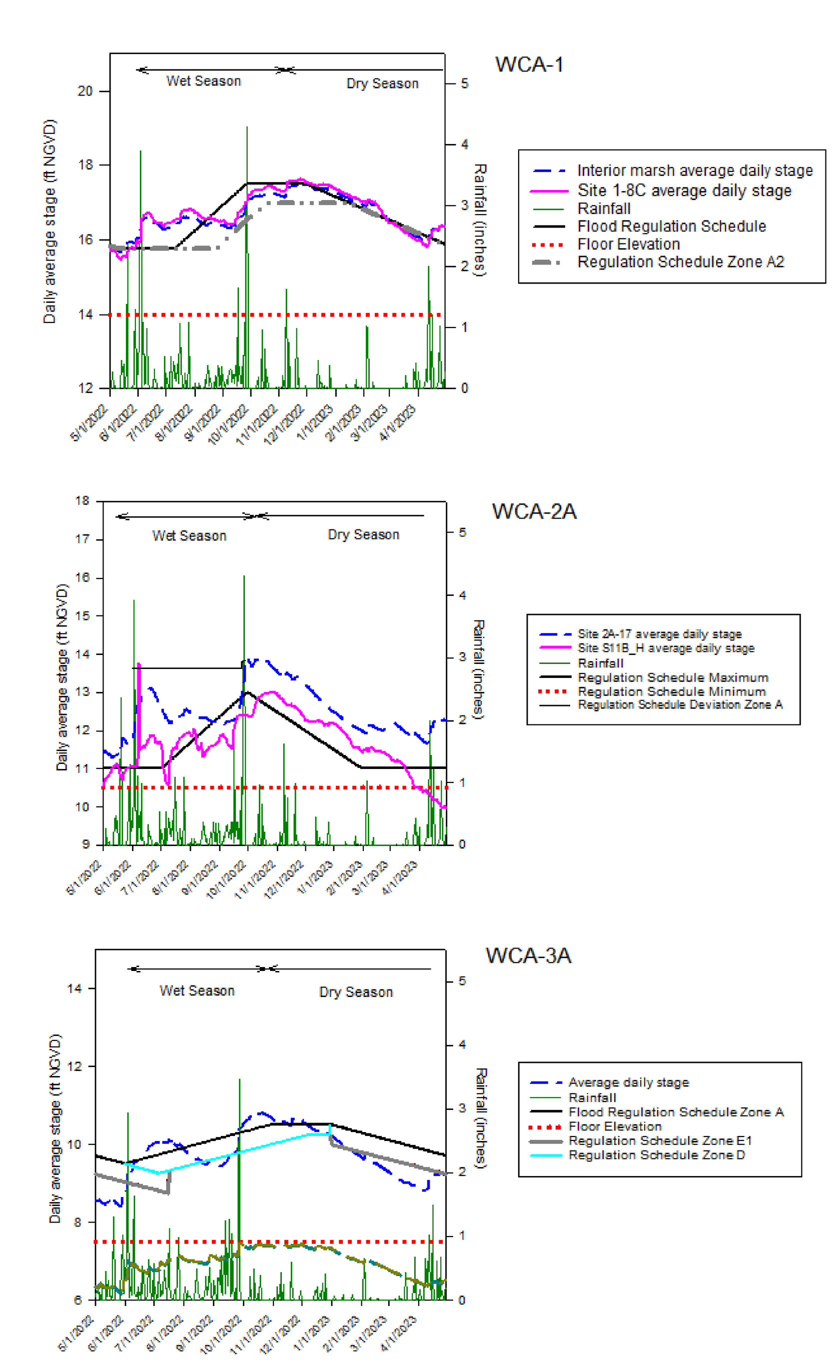
WY2023, WY2022, and historical stage statistics for major lakes and impoundments. Stages are in feet (ft) National Geodetic Vertical Datum of 1929 (NGVD29).

ENP - Everglades National Park, **WCA -** Water Conservation Area

Lake or Impoundment	WY2023 Average	Stage in Periods of Records				WY2022
		Average	Minimum	Maximum	Historic Period	
Alligator Lake	63.18	62.75	58.13	64.52	1993–2022	63.29
Lake Myrtle	61.21	60.92	58.45	65.67	1993–2022	61.07
Lake Mary Jane	60.43	60.25	57.34	63.86	1993–2022	60.31
Lake Gentry	60.83	60.76	58.31	61.97	1993–2022	60.98
East Lake Tohopekaliga	56.63	56.58	52.24	60.57	1993–2022	56.61
Lake Tohopekaliga	53.79	53.63	48.28	56.82	1993–2022	53.65
Lake Kissimmee	50.83	50.41	42.87	56.64	1929–2022	50.38
Lake Istokpoga	38.79	38.80	35.84	39.78	1993–2022	38.86
Lake Okeechobee	14.42	14.01	8.82	18.77	1931–2022	14.48
WCA-1	16.67	15.80	10.00	18.16	1953–2022	16.69
WCA-2A	12.49	12.51	9.33	15.64	1961–2022	12.50
WCA-3A	9.73	9.64	0.00	12.80	1962–2022	9.54
ENP, Slough	6.95	6.08	2.01	8.08	1952–2022	6.65
ENP, Wet Prairie	3.14	2.26	-2.69	7.10	1953–2022	2.44



Average daily water levels (stage), regulation schedule, and rainfall for Lake Kissimmee and Lake Istokpoga.



Average daily water levels (stage), regulation schedule, and rainfall for (a) WCA-1, (b) WCA-2A, and (c) WCA-3A.

For more information:

SCAN ME

Chapter 2A: South Florida Hydrology and Water Management

Storm Summaries

Nicole A. Cortez, Office of District Resiliency

Todd Kimberlain, Mark Nissenbaum, Tibebe Dessalegne, and Brad Jackson contributed to the content of this poster.

CHAPTER BACKGROUND

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WATER YEAR 2023 EXTREME EVENT SUMMARIES

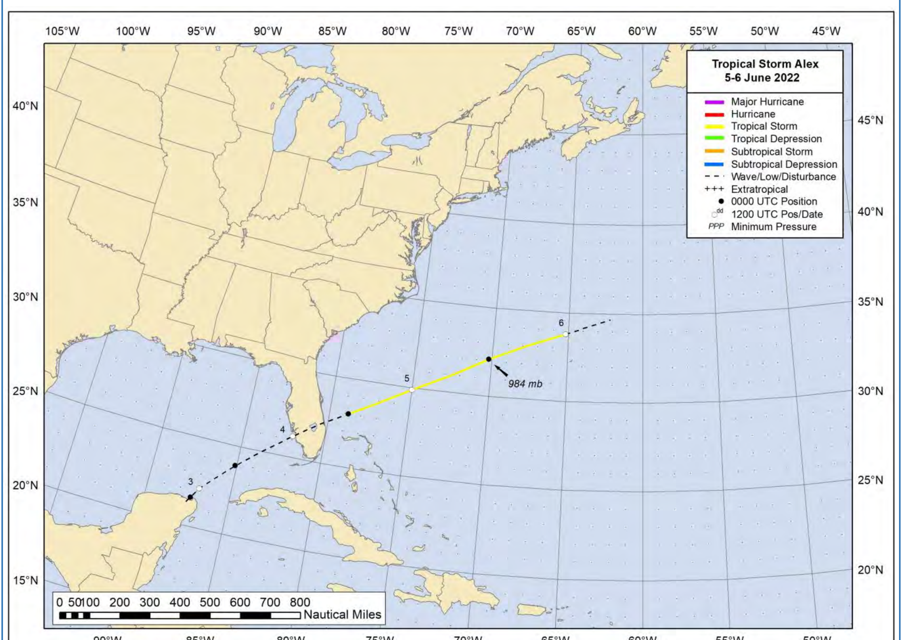
The summaries, derived from operational meetings and authoritative data sources, document key aspects of major and extreme events during Water Year 2023 (WY2023; May 1, 2022-April 30, 2023) that influenced water management. Each summary includes event type, development, pre-event conditions, observations during and after, recorded rainfall and flooding, alongside event-specific details like storm surge, wind speed, and other relevant information.

The purpose of this annual report on major tropical storms, hurricanes, and extreme rainfall events in South Florida is twofold:

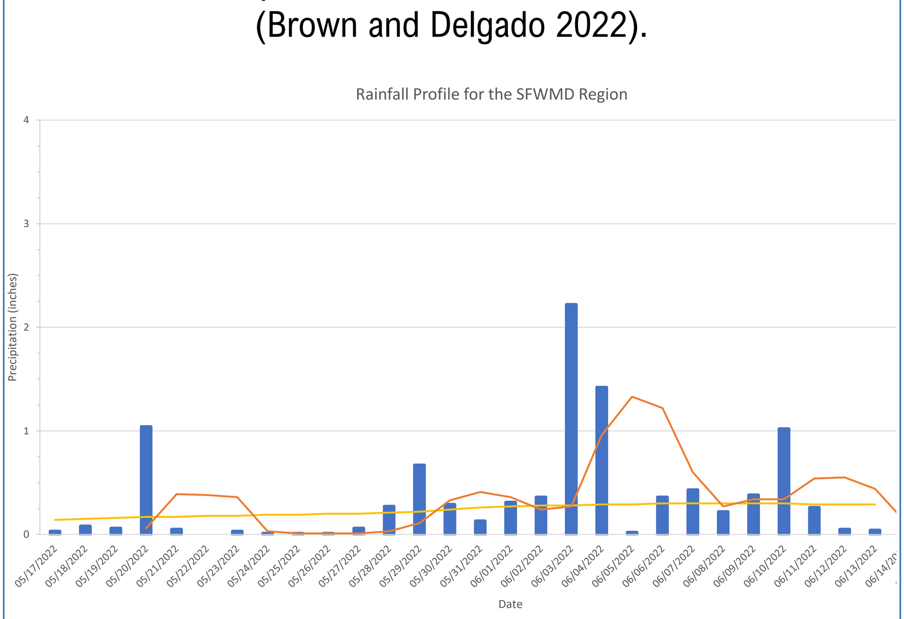
- **Document Historical Data:** It records major and extreme events impacting the region over the years, facilitating research, historical reference, and future planning. It also aids in model calibration and refinement for adaptation planning.
- **Evaluate Water Management:** The report enables analysis of the water management system's response to storms, identifying operational enhancements or necessary infrastructure investments.

Four major storm events impacted the region during WY2023: (1) Potential Tropical Cyclone One (PC1) in June 2022, (2) Hurricane Ian in September 2022, (3) Hurricane Nicole (November 7-22, 2022, and (4) an extreme rainfall event in Fort Lauderdale, located in eastern Broward County, in April 2023.

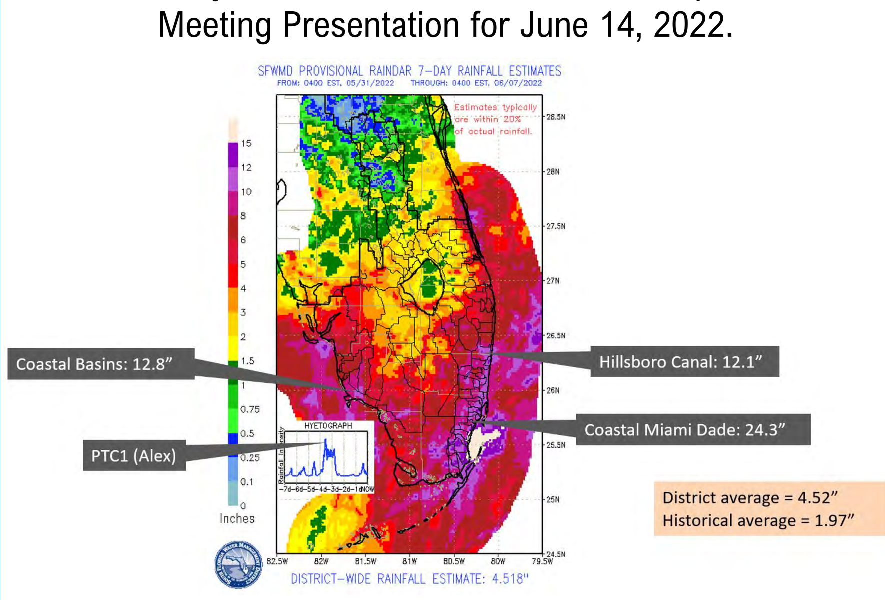
POTENTIAL TROPICAL CYCLONE ONE (PC1) – JUNE 4-5, 2022



Best track positions for TS Alex, June 5–6, 2022 (Brown and Delgado 2022).



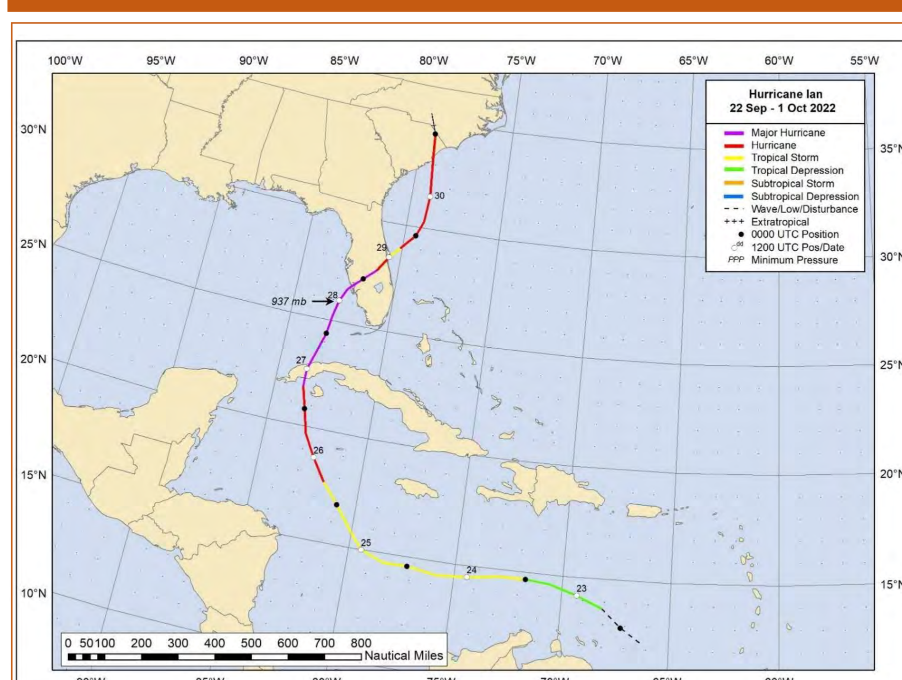
Rainfall profile for the SFWMD region before, during, and after PTC1. Data sources: https://apps.sfwmd.gov/nexrad2 and Weekly Environmental Conditions and Operations Meeting Presentation for June 14, 2022.



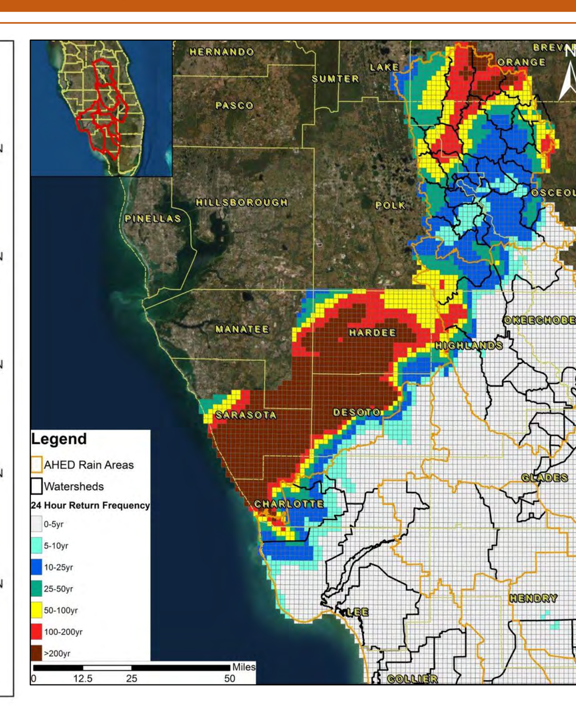
7-Day rainfall estimates May 31, 2022-June 7, 2022, over the entire SFWMD region. Source: Weekly Environmental Conditions and Operations Meeting Presentation for June 7, 2022.

PTC1 transitioned into a post-tropical cyclone then regaining tropical storm status as Tropical Storm Alex (TS Alex) upon passing east of Florida and entering the Atlantic Ocean.

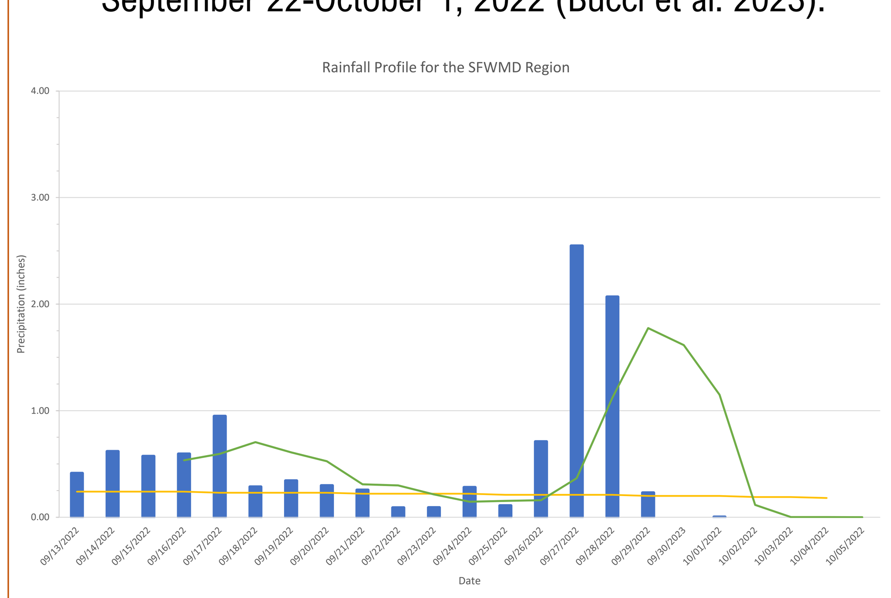
HURRICANE IAN – SEPTEMBER 27-28, 2023



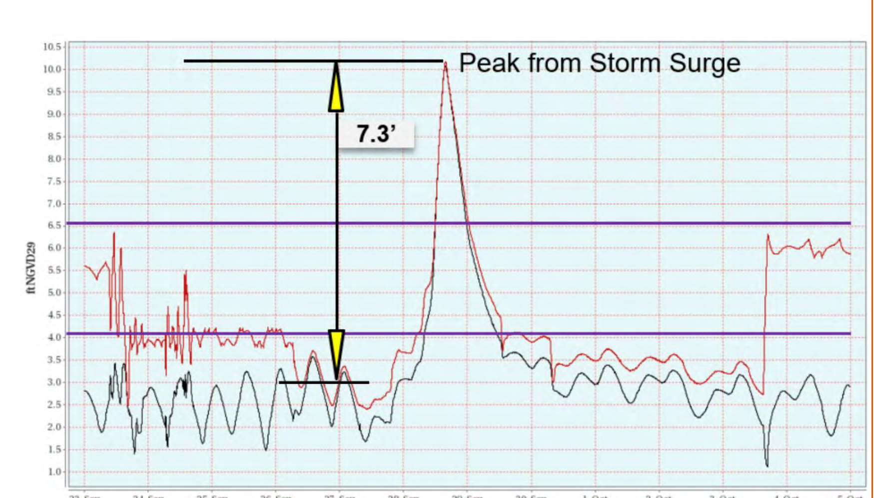
Best track positions for Hurricane Ian, September 22-October 1, 2022 (Bucci et al. 2023).



Peak 24-hr Next Generation Radar (NEXRAD) rainfall data observed during Hurricane Ian, referenced to National Oceanic and Atmospheric Administration (NOAA) Atlas 14 precipitation frequency estimates. Data source: https://apps.sfwmd.gov/nexrad2/.



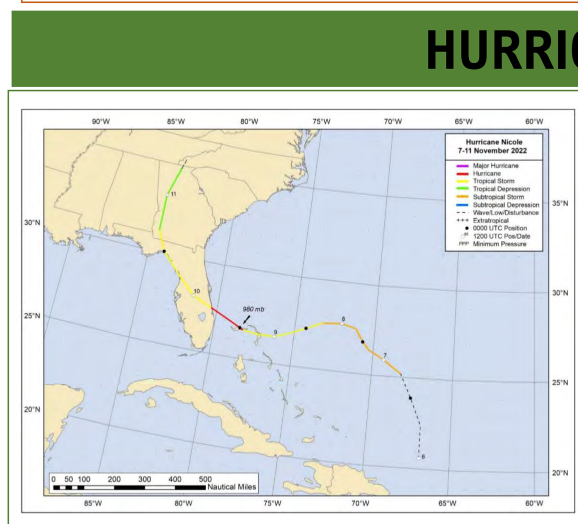
Rainfall profile for the SFWMD region before, during, and after Hurricane Ian. Data sources: https://apps.sfwmd.gov/nexrad2 and Weekly Environmental Conditions and Operations Meeting Presentation for October 4, 2022.



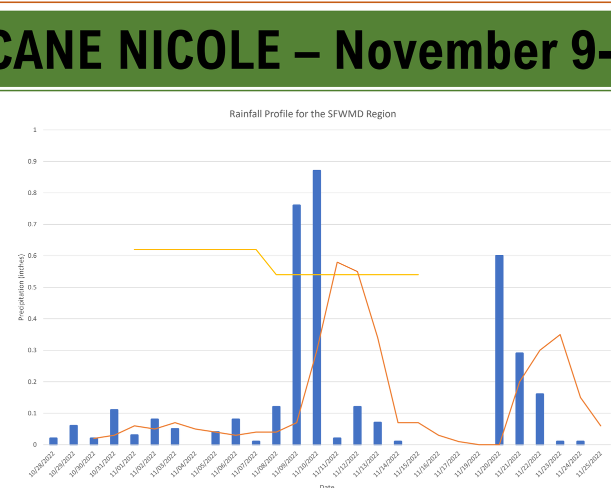
Storm surge profile analysis at COCO1 coastal structure outfall. The two purple lines denote low and high operating ranges of the structure, and the red and black lines denote the headwater and tailwater, respectively. Normally, there is several feet difference between the headwater and tailwater. During the event, when the gates were locked open, the headwater and tailwater nearly matched.

Ian ranks as the third costliest hurricane to have made landfall in the continental United States impacting Florida, Georgia, and the Carolinas.

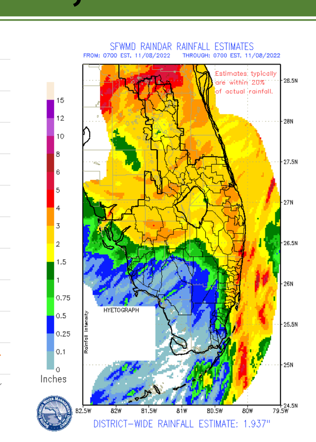
HURRICANE NICOLE – November 9-10, 2022



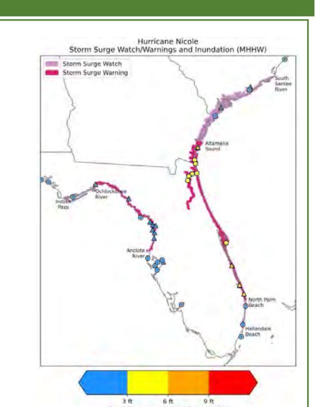
Best track positions for Hurricane Nicole, November 7–11, 2022 (Beven and Alaka 2023).



Rainfall profile for the SFWMD region before, during, and after Hurricane Nicole. Data sources: https://apps.sfwmd.gov/nexrad2 and Weekly Environmental Conditions and Operations Meeting Presentations for November 8 and 15, 2022.



Storm total rainfall associated with Hurricane Nicole, November 8-11, 2023.

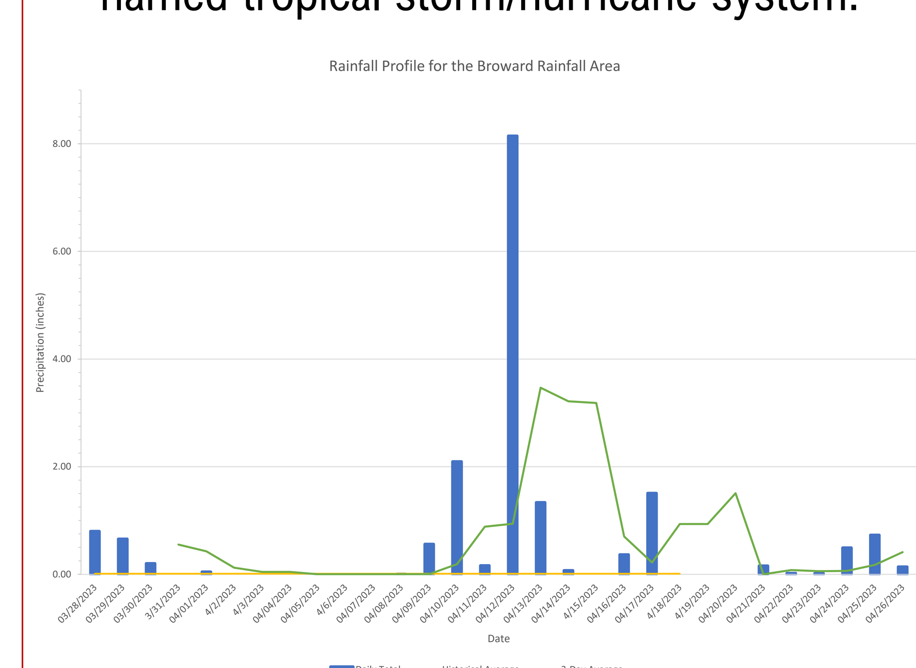


Maximum water levels measured in feet above mean higher high water (MHHW) during Hurricane Nicole (Beven and Alaka 2023).

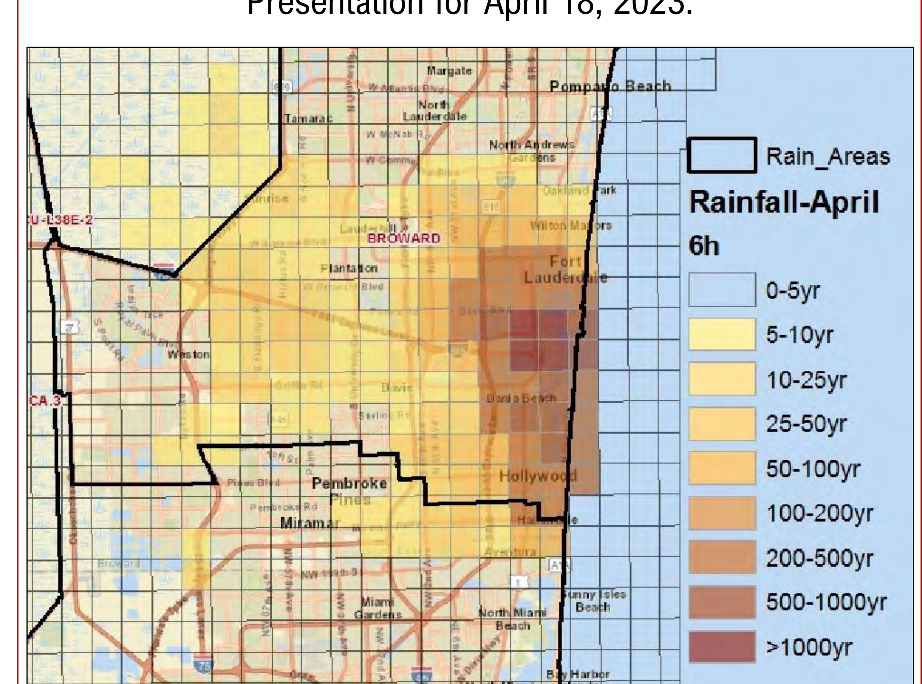
Becoming a hurricane late in the season, Nicole was only the third hurricane on record to make landfall in Florida during the month of November, with the last storm being Hurricane Kate in 1985.

FORT LAUDERDALE EXTREME RAINFALL EVENT – APRIL 13, 2023

- Wettest single-day rainfall total was the wettest for the Broward County rainfall area in the last 32 years.
- Surpasses the wettest April over the same period.
- Not associated with tropical activity or named tropical storm/hurricane system.



Rainfall profile for the Broward rainfall area before, during, and after the Fort Lauderdale extreme rainfall event. Data sources: https://apps.sfwmd.gov/nexrad2 and Weekly Environmental Conditions and Operations Meeting Presentation for April 18, 2023.



Peak 6-hour rainfall return frequency analysis for the Fort Lauderdale extreme rainfall event on April 12, 2023, data referenced to NOAA Atlas 14 precipitation frequency estimates. Data Source: https://apps.sfwmd.gov/nexrad2/.

Set the state's wettest day on record registered at the Fort Lauderdale-Hollywood International Airport WeatherSTEM weather station.

For more information: SCAN ME

Chapter 2B: Water and Climate Resilience Metrics

Trends in Tidal Elevations at Coastal Structures in South Florida

Tibebe Dessalegne, Nicole Cortez

BACKGROUND

To assess the effects of sea level rise on stormwater discharge capacity and saltwater intrusions risks in South Florida, the tidal elevation data at SFWMD's thirty-two coastal structures (**Figure 1**) is examined as part of the Water and Climate Resilience Metrics. The analysis was conducted on long-term water level observations taken at downstream of coastal structures. The results of this data analysis, combined with flood protection level-of-service performance analysis, help identify limitations and deficiencies in flood control infrastructure.

DRIVERS AND INFLUENCING FACTORS

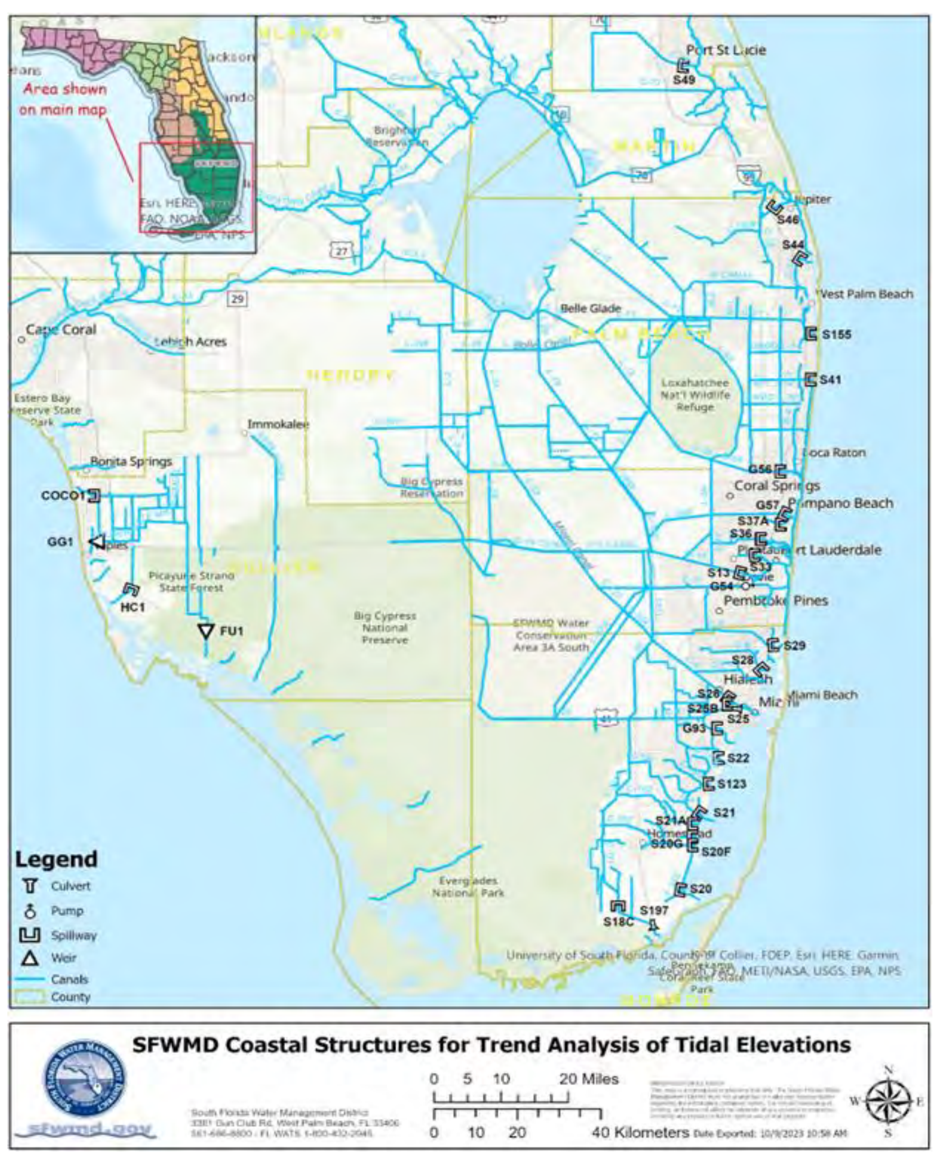


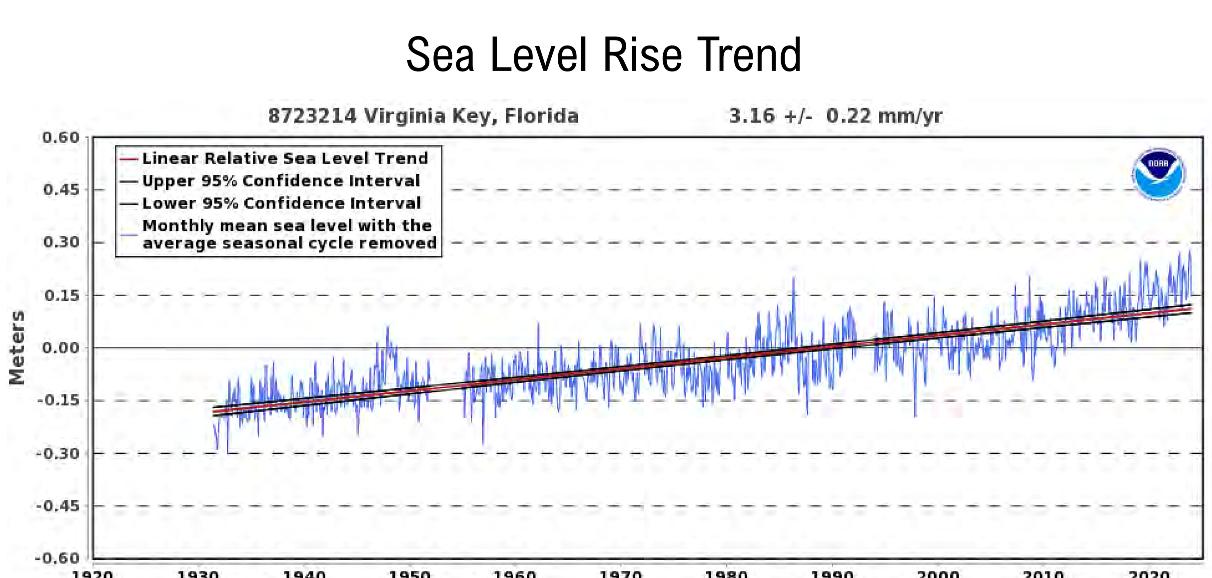
Figure 1. Locations of the 32 SFWMD-operated coastal structures used in the analysis.

Sea level rise: As global sea levels continue to rise, coastal gravity structures face increased pressure to prevent saltwater intrusion into freshwater systems. Rising sea levels can also lead to higher downstream water levels in canals and estuaries, making it more challenging to maintain the necessary balance between salt and fresh water.

Changes in precipitation patterns and extreme events: As climate conditions evolve, South Florida may experience altered precipitation patterns, relative to historical observations, including more extreme rainfall and extreme drought occurrences, along with shifts in dry and wet season duration and averages. These scenarios will impact the overall water levels, discharges, and flow capacity at the coastal gravity structures, requiring adaptive management strategies to cope with the changed environment.

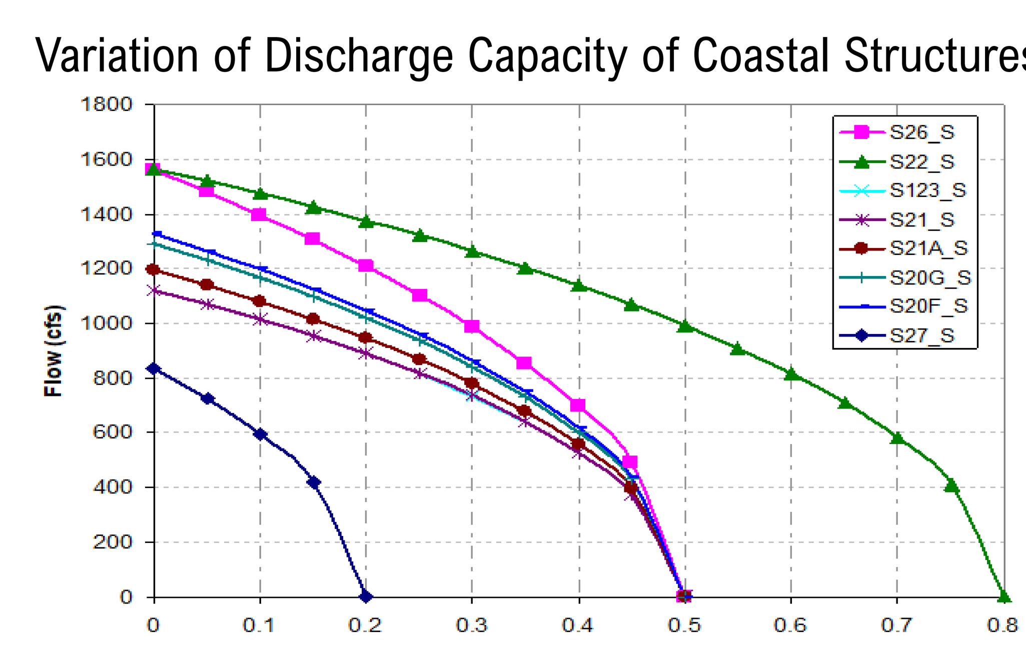
Storm Surge: South Florida is prone to hurricanes and tropical storms, along with storm surges. These surges can lead to destructive flooding and erosion, potentially damaging or compromising coastal infrastructure.

Gulf Stream Effects: The Gulf Stream, a strong and fast-moving ocean current off the coast of Florida, may contribute to local tidal levels in South Florida. Though it is important to note that the interaction between the Gulf Stream and local tidal levels in South Florida is complex, involves several global mechanisms, and varies temporally. Its influence on local tidal levels can vary depending on factors such as the Gulf Stream's distance from the coast, its strength, and the characteristics of the coastline. Additionally, other local factors, such as winds and atmospheric pressure, can also influence tidal levels in conjunction with the Gulf Stream. Understanding the complex interactions between the Gulf Stream and local tidal levels is essential for coastal planning, management, and hazard mitigation in Florida.



mm/yr – millimeters per year, **NOAA** – National Oceanic and Atmospheric Administration

Figure 2. Relative Sea Level Trend at the Virginia Key, Florida tide station (1931-2023). Source: NOAA Tides & Currents - Sea Level Trends.



cfs – cubic feet per second, **ft** – feet.

Figure 3. Correlation between reduction in discharge capacity and the corresponding increase in tailwater levels based on specific design conditions.

Figure 4. Typical coastal structure.

OBSERVED TRENDS

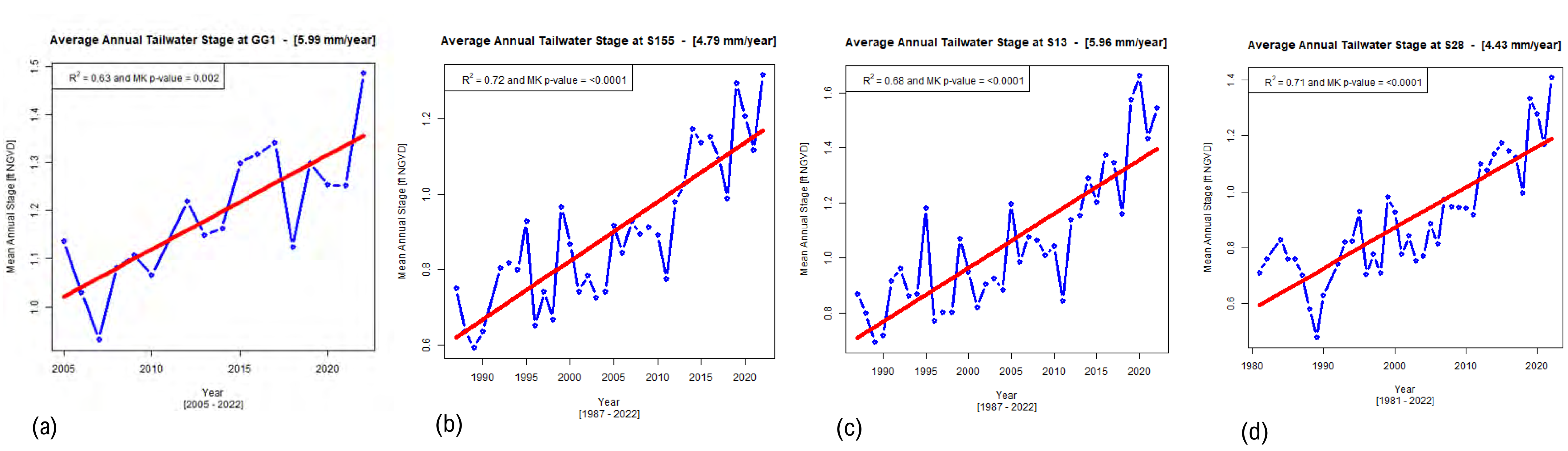


Figure 5. Plotted average annual tailwater stage and trendline at the (a) GG1 structure along South Florida's west coast; and (b) S-155, (c) S-13, and (d) S-28 structures along South Florida's east coast.

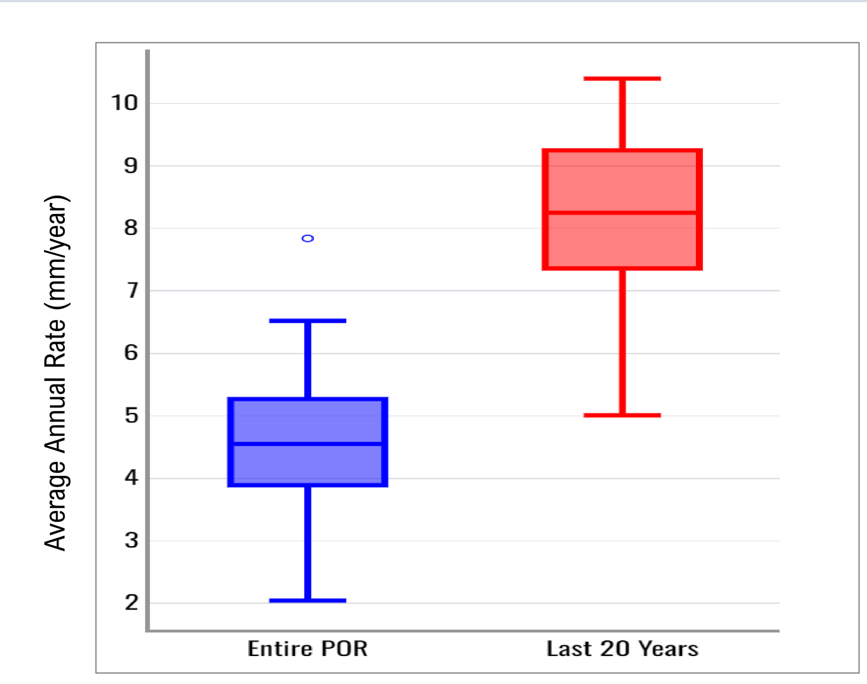


Figure 6. Comparison of average annual water level change distributions – entire period of record versus last 20 years. Source: Dessalegne 2024.

Dessalegne, T. (2024). *Characterizing Water Level Trends at South Florida Coastal Structures.* University of Florida Water Institute Symposium, Gainesville, FL, February 20-21, 2024.

CONCLUSION

- Tidal water level data collected at 32 SFWMD-operated gravity coastal structures between 1967 and 2022 exhibit statistically significant upward trends based on Mann-Kendall statistical test.
- Trend analysis revealed that over the past 20 years, annual average tidal stages had rapid increases.
- To address the risks associated with these upward trends in tidal water levels at coastal gravity structures, the South Florida Water Management District, in partnership with federal, state, and local governments and local water management districts in South Florida, are actively engaged in comprehensive flood resiliency studies, conducting monitoring and modeling exercises to assess system vulnerabilities and developing adaptive strategies to ensure the resilience and effectiveness of the Central and Southern Florida Flood Control Project (C&SF Project) water management system and its coastal gravity structures under changing climatic conditions.

For more information: SCAN ME

Chapter 2B: Water and Climate Resilience Metrics

Trends in Minimum Flows and Minimum Water Levels in South Florida - Biscayne Aquifer

Karin Smith, P.G., Nicole Cortez

Mark Elsner and Pete Kwiatkowski contributed to the content of this poster.

BACKGROUND

The establishment and implementation of minimum flows and minimum water levels (MFLs) are essential tools for maintaining the resilience of aquatic ecosystems and supporting adaptive water management practices amid changing climate conditions and associated environmental challenges. MFLs are defined as the minimum flows or minimum water levels for select water bodies (rivers, bays, estuaries, wetlands, lakes, aquifers), at which further permitted water withdrawals would be significantly harmful to the water resources or ecology of the area. Prevention or recovery strategies are adopted to help maintain or achieve the established MFL for the water body.

DRIVERS AND INFLUENCING FACTORS

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: SFWMD staff.

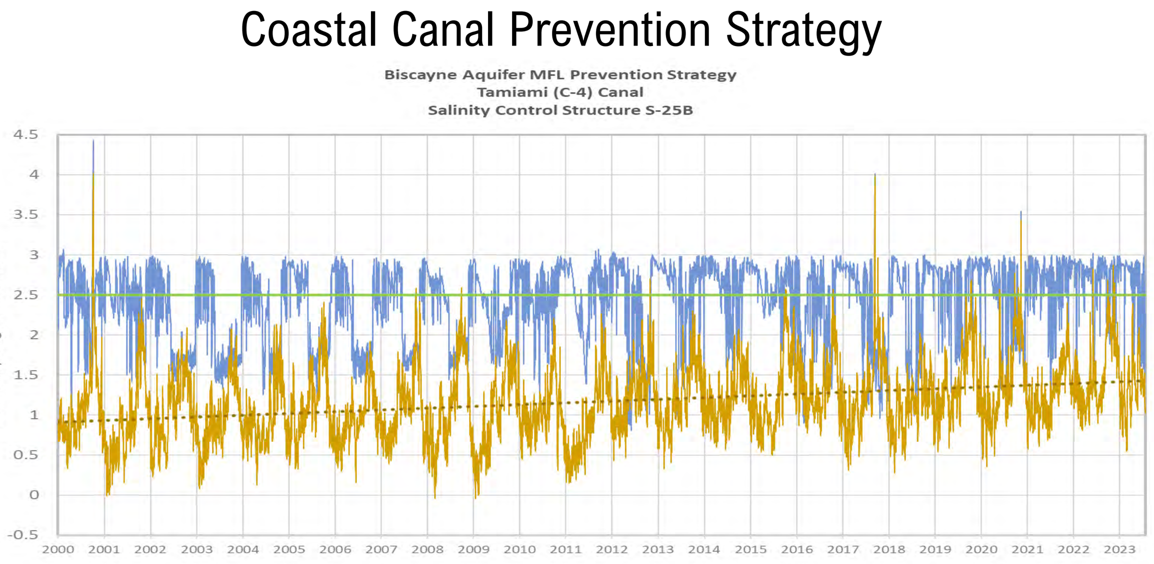
The Biscayne Aquifer is a crucial groundwater resource supporting the following:

- Drinking water for millions of residents
- Water for agriculture and industry

Significant harm occurs when the following occurs:

- Inland migration of saline water degrades water quality
- Established well or surface water withdrawal point can no longer serve as a water supply source

Coastal Canal Prevention Strategy



NGVD – National Geodetic Vertical Datum of 1929

Structure S-29 headwater and tailwater plotted relative to minimum operation level.

Rainfall: Groundwater levels are influenced by local rainfall volumes; both storms and droughts.

Canal Operations: Canals play a significant role in determining the elevation of freshwater levels in the Biscayne aquifer near the canals.

Permitted Wellfield Pumpage: Pumping water affects groundwater levels. Permit conditions provide clear standards to protect the aquifer by maintaining water levels, which reduce the potential for saltwater intrusion.

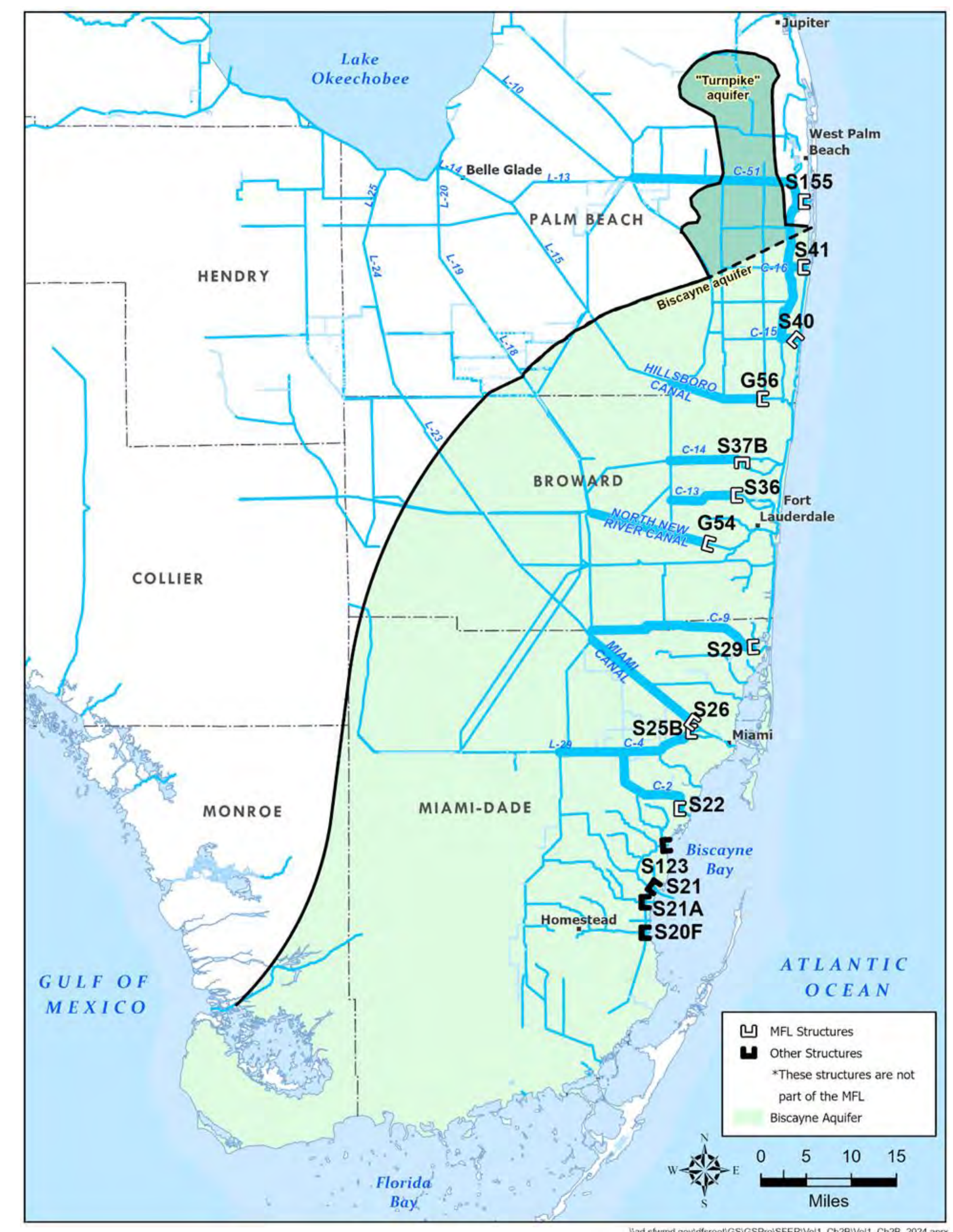
Saltwater Intrusion: With sea level rise and prolonged reductions in inland water levels, the saltwater interface can advance inland, threatening the aquifer's freshwater quality.

Long-term Low Water Levels: When water levels in the canals and aquifer remain low for an extended period, significant inland migration of the freshwater-saltwater interface may occur.

Water Levels at Salinity Control Structures

NGVD – National Geodetic Vertical Datum of 1929

Downstream and upstream water levels at 11 salinity control structures. Source: South Florida Water Management District (SFWMD) DBHYDRO.

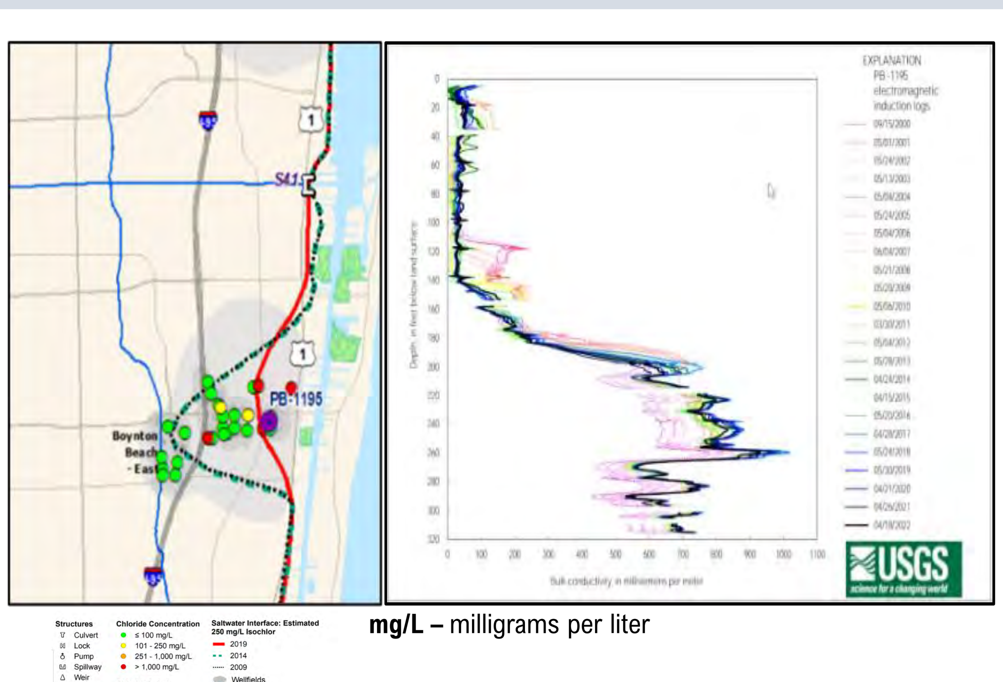


Salinity control structures with Biscayne aquifer MFL minimum operating levels.

Biscayne Aquifer MFL Prevention Strategies

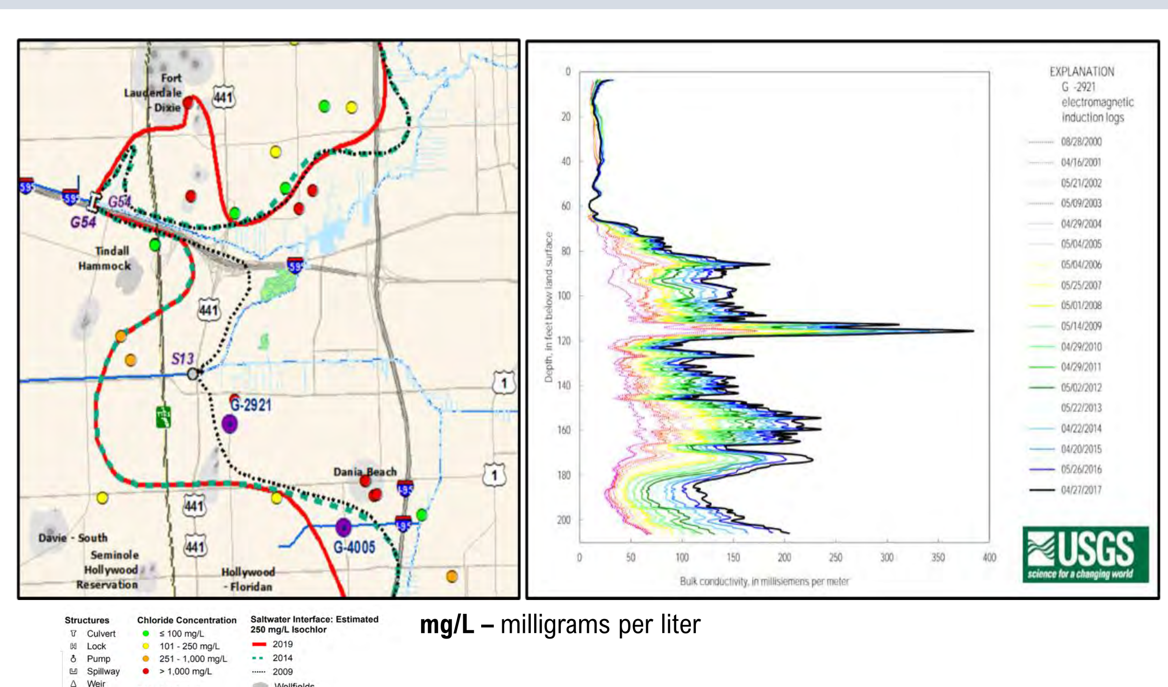
- Maintaining minimum canal stages upstream of 11 salinity control structures
- Constraints in water use permits
- Monitoring and research
- Water resource and water supply development projects

OBSERVED TRENDS



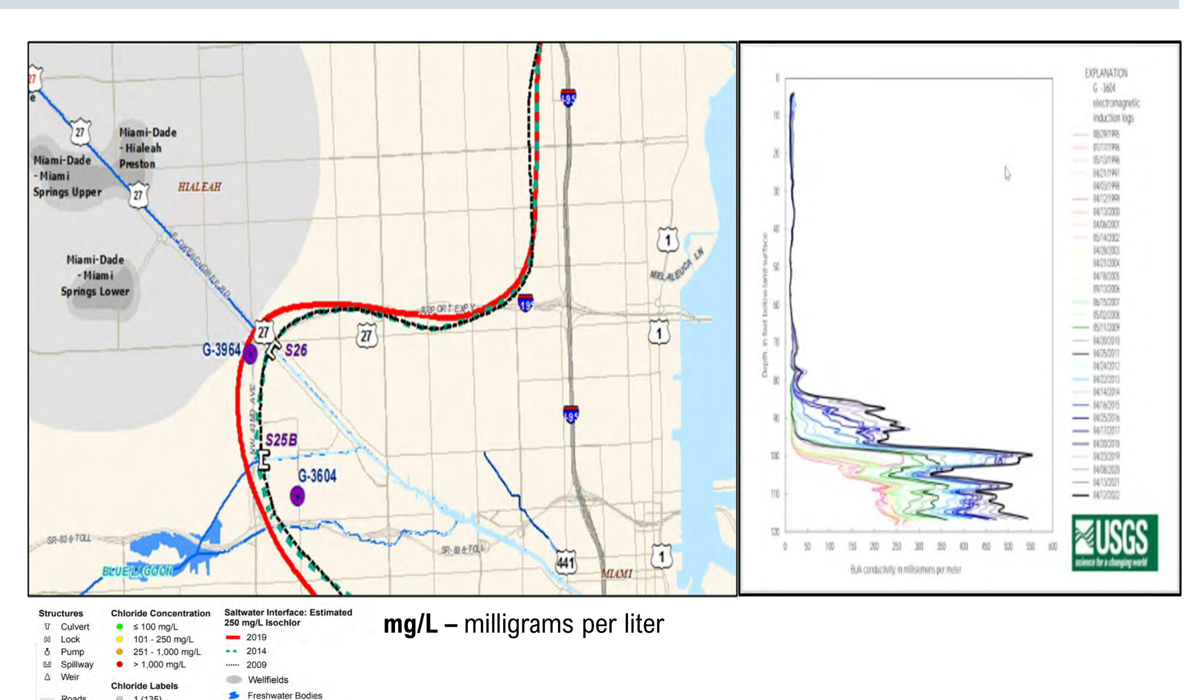
mg/L – milligrams per liter

Evidence of eastward saline migration after pumpage reduction around Boynton Beach (left panel) and induction log for monitor well PB-1195, which shows decline in bulk conductivity from 100 to 200 feet depth but increasing annually below 200 feet (black line 2022; right panel). Sources: SFWMD 2019, USGS 2023.



mg/L – milligrams per liter

Westward (inland) movement of saltwater interface impacting Dania Beach and Hallandale wellfields (left panel) and induction log for monitor well G-2921, showing increasing bulk conductivity annually (black line 2017) with preferential intrusion at depth of area wellfield withdrawals (right panel). Sources: SFWMD 2019, USGS 2023.



mg/L – milligrams per liter

Westward (inland) movement of the saltwater towards Miami-Dade wellfields (left panel) and induction log for monitor well G-3604, showing increasing bulk conductivity annually (black line 2022) at base of aquifer (right panel). Sources: SFWMD 2019, USGS 2023.

CONCLUSIONS

- As sea level rises, the ability to operate salinity control structures with a sufficient headwater/tailwater difference to prevent saltwater intrusion while providing adequate flood protection will be physically challenging.
- Since the time of MFL implementation, SFWMD has implemented more direct measures to evaluate saltwater intrusion including increased chloride monitoring of wells, electromagnetic induction logs in select wells, and regional saltwater interface mapping efforts. In addition, density-dependent groundwater models are being developed to more explicitly simulate saltwater intrusion and the effects of sea level rise and climate change.
- Technological advances will enable SFWMD to better protect resources by proactively identifying areas of concern, providing time to manage wellfield operations, and identify alternative water supply sources to meet future water demands.

For more information: SCAN ME

Chapter 2B: Water and Climate Resilience Metrics

Trends in Flood Occurrences in South Florida

Christine Carlson, Nicole Cortez

Azizbek Nuriddinov, Florida State University, 2023 intern with Office of District Resiliency, contributed to the content of this poster.

BACKGROUND

Flood occurrence data collected in South Florida identified an initial set of 25 flood prone areas within the South Florida Water Management District (SFWMD) region. These data will contribute to flood risk management, adaptive strategies, and incident response and help better inform regional and local governments and water managers on flood occurrence within the primary, secondary, and tertiary systems. Additionally, ongoing efforts to collect flood observations using the Document the Floods Survey will be used in conjunction with satellite and radar imagery acquisition to provide more comprehensive and quantitative information about flood occurrence and extent.

FLOOD PRONE AREA DETERMINAATION

Flood Prone Area = Locations with recurrent flood occurrence associated with rainfall, storm surge, tidal, and compound flooding.

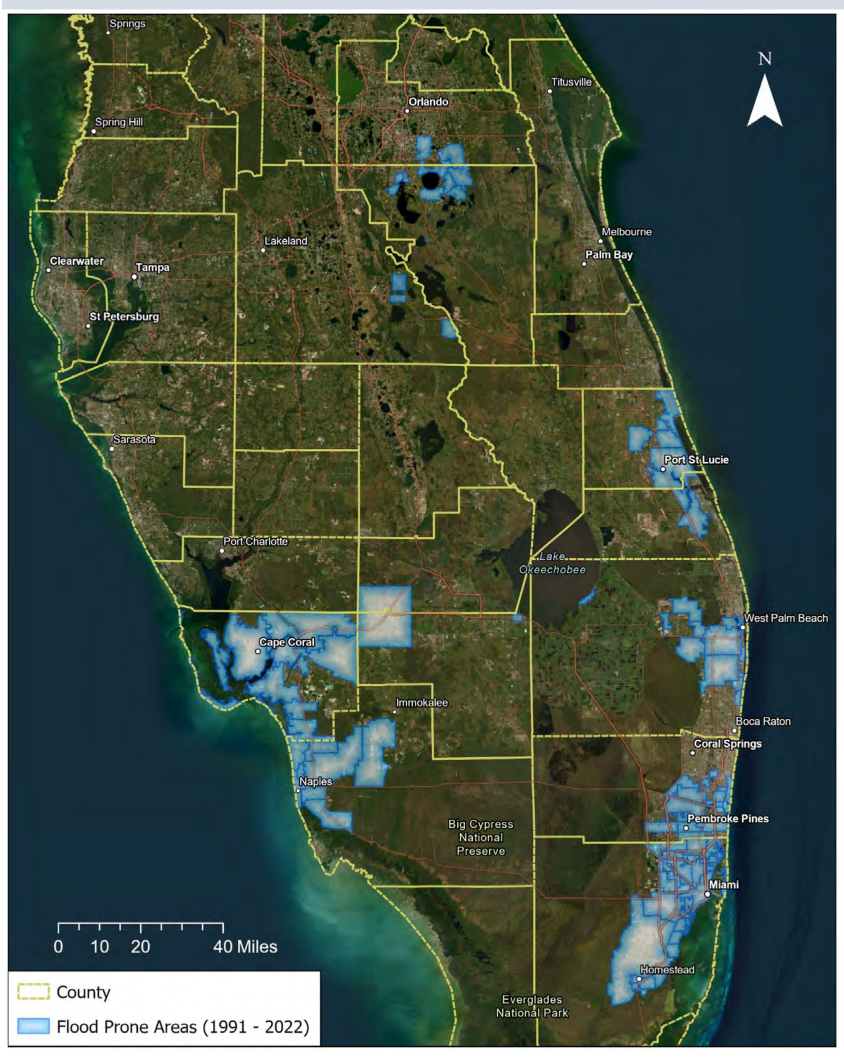


Figure 1. Map of flood prone areas based on established data sets and historically impacted areas.

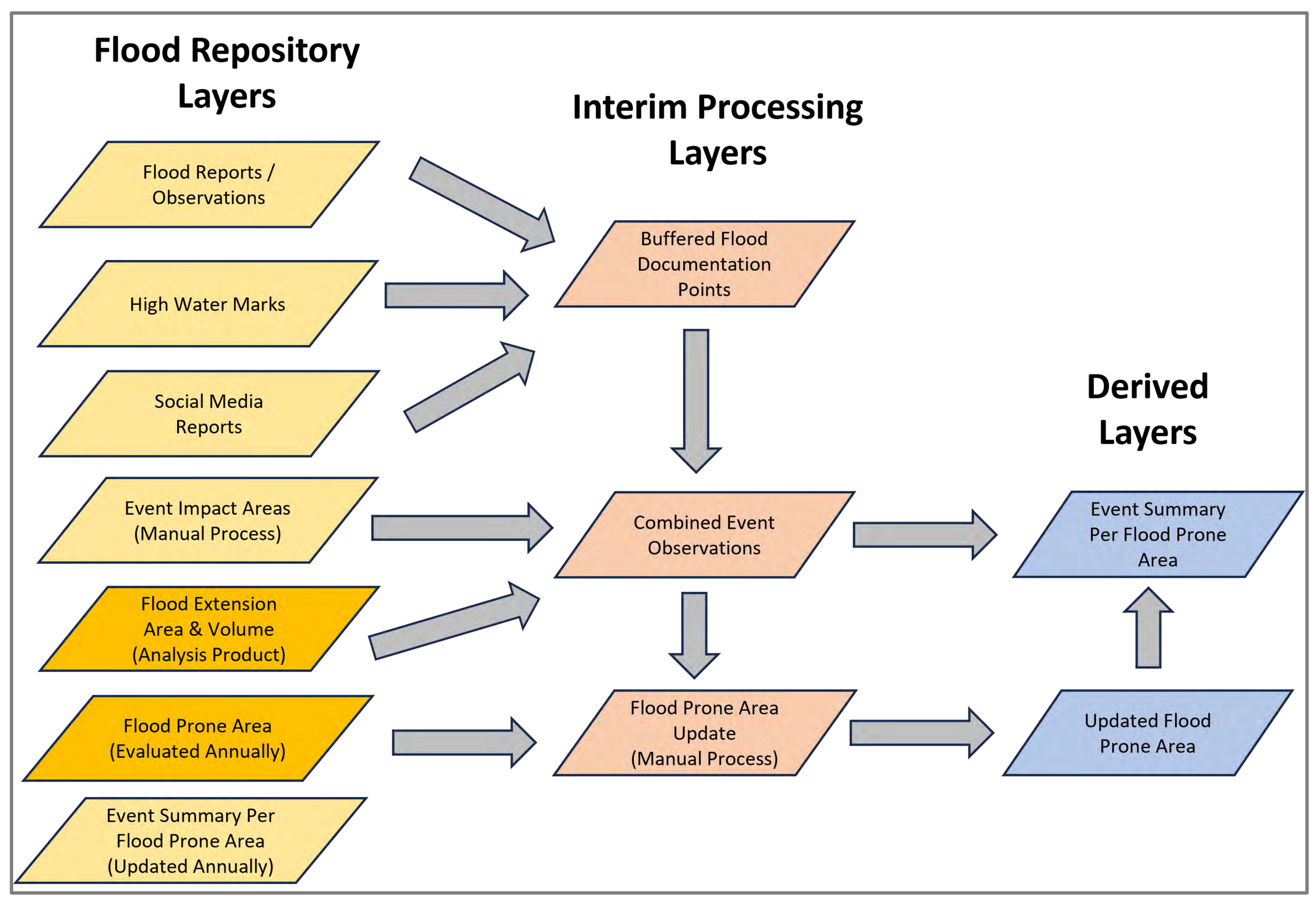


Figure 2. Flood prone areas determination workflow.

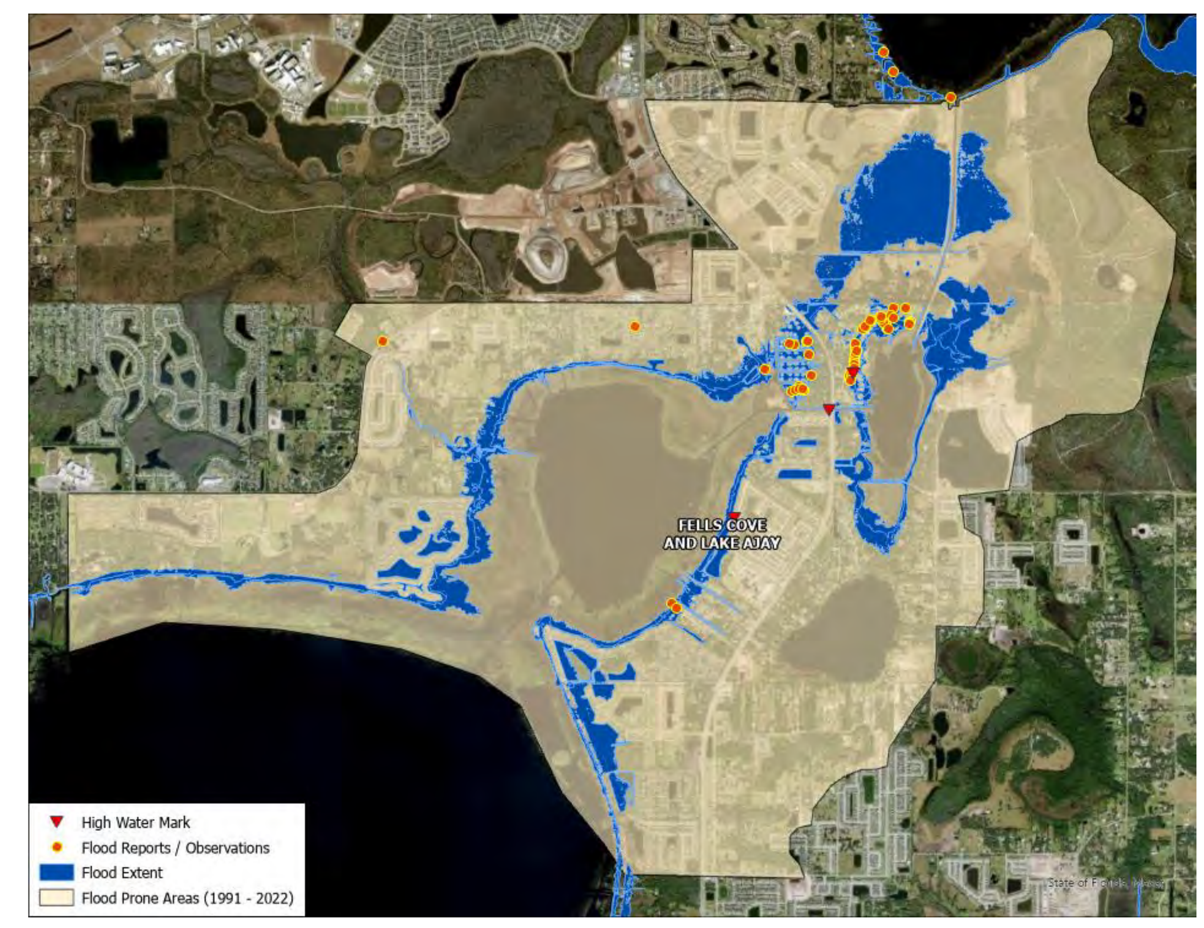


Figure 3. Example of measured flood extent within a flood prone area using a combination of radar and measured stage data.

HISTORICAL FLOOD OBSERVATIONS AND IMPACT AREAS

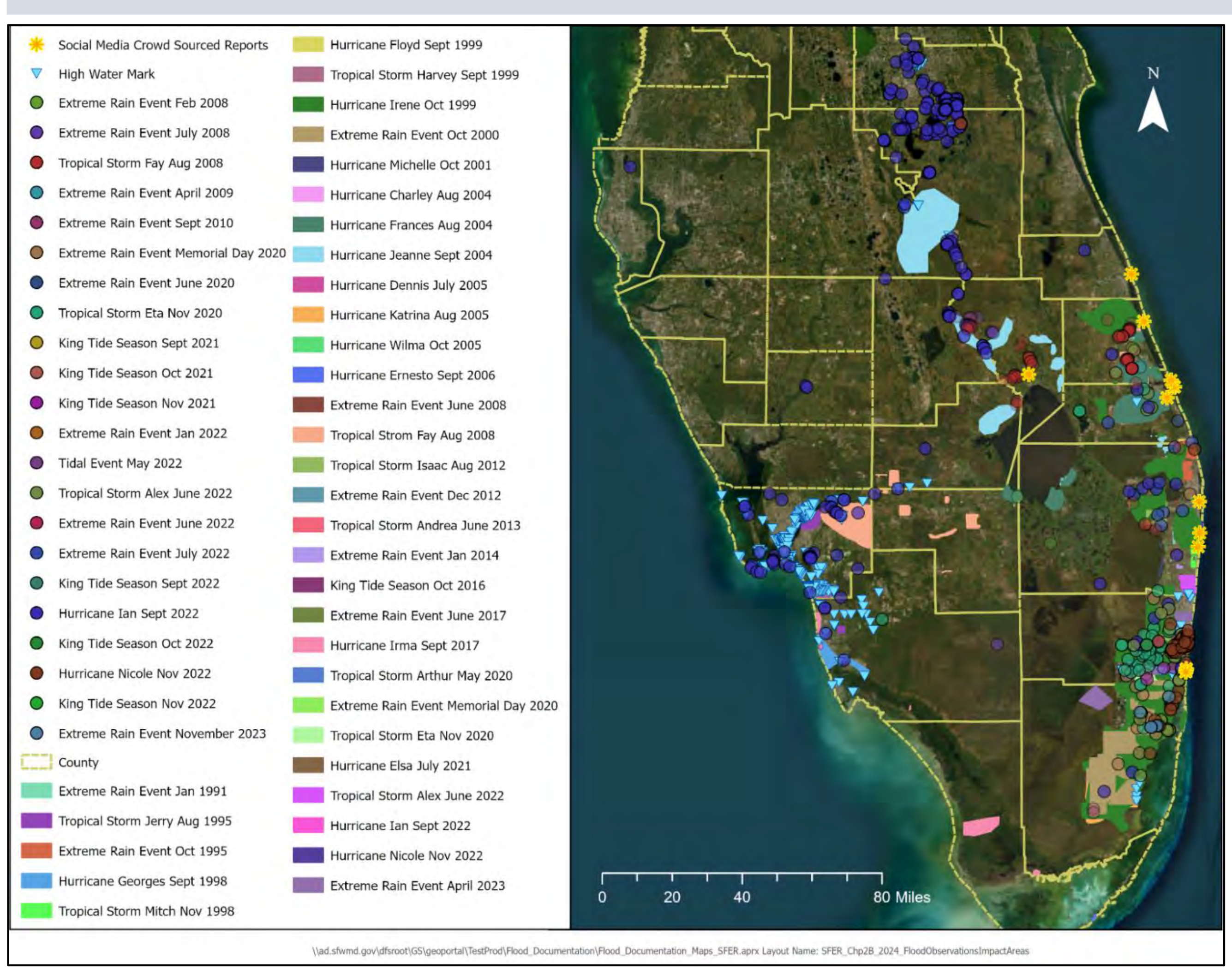


Figure 4. Mapped flood observations and historically impacted areas (1991 to 2022).

SFWMD Flood Occurrence Data Sets:

- Pre-2017 public reports by phone
- Public reports by e-mail used since 2017
- Document the Flood Survey deployed in 2023 and accessible at www.sfwmd.gov/floodingapp
- Environmental Conditions Team / High Water Mark Tool

Historically Flood Impacted Areas:

- SFWMD's Technical Publications Library (www.sfwmd.gov/SFER)
- South Florida Hydrology and Water Management chapters in Volume I of historical SFERs (www.sfwmd.gov/SFER)
- Geolocated photos in SFWMD's internal photo database
- National Hurricane Center tropical cyclone reports (https://www.nhc.noaa.gov/data/tcr/)
- National Weather Service Event Index (www.weather.gov/mfl/events_index)
- Other web sources from local news agencies

EVENT FINDINGS

Figure 5 summarizes the results. Events on the left are major storm events with recorded rainfall, tidal levels, and surge data characteristics that would suggest flooding. Events on the right are events with documentation of flooding not associated with major storms. The overlap represents where there is both flood observations and other information characterizing the severity of the events. Two sets of event-based data were identified:

- Major events characterized by recorded rainfall, tidal levels, and surge data, indicating their severity and potential to cause significant flooding
- Events with documentation of flood occurrence including flood observations

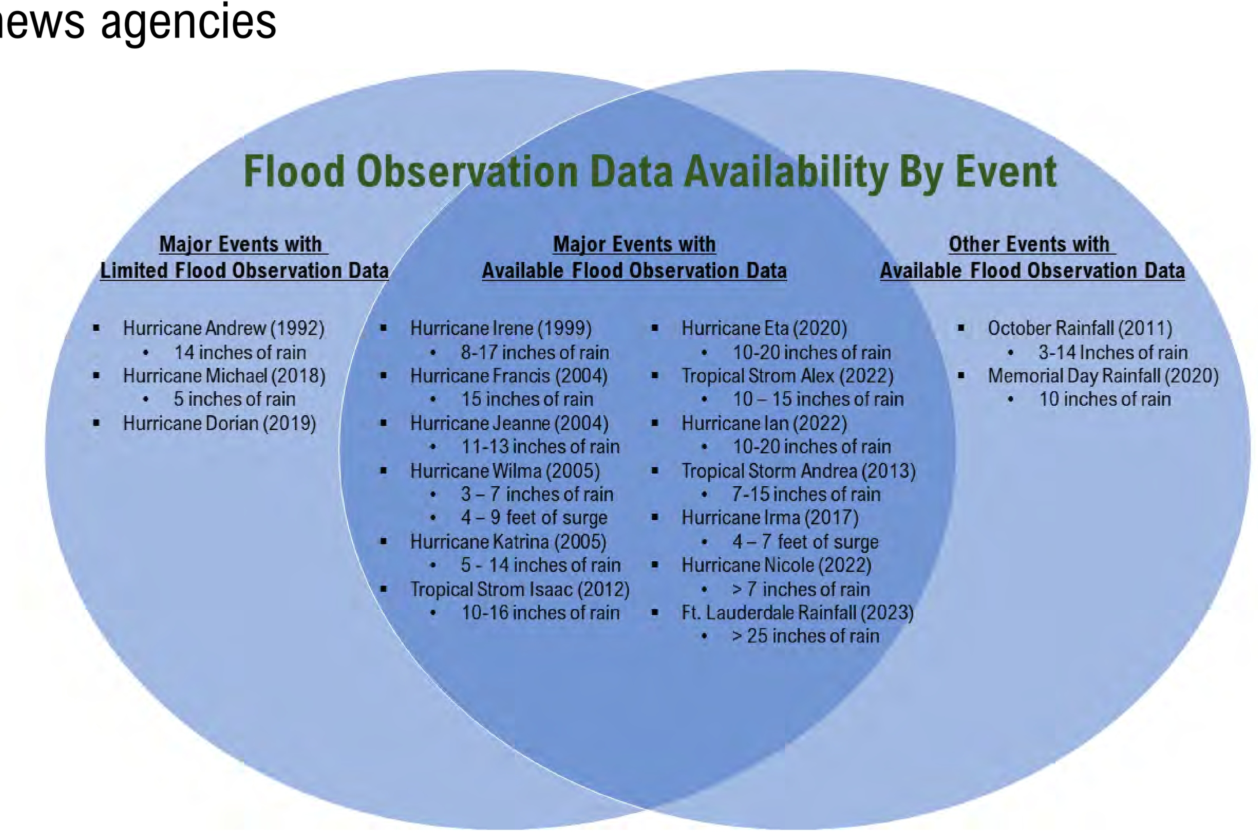


Figure 5. Availability of Flood Observation by Events.

CONCLUSIONS

The Document the Floods Survey (www.sfwmd.gov/floodingapp) is a regionally available tool used to improve flood documentation throughout South Florida and facilitate information sharing and incident response coordination between regional and local governments and water managers responsible for operation of the primary, secondary, and tertiary water management systems throughout South Florida.

- An initial set of flood prone areas within the SFWMD region was identified using flood occurrence data for South Florida's urban areas from 1990 to 2022.
- These data were compiled in a GIS-based repository that will be used to pinpoint data gaps, highlight additional monitoring needs, support standardizing current and future data collection, and support subsequent flood resiliency metric development.
- Flood observations will be augmented with satellite and radar imagery, high water mark data collection, and supplementary water level and flood sensor data to estimate flood extension.
- Understanding spatial extent, magnitude, and frequency of flood occurrences will contribute to more effective flood risk management and the development of better adaptive strategies.

For more information: SCAN ME

Chapter 7: Status of Invasive Species

Iguanas: Impacts to SFWMD Infrastructure

Jenna M. Cole, Mike Kirkland
Vegetation Management Section, Land Resources Bureau

Green Iguana Invasion

- Green iguanas (*Iguana iguana*) are herbivorous lizards native to South and Central America (**Figure 1**).
- First reported in South Florida in the 1960s, they are now invasive.
- Populations established from Palm Beach to Key West, with sightings extending to Nassau and Escambia Counties (**Figure 2**).
- Commonly seen near urban water resources and South Florida Water Management District (SFWMD) canals.
- Threaten SFWMD levee integrity and cause bank erosion through burrowing.
- Consume native vegetation, displace animals like burrowing owls, and carry salmonella.
- Considered a priority species due to rapid population growth in South Florida.

Figure 1. Green iguanas (*Iguana iguana).* A. Female green iguana; B. Male green iguana; C. Male green iguana presenting orange coloration, which is typical during breeding season.

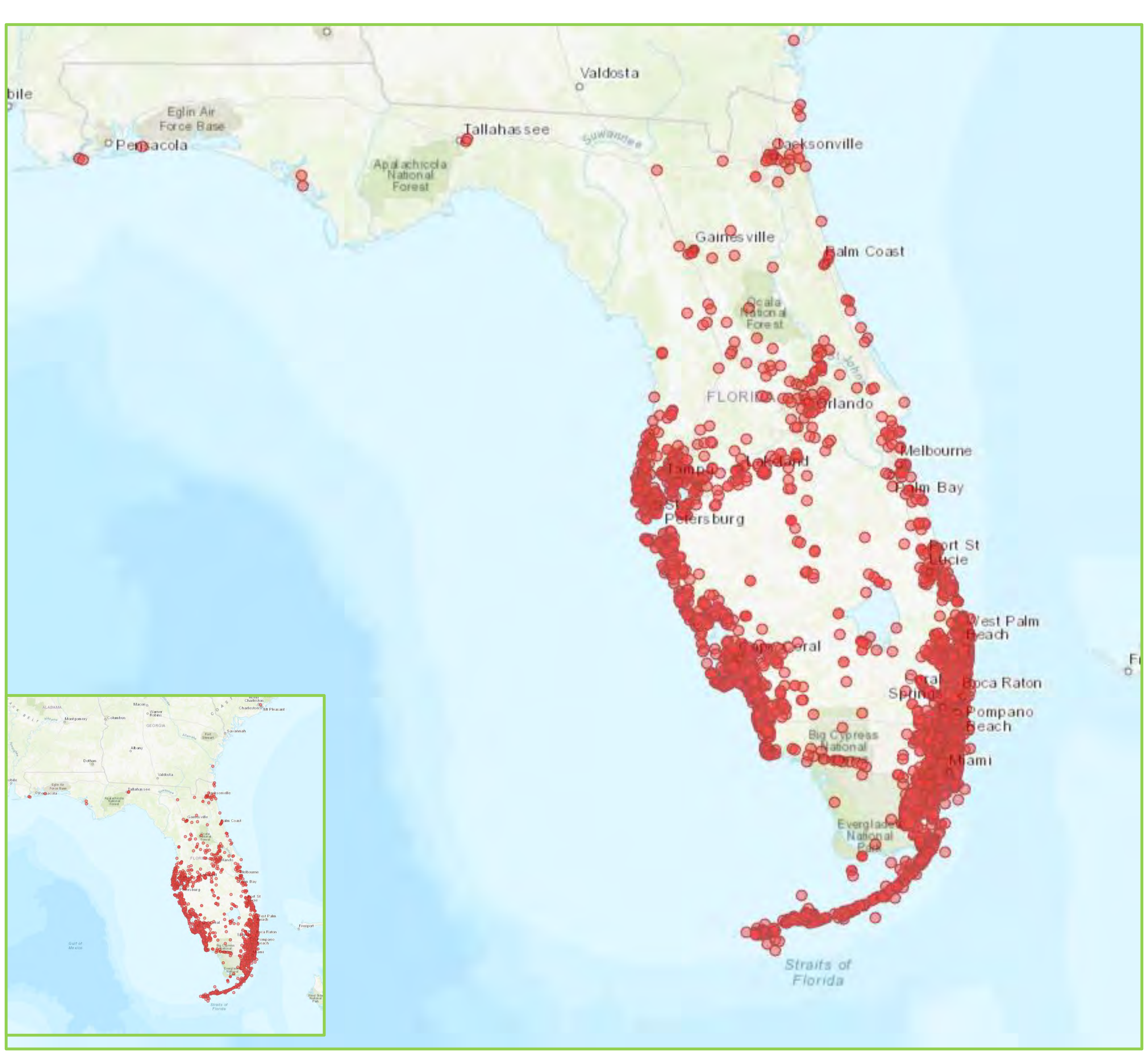


Figure 2. Observations of iguanas in Florida. Source: EDDMapS 2023, University of Georgia.

Threat to SFWMD Operations & Maintenance

- Green iguanas pose a significant threat to SFWMD operations.
- High burrow densities along canals and near water control structures accelerate erosion and may compromise levee integrity during high flow events (**Figures 3** and **4**).
- Repairing the impacts of green iguana activity is costly and could be detrimental to the success of flood control and long-term climate change resiliency.

Figure 3. Iguana burrows beneath SFWMD structures at (A) G-311 and (B) S-5A.

Figure 4 . Iguana burrows in the sides of levees increase erosion.

Management Needs

- SFWMD has conducted control efforts at its West Palm Beach headquarters to assess costs and effectiveness of management strategies.
- Priority areas for iguana management should be identified for future efforts.
- Iguana population reductions need to be regularly conducted by paid contractors or trained staff, with consistent maintenance to prevent repopulation.
- Future levee and structure reinforcements should consider approaches to prevent damage from iguana burrowing, including alternatives or modifications to riprap and other substrates that create suitable iguana habitat.

Figure 5. Riprap used to reinforce levees creates habitat for iguanas to utilize and burrow beneath.

For more information: SCAN ME

Chapter 9: Kissimmee River Restoration and Other Kissimmee Basin Initiatives

Mapping Kissimmee Basin Vegetation Using Machine Learning

Camille Carroll, Lawrence Spencer
Lake and River Ecosystems Section, Applied Sciences Bureau

Background and Introduction

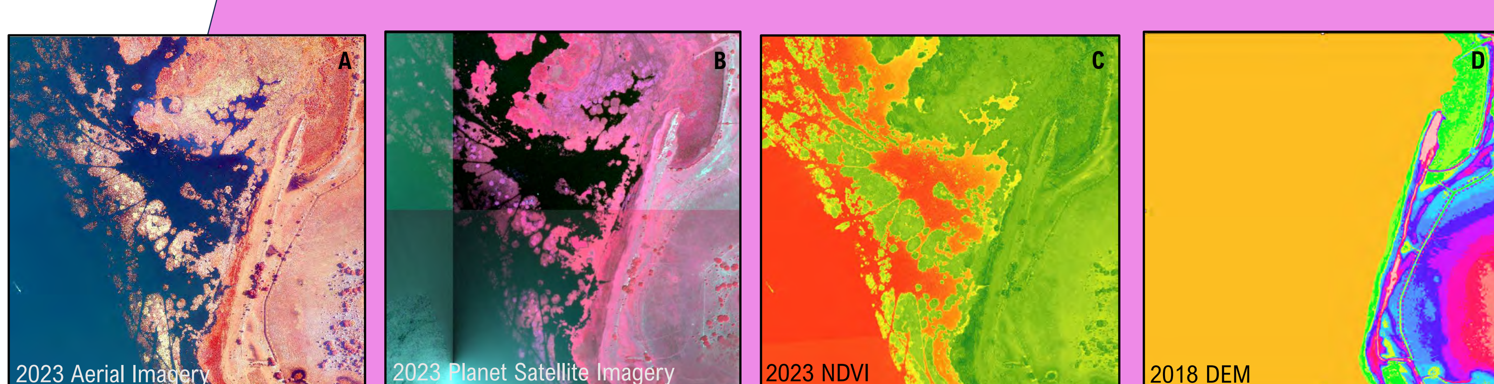
The South Florida Water Management District (SFWMD) maps vegetation in the Kissimmee Basin to look at effects of restoration and hydrological management. Using machine learning processes to do these mapping tasks allows for quicker turn-around and more economical use of resources than traditional mapping methods. The use of cloud-based resources such as Google Earth Engine (GEE) and high-resolution satellite imagery, which can be collected more often, offers the possibility of even greater improvements going forward. The mapping workflow we present here is similar when using a variety of datasets, including those described in the first step.

Workflow starts here

Prepare Dataset for Input

Imagery is preprocessed prior to Step 1.

1. Individual image tiles are **mosaicked** to create one image covering the area of interest (AOI); examples below are from aerial (**A**) and satellite (**B**) imagery.
2. The mosaicked image is fused with other data sources, such as Normalized Difference Vegetation Index (NDVI) (**C**) or other spectral indices, and elevation layers such as a digital elevation model (DEM) (**D**) to create a **composite dataset**.



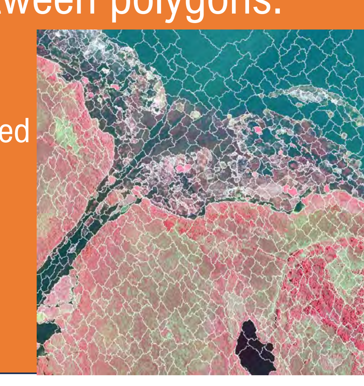
Step 2

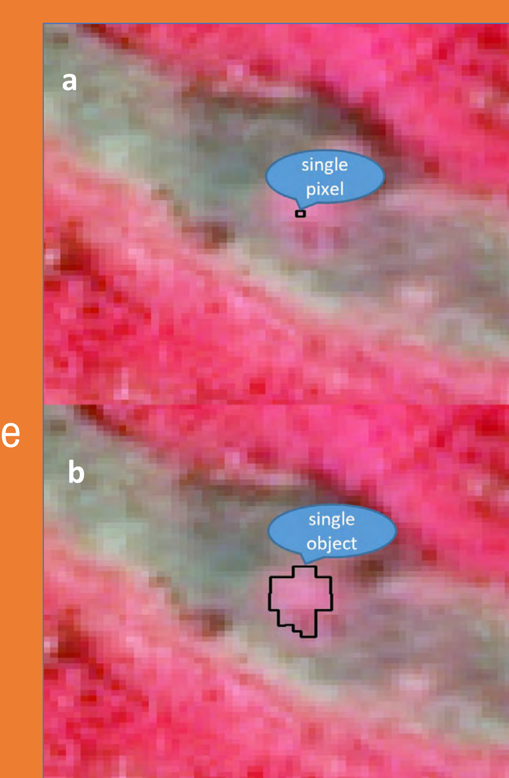
Segmentation Applied to Composite Dataset

High-resolution aerial or satellite images are made up of thousands of individual pixels, each with their own spectral values. However, classification at the pixel level can produce difficult-to-interpret maps.

- Segmentation is a machine-based process that joins together pixels with similar spectral values, creating polygons much larger than an individual pixel, which are the basis for a classified vegetation map.
- Segmentation is a more objective way of creating natural boundaries between polygons.

Example of segmented image tile.





Segmentation allows for machine classification based on polygon objects (b) rather than individual pixels (a).

Step 3

Mapping Workflow

Prepare Dataset Inputs
→ Segmentation
→ Classification Analysis (Machine Learning, Majority Rules)
→ Accuracy Assessment
→ Final Classified Map

Classification Analysis, Part 1 – Field Data Collection

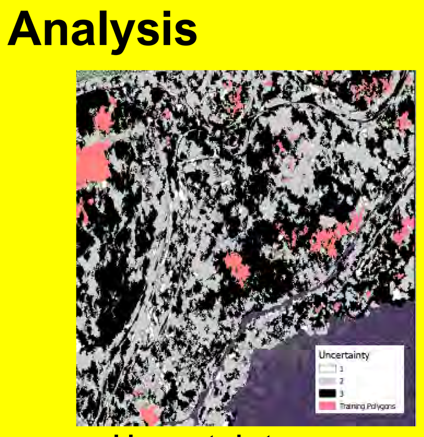
Analysis for classification mapping begins in the field!

1. Reference data is collected by helicopter video transects and airboat.
2. The reference dataset is expanded through photo-interpretation using three-dimensional (3D) workstations.
3. Finally, the dataset is divided into a training dataset and a validation dataset for use in machine learning and accuracy assessment.

Sparse waterlily and deepwater grass, surrounded by dense spatterdock.

Classification Analysis, Part 2 – Ensemble Analysis

- Combines predictions from multiple models to improve accuracy.
- Class predictions are refined by evaluating the accuracy of each model in predicting each vegetation class.
- Results include a classification layer and an uncertainty layer, which evaluates the strength of the classification for each segment.



Uncertainty map.

Step 4

Accuracy Assessment

- All classified maps require a measure of accuracy to give the map's producers a measure of their success, as well as giving the map's users an idea of how reliable the map is.
- Accuracy assessment methods entail using field-collected (reference) data from specific ground locations and comparing it to the same locations depicted on the classified map.
- A measure of accuracy for the entire map is attained using a square matrix (error or confusion matrix) with the reference values in columns and the mapped values in rows.
- All points where reference data match mapped values appear in the diagonal cells, while off-diagonal matrix cells show incorrect points.

Error Matrix: This error (or confusion) matrix allows for an objective measure of map accuracy. The Overall Accuracy value is in the lower right cell.

		Reference (Ground Truth)													
		AQ	BLM	MW	NV	UF	UP	US	VN	WF	WP	WS	WPE	Row Totals	User's
Mapped (Classified)	AQ	17		1		1						1	1	21	81%
	BLM		20								1	1		22	91%
	MW			20				1				1	1	23	87%
	NV				41	1						2	2	46	89%
	UF				1	36						1		38	95%
	UP					1	18						1	20	90%
	US							17			1	3		21	81%
	VN			1					18					19	95%
	WF					3				24				27	89%
	WP	1									20	1		22	91%
	WS	1		1		2						70	1	75	93%
	WPE	1		1							1	3	30	36	83%
	Column Totals	20	20	24	42	44	18	18	18	24	23	83	36	370	Overall Accuracy
	Producer's	85%	100%	83%	98%	82%	100%	94%	100%	100%	87%	84%	83%	370	89%

APPLICATIONS

Final Classified Maps: Kissimmee River Wetland Vegetation

Wetland vegetation covered more than 80% of the floodplain in 2020, but constituent communities were not as expected.

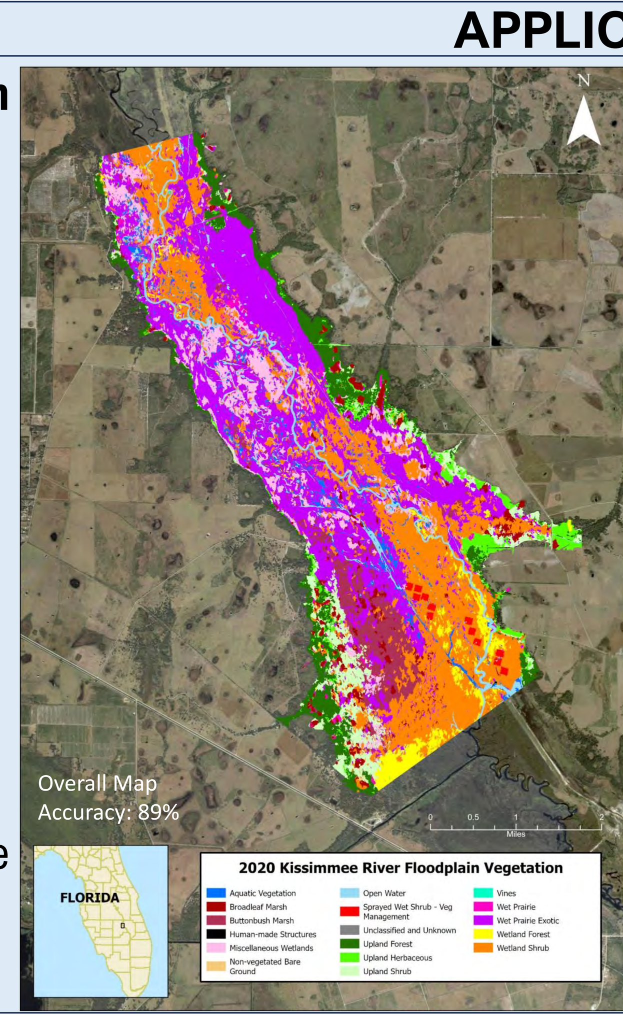
- Broadleaf Marsh was not widespread and exotic grasses such as para grass and West Indian marsh grass predominated in wet prairie areas, out-competing natives.
- Primrose willow and Carolina willow were spreading.

Why?

- Inundation is lower than expected in depth and duration. This issue will be alleviated by implementation of the Headwaters Revitalization Schedule (HRS), a new basin hydrologic regime.

Reversing expansions of invasive species:

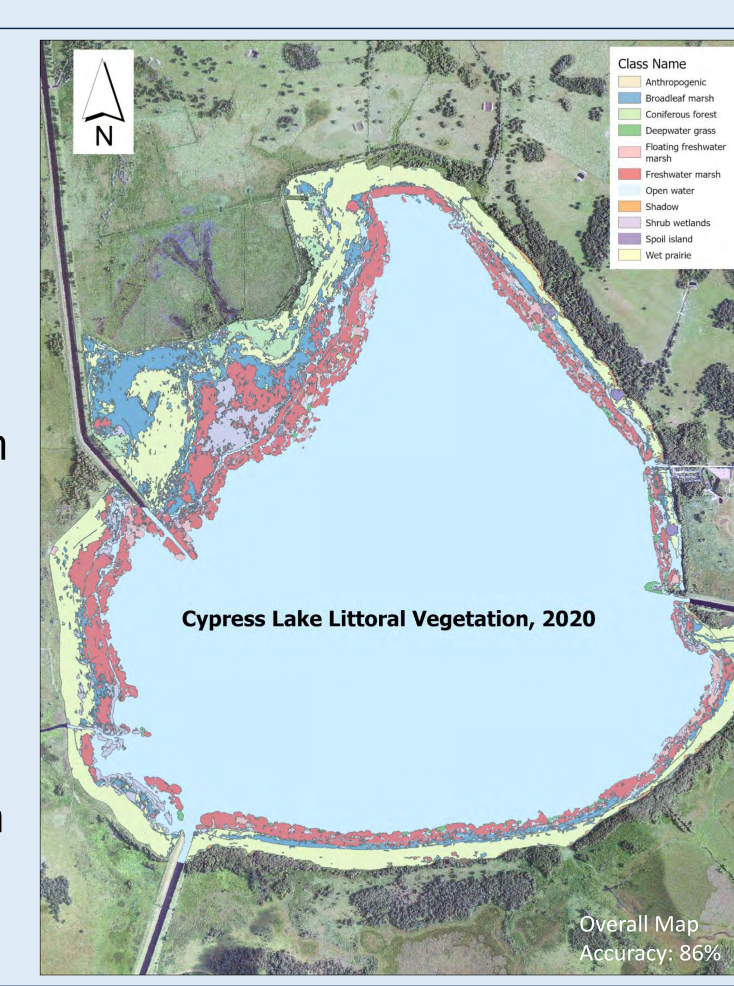
- SFWMD personnel are testing vegetation management techniques, including herbicide and fire.
- Results have been promising but measurable changes over the long term require more trials and application of an integrated approach.



Final Classified Maps: Changes in Cypress Lake Littoral Zone Vegetation from 2009 to 2020

Medium and long hydroperiod plant communities increased in 2020 probably due to prior weather conditions, which were more extreme in 2009.

- The 2020 map showed a 15% increase in vegetation across the littoral zone, mainly more cattail and bulrush along the lakeward edge.
- Changes were likely due to a prolonged drought (February 2006 to June 2008) when hydroperiods across the littoral zone decreased; there were also numerous hurricanes from 2004 through 2009.
- In 2020 there was an extensive invasion of West Indian marsh grass not present in 2009.



Future Developments

- Incorporate the use of cloud-based machine coding to conduct all parts of this mapping workflow. New interfaces such as Google Earth Engine (GEE) offer more flexibility, one-stop processing, as well as more rapid throughput for the method we have outlined here.
- High-resolution, high return frequency satellite imagery, such as ©Planet Labs imagery, may allow us to produce maps more often.
- Enabling traditional data sources like DBHYDRO to inform geospatial analysis workflows.

For more information: SCAN ME

Chapter 9: Kissimmee River Restoration and Other Kissimmee Basin Initiatives

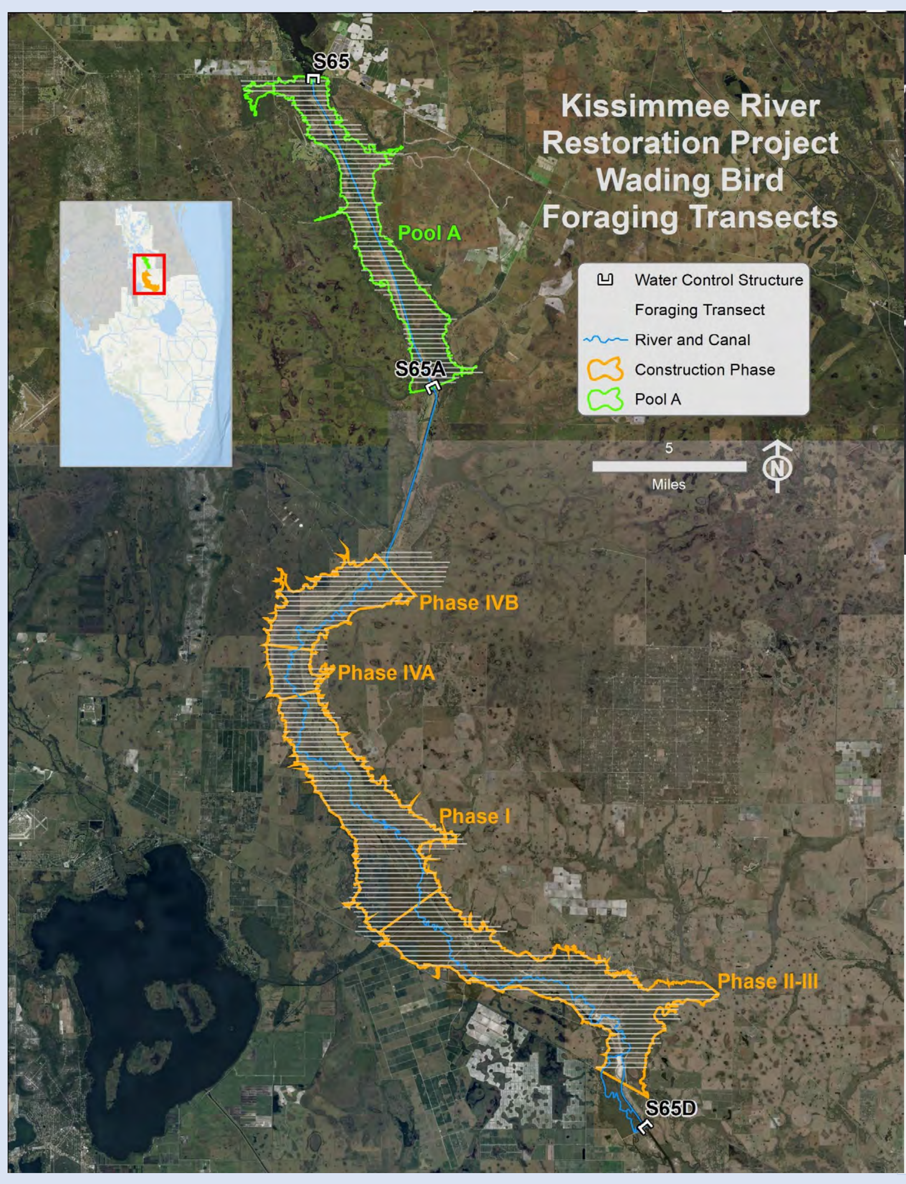
Avian Response to Date to the Kissimmee River Restoration Project

Rich Botta

Lake and River Ecosystems Section, Applied Sciences Bureau

Introduction

The primary goal of the Kissimmee River Restoration Project (KRRP) is to restore ecological integrity to the river-floodplain system. Birds are integral to the Kissimmee River ecosystem and highly valued by the public. While quantitative pre-channelization data are sparse, available data and anecdotal accounts suggest the system supported an abundant and diverse bird population prior to channelization. Restoration of the Kissimmee River and floodplain is expected to reproduce the necessary conditions to support such an assemblage once again. Because many bird guilds, including wading birds, exhibit a high degree of mobility, they are likely to respond rapidly to restoration of appropriate habitat.



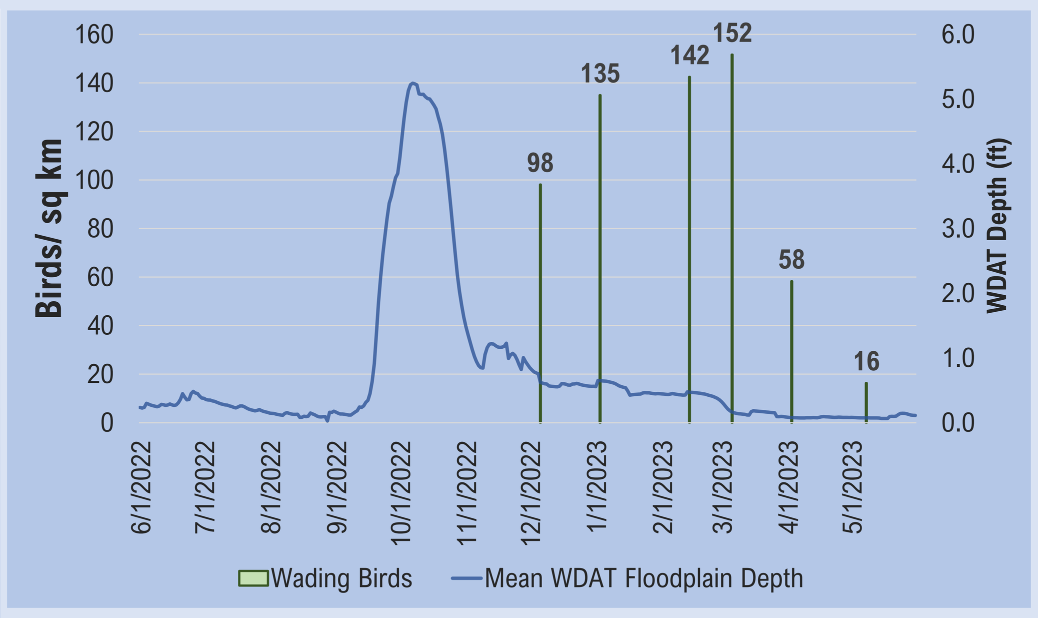
KRRP Expectation 24

[a] Mean annual dry season density of long-legged wading birds (excluding cattle egrets) on the restored floodplain will be ≥ 30.6 birds/square kilometer (km^2) (3-year running average) and

[b] at least 85% of the monthly surveys will have ≥ 30.6 birds/km^2.

Study Area and Methods

- Monthly east-west transects are randomly selected within the floodplain to cover 20% of the restored area (November-May).
- Flown by helicopter at an elevation of 30.5 meters (m) and approximately 130 kilometers per hour (km/hr).
- Wading birds within the 200 m transect strip are counted and identified.



ft – feet, **WDAT** – Water Depth Assessment Tool.

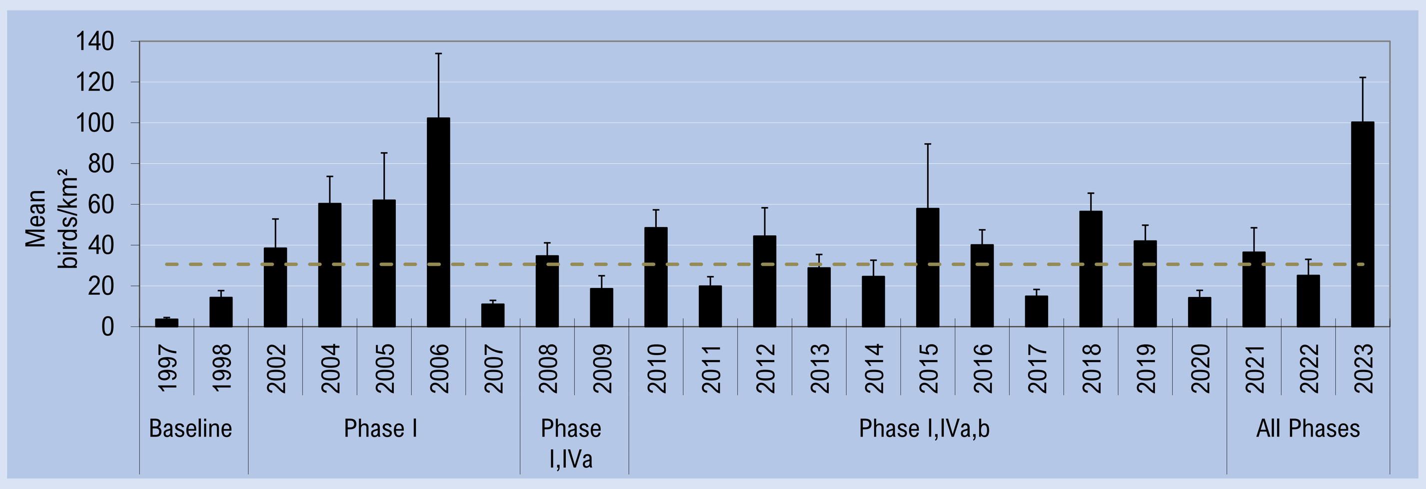
2023 Results

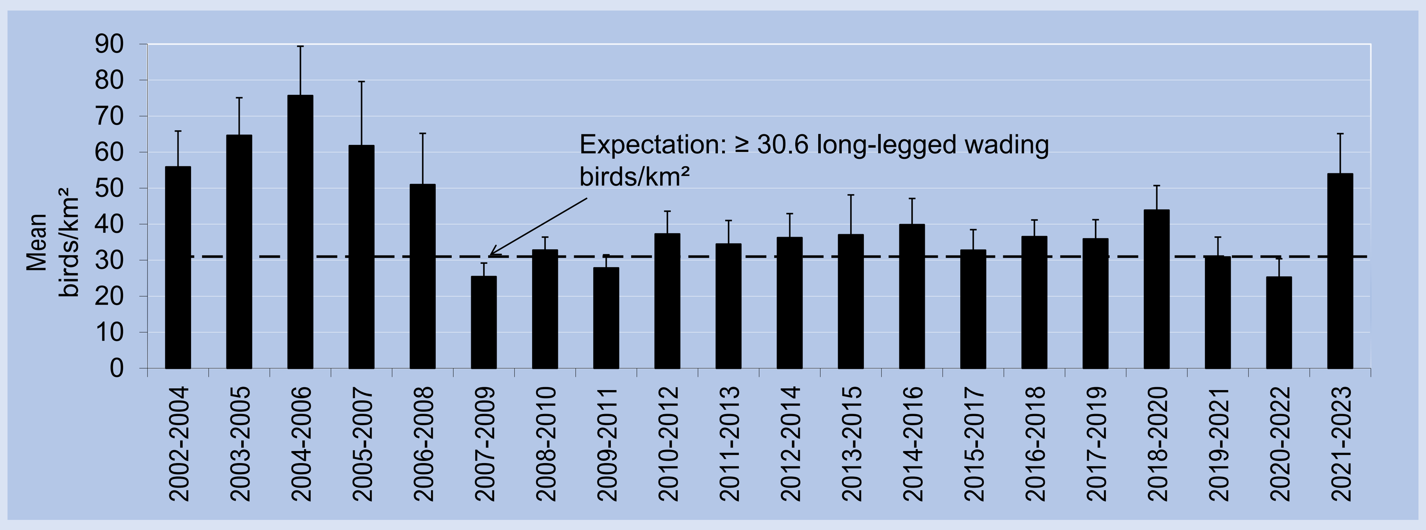
- 2023 mean abundance: 100 ± 22 birds/km^2
- 3-year running average: 54 ± 12 birds/km^2
- 5 of 6 surveys ≥ 30.6 birds/km^2 (83%)
- Expectation 24 not met

Long-term Dry Season Wading Bird Trends

- Pre-KRRP: 4 ± 1 birds/km^2 in 1997 and 14 ± 3 birds/km^2 in 1998.
- Interim restoration abundance has ranged from 102 ± 32 birds/km^2 to 11 ± 2 birds/km^2 (mean for 2002–2023 = 39 ± 3 birds/km^2).
- Three-year running mean (2002–2023): 41.4 ± 3.2 birds/km^2, significantly greater than the restoration expectation of 30.6 birds/km^2 (t-test, $p < 0.002$).
- Annual three-year running means have been significantly greater than the restoration expectation of 30.6 birds/km^2 in only 6 of the past 19 years.
- Since surveys began in 2002, only 4 years have had at least 85% of surveys with over 30.6 birds/km^2
- Only 3 years since 2001 have met both components of the expectation.

Project Window Year	Expectation 24	
	a	b
	>30.6	>85%
2002	NA	50%
2003	NA	100%
2004	55.9	86%
2005	64.7	67%
2006	75.7	100%
2007	61.8	0%
2008	51	57%
2009	25.5	33%
2010	32.8	63%
2011	27.9	14%
2012	37.3	71%
2013	34.5	43%
2014	36.3	29%
2015	37.1	43%
2016	39.9	43%
2017	32.8	39%
2018	36.5	65%
2019	35.9	86%
2020	43.9	14%
2021	30.9	57%
2022	25.3	29%
2023	54	83%



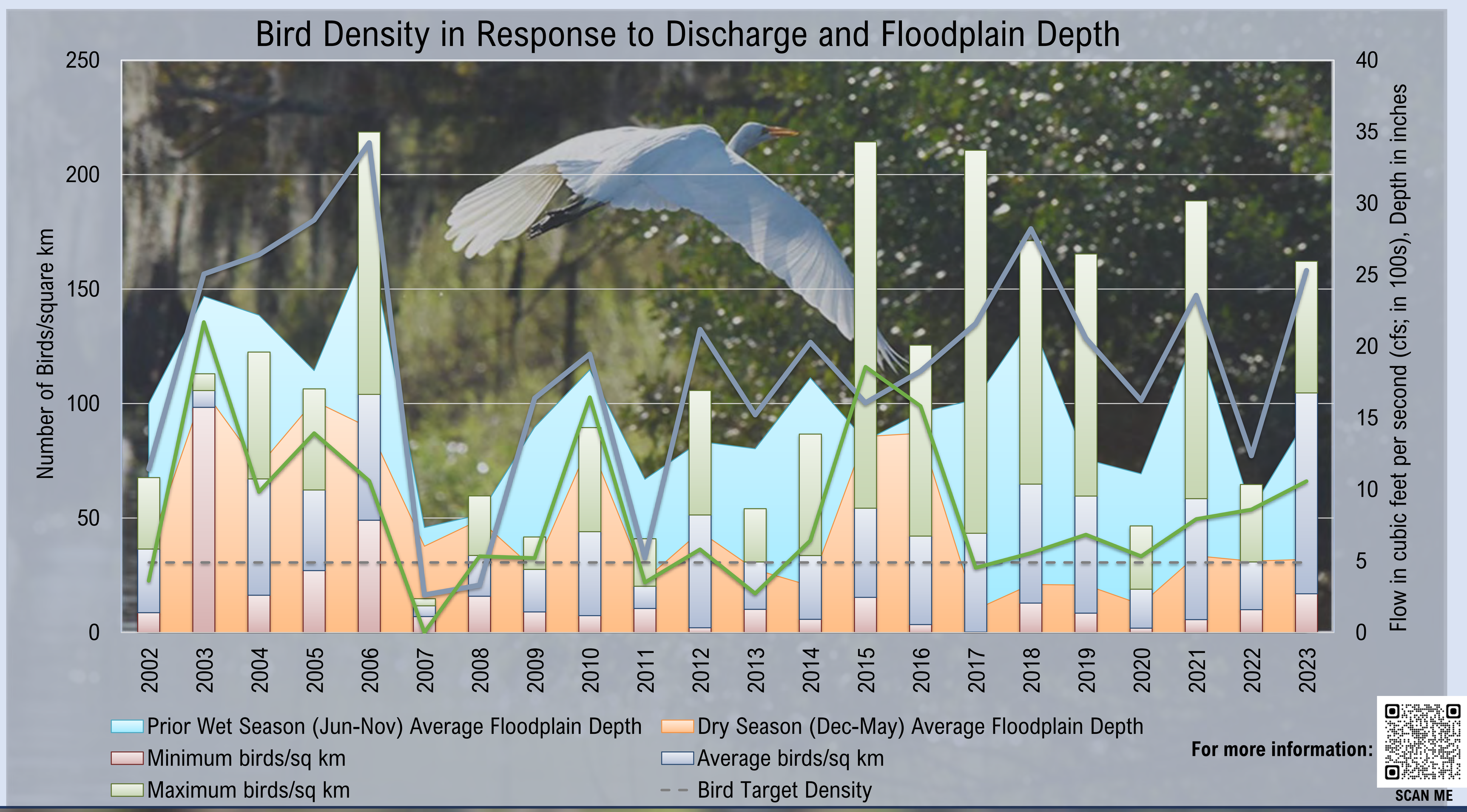


On the left, higher inundation on the floodplain near the end of the west season.

On the right, receding water levels as the dry season progresses

Conclusion and Discussion

Restoration of the physical characteristics of the Kissimmee River and floodplain, along with future improvements in the hydrologic characteristics of inflows under the Headwaters Revitalization Schedule (HRS), are expected to produce hydropatterns and hydroperiods that will lead to improved foraging conditions in the dry season and development of extensive areas of quality wetland habitat, which should lead to higher aquatic faunal production. Improved inundation during the wet season should lead to increased fish and invertebrate populations. If followed by appropriate inundation and recession in the dry season, the result should be good accessibility to prey. Some of the best years on the Kissimmee River floodplain have shown this response with wading birds, and full implementation of HRS should expand on this trend. Failures to meet the expectation are likely due to inadequate floodplain inundation during the wet season to sustain a suitable prey base, and premature drying of the floodplain in the dry season, resulting in insufficient usable foraging habitat. Both are expected to improve under HRS.



For more information: SCAN ME

Chapter 9: Kissimmee River Restoration and Other Kissimmee Basin Initiatives

Evaluation of Dissolved Oxygen Levels for the Kissimmee River Restoration Area

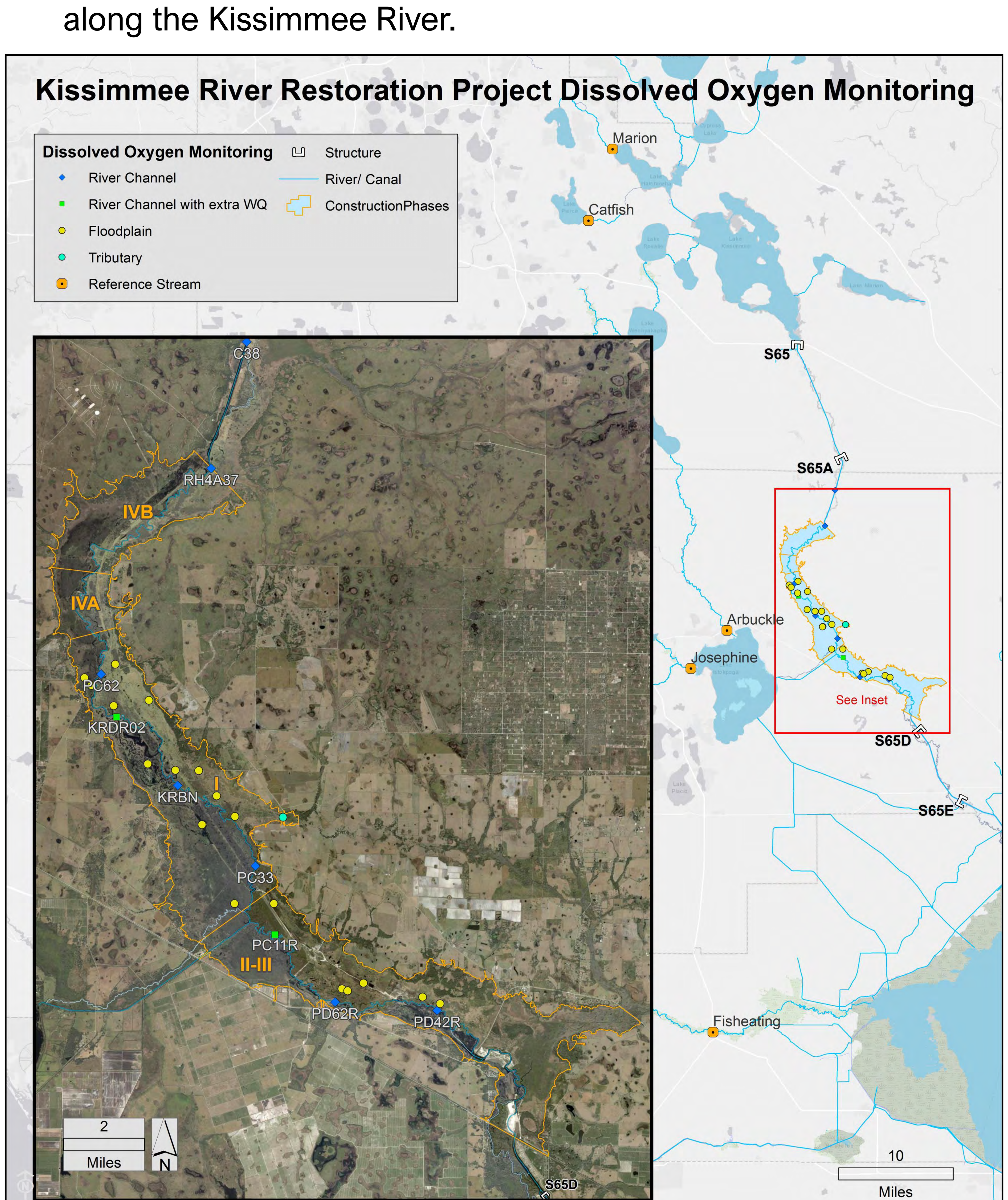
Erik Tate-Boldt, Darryl Marois, Richard Botta, Steve Bousquin
Lake and River Ecosystems Section, Applied Sciences Bureau

Summary

- Gamefish and other aquatic species depend on dissolved oxygen (DO) for survival.
- This is why dissolved oxygen was included as Expectation 8 in the Kissimmee River Restoration Evaluation Program (KRREP).
- Presently, Expectation 8 is being revised to more accurately reflect the natural dynamics of dissolved oxygen in the river.

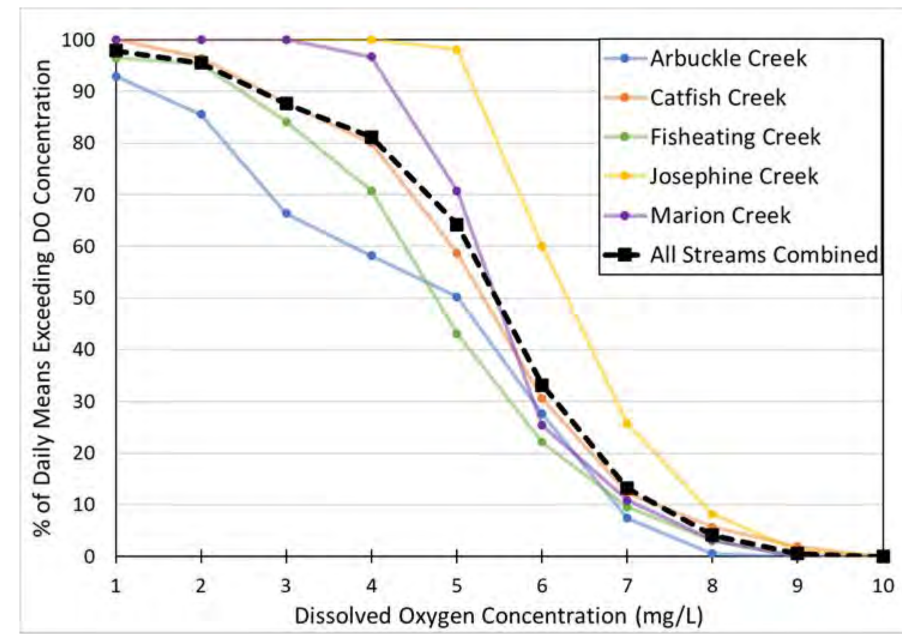
How Is Dissolved Oxygen Measured?

DO sensors are deployed at a network of monitoring sites along the Kissimmee River.



How Is Dissolved Oxygen Evaluated?

- Expectation 8 targets were originally developed from data collected from five reference creeks near the Kissimmee River.
- New targets have been developed based on a more comprehensive dataset using continuous data instead of grab samples.



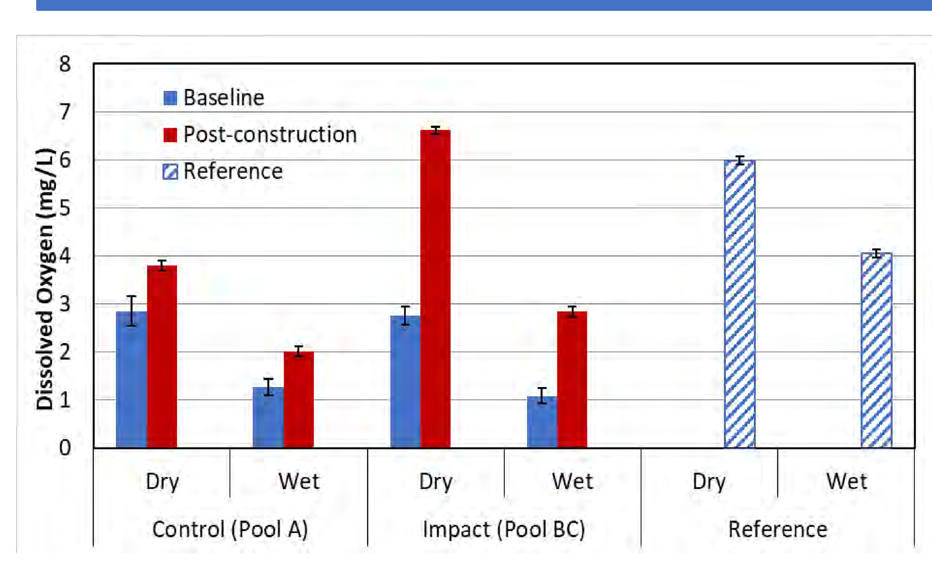
Reference Creek Summary

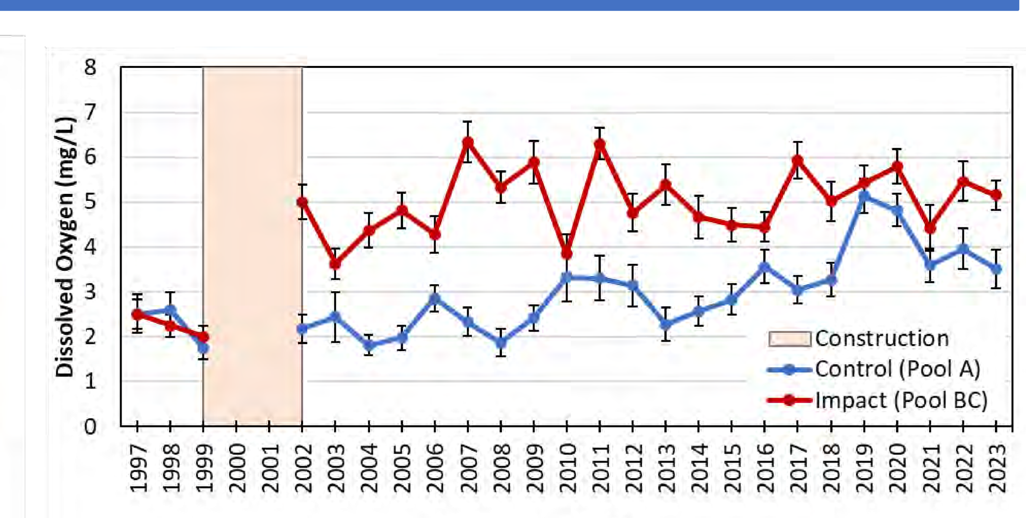
Parameter	DO (mg/L)
Wet Season Avg- SD	2.71
Wet Season Avg	**4.19**
Wet Season Avg + SD	5.67
Dry Season Avg - SD	7.50
Dry Season Avg	**6.06**
Dry Season Avg + SD	4.62

Avg – Average, **mg/L -** milligrams per liter, **SD** – standard deviation

Current Expectation Components	Proposed Expectation Components
[a] Mean **daytime** DO of **3 to 6** mg/L during the wet season (June-October).	[a] Mean **daily** DO of **2.5 to 6.0** mg/L during the wet season (June-October).
[b] Mean **daytime** DO of **5 to 7** mg/L during the dry season (November-May).	[b] Mean **daily** DO of **4.5 to 7.5** mg/L during the dry season (November-May).
[c] **Mean daytime DO concentrations within 1 meter (m) of the channel bottom will be > 1 mg/L more than 50% of the time annually.**	[c] **Mean daily channel DO will be > 1 mg/L more than 98% of the time annually.**
[d] Mean daily channel DO at 0.5- to 1.0-m depth will be > 2 mg/L more than **90%** of the time annually.	[d] Mean daily channel DO will be > 2 mg/L more than **95%** of the time annually.

Restoration Successes



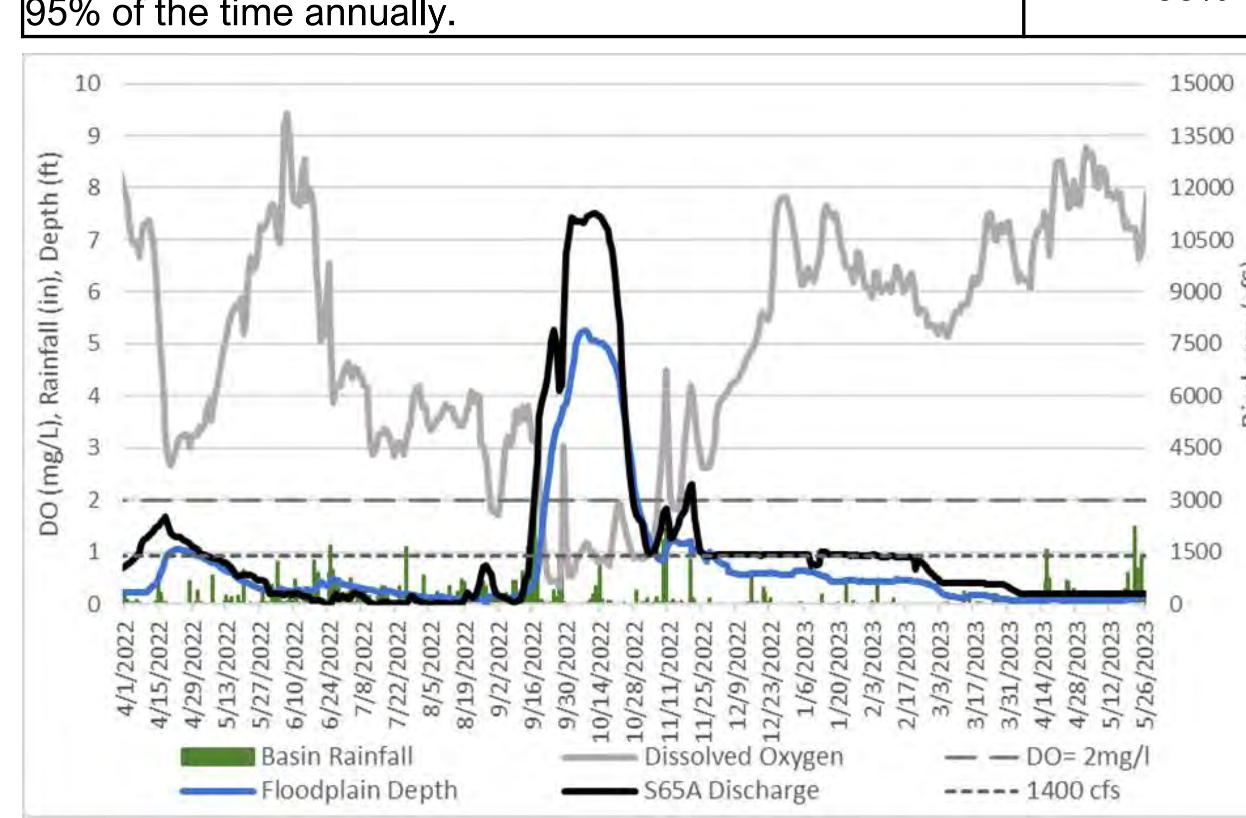


DO concentrations show overall improvement in control and impact areas in wet and dry seasons during the Post-Phase I Construction periods.

Challenges

However, while the DO expectation was met in Planning Window 2022-2023 (PW2023; June 1, 2022-May 31, 2023), hypoxic events (DO declines during high discharges) continue to pose a challenge to meeting parts [c] and [d] of Expectation 8.

Expectation Components	Phase I & Phase II/III PW2023	Metric Achieved in Phase I & Phase II/III in PW2023
[a] Mean daily DO of 2.5 to 6.0 mg/L during the wet season (June–October).	3.1	Yes
[b] Mean daily DO of 4.5 to 7.5 mg/L during the dry season (November–May).	6.0	Yes
[c] Mean daily channel DO will be > 1 mg/L more than 98% of the time annually.	93%	No
[d] Mean daily channel DO will be > 2 mg/L more than 95% of the time annually.	85%	No



cfs – cubic feet per second, **ft** – feet, in – inches, **mg/L** - milligrams per liter

Researcher maintaining DO sensor.

For more information: SCAN ME

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

Part III: Lake Okeechobee Watershed Construction Project

Anthony Betts

Planning and Project Management Section, Everglades and Estuaries Protection Bureau

The Northern Everglades and Estuaries Protection Program (NEEPP) promotes a comprehensive approach to the Lake Okeechobee Watershed. Using a combination of research, monitoring, source controls, and construction projects, the NEEPP works to restore and protect surface water resources by addressing water quality and storage within the natural system. This poster documents the key accomplishments and successes during the Water Year 2023 (WY2023; May 1, 2022 – April 30, 2023) reporting period.

Twenty (20) operational projects in WY2023 provided approximately:

- > **80,000 acre-feet** (ac-ft) of storage
- > **29.5 metric tons** (t) total phosphorus (TP) retention
- > **161 metric tons** (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 & Upper Kissimmee subwatersheds were added.

Advancing Watershed Construction Projects


Began Operations March 2024

Partin Family Ranch

Basin: **Upper Kissimmee**
Project Area: **3,050 ac**
Est. Storage:
4,270 ac-ft/yr
Estimated TP: **0.4 t/yr**
Estimated TN: **5.2 t/yr**

Operations Extended until 2033

Basin: **Upper Kissimmee**
Project Area: **730 ac**
WY23 Storage: **758 ac-ft**
WY23 TP Retention: **0.1 t**
WY23 TN Retention: **1.2 t**


Eagle Haven Ranch


COMING SOON

El Maximo Ranch

Basin: **Lower Kissimmee**
Project Area: **7,030 ac**
Est. Storage:
2,500 ac-ft/yr
Estimated TP: **2.4 t/yr**
Estimated TN: **7.0 t/yr**

COMING SOON

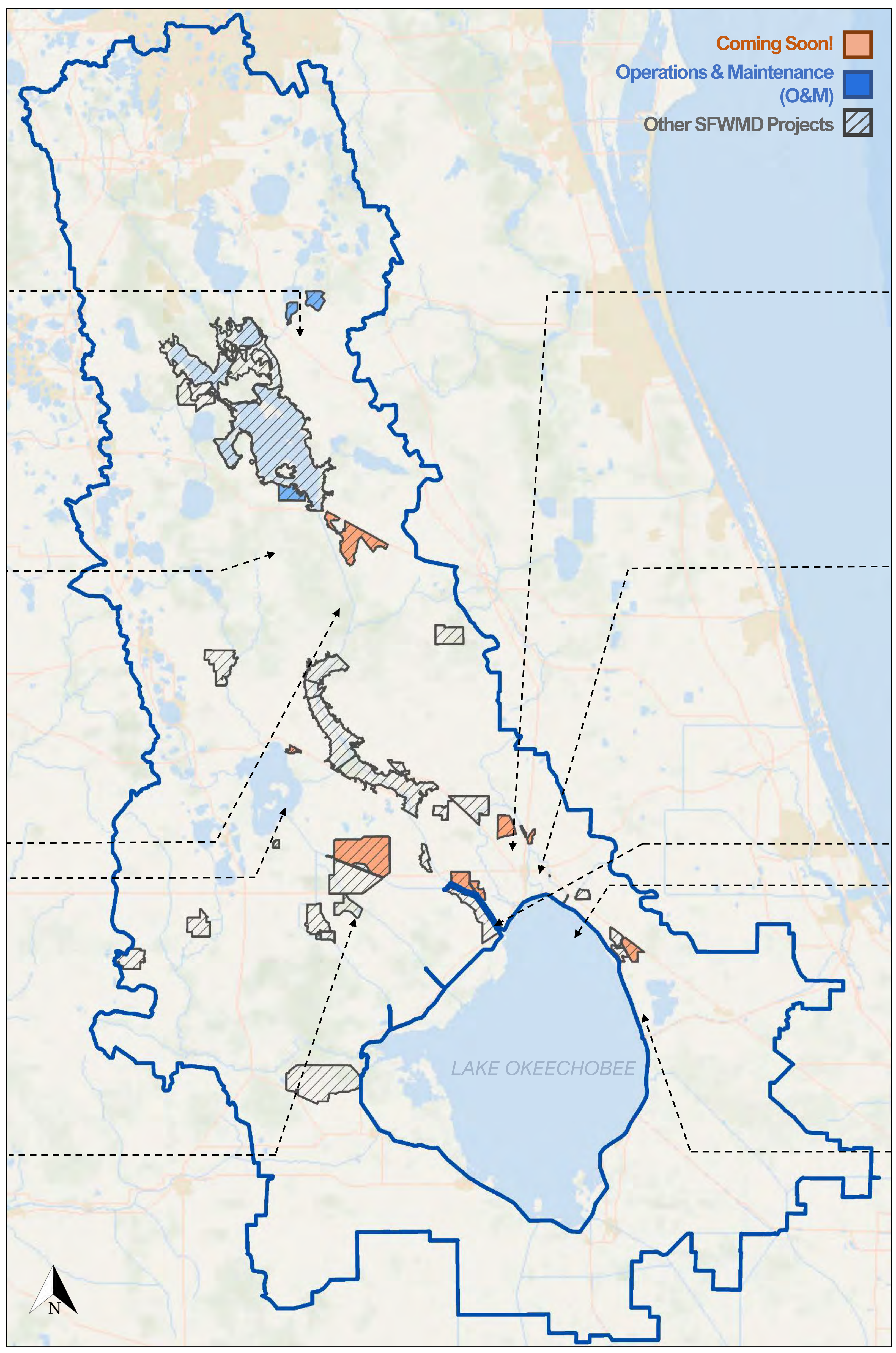
Basin: **Lake Istokpoga**
Project Area: **N/A**
Est. Storage: **N/A**
Estimated TP: **4.5 t/yr**
Estimated TN: **TBD**

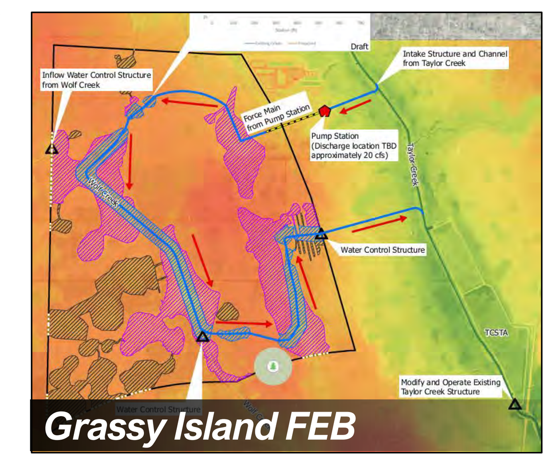

Aguaculture - Lake Istokpoga


COMING SOON

Lake Okeechobee Component A Reservoir

Basin: **C-41**
Project Area: **12,300 ac**
Est. Storage:
200,000 ac-ft
Estimated TP: **N/A**
Estimated TN: **N/A**




Grassy Island FEB

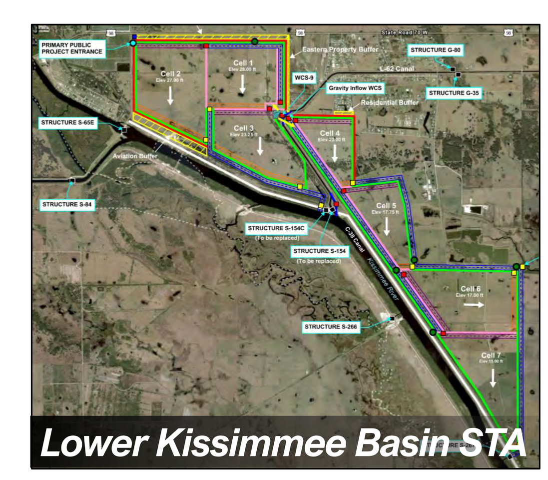
COMING SOON

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

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


COMING SOON

TCNS 214 Storage & Treatment


Lower Kissimmee Basin STA

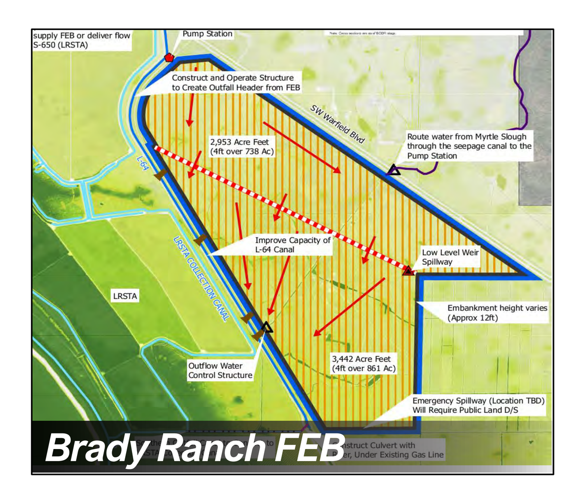
COMING SOON

Basin: **S-154C**
Project Area: **3,350 ac**
Est. Storage:
5,900 ac-ft/yr
Estimated TP: **19.0 t/yr**
Estimated TN: **TBD**

Basin: **S-191**
Project Area: **N/A**
Est. Storage: **N/A**
Estimated TP: **2.9 t/yr**
Estimated TN: **N/A**


COMING SOON

S191 Phosphorus Retention

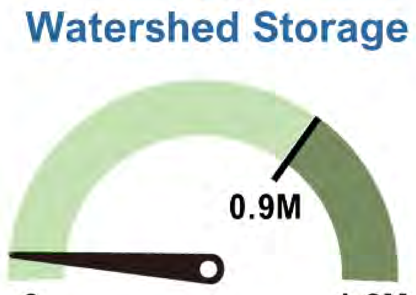

Brady Ranch FEB

COMING SOON

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

Progress Towards Water Quality and Storage Goals

Total Watershed Storage



GOAL = 0.9 – 1.3 million
WY2023 = 80,627
Units = acre-feet

Total Phosphorus (TP) Total Maximum Daily Load

GOAL ≤ 140
5-Year Average = 402
Units = metric tons

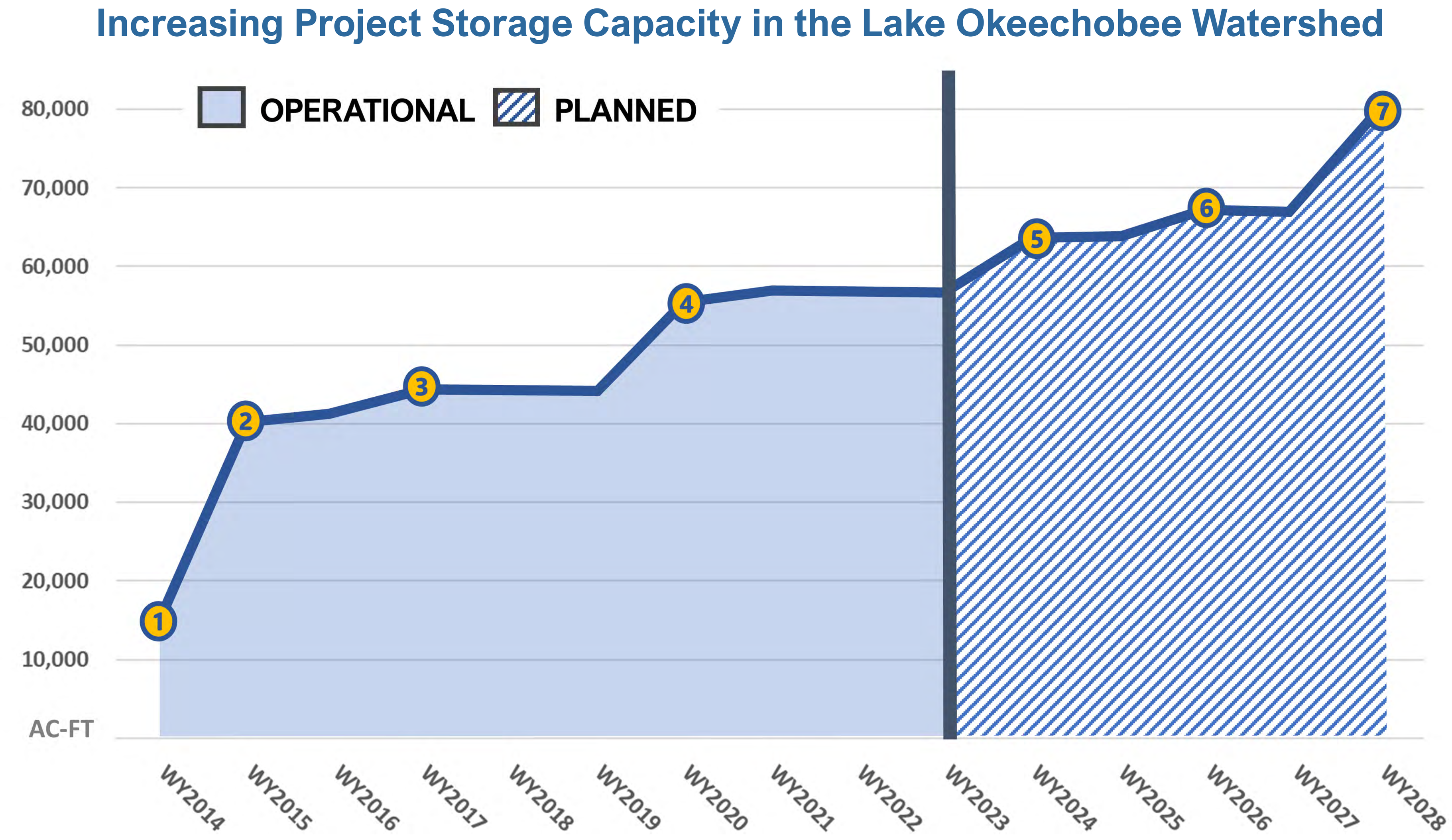
Pelagic TP Concentration

GOAL ≤ 40
WY2023 = 162
Units = micrograms per liter

Submerged Aquatic Vegetation

GOAL ≥ 35,000
WY2023 = 5,187
Units = acres

Increasing Project Storage Capacity in the Lake Okeechobee Watershed



1. BUCK ISLAND RANCH, DIXIE RANCH, WEST WATERHOLE
2. NICODEMUS SLOUGH, RAFTER T RANCH
3. LLANO RANCHES
4. BRIGHTON VALLEY
5. PARTIN FAMILY RANCH, EL MAXIMO RANCH
6. TCNS 214, GRASSY ISLAND FEB
7. BRADY RANCH FEB, LOWER KISSIMMEE STA

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

For more information: SCAN ME

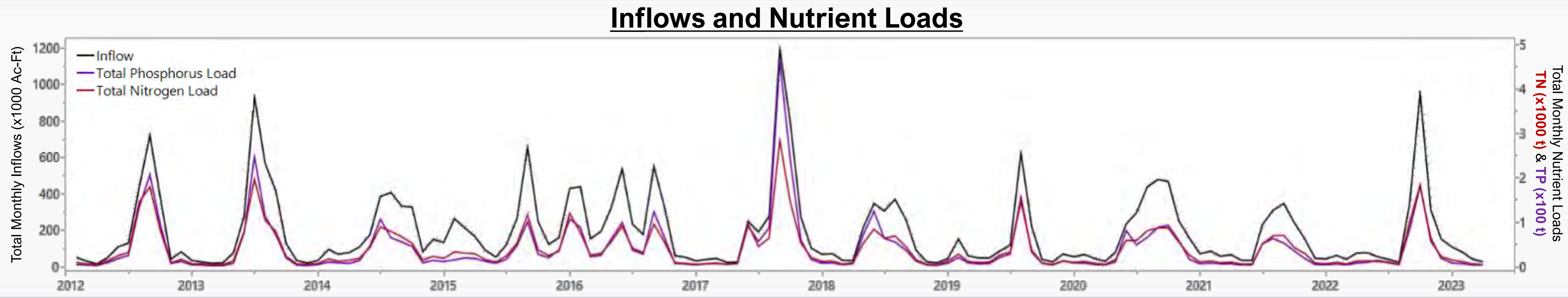
Chapter 8B: Lake Okeechobee Watershed Protection Plan Annual Progress Report

Lake Okeechobee Hydrology, Water Quality and the Ecological Envelope

Paul Jones, Ph.D., Lake and River Ecosystem Section, Applied Sciences Bureau

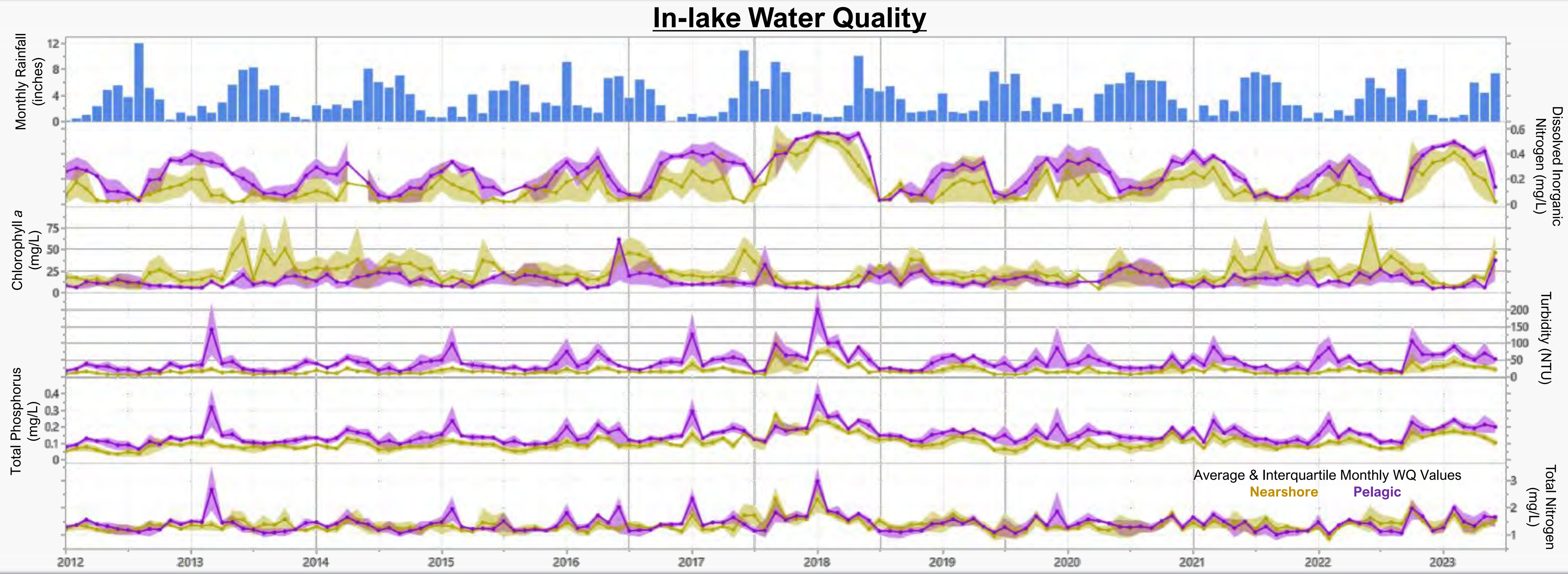
Inflows and Nutrient Loads

- Nutrient loads to Lake Okeechobee are determined primarily by surface water inflow volumes.
- Elevated inflows are the main driver of rapid rises in lake stage.
- H. Ian (2022) caused the highest inflows since H. Irma (2017), but TP loads were considerably lower.



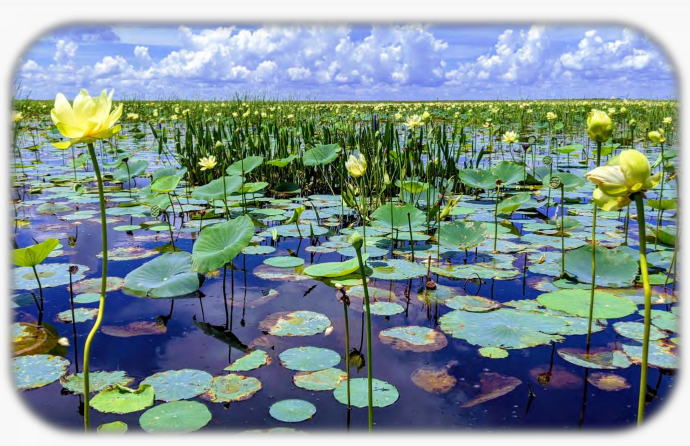
In-lake Water Quality

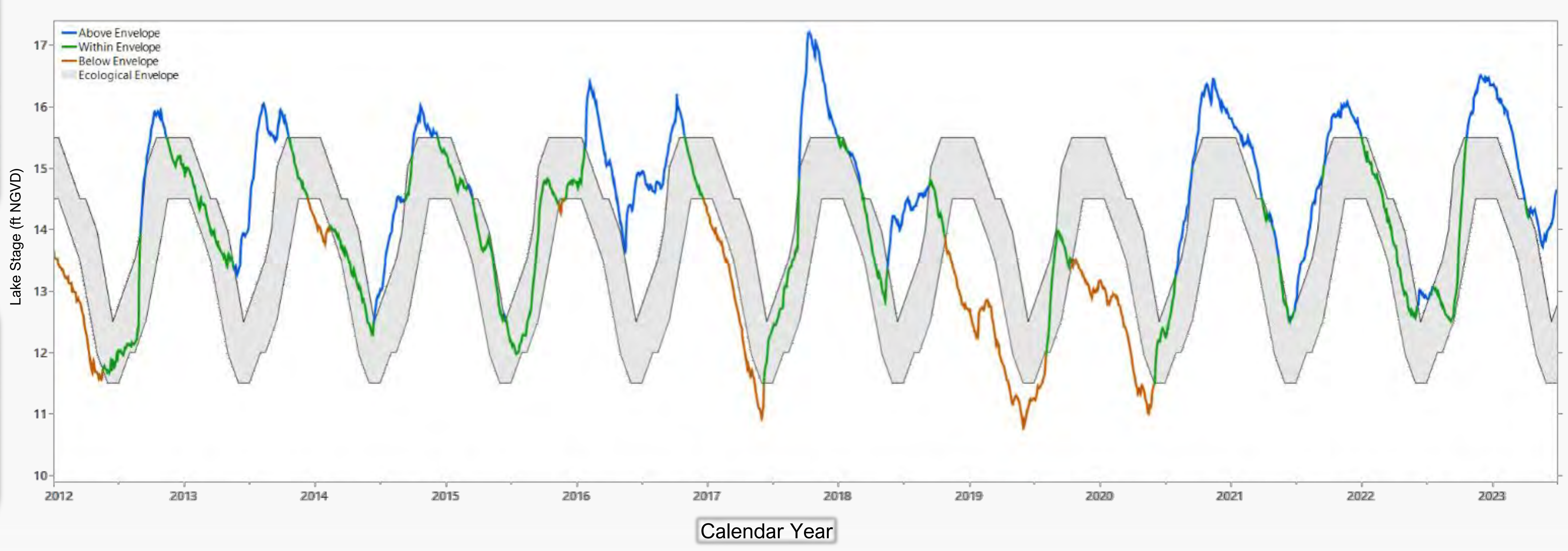
- TN and TP levels in the **Pelagic** (central) region follow a similar pattern to turbidity, suggesting they are associated with particulates.
- With large surface area and shallow water, particulate levels are highly influenced by strong winds.



- Changes in concentrations of dissolved inorganic nitrogen (DIN) and chlorophyll *a* are indicators of biological activity.
- High inflows often increase DIN, which is rapidly consumed by algae and cyanobacteria and intensifies the risk of phytoplankton blooms (higher chlorophyll *a*).
- Poor water clarity after strong storms, such as H. Irma in Sept 2017, may cause prolonged periods of low light and elevated DIN, until conditions for biological uptake improve.

Lake Stage Ecological Envelope

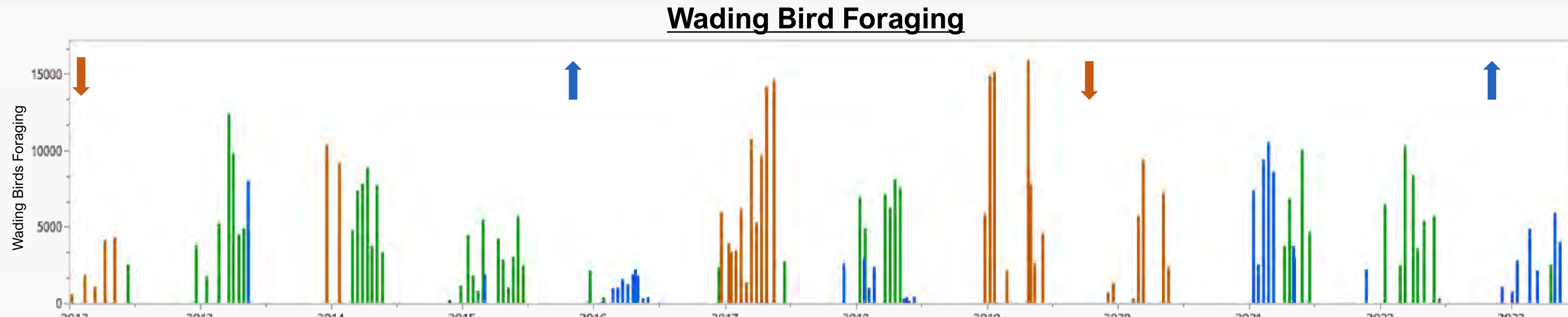




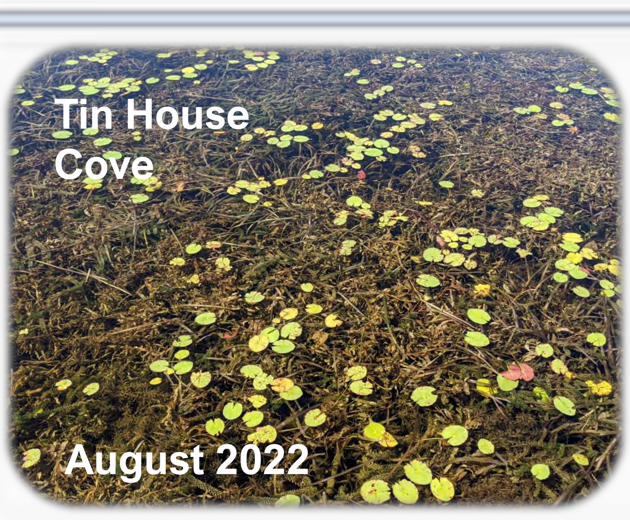
- Lake Okeechobee stages (line) fluctuate in response to changes in inflows, outflows, rainfall, and evaporation.
- Ecological envelope (gray band) defines the range of water levels that represent a compromise of optimal conditions across seasons, habitats, flora, and fauna.
- Short periods **above** or **below** the envelope are not necessarily ecologically harmful, but slow rates of change are desirable.
- Rapid and extreme variations in water levels are unnatural and a function of the highly channelized watershed.

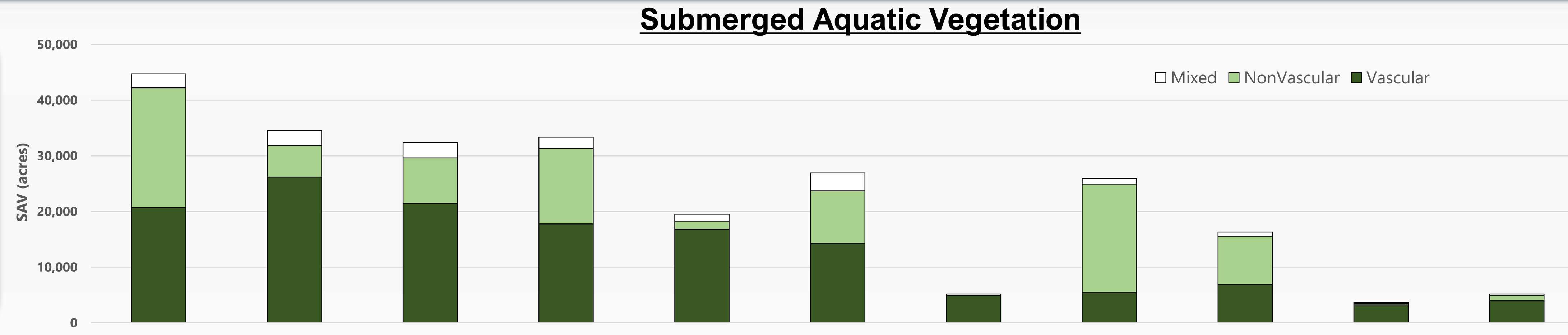
Wading Bird Foraging

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



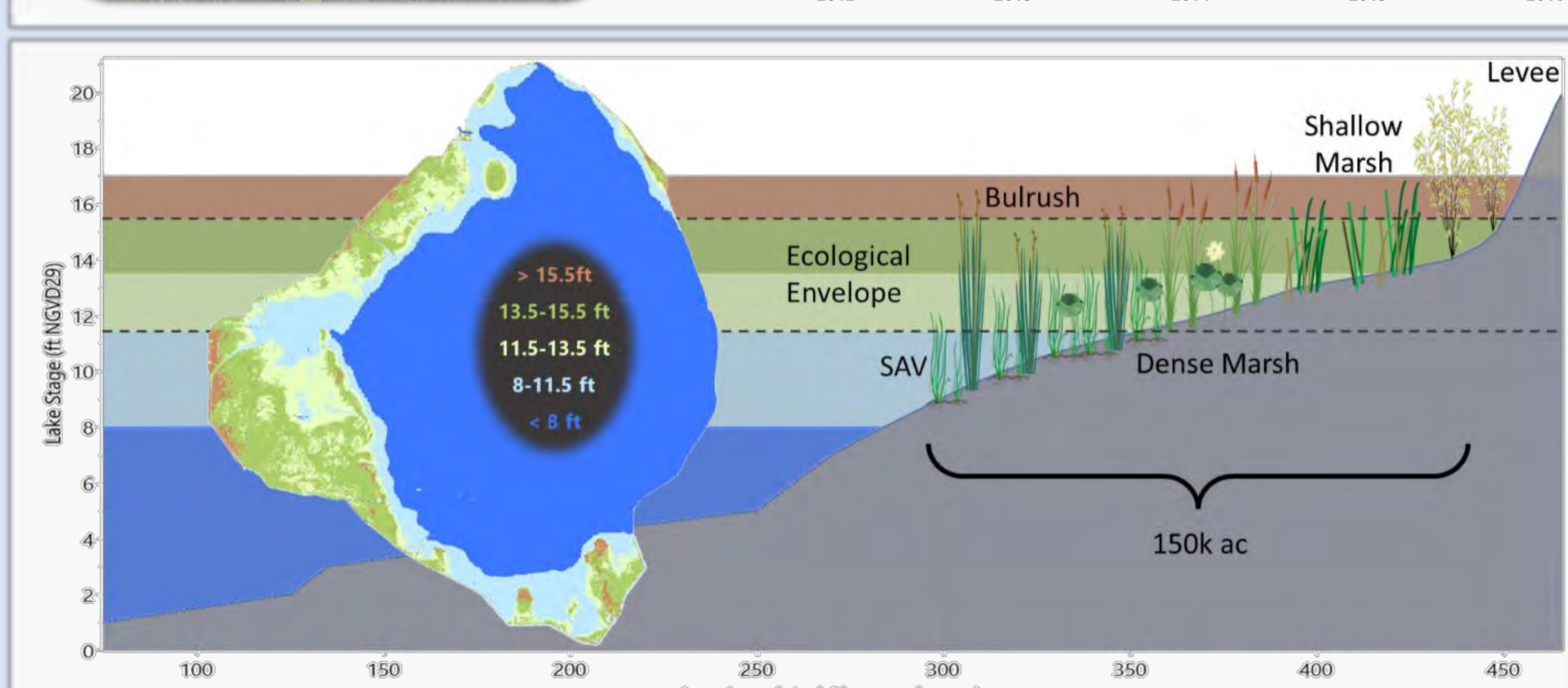
Submerged Aquatic Vegetation

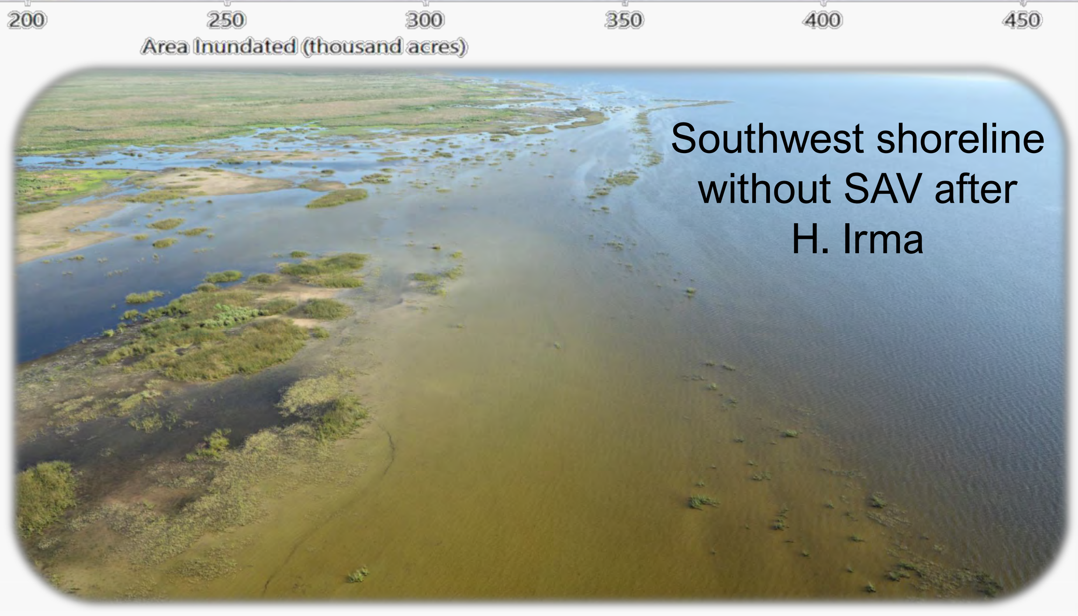




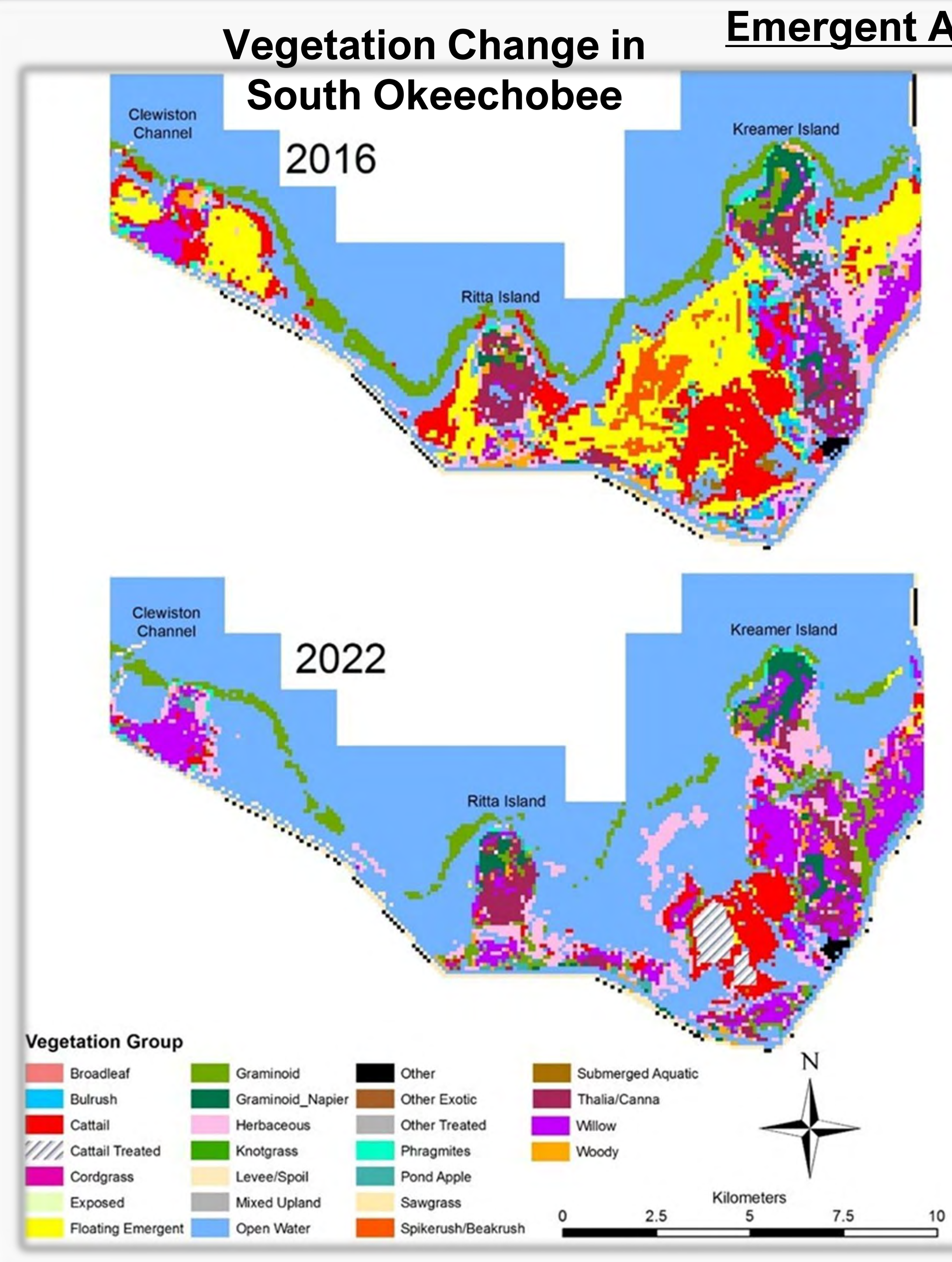
- Lower lake stages increase the light reaching young/seedling submerged aquatic vegetation SAV and promote growth.
- If stages stay too low, SAV beds may dry out and become dominated by emergent plants.
- If lake stages stay too high, even tall and well established SAV can die out.

SAV sampled in Aug, prior to H. Ian (Sept. 2022) and H. Nicole (Nov. 2022)





Emergent Aquatic Vegetation



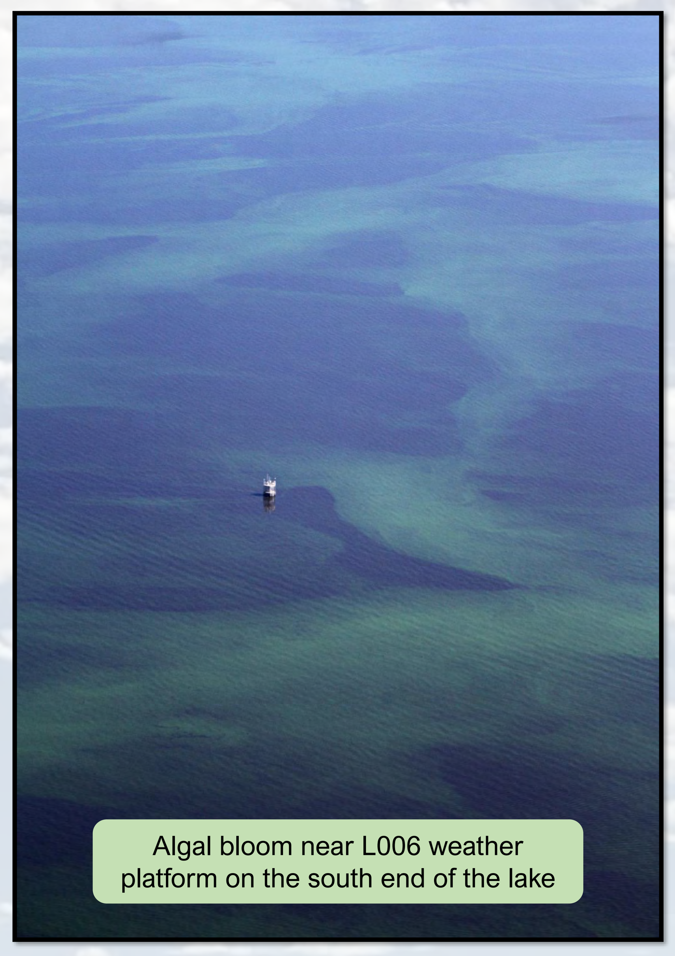
For more information:

Chapter 8B: Lake Okeechobee Phytoplankton Monitoring in Water Year 2023

Anna Swigris
Lake and River Ecosystems Section, Applied Sciences Bureau

Sampling Florida's Inland Sea

For decades, the South Florida Water Management District (SFWMD) has monitored the presence and distribution of phytoplankton blooms and their associated toxins on Lake Okeechobee. To maintain this long-term dataset, SFWMD monitors six historic sampling stations on the lake for a multitude of phytoplankton-related parameters. Here is a look at that sampling effort in Water Year 2023 (WY2023) and how it compares to the last decade.



Algal bloom near L006 weather platform on the south end of the lake

Setting the Stage

- WY2023 = May 2022 – April 2023
- Dry Season = November – April
- Wet Season = May – October
- Monthly monitoring at 6 stations (**Figure 1**)
- Measured parameters:
  - Chlorophyll *a* (chl-*a*), as a proxy for phytoplankton biomass
    - Algal Bloom = chl-*a* concentrations > 40 micrograms per liter (µg/L)
  - Microcystin toxin concentrations
    - Most microcystins monitored are detectable at 0.25 µg/L
  - Algal identification
  - Surface water quality parameters

Bloom Detections

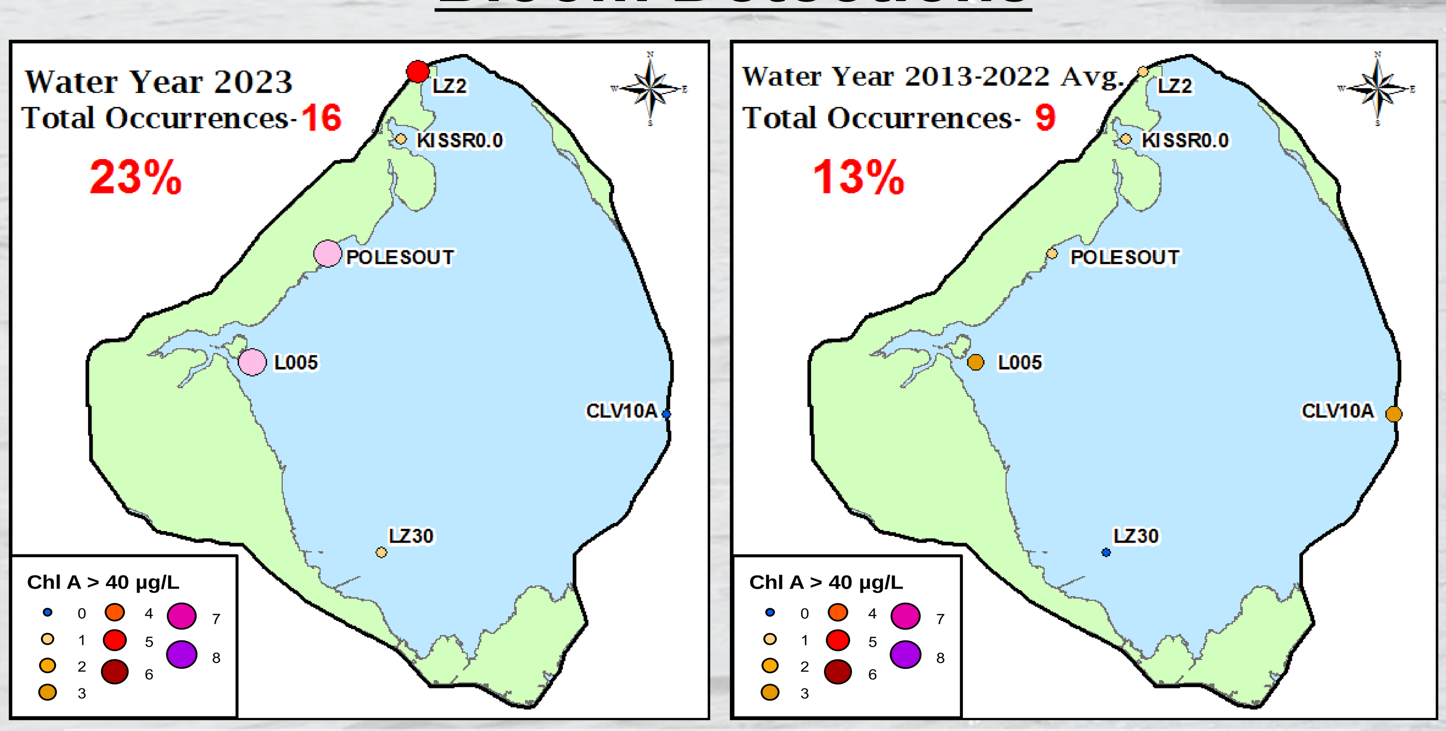


Figure 2. Algal bloom occurrences in WY2023 (left) compared to the last ten water years (right).

Toxin Detections

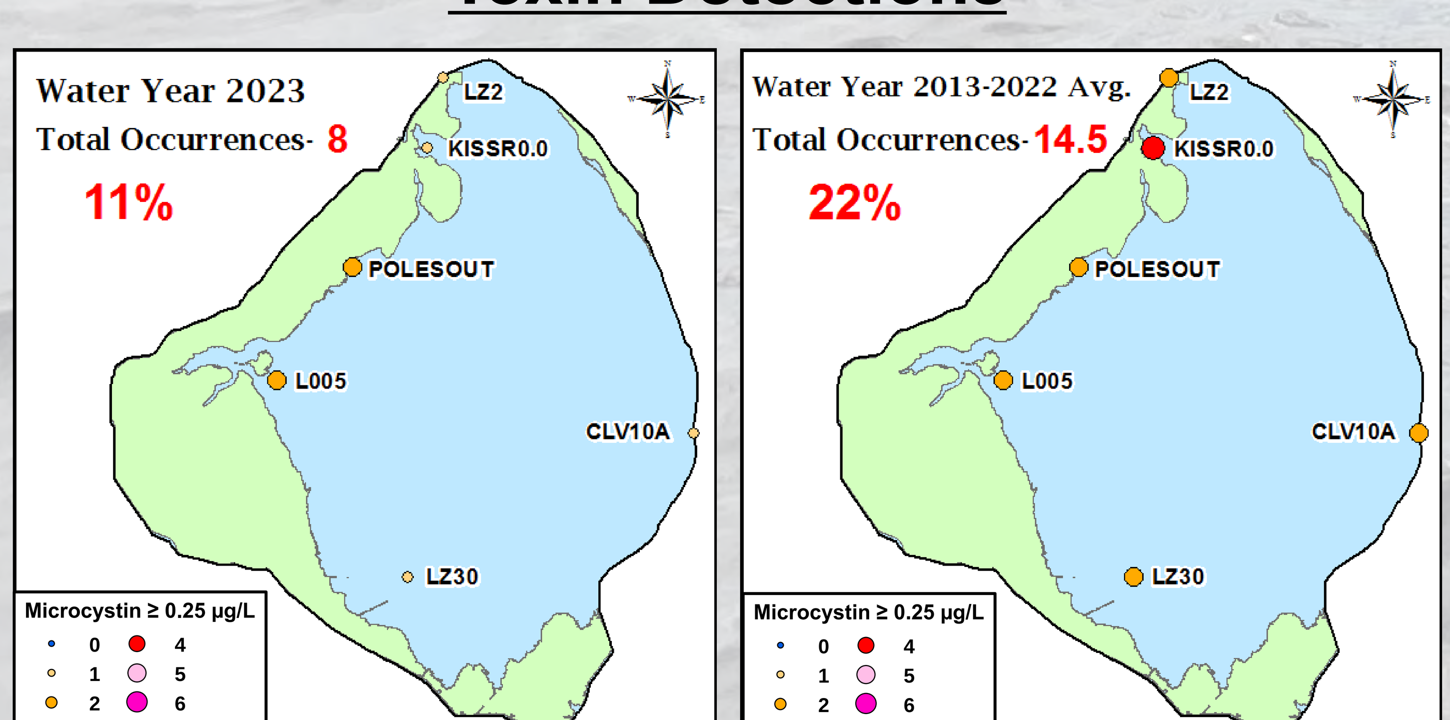


Figure 3. Detectable microcystin levels in WY2023 (left) compared to the last ten water years (right).

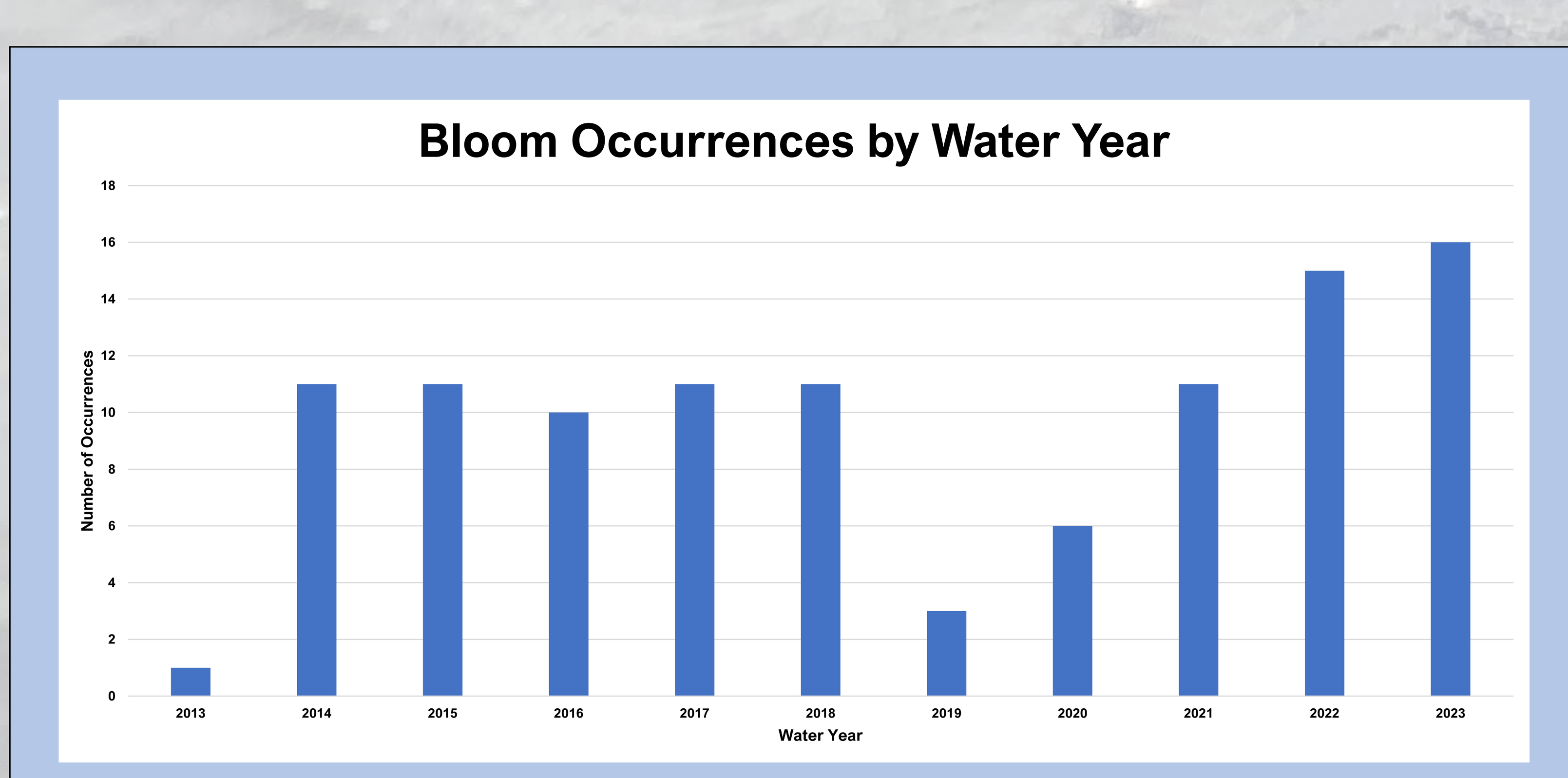


Figure 5. Frequency of algal blooms represented in the historic dataset from WY2013 through WY2023.

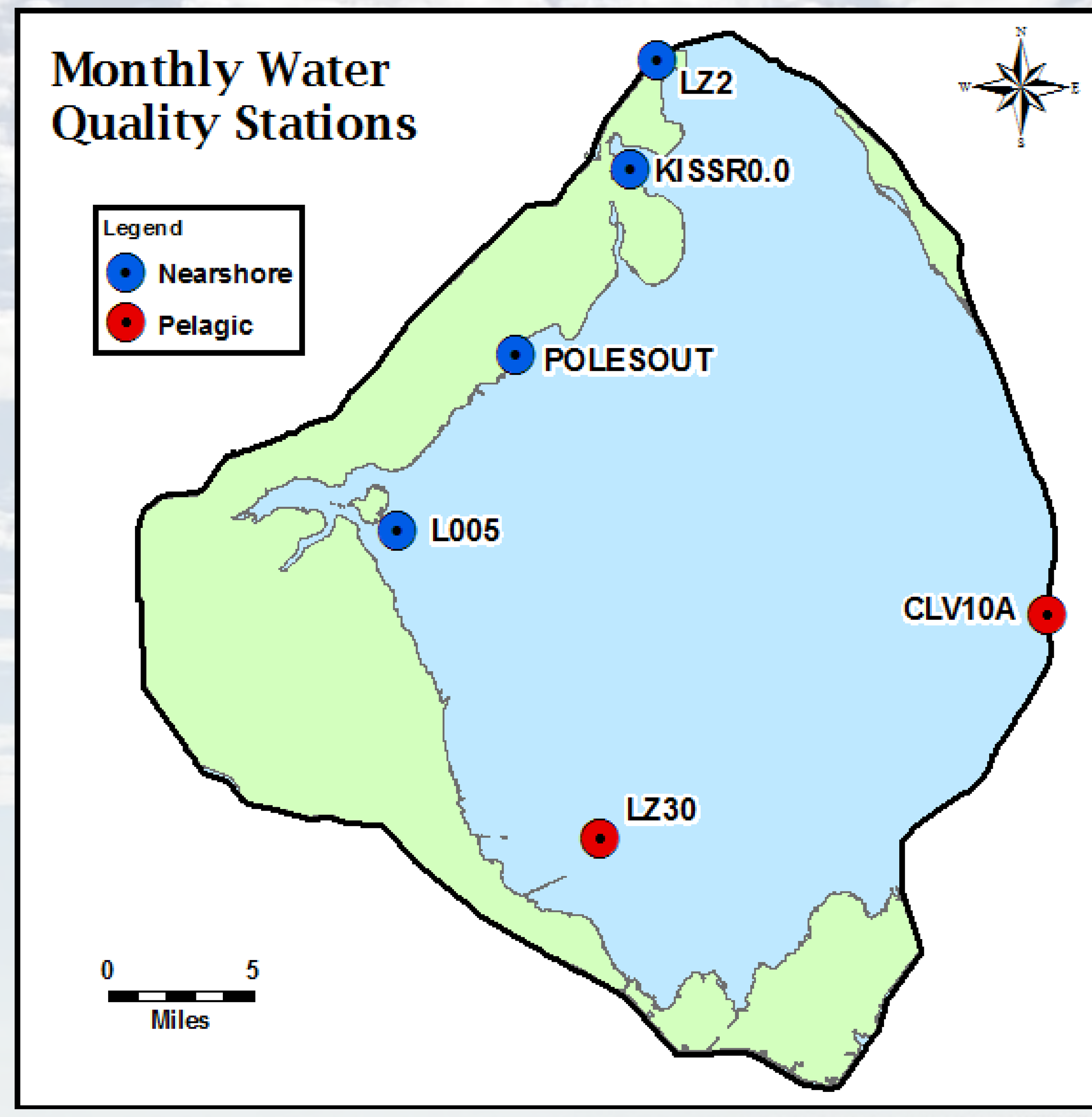


Figure 1. Long-term monitoring stations for chlorophyll *a*, microcystin toxins, and algal identification. Pelagic stations are outlined in red, while nearshore stations are outlined in blue.

Wet versus Dry

Algal blooms and detectable toxin levels occur more in the wet season than in the dry season on Lake Okeechobee. Here are some of those differences over the last eleven water years.

Wet Season
May – October

- 82% of total bloom occurrences
- 77% of detectible microcystin toxins
- Average chl-*a* concentration of 29.6 µg/L
- Average microcystin concentration of 0.9 µg/L

Dry Season
November – April

- 18% of total bloom occurrences
- 23% of detectible microcystin toxins
- Average chl-*a* concentration of 15.7 µg/L
- Average microcystin concentration of 0.04 µg/L

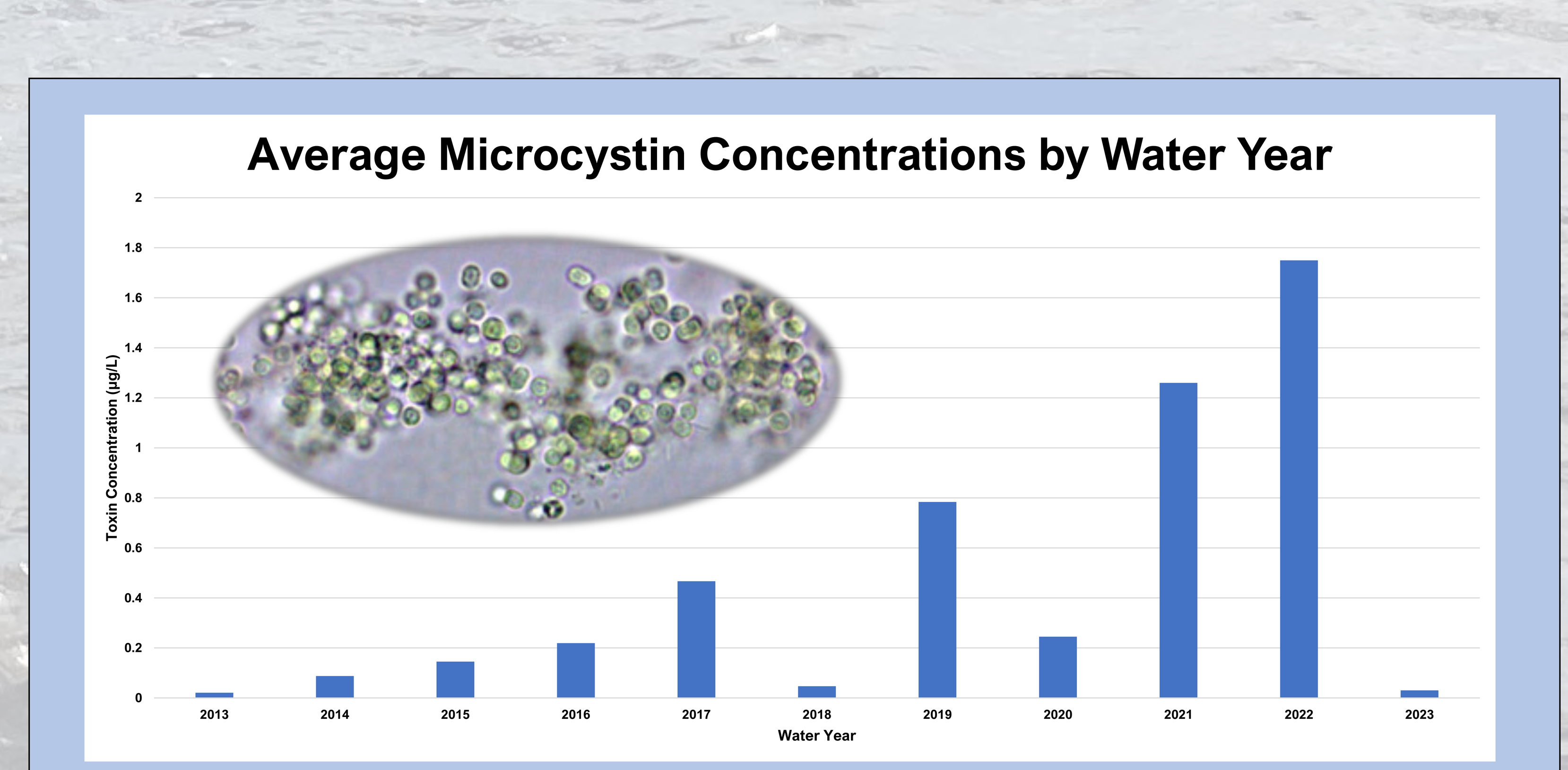


Figure 4. Average microcystin toxin concentrations represented in the historic dataset from WY2013 through WY2023.

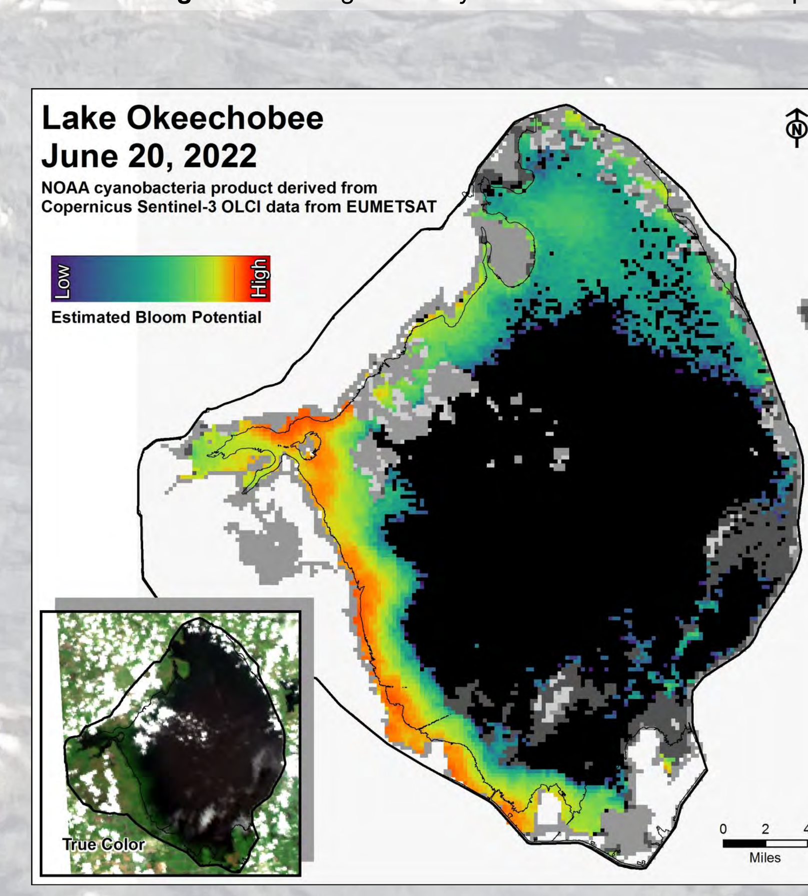


Figure 6. Satellite imagery showing bloom potential on Lake Okeechobee one day during WY2023's wet season.

Space and Time

Algal blooms occur more often in nearshore areas than offshore areas in Lake Okeechobee. In the eleven-year dataset, nearshore areas experienced blooms 18% of the time, and offshore areas experienced blooms 4% of the time. This trend can be seen in greater detail in Appendix 8B-2 of the South Florida Environmental Report, which, due to an expansion of phytoplankton monitoring in March of 2020, elucidates finer-scale trends in toxins and chlorophyll *a*.

For more information:
SCAN ME

Chapter 8B: Lake Okeechobee Submerged Aquatic Vegetation Update

Daniel Marchio

Lake and River Ecosystems, Applied Sciences Bureau

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

- Increased water clarity
- Improved water quality
- Stabilization of sediments
- Increased mammalian and Invertebrate species richness

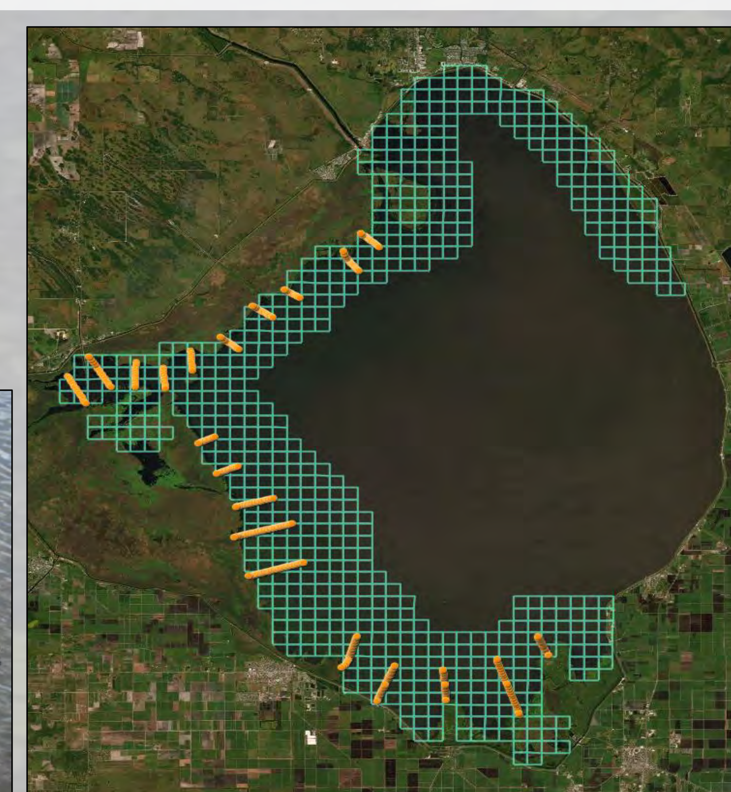
SAV distribution and abundance is principally governed by light availability and water depth in Lake Okeechobee.

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

- SAV coverage generally peaks 1-2 years after low lake stage and increased underwater light availability.
- 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 while biomass of SAV species is measured twice a year on transects.

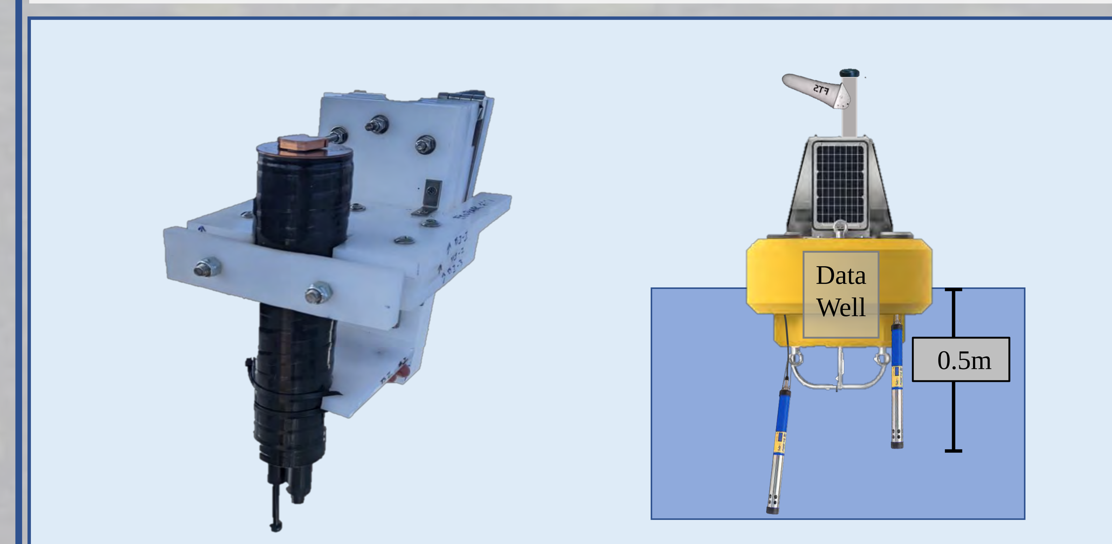
Secchi disk (upper left) and modified-rake SAV sampler.



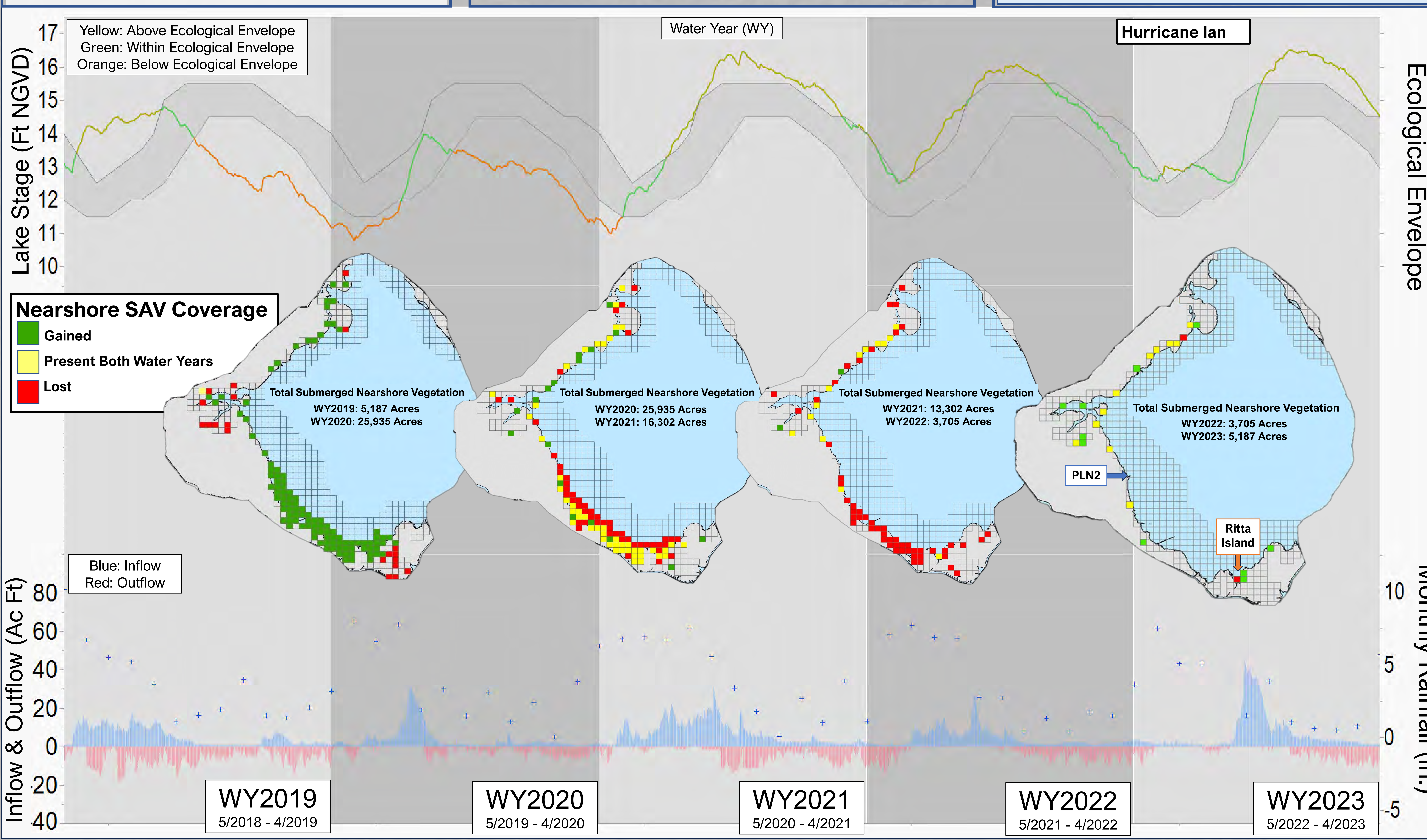
Combined SAV grid (blue boxes) projection and transects (orange dots) on Lake Okeechobee.

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.



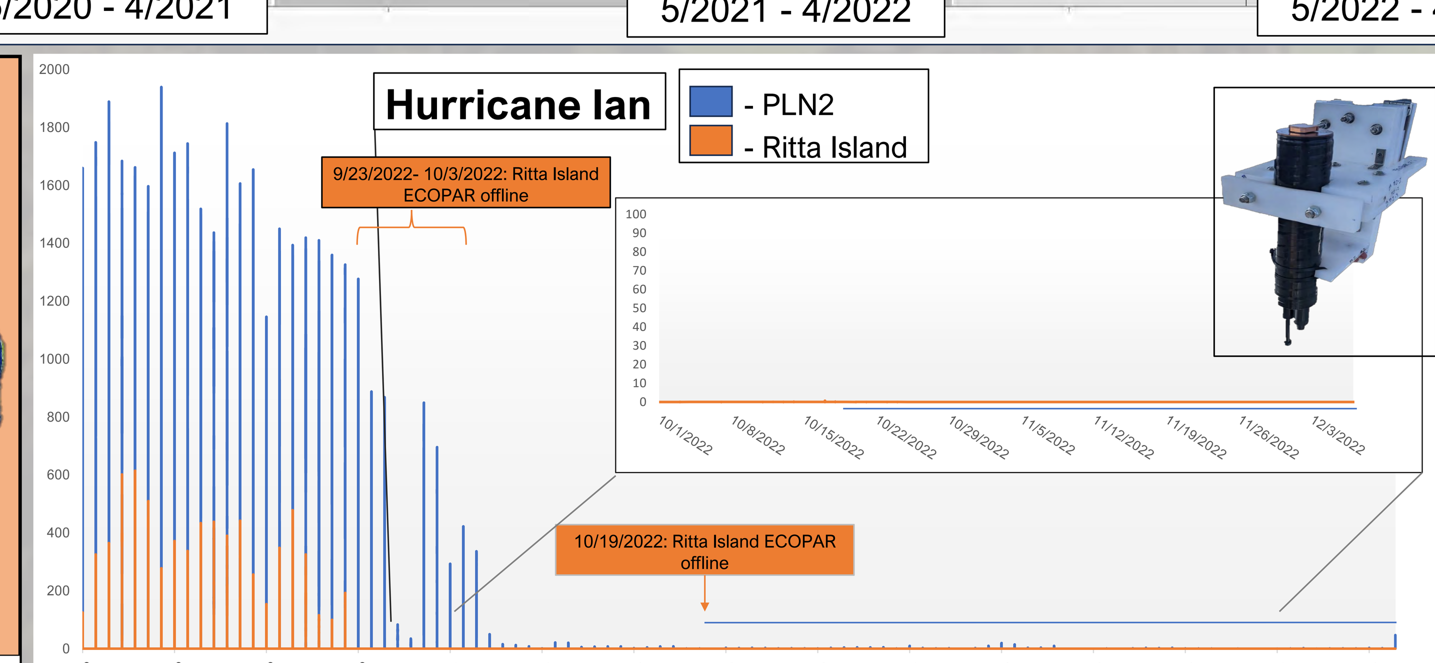
Photosynthetic Active Radiation sensor* (left) and water quality buoy (right). *not to scale



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

SW Shore Lake Okeechobee, 2020

Resampling after Hurricane Ian showed 2,470 ac of lost SAV (red grids) and 2,717 ac persisted (green).



Measured underwater light availability at PLN2 and Ritta Island from before and after Hurricane Ian.

For more information: SCAN ME

Technological Advances in Coastal Ecosystems

Danielle Taylor, Stacie Flood, Detong Sun, Cassondra Armstrong
Coastal Ecosystems Section, Applied Sciences Bureau

District Drone Program

- Benefits of using drones:
  - Quicker mobilization and data collection in near real-time
  - Higher resolution imagery
  - Repeatable mapping surveys
- Coastal monitoring use cases:
  - Harmful algal blooms
  - Estuary habitat use
  - Fish seining surveys
  - Vegetation mapping

UAS PROGRAM

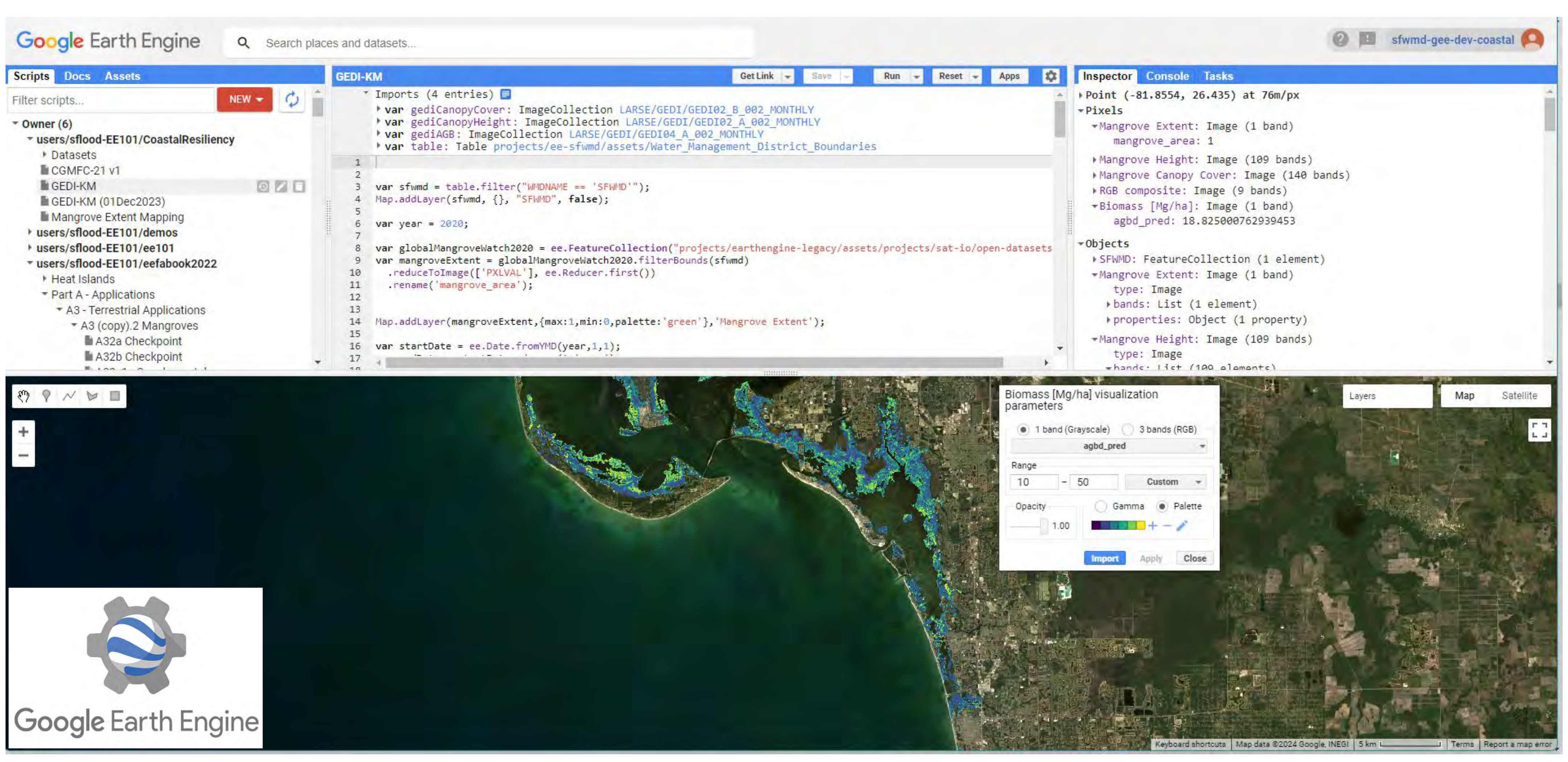
District drone pilot


St. Lucie River Estuary

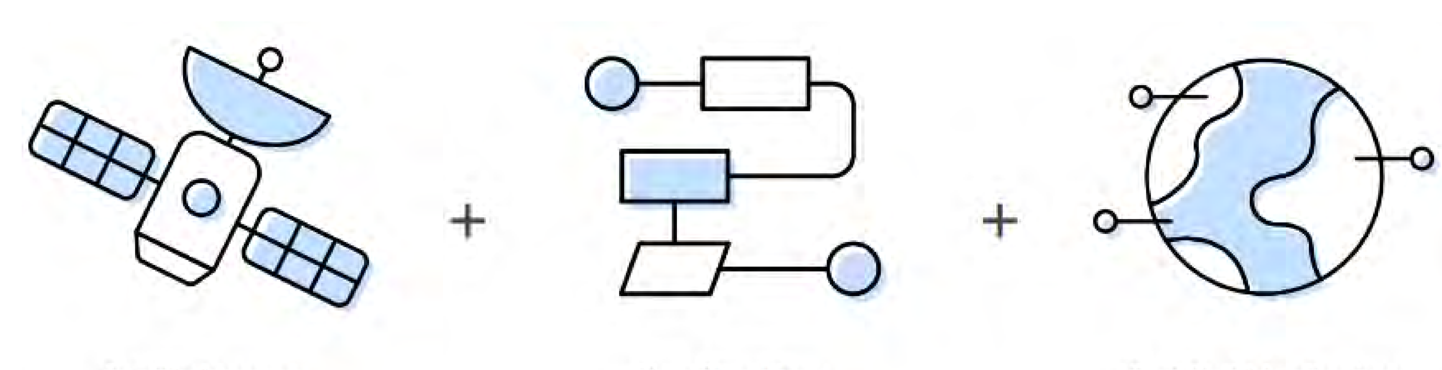

Algal bloom monitoring


Fish seining

Google Earth Engine



- Access to big data and assessment tools
- Mangrove monitoring in Loxahatchee utilizing satellite and drone imagery
- Enhanced system status reporting
- Improve modeling capabilities



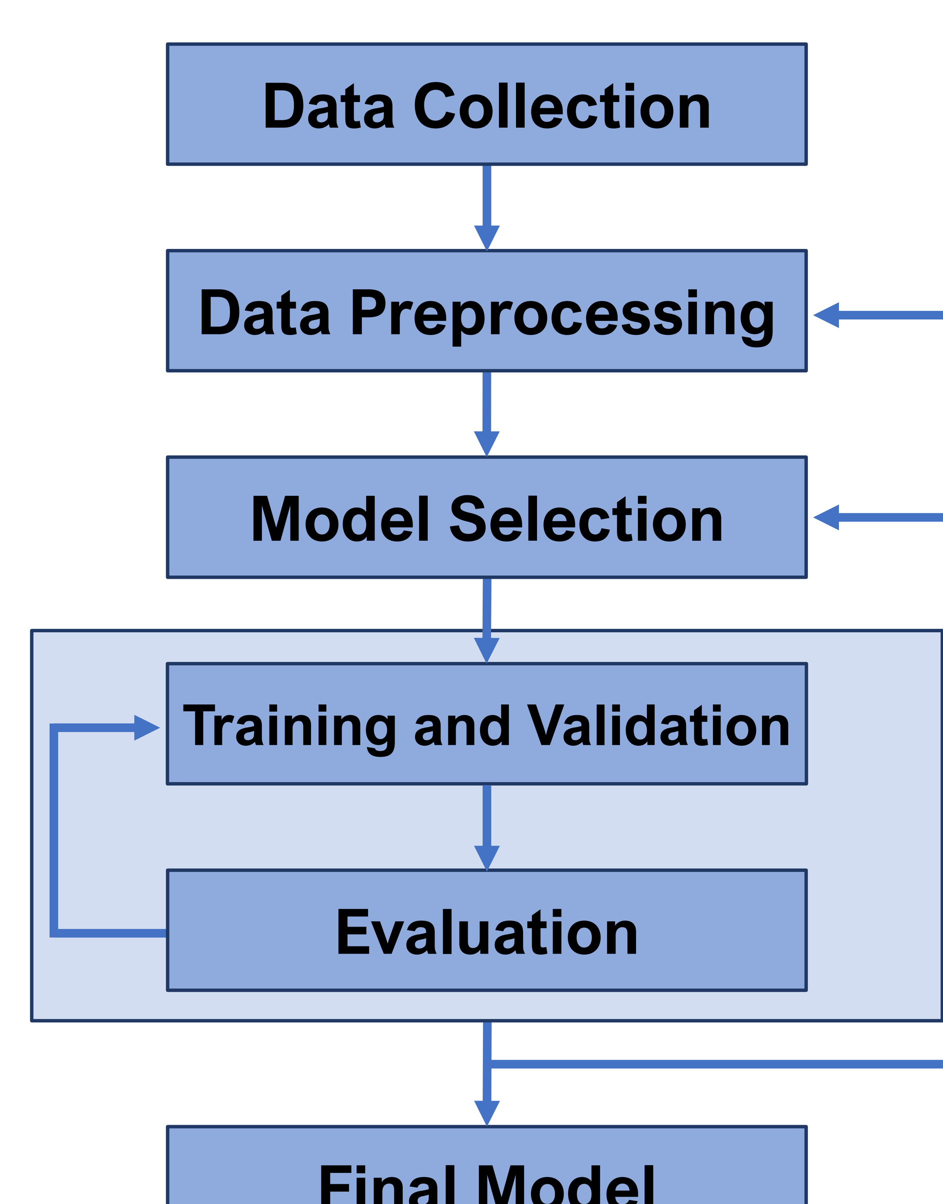
Machine Learning (Google Cloud Platform)

- Develop predictive modeling tools for:
  - Restoring oyster and seagrass habitat
  - Identifying key contributors to harmful algal blooms
  - Forecasting chlorophyll *a* in the estuaries
- Create algorithms to optimize flow allocations for operating water management systems


S-80 structure


Canal conveyance system

Machine Learning Workflow:



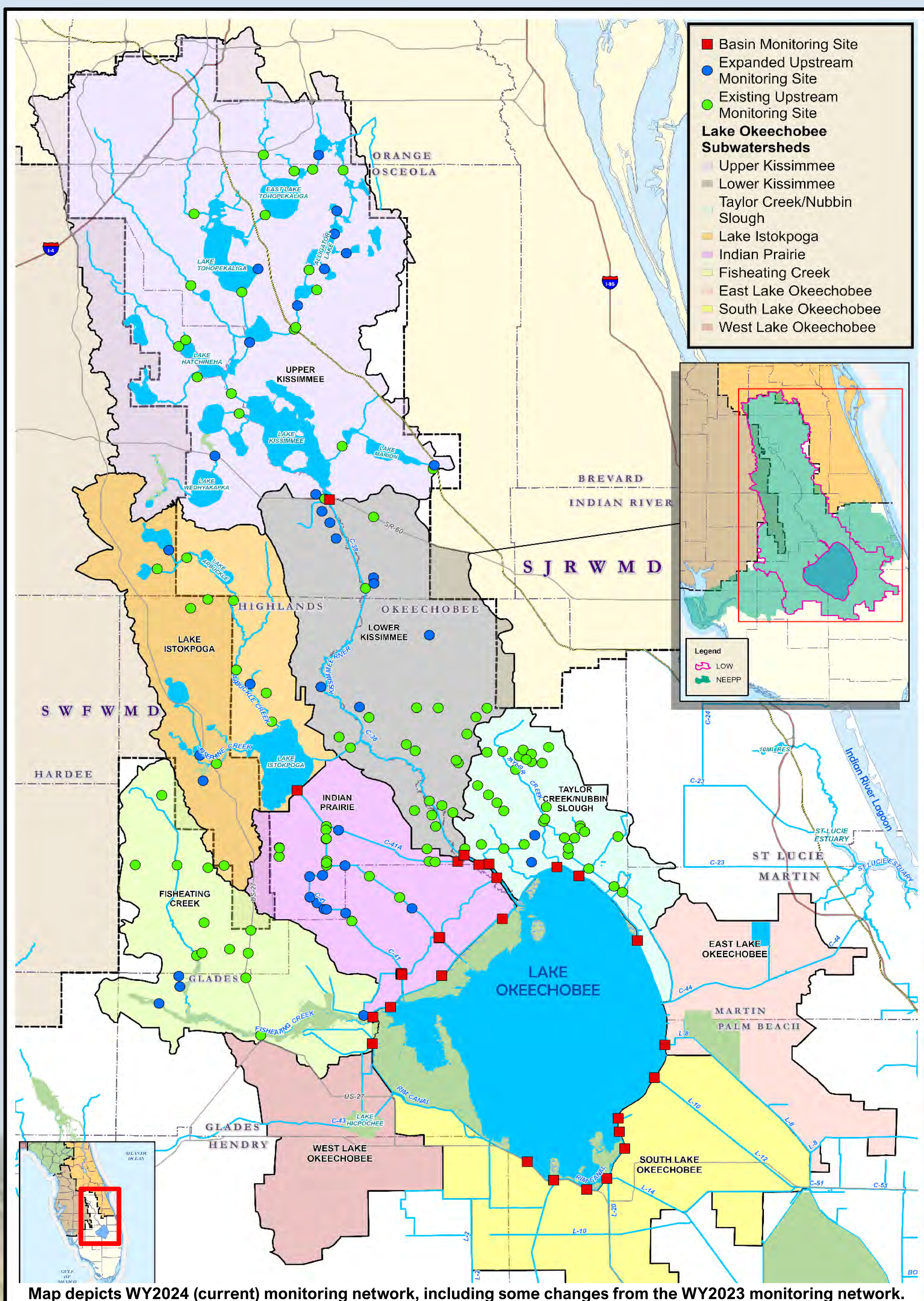
Source: https://www.researchgate.net/figure/Flow-chart-for-machine-learning-workflow_fig1_342778782

Appendix 8B-1: Water Year 2023 Lake Okeechobee Watershed Upstream Monitoring

Steffany Olson, Alyssa O'Neill, Carolina Hernandez Burgos
Project Operations & Assessment Section, Everglades & Estuaries Protection Bureau

Purpose of Upstream Monitoring: ➢Highlight Areas of Concern ➢Prioritize Resources ➢Track Progress

Water Quality Monitoring Network



Map depicts WY2024 (current) monitoring network, including some changes from the WY2023 monitoring network.

Acknowledgements: Thank you to the staff from the Okeechobee Water Quality Office and Analytical Services Section. Without their efforts these data would not exist. Additionally, the maps were produced by Allison Lamb, Madelyn Rinka, and Edwin Rios of the Geospatial Services Section.

Governing Board Expansion of Upstream Network

➢Fully implemented in WY2021
➢Increased:
- Number of sites
- Collection frequency to biweekly
- Number of parameters collected

Monitoring Level	Total Sites
Basin	37
Upstream	150

Parameters	Definitions
TP	total phosphorus
OPO_4-P	orthophosphate
TN	total nitrogen
NH_3-N	ammonial nitrogen
NO_x-N	nitrate + nitrate
pH	potential of hydrogen
Temp	temperature
DO	dissolved oxygen
Conductivity	Measures the ability of water to pass an electrical current.

Upstream Monitoring Plan	
Frequency	Biweekly when flowing (some weekly)
Parameters	TP, OPO_4-P, TN, NH_3-N, NO_x-N, pH, Temp, DO, Conductivity

WY2023 Upstream Monitoring Network Results

Focus on S-191 Basin

- ➢ WY2023 average TP at every site was > 120 µg/L (Florida Department of Environmental Protection numeric nutrient criteria).
- ➢ Six sites with 5-year annual average TP concentrations > 1,000 µg/L.
- ➢ Three sites with 5-year annual average TN concentrations > 10 mg/L).
- ➢ Had slightly above average rainfall for basin.

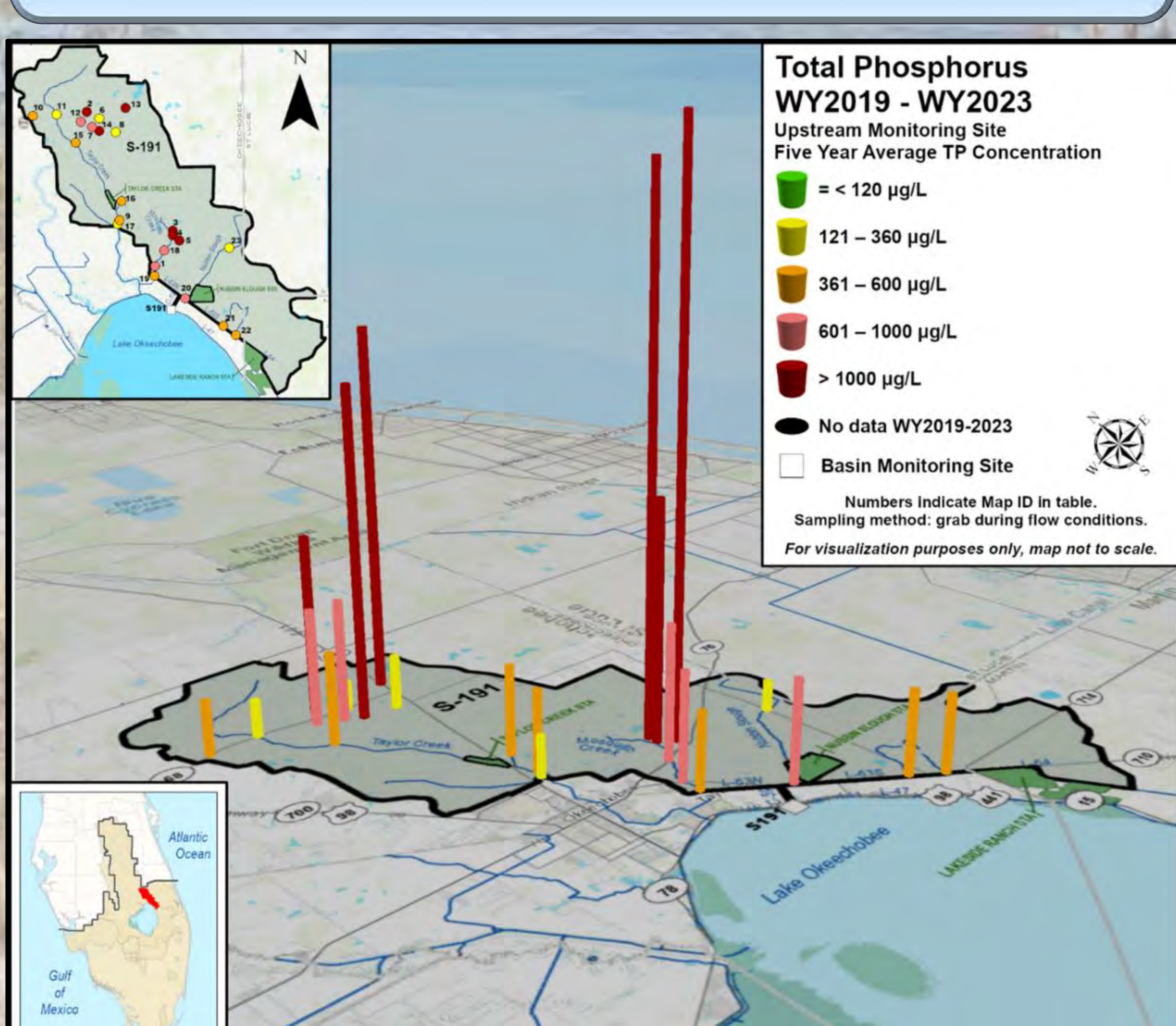
TCNS 207 Rapid Assessment

- ➢ There were four rapid assessment triggers when TN > 10 mg/L.
- ➢ Coordinating Agencies notified.
- ➢ SFWMD currently brainstorming projects.

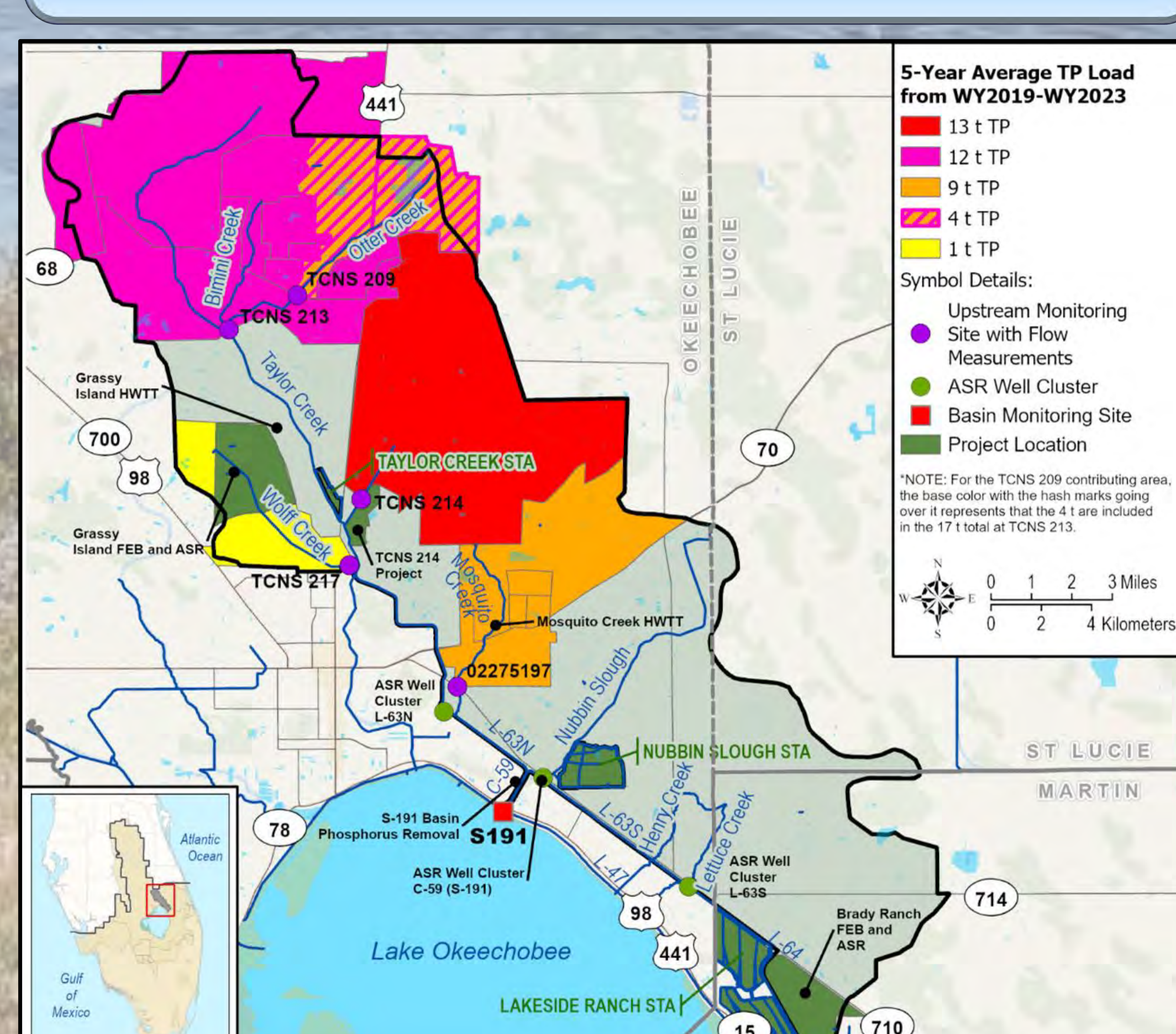
Nutrient Concentrations Water Years 2019–2023

TCNS S191		WY2019-WY2023									
		TP (µg/L)		OPO_4-P (µg/L)		TN (mg/L)		NH_3-N (mg/L)		NO_X-N (mg/L)	
Map ID	Site	No.	Avg.	No.	Avg.	No.	Avg.	No.	Avg.	No.	Avg.
1	02275197	50	694	41	477	50	3.39	36	0.49	41	0.46
2	LB29353513	31	1163	8	916	24	2.65	8	0.27	8	0.04
3	MS05373613	15	3417	4	2307	14	11.90	4	1.78	4	0.52
4	MS08373611	20	1539	5	2039	16	7.60	5	0.26	5	1.12
5	MS08373624	12	3655	11	2264	11	6.12	11	2.85	11	0.10
6	OT29353514	7	187	4	160	6	1.71	5	0.10	5	0.04
7	OT32353511	27	795	13	862	23	6.82	13	2.13	12	0.56
8	OT34353513	32	352	20	353	27	2.34	21	0.52	20	0.11
9	TC03373511	24	528	16	426	16	2.82	16	1.11	15	0.12
10	TC27353413	18	362	9	246	12	2.98	9	0.26	8	0.08
11	TCNS 201	42	246	31	187	42	1.66	32	0.11	31	0.15
12	TCNS 204	31	756	22	673	31	3.35	23	0.30	21	1.08
13	TCNS 207	34	2350	5	436	34	16.80	5	1.74	5	0.16
14	TCNS 209	32	2118	22	1643	32	14.22	22	7.15	20	1.40
15	TCNS 213	73	594	55	533	73	3.50	56	2.03	52	0.55
16	TCNS 214	74	575	60	479	74	1.79	60	0.34	59	0.15
17	TCNS 217	56	268	43	175	56	1.53	41	0.09	42	0.10
18	TCNS 220	45	864	35	605	45	3.78	35	0.89	33	0.19
19	TCNS 222	81	499	62	364	81	3.02	58	0.87	60	0.54
20	TCNS 228	11	658	9	590	11	2.38	9	0.17	8	0.17
21	TCNS 230	9	545	8	438	9	1.95	7	0.13	7	0.07
22	TCNS 233	28	505	24	442	28	1.86	22	0.14	23	0.09
23	TCNS 249	23	201	3	369	22	1.51	2	0.18	3	0.01

S-191 Basin Total Phosphorus Concentrations



S-191 Basin Total Phosphorus Loads



Meghan Anderson collecting a water sample in the Lake Okeechobee Watershed.

Unit of Measurement	Definitions
µg/L	microgram(s) per liter
mg/L	milligram(s) per liter

For more information: SCAN ME

Chapter 8C: St. Lucie River Watershed Protection Plan Annual Progress Report

Part III: St. Lucie River Watershed Construction Project

Sara Ouly

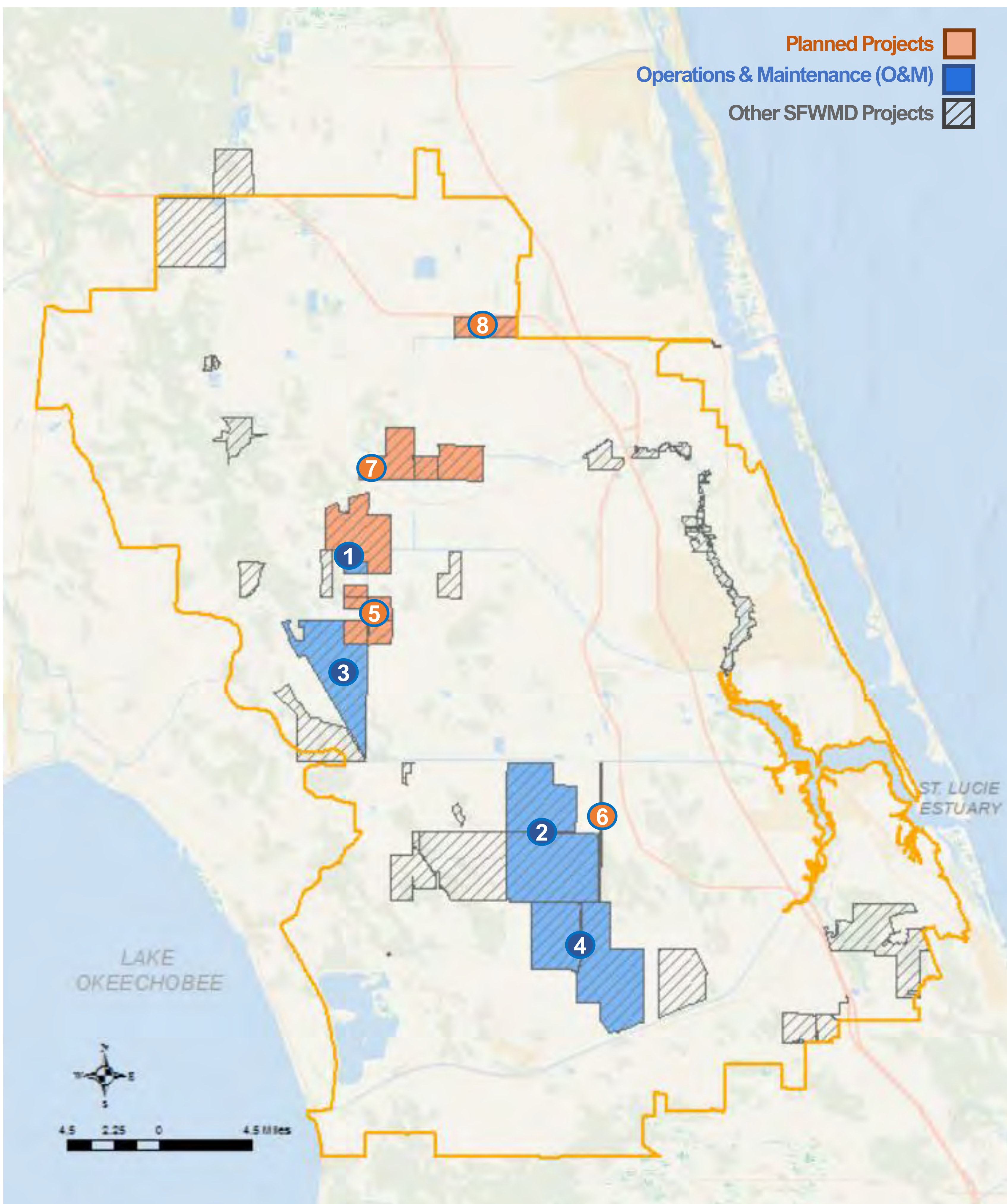
Planning and Project Management Section, Everglades and Estuaries Protection Bureau

Sixteen Operation Projects in WY2023, providing approximately:

- **128,011 acre-feet** (ac-ft) of storage
- **41 metric tons** (t) total phosphorus (TP) retention
- **266 metric tons** (t) total nitrogen (TN) retention

Highlighted Project: Scott Water Farm is a public-private partnership that retains stormwater on **7,549** acres, thus reducing overall loading to the C-25 Basin. During the first full year of operation (WY2023), the project removed **11.6 t/year (yr) of** TP and **69.8** t/yr of TN.

Advancing Watershed Construction Projects

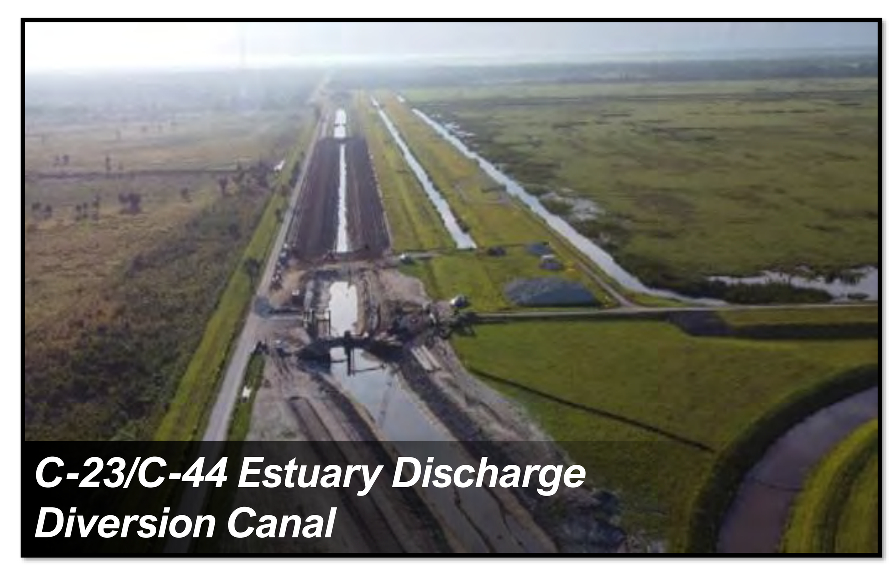


Planned Projects


C-23/C-24 District Lands Hydrologic Enhancement

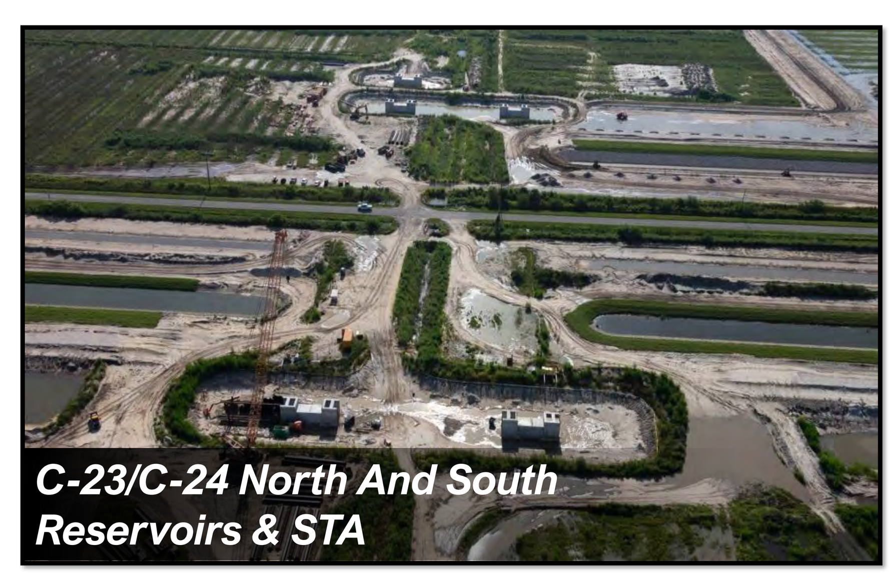
5. C-23/C-24 District Lands Hydrologic Enhancements

- Improve retention through hydrologic enhancements
- Status: Planning
- Estimated to store rainfall on 2,648 ac of District-owned land


C-23/C-44 Estuary Discharge Diversion Canal

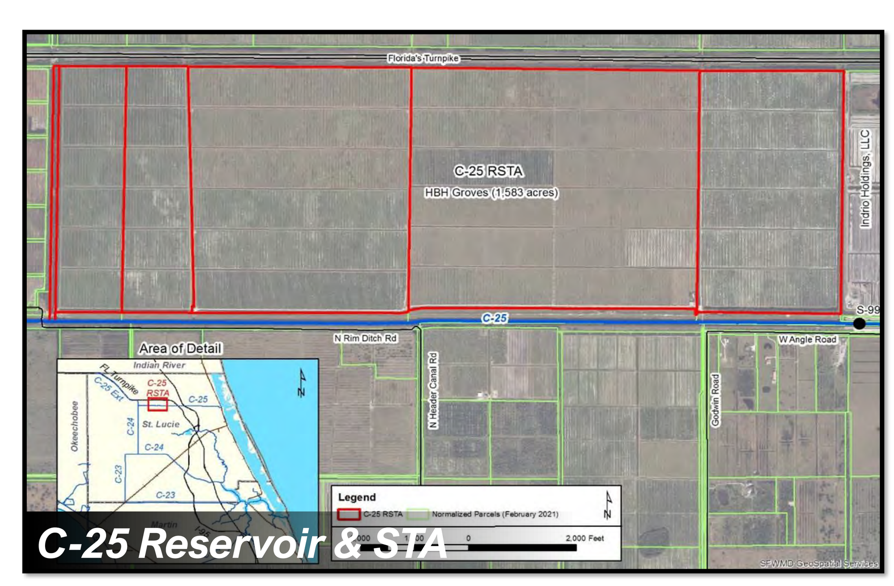
6. C-23/C-44 Estuary Discharge Diversion Canal

- Directs excess water from the C-23 Canal through the C-44 Reservoir & STA and into the C-44
- Status: Construction
- Expected to be operational by WY2026
- Estimated to divert 53,000 ac-ft/yr


C-23/C-24 North And South Reservoirs & STA

7. C-23/C-24 North and South Reservoirs & Stormwater Treatment Area (STA)

- Capture rainfall on 7,110-acre reservoirs and 2,568-acre STA
- Status: STA-Construction, Reservoirs-Design
- Expected to be operational by WY2030
- **Estimated storage: 95,242 ac-ft/yr**


C-25 Reservoir & STA

8. C-25 Reservoir & Stormwater Treatment Area (STA)

- Capture water from the C-25 Canal on 1,276 acres
- Status: Design
- Expected to be operational by WY2030
- **Estimated storage: 5,392 ac-ft/yr**

Operational Projects


C-23/C-24 Interim Storage Section C

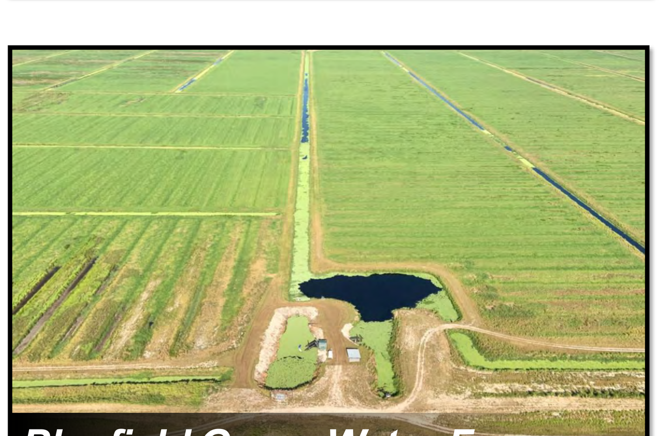
1. C-23/C-24 Interim Storage Section C

- Retains rainfall and excess water pumped from the C-23 Canal on 297 acres
- Operational since FY2019
- **WY2023 storage: 2,449 ac-ft**


Allapattah Flats Parcels A and B

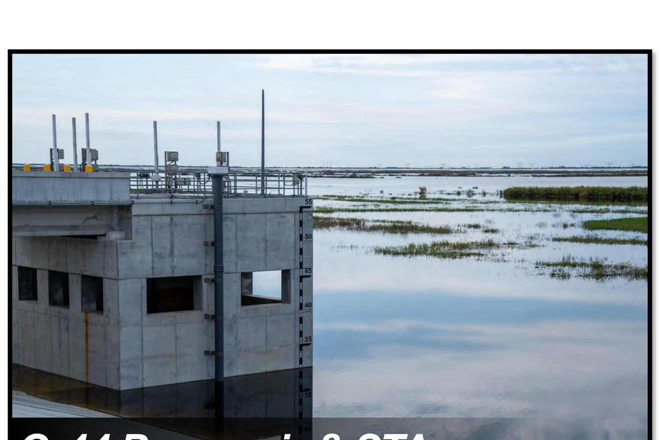
2. Allapattah Flats Parcels A and B

- Restored 6,621 acres of wetland habitat for storage retention
- Operational since FY2021
- **WY2023 storage: 5,350 ac-ft**


Bluefield Grove Water Farm

3. Bluefield Grove Water Farm

- 6,104-acre above ground impoundment (AGI)
- Operational since FY2022
- **WY2023 storage: 35,931 ac-ft**


C-44 Reservoir & STA

4. C-44 Reservoir & Stormwater Treatment Area (STA)

- Captures rainfall on 3,400-acre reservoir and 6,300-acre STA
- Operational Testing and Monitoring Period since FY2022
- **WY2023 storage: 9,370 ac-ft**

Progress Towards Water Quality and Storage Goals

*An additional 100,634 ac-ft/yr is expected to be added by WY2030

For more information:
SCAN ME

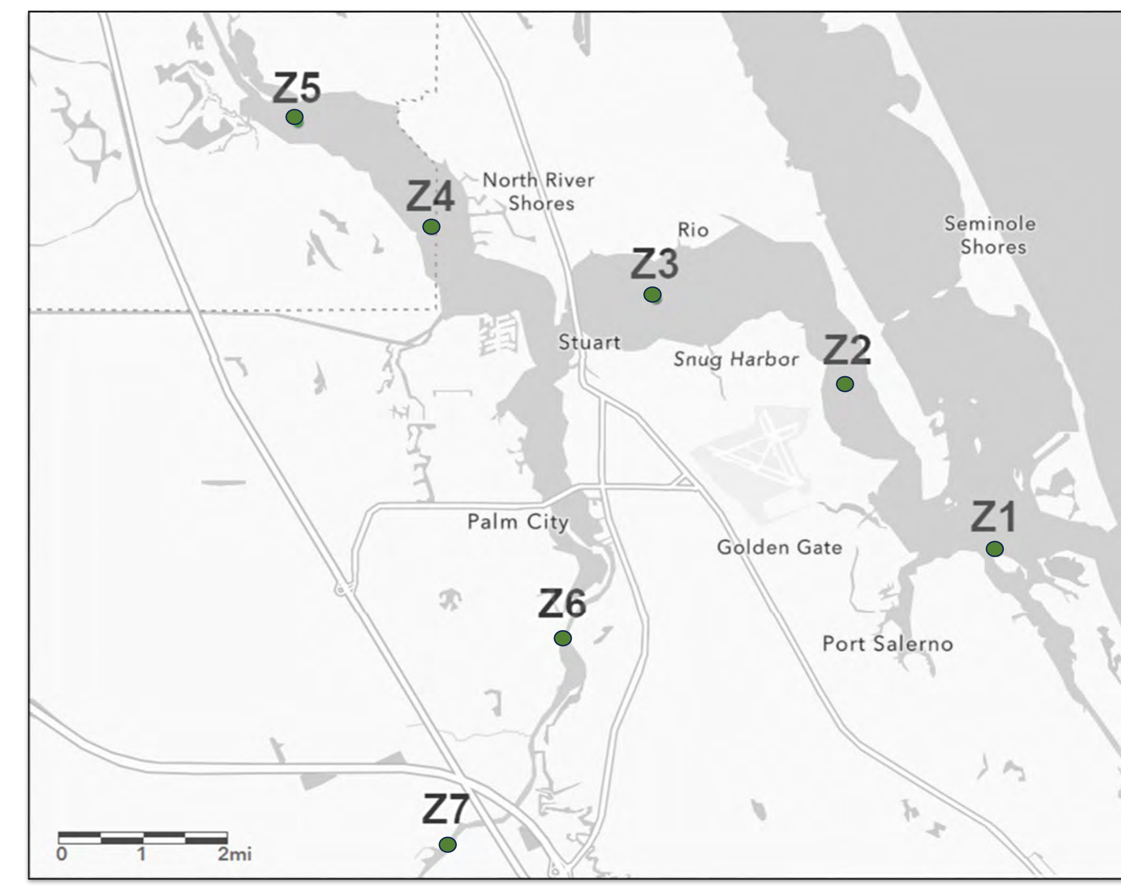
Chapter 8C: St. Lucie River Watershed Protection Plan Annual Progress Report

Zooplankton Monitoring in the St. Lucie River Estuary

Elizabeth Pudlak
Coastal Ecosystems Section, Applied Sciences Bureau

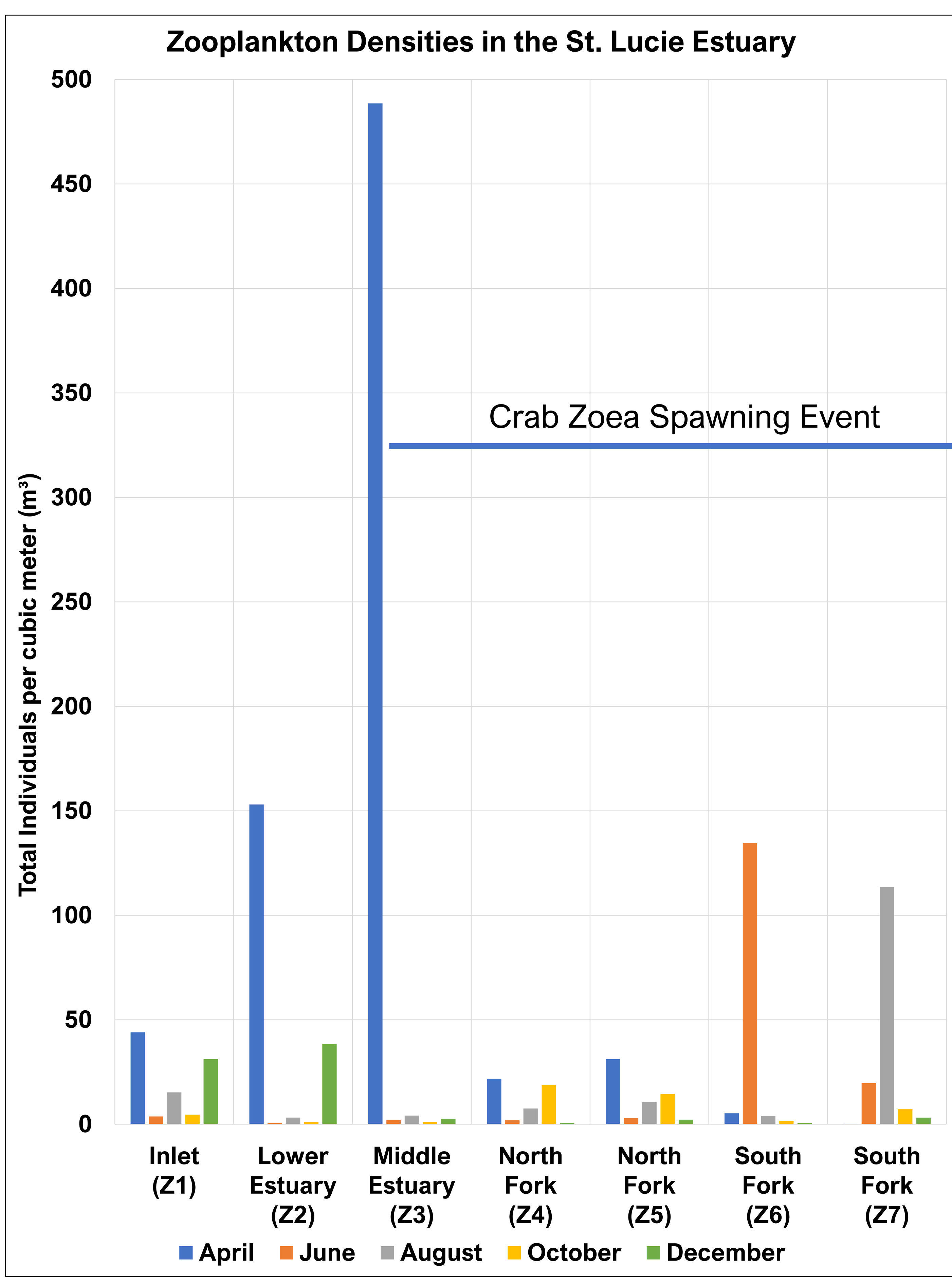
Purpose of Zooplankton Monitoring

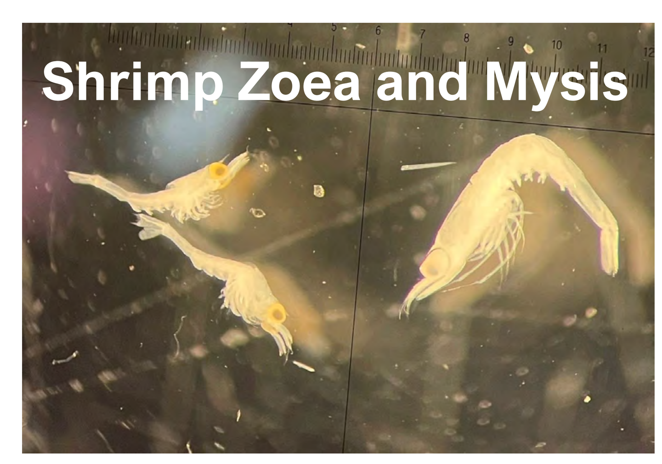
- Zooplankton are the base of the food chain and are relied on by many animals like fish and crustaceans.
- Many of our estuarine fauna begin as zooplankton.
- Zooplankton are sensitive to temperature and salinity changes, so they can be an indicator of changes in water quality.
- Zooplankton spawning is often triggered by salinity or temperature changes.



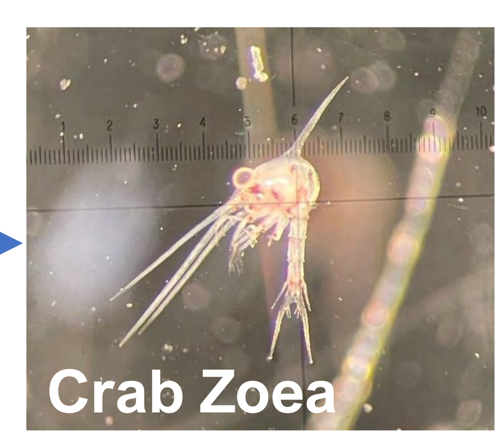
Zooplankton Communities

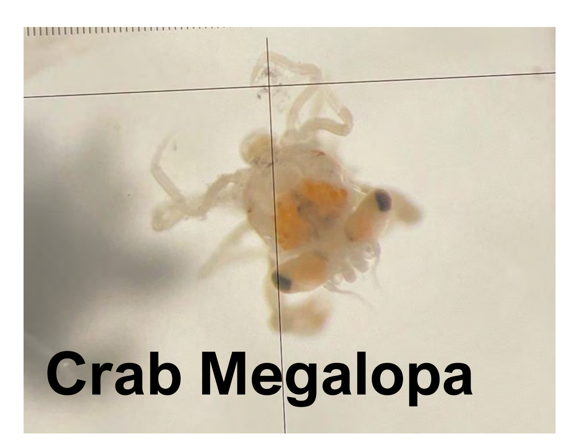
- The highest zooplankton densities were at different sites each sampling month.
- Peaks in zooplankton densities were usually a result of a spawning event triggered by temperature or salinity changes.

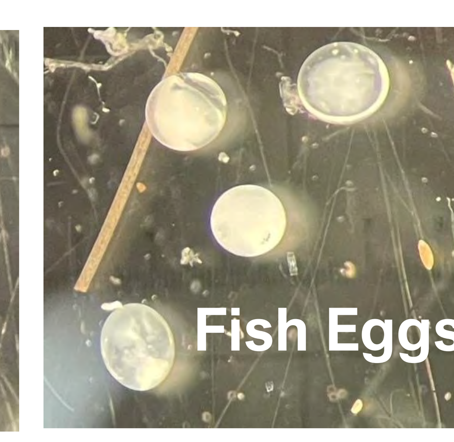




Taxonomic Group	Percent Present
Crab Zoea	100.0 %
Shrimp Zoea	91.4 %
Fish Larvae	94.3 %
Calanoid Copepods	85.7 %
Chaetognaths	77.1 %
Crab Megalopa	77.1 %
Shrimp Mysis	65.7 %
Barnacle Nauplii	62.8 %
Amphipods	62.8 %

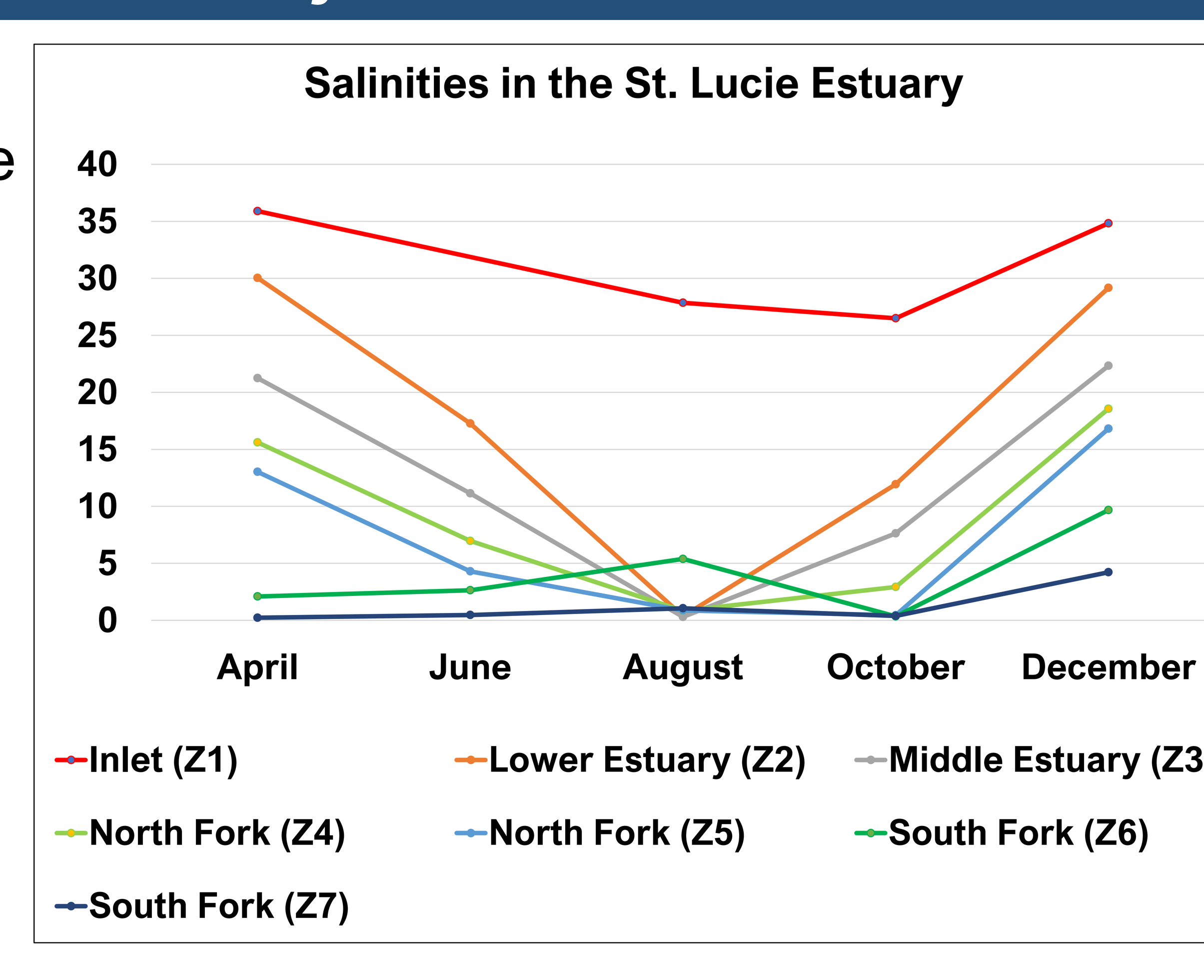




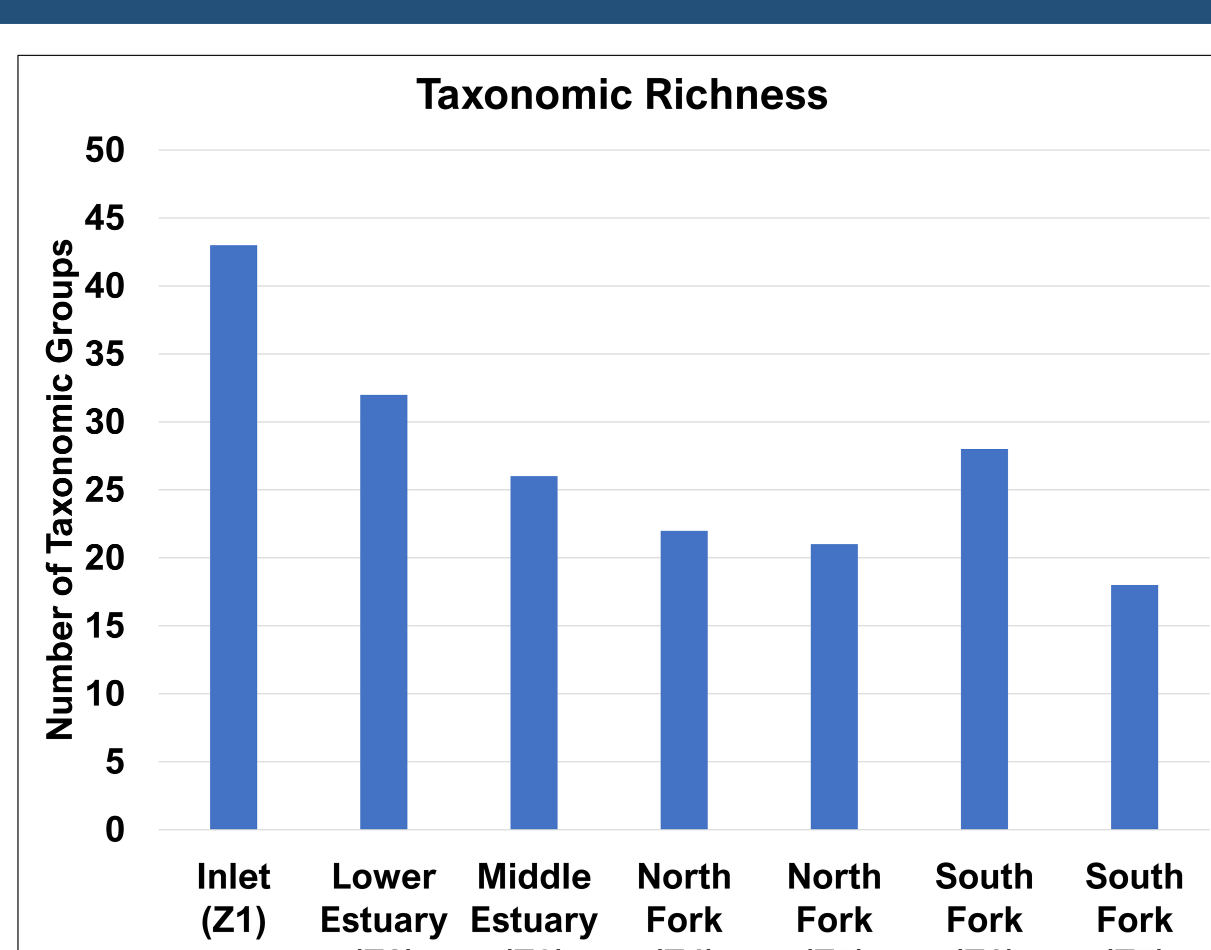


Water Quality

- Salinities differ between sites.
- Dry months (April, December) have higher salinities.
- Wet months (June, August, October) have lower salinities.
- High freshwater inflows can cause changes to diversity and abundance by flushing of zooplankton out of the system, triggering spawning events, and altering the salinity gradients throughout the system.



Taxonomic Richness



- Understanding zooplankton communities and their spatial and temporal changes can help better understand how they are impacted by freshwater inflows.
- Using zooplankton as an indicator can determine the health of the system and future decisions in water management.

For more information: SCAN ME

Chapter 8C: St. Lucie River Watershed Protection Plan Annual Progress Report

Fishes in the Northern Estuaries Monitoring (FNEMO)

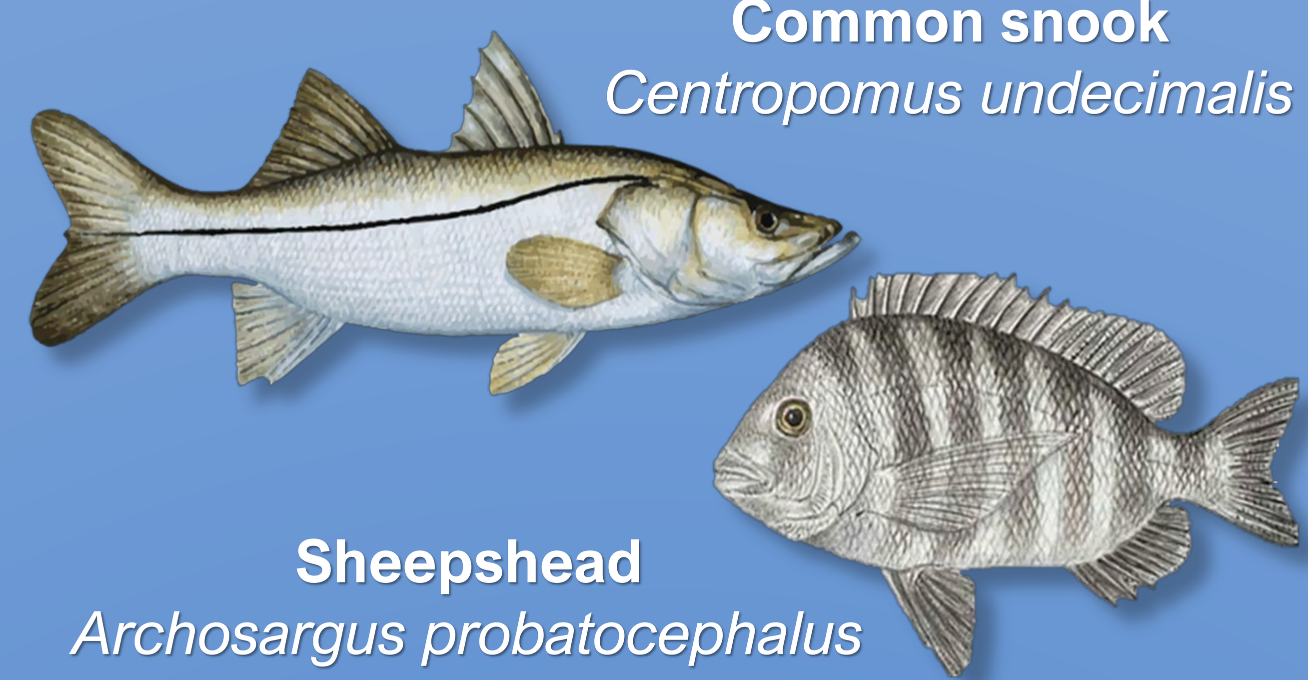
Sarah Webb, Juliane Caughron, Mark Barton
Coastal Ecosystems Section, Applied Sciences Bureau

Introduction and Background

Comprehensive Everglades Restoration Plan (CERP)
Restoration Coordination and Verification (RECOVER)

- Will fish be affected by flow restoration?
- Are fish moving out of the system?
- Are fish subjected to stressful conditions?
- Do prey base and diet patterns change?

Target Species



Common snook
Centropomus undecimalis

Sheepshead
Archosargus probatocephalus

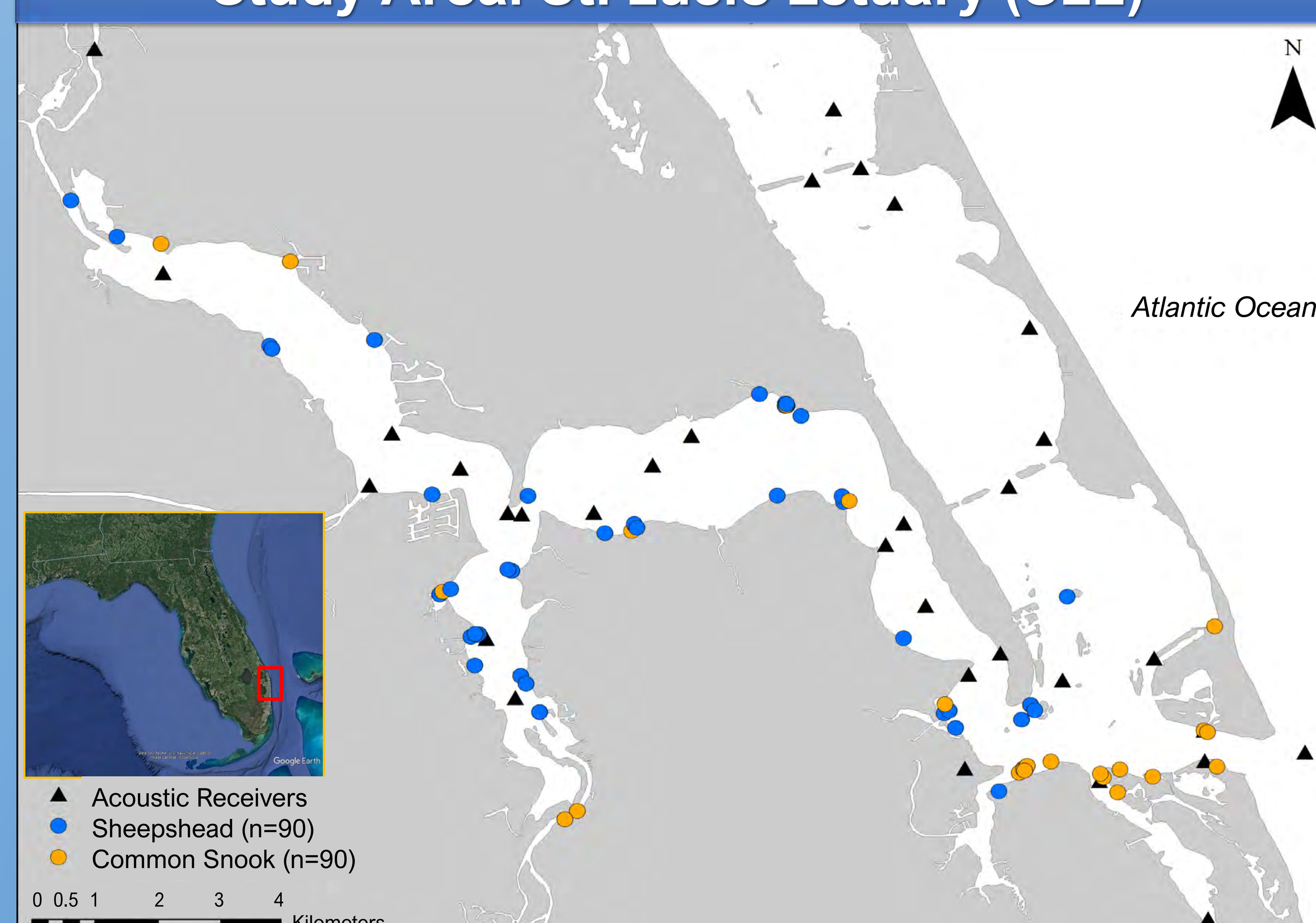
Collection Methods

Fish were caught via seine net or fishing in collaboration with the Florida Fish and Wildlife Conservation Commission Fish and Wildlife Research Institute.

Objective 1: Correlate Fish Movement

180 fish were surgically implanted with acoustic telemetry tags to identify distribution in relation to changing environmental conditions. External dart tags were used for recapture information.

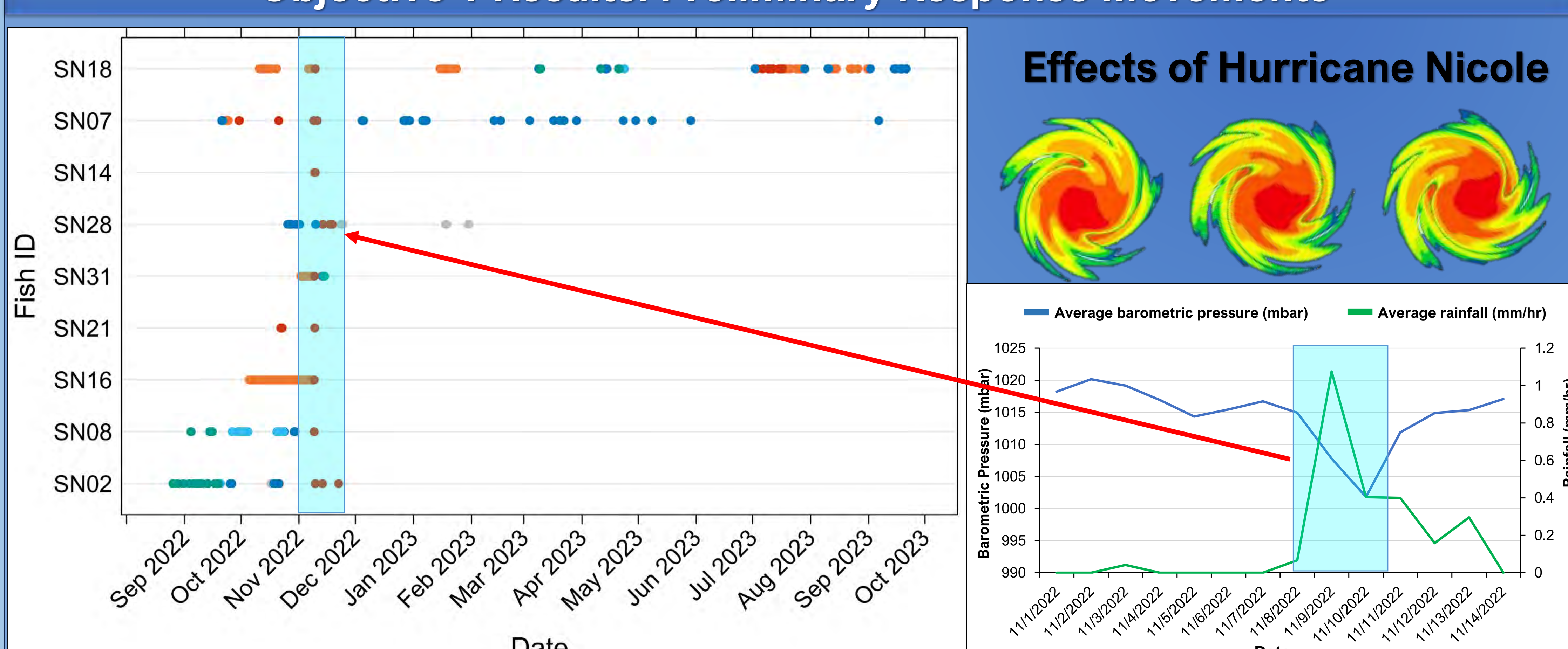
Study Area: St. Lucie Estuary (SLE)



Objective 2: Identify Baseline Health

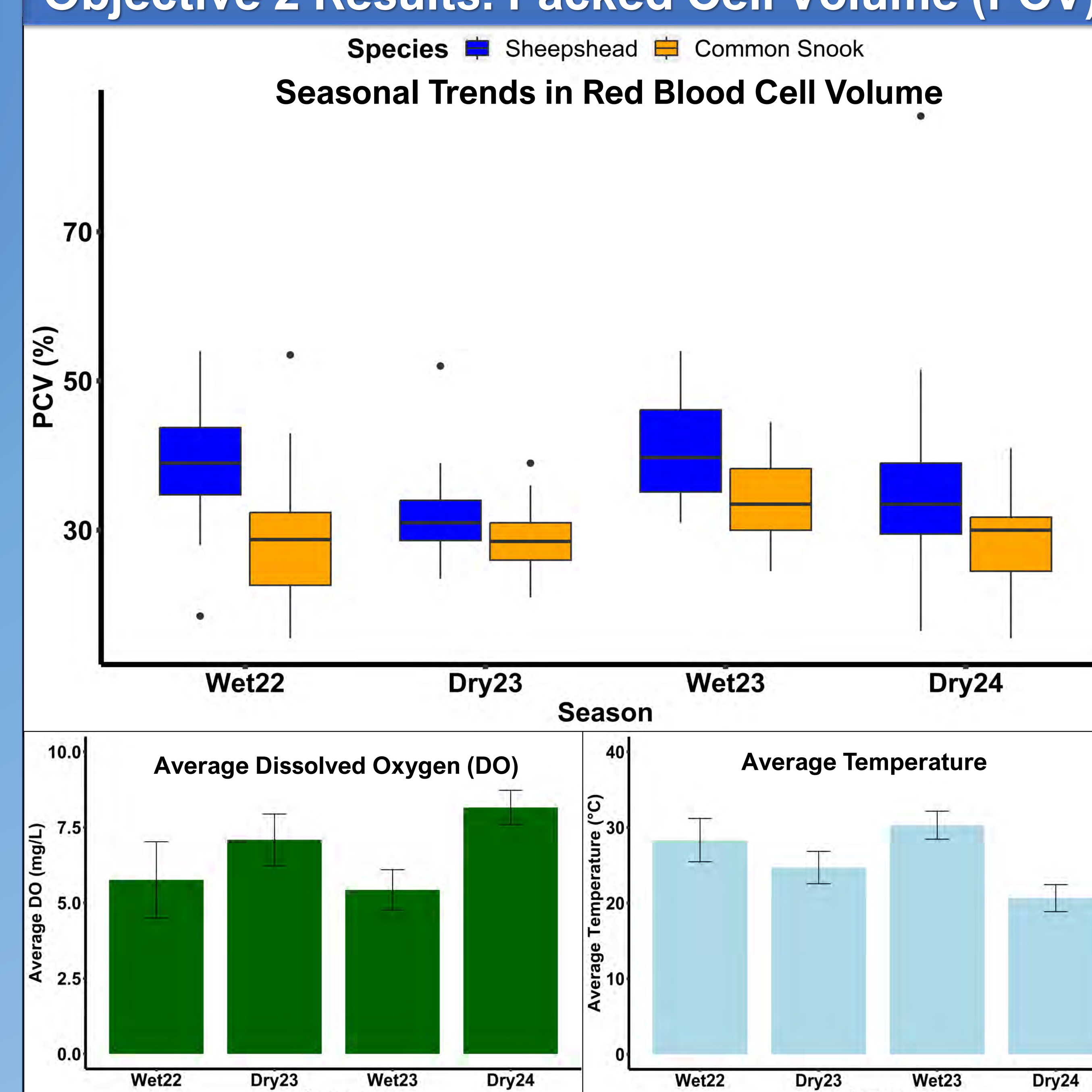
Blood draws and muscle biopsies were taken from snook and sheepshead to identify health parameters and food usage.

Objective 1 Results: Preliminary Response Movements



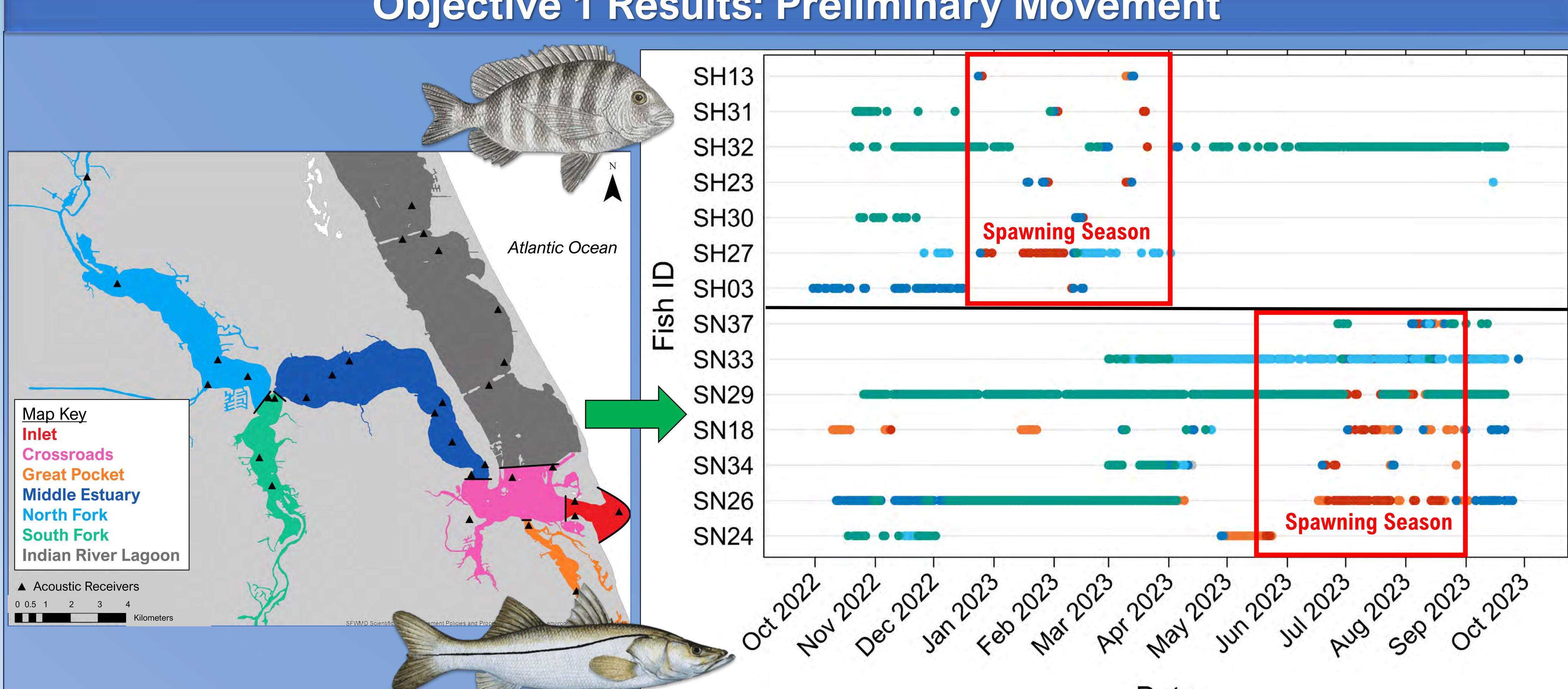
9 snook left the SLE in response to Hurricane Nicole on 11/10/23 and were detected in partner arrays south of the SLE from Jupiter to Elliot Key.

Objective 2 Results: Packed Cell Volume (PCV)



Red blood cell volume can be used as a proxy for oxidative stress. Cell volume typically increases with low dissolved oxygen (DO). Dissolved oxygen decreases with higher temperatures. Higher packed cell volume (PCV) allows for retention of oxygen in low DO (stressful) environments.

Objective 1 Results: Preliminary Movement



Sheepshead were detected at less receivers and had less detections on average than snook. Both species were detected at stations near the inlet during documented spawning seasons.

Summary

- Fish detected south of SLE after Hurricane Nicole.
- Implications for guidance of water releases from Lake Okeechobee in relation to spawning & larval settlement.
- Sheepshead PCV > Snook PCV:
  - Snook may be leaving unfavorable environments.
  - Sheepshead may remain in unfavorable conditions.

For more information:
SCAN ME

Appendix 8C-1: Water Year 2023 St. Lucie River Watershed Upstream Monitoring

Amanda McDonald, Steffany Olson, Jacob Landfield
Project Operations & Assessment Section, Everglades & Estuaries Protection Bureau

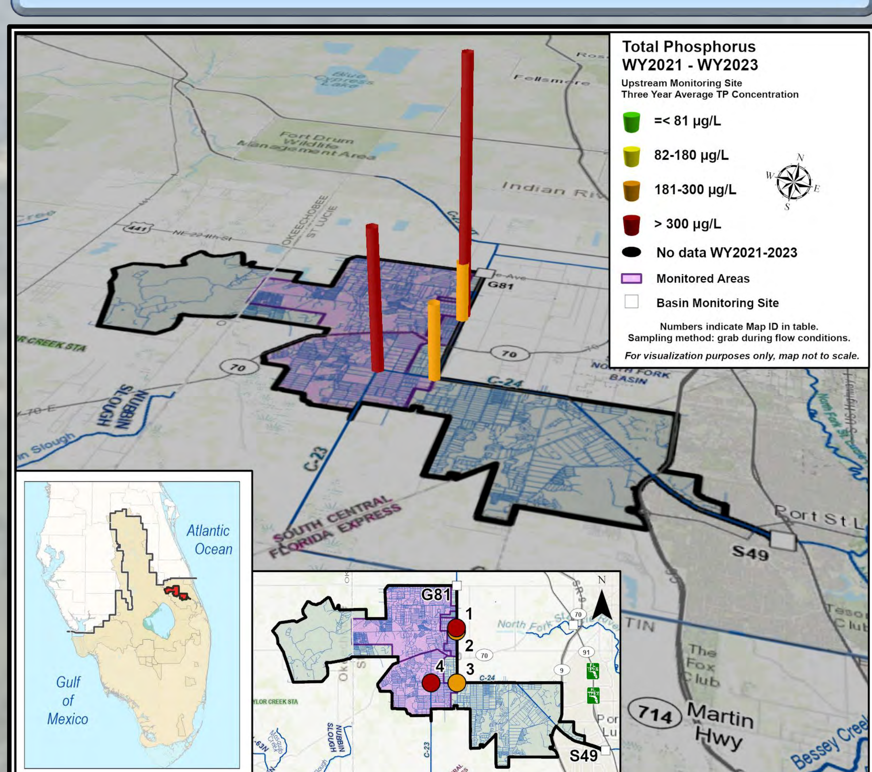
Purpose of Upstream Monitoring: ➢Highlight Areas of Concern ➢Prioritize Resources ➢Track Progress

Acknowledgements: Thank you to the staff from the Water Quality Monitoring Section and Analytical Services Section. Without their efforts these data would not exist. Additionally, the maps were produced by Allison Lamb, Madelyn Rinka, and Edwin Rios of the Geospatial Services Section.

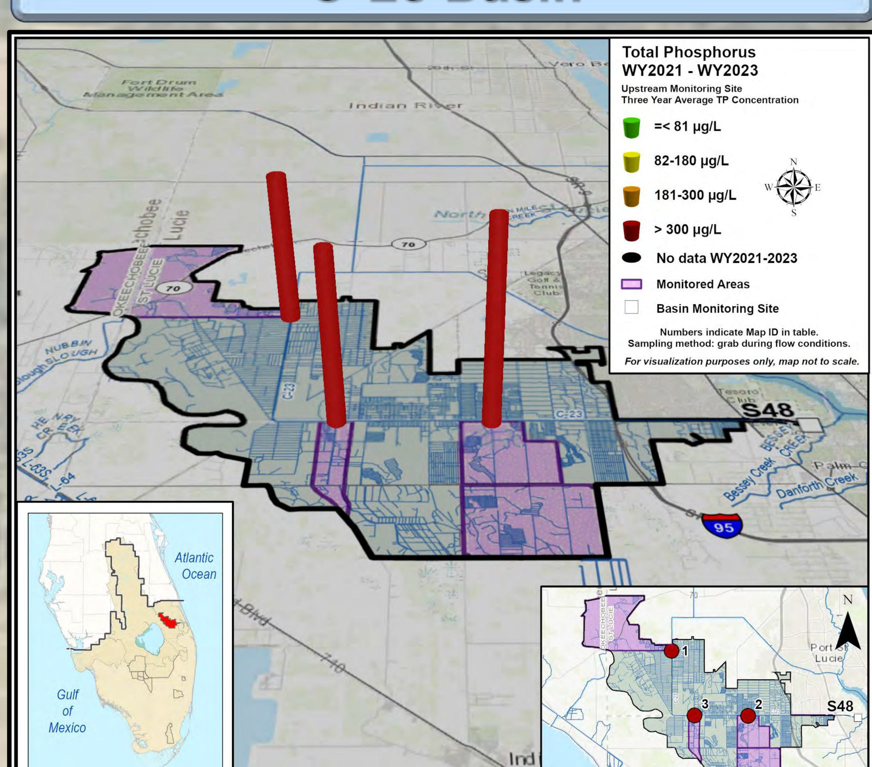
Nevada Wagoner collecting sonde data at station C44SC5.

WY2021 Expanded Network

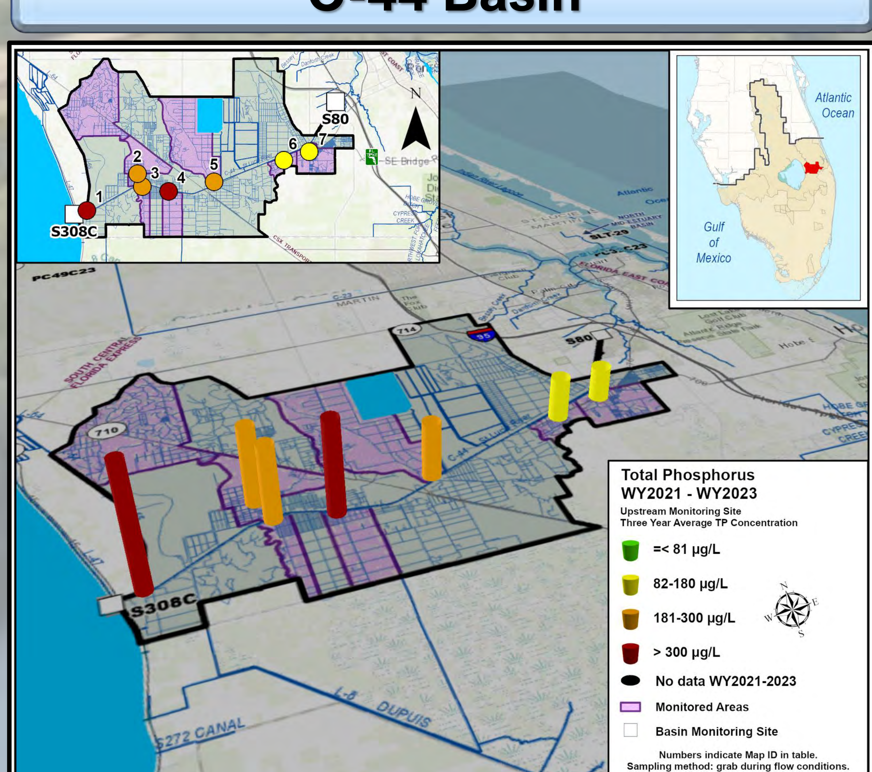
C-24 Basin



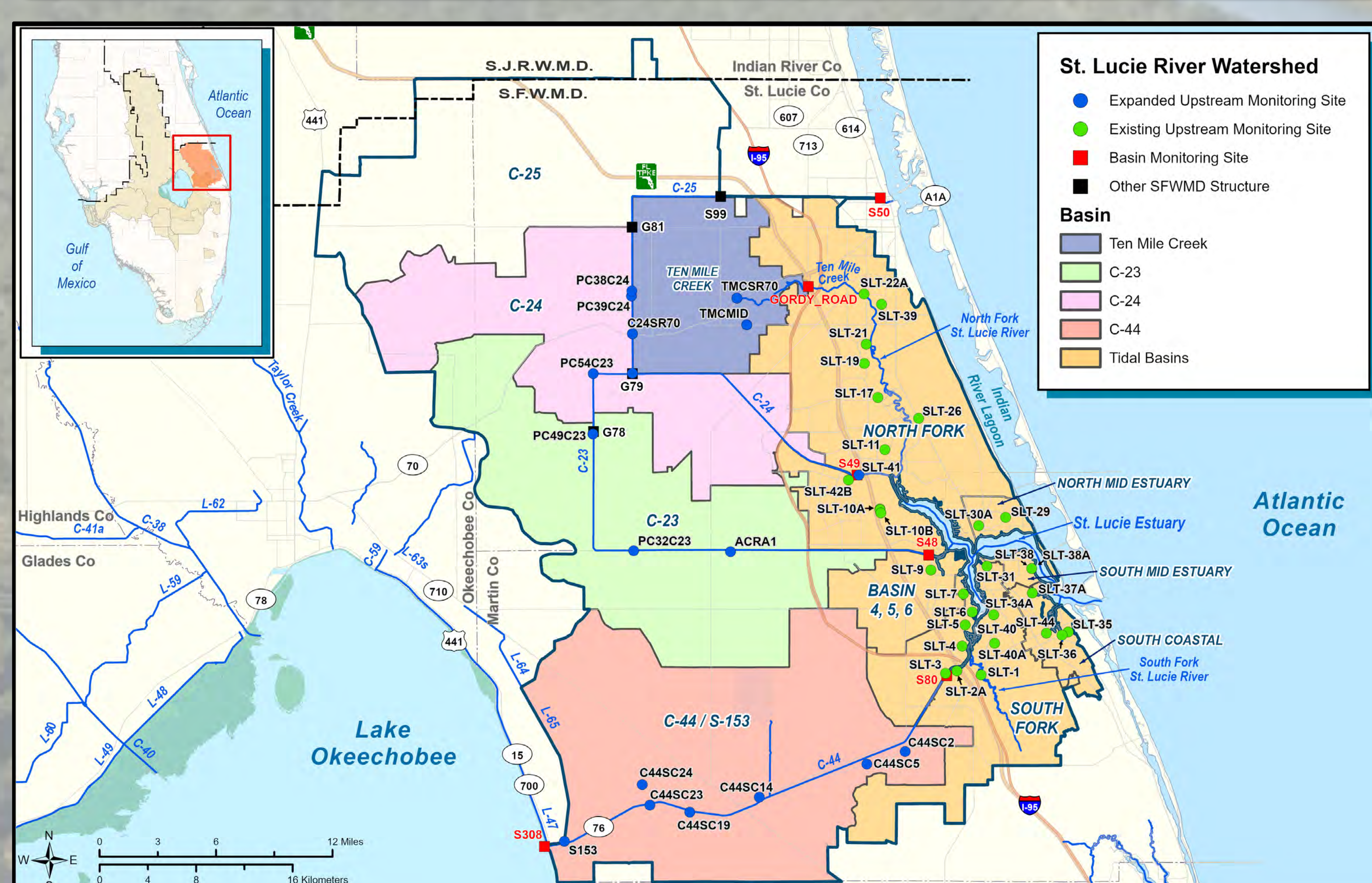
C-23 Basin



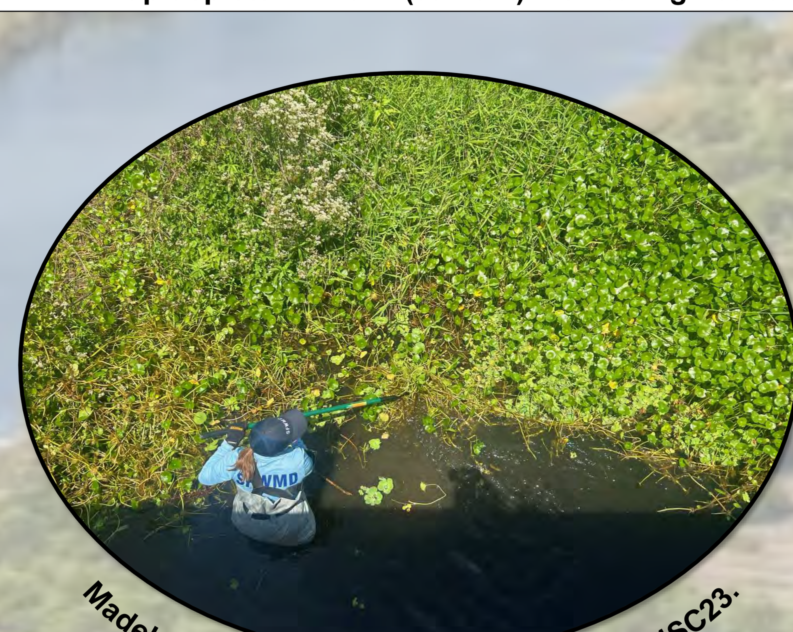
C-44 Basin



Water Quality Monitoring Network



Map depicts WY2024 (current) monitoring network, including some changes from the WY2023 monitoring network.

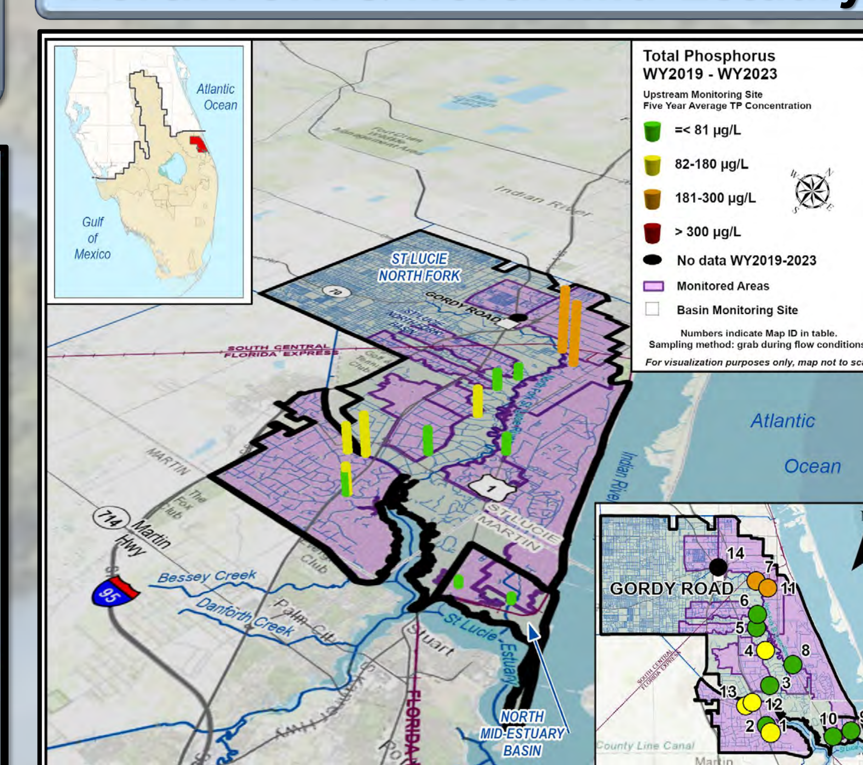


Madeleine Bitting clearing vegetation at C44SC23.

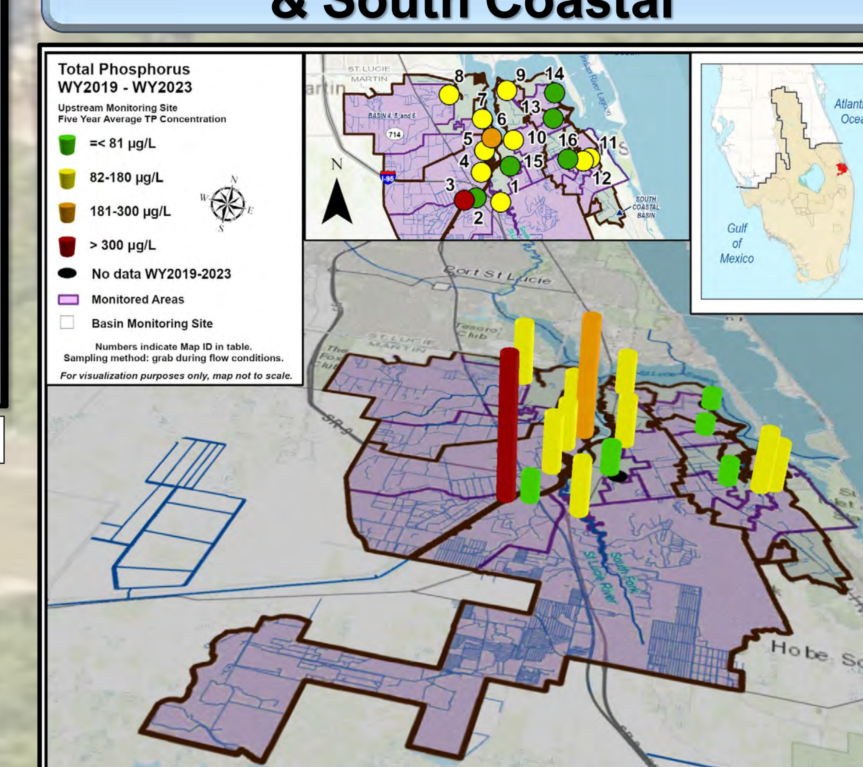
Chase Lausted collecting a water sample at PC54C23.

Long-Term Network

North Fork & North Mid-Estuary



South Fork, South Mid-Estuary, & South Coastal



Nutrient Concentrations Water Years 2021–2023

Basin	Site	WY2021-WY2023 TP (µg/L) No.	TP Avg.	OPO$_4$-P (µg/L) No.	OPO$_4$-P Avg.	TN (mg/L) No.	TN Avg.	NH$_3$-N (mg/L) No.	NH$_3$-N Avg.	NO$_X$-N (mg/L) No.	NO$_X$-N Avg.
C-24	PC39C24	9	784	9	686	9	1.50	9	0.12	8	0.01
	PC38C24	17	189	17	126	17	1.66	15	0.12	15	0.04
	G79	68	237	66	154	68	1.45	65	0.08	68	0.02
	PC54C23	22	436	22	287	22	1.98	20	0.10	22	0.01
C-23	PC49C23	12	455	12	392	12	1.96	11	0.16	11	0.11
	ACRA1	17	605	16	511	17	1.66	14	0.07	16	0.01
	PC32C23	10	519	9	408	10	2.26	8	0.13	9	0.01
C-44	S153	21	412	21	370	21	1.60	21	0.13	21	0.07
	C44SC24	13	259	13	182	13	1.31	11	0.09	13	0.20
	C44SC23	21	253	21	200	21	1.26	21	0.18	21	0.13
	C44SC19	51	314	51	234	51	1.32	50	0.16	51	0.11
	C44SC14	27	186	27	127	27	1.26	27	0.11	27	0.09
	C44SC5	25	141	25	83	25	1.57	24	0.10	23	0.04
	C44SC2	16	111	17	43	16	1.25	17	0.09	15	0.01

Parameters	Definitions
TP	total phosphorus
OPO$_4$-P	orthophosphate
TN	total nitrogen
NH$_3$-N	ammonial nitrogen
NO$_X$-N	nitrate + nitrate

Unit of Measurement	Definitions
µg/L	microgram(s) per liter
mg/L	milligram(s) per liter

Nutrient Concentrations Water Years 2019–2023

Basin	Site	WY2019 - WY2023 TP (µg/L) No.	TP Avg.	OPO$_4$-P (µg/L) No.	OPO$_4$-P Avg.	TN (mg/L) No.	TN Avg.	NH$_3$-N (mg/L) No.	NH$_3$-N Avg.	NO$_X$-N (mg/L) No.	NO$_X$-N Avg.
North Fork & North Mid-Estuary	SLT-10A	109	84	103	29	110	0.96	107	0.12	107	0.05
	SLT-10B	87	68	79	22	88	0.88	87	0.09	86	0.07
	SLT-11	103	76	98	17	103	0.83	100	0.04	101	0.04
	SLT-17	115	87	107	17	115	0.81	113	0.10	112	0.11
	SLT-19	115	58	106	12	115	0.81	113	0.06	113	0.02
	SLT-21	96	44	87	8	96	0.75	93	0.02	93	0.02
	SLT-22A	53	201	52	112	53	0.85	51	0.07	52	0.09
	SLT-26	120	56	111	21	120	0.80	117	0.02	117	0.09
	SLT-29	108	21	103	3	110	0.90	108	0.04	107	0.04
	SLT-30A	20	23	19	2	20	0.89	20	0.04	19	0.01
	SLT-39	57	194	48	125	57	1.07	48	0.20	47	0.10
	SLT-41	77	121	72	33	77	0.95	75	0.10	75	0.08
	SLT-42B	76	83	72	19	76	0.70	75	0.06	74	0.04
	SLT-45	17	127	17	23	17	0.82	17	0.06	17	0.05
South Fork, South Mid-Estuary, & South Coastal	SLT-1	52	128	50	70	52	0.99	50	0.05	51	0.06
	SLT-2A	78	62	74	16	78	0.91	75	0.02	76	0.01
	SLT-3	108	333	106	260	108	1.08	107	0.07	106	0.22
	SLT-4	35	137	35	75	35	0.97	34	0.05	35	0.12
	SLT-5	47	113	14	69	47	1.37	13	0.04	14	0.19
	SLT-6	33	286	33	229	33	1.48	33	0.30	32	0.20
	SLT-7	53	102	47	46	52	0.89	50	0.08	51	0.12
	SLT-9	29	152	29	97	29	0.97	29	0.07	28	0.10
	SLT-31	95	97	86	7	95	0.89	92	0.01	95	0.01
	SLT-34A	119	116	91	29	118	1.04	94	0.13	93	0.11
	SLT-35	107	109	79	71	107	1.14	78	0.05	81	0.21
	SLT-36	11	142	10	100	11	1.00	11	0.05	11	0.09
	SLT-37A	93	33	87	5	92	0.72	91	0.10	91	0.06
	SLT-38	137	37	129	7	137	0.65	133	0.05	135	0.04
	SLT-40	81	68	69	15	81	0.95	68	0.03	70	0.01
	SLT-44	125	51	115	9	125	0.91	122	0.05	124	0.06

For more information: SCAN ME

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

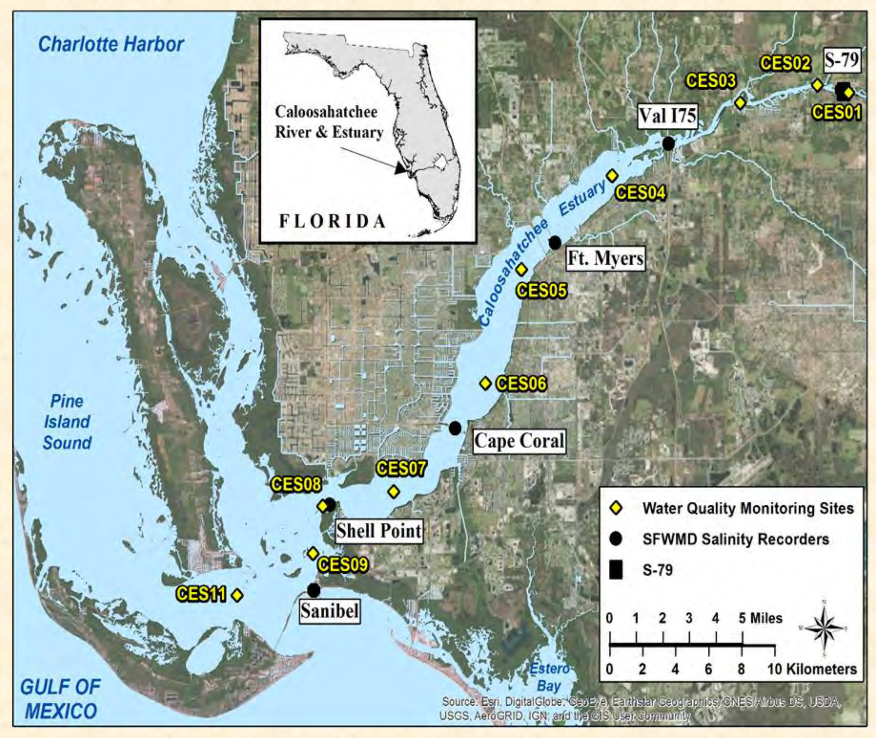
Synthesizing Monitoring Data With a 1D Model for Water Quality Conditions

Detong Sun, Tom Behlmer

Coastal Ecosystems Section, Applied Sciences Bureau

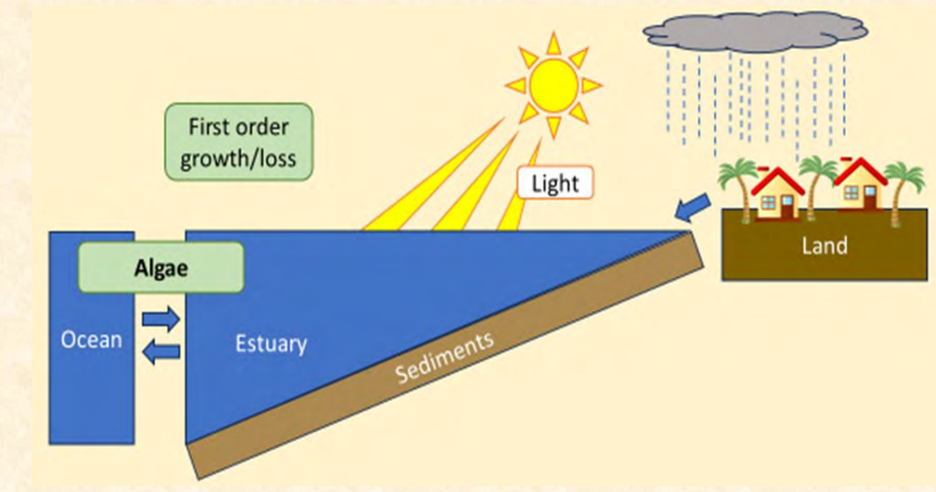
Background and Objective

- The Lake (Okeechobee)-Canal-Estuary systems in Florida are heavily altered and managed.
- More frequent and more intensified harmful algal blooms (HABs) have occurred in recent years.
- Water quality monitoring and modeling are important for the assessment of conditions.
- Kinetic rates are critical for the assessment.
- Quantification of the rates are difficult as direct measurement are not feasible and empirical relationships are often inadequate.
- A mathematical model can be helpful to synthesize survey data to estimate the rates and assessment of water quality conditions.



Approach

- One-dimensional (1D) salt-balanced tidally-averaged advection-diffusion-reaction model as basis.
- Analytical and semi-analytical solutions to the 1D model.
- Calibrate the 1D model with survey data.
- Calibrated rates are the estimated net rates.
- The estimated rates can be important water quality condition indicators that will be helpful for the assessment of algal bloom risk.



Monitoring

- Regular monthly survey.
- Surveying Estuary Responses to Freshwater Inflows (SERFIS) events.
- Nutrients, chlorophyll *a*, salinity, temperature, light, color, turbidity, etc.

1D Model and Solutions

$$\frac{\partial Ac}{\partial t}+\frac{\partial Qc}{\partial x}=\frac{\partial}{\partial x}\left(AE\frac{\partial c}{\partial x}\right)+\mu Ac$$

$$\mu = P_M f(I) f(T) - M$$

where: *x* is coordinate
C is estuary concentration
μ is net growth rate
E is mixing coefficient
Q is river discharge
A is cross-section area
t is time

Application to the Caloosahatchee River Estuary

- Discharge at S-79.
- Salinity from a hydrodynamic model.
- Boundary conditions from survey at S-79 and station CES09.
- A modified BZI model used to compute phytoplankton growth rate as a function of temperature, light, color, and turbidity.
- Empirical parameters determined through calibration for each survey.
- Model was applied to monthly surveys from 1999 to 2015.

Analytical Solution for Idealized Conditions

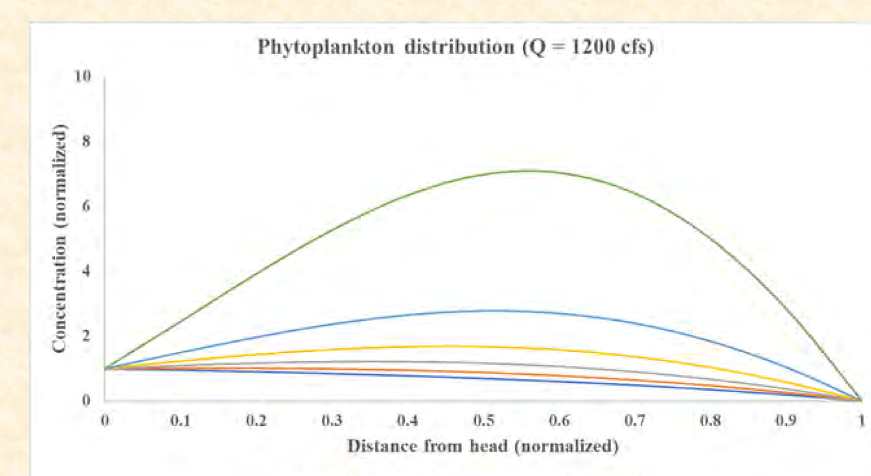
- From Sun et al. 2022.
- Upstream boundary conditions have a controlling effect on downstream estuary for both nutrients and phytoplankton.
- Residence time is critical for algal bloom: when μ is greater than flushing rate, potential algal bloom may develop.
- Higher μ leads to higher chlorophyll maximum, the location of which moves downstream with increasing discharge.

Sun, D., Barton, M., Parker M. and Sheng, Y. P., 2022. Estuarine water quality: One-dimensional model theory and its application to a riverine subtropical estuary in Florida. Estuarine, Coastal and Shelf Sciences 277 (2022) 108058

$$C = C_s(x) + C_t(x, t)$$

$$C_s = C_r\frac{e^{\frac{ux}{2E}}sinh\left(\beta\left(1-\frac{x}{L}\right)\right)}{\sinh(\beta)}$$

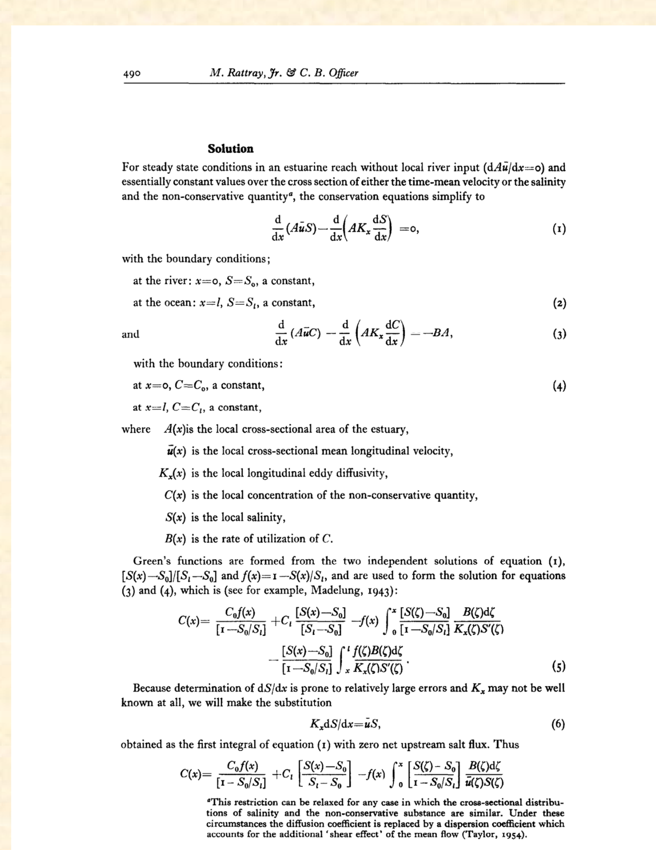
$$C_t = e^{\frac{ux}{2E}}\sum_{m=1}^{\infty}B_m\, e^{-\left[\frac{u^2}{4E}+E\left(\frac{m\pi}{L}\right)^2-\mu_{net}\right]t}\sin\frac{m\pi x}{L}$$



Semi-analytical Solution

- Sun et al. 2023 (manuscript in preparation).
- Steady state semi-analytical solutions for a real estuary.
- Salt-balance approach.
- Salinity from monitoring or a hydrodynamic model.
- Green function constructed to compute nutrient and phytoplankton concentrations (Rattray and Officer 1979).
- Iterations are needed.

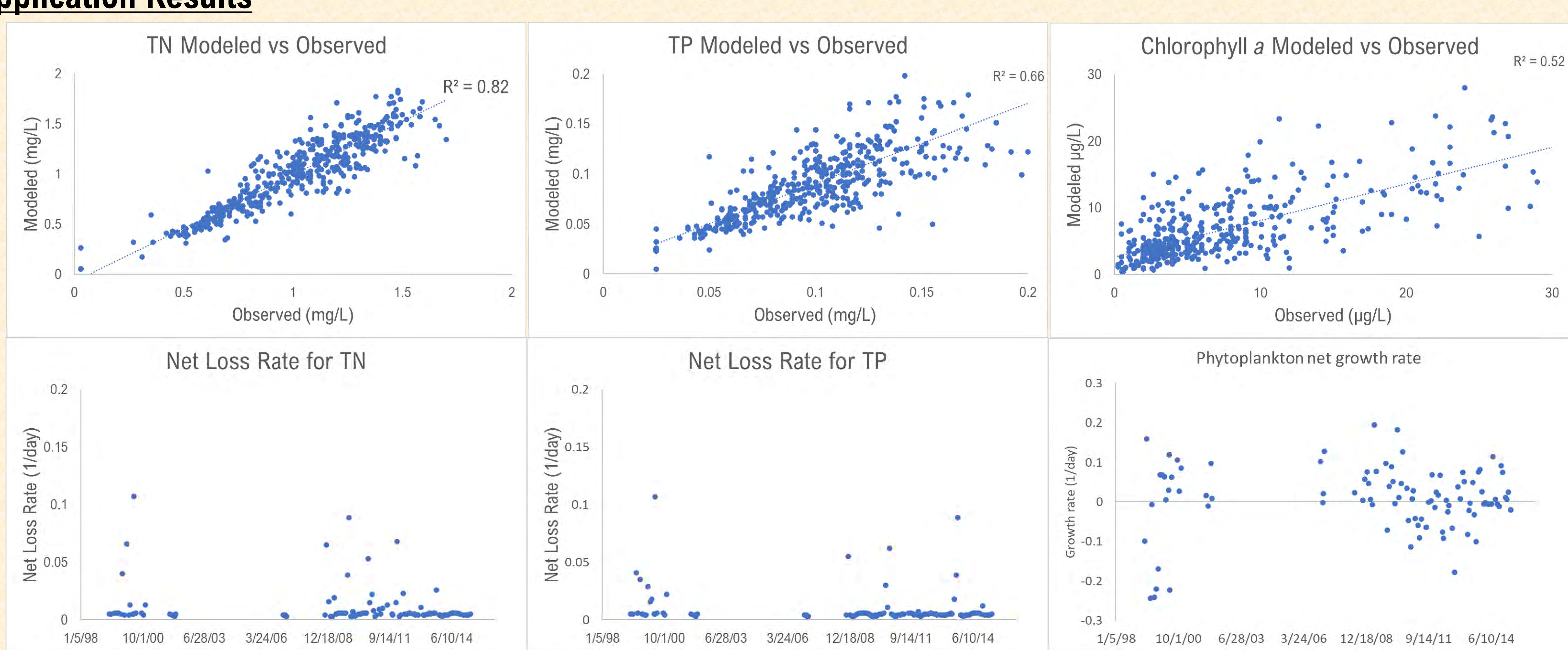
Sun, D., T. Behlmer and M. Barton, 2024. Estuarine water quality: Semi-analytical one-dimensional model and its application to a riverine subtropical estuary in Florida. (manuscript in preparation)



Summary of calibrated net rates for nutrients and chlorophyll *a*.

Constituent	Number of Surveys	R^2	Net Loss/Growth Rate (1/day)		
			Maximum	Minimum	Average
Total Nitrogen	100	0.82	0.107	0.003	0.011
Total Phosphorus	103	0.66	0.110	0.004	0.012
Dissolved Inorganic Nitrogen	90	0.74	0.119	0.003	0.030
Dissolved Inorganic Phosphorus	98	0.71	0.120	0.003	0.015
Chlorophyll *a*	97	0.52	0.195	-0.24	0.008

Model Application Results



Upper panel: Modeled total nitrogen (TN), total phosphorus (TP), and chlorophyll *a* versus (vs) observation. Lower panel: Calibrated loss rates for TN and TP, and net growth rate for chlorophyll *a*.

Discussion and Summary

- Analytical solution suggests the higher the net growth rate, the higher the maximum phytoplankton concentration, a rationale for the estimates of net growth rates using observed profile.
- The calibrated net loss rate for nutrients are low compared with few literature available, e.g., Dettmann 2001 for TN.
- The calibrated net growth rates are an order of magnitude lower than reported gross primary production rates for phytoplankton, which is likely true as most of these surveys are taken during normal conditions. Net growth rates in the same order as gross growth rate would mean algal bloom in the estuary.
- Study is experimental. A more vigorous inverse method is under development using more detailed survey data such as SERFIS.

Dettmann, E.H., 2001. Effect of water residence time on annual export and denitrification of nitrogen in estuaries: A model analysis. Estuaries 24: 481-490

For more information:

SCAN ME

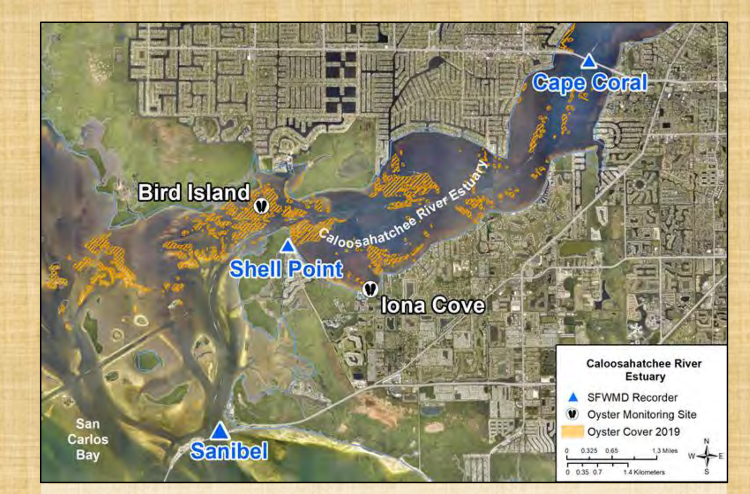
Chapter 8D: Caloosahatchee River Watershed Protection Plan Annual Progress Report

Modeling Oyster Recruitment to Optimize Yields Through Enhanced Restoration

Detong Sun, Cassondra Armstrong, Melanie Parker, Mark Barton, Phyllis Klarmann, Juliane Caughron
Coastal Ecosystems Section, Applied Sciences Bureau

Background & Objectives

- Oyster reefs are essential habitats in estuaries.
- Altered hydrology and severe drought/wet conditions are stressors for eastern oysters in the Caloosahatchee River Estuary.
- Freshwater water management is critical for oyster restoration.
- Objectives: a) develop model tools to quantify oyster population/density and habitat area; b) test management strategy under different hydrological and hydrodynamic conditions; and c) pilot restoration and monitoring with assist from modeling.



Study Site

Oyster Reef

Oyster Sampling T-bars

Methods & Approaches

1. Machine learning (ML) to explore possible patterns between oyster population/density physical drivers.
2. Particle tracking model to predict oyster larvae transport and settlement.
3. Spatial oyster habitat model to predict the evolution of oyster habitat.
4. A pilot restoration with model support and feedback to improve and validate the models.
5. Benthic mapping to collect more oyster habitat data to support modeling efforts and to help the pilot restoration.

Research Questions

	Research Questions	Data/Model Needs
Q1	How changes in climate, inflow and management affect oyster population and larval transport?	Historical data, machine learning, hydrodynamic and larval transport model
Q2	How changes in climate, inflow and management affect available estuarine oyster habitat?	Oyster habitat model, oyster mapping
Q3	How changes in climate, inflow and management affect available estuarine oyster productivity?	Oyster ecological model, hydrodynamic and water quality model
Q4	Where and when does oyster spat settle?	Field survey, YSI data sonde, and larval transport model
Q5	What are the site characteristics for ideal oyster habitat conditions?	Larval transport model and ecological model combined with field data
Q6	How do the model and empirical outputs inform oyster restoration?	Field survey data and model outputs

Project Organization

Principal Investigator (PI)/Project Manager
Detong Sun, SFWMD

EPA Program Officer
Ade Adesiji

Quality Assurance/ Quality Control Manager
Juliane Caughron, SFWMD

EPA Technical Officer
Steven Blackburn

CO-PI
Phyllis Klarmann, SFWMD

CO-PI, ML, and Larvae Transport
Yonggang Liu, USF

CO-PI, Ecological Modeling
Chris Buzzelli, CELLC
SFWMD Consultant

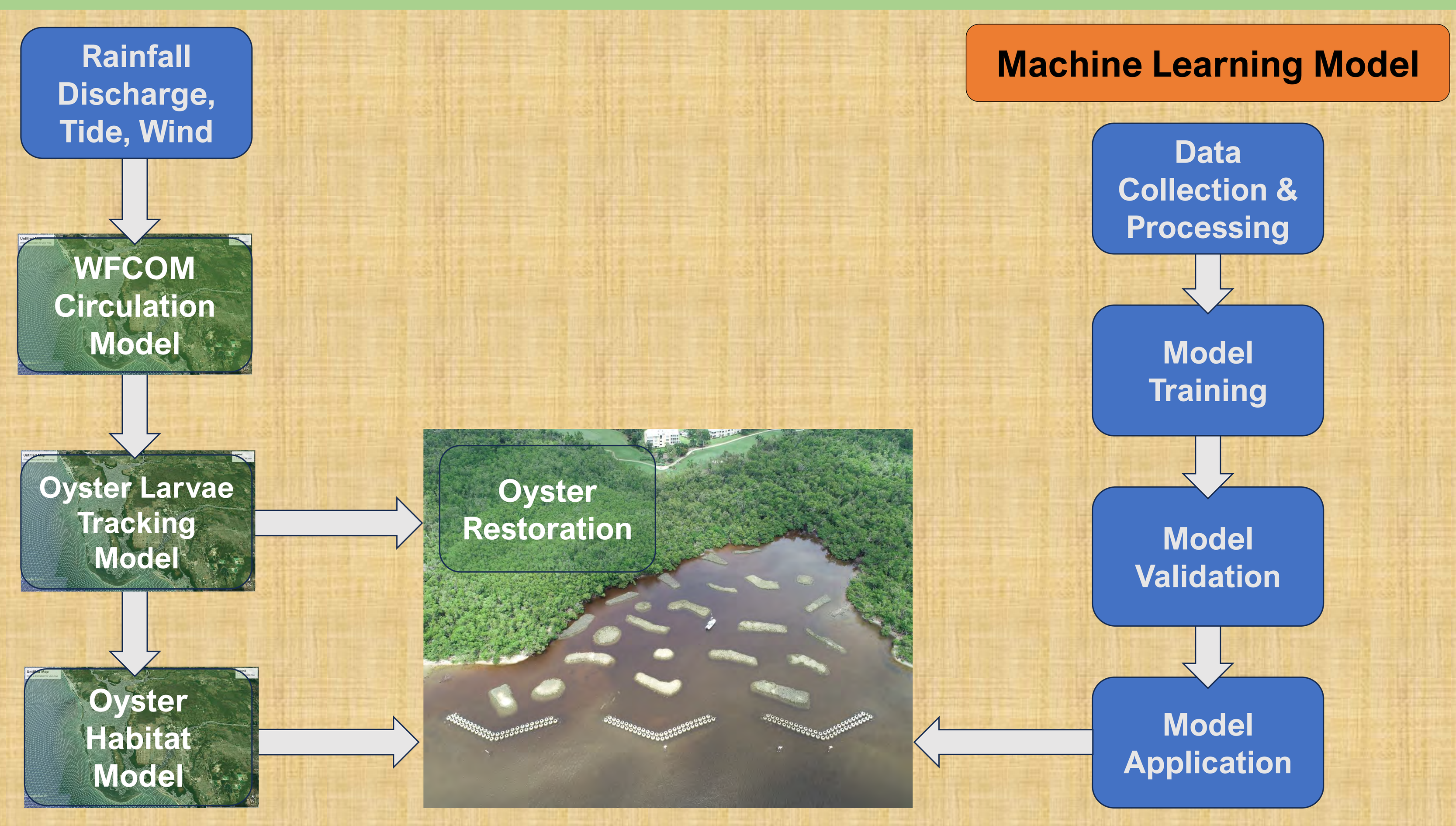
CO-PI, Oyster Restoration
Eric Milbrandt, SCCF

Collaborators

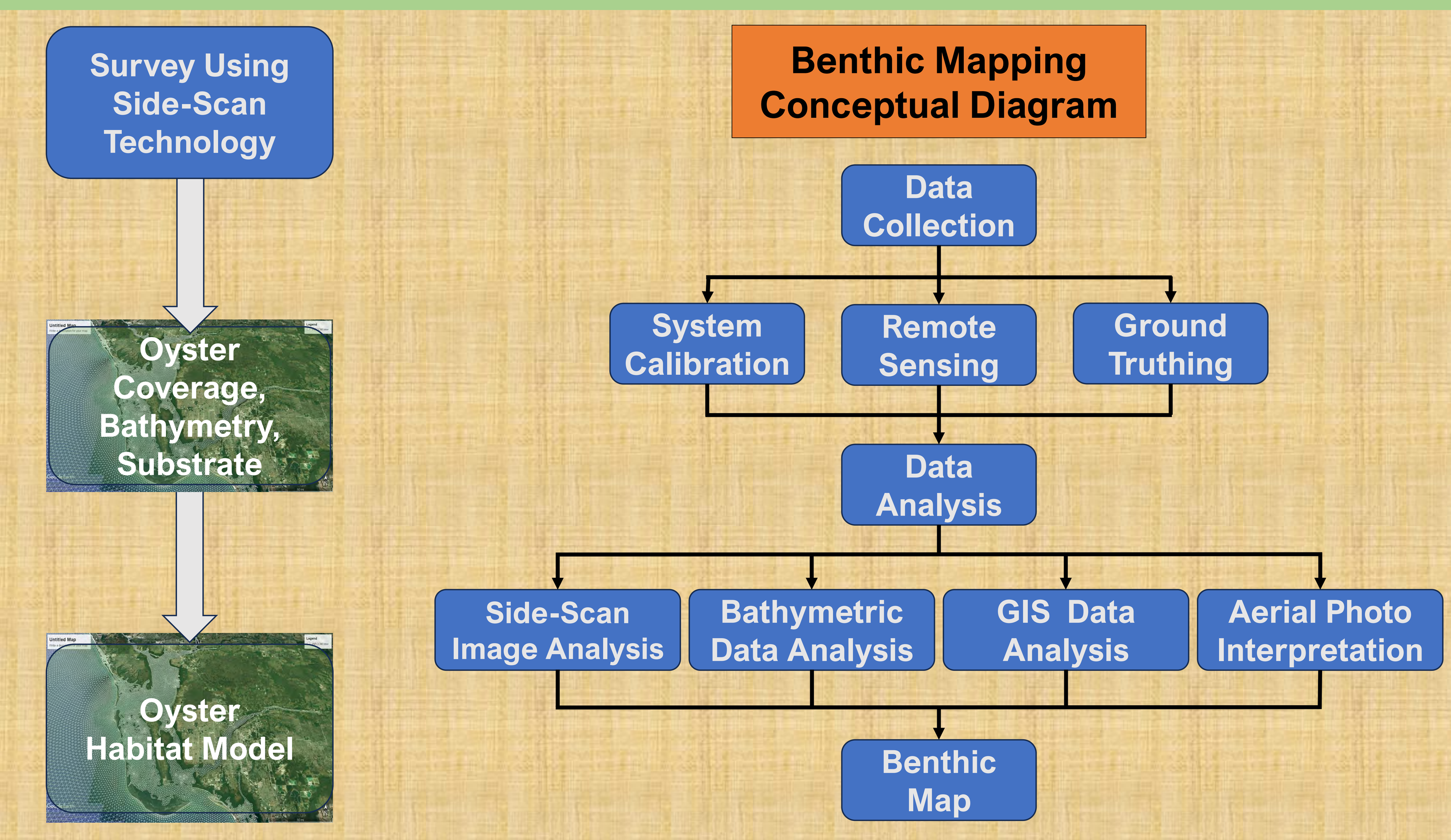
Project Schedule

- The entire project will span the next five years.
- The first half of the project focuses on model development (Tasks 1 and 3), while the later half focuses on model applications and integration.
- Benthic mapping (Task 2) is expected to be completed within the first two years.
- Oyster reef restoration (Task 4) starts later with assistance from model applications for site selection and operation. Pre- and post-construction monitoring will feed into models.
- Monthly spat settlement monitoring (Task 5) will be performed throughout the project period.

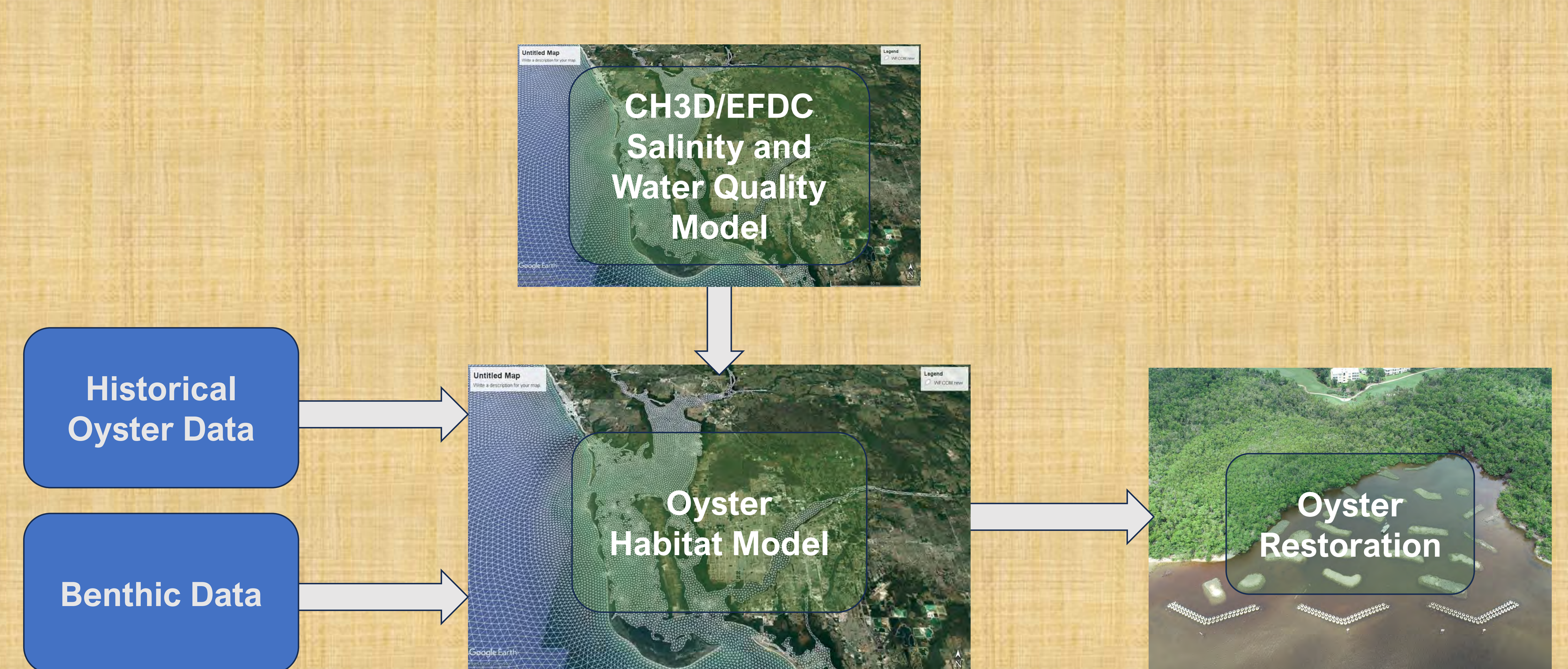
Task 1: ML and Oyster Larvae Tracking



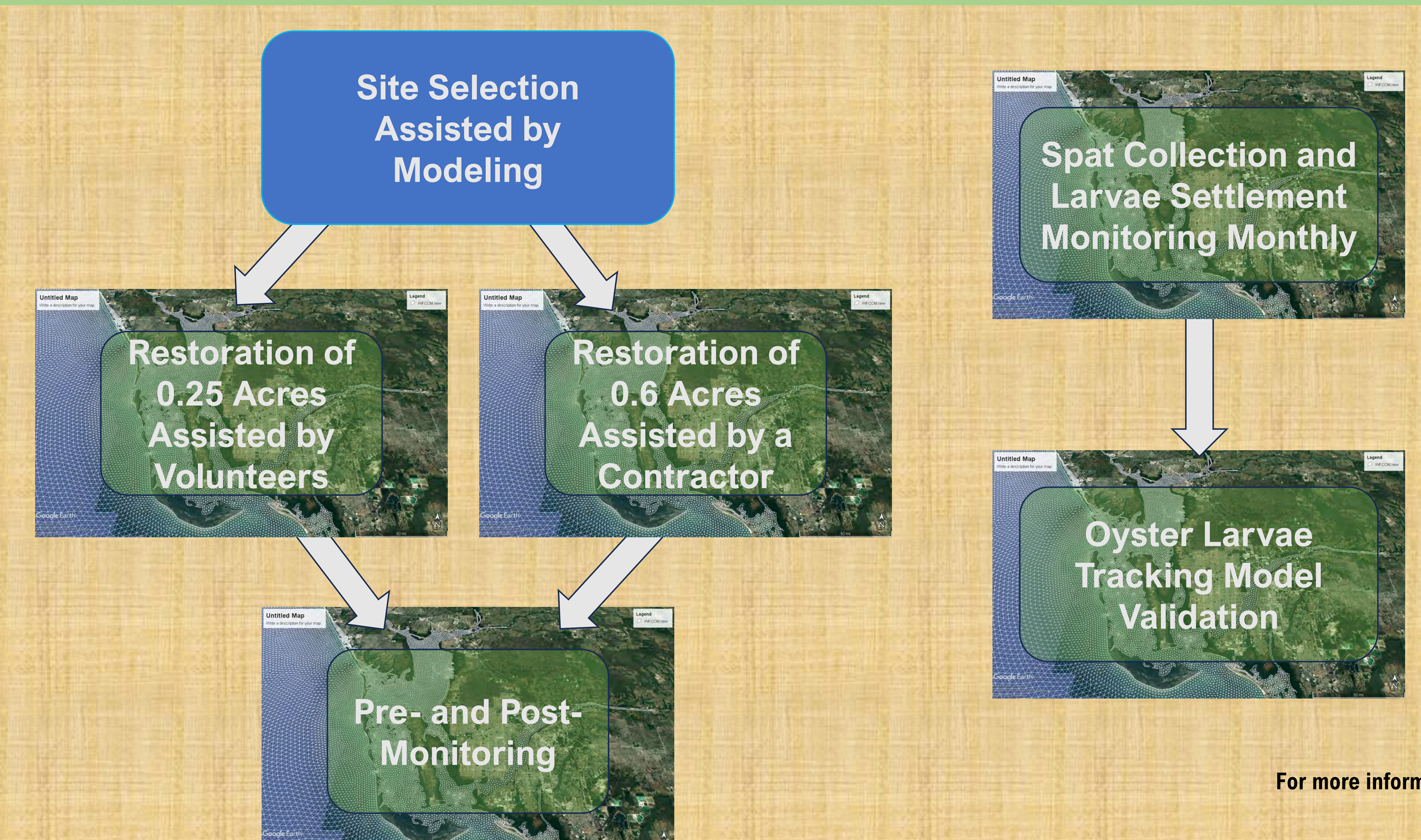
Task 2: Benthic Mapping



Task 3: Oyster Habitat Model



Tasks 4 & 5: Oyster Restoration & Monitoring



For more information: SCAN ME

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

Part III: Caloosahatchee River Watershed Construction Project

Jenna Bobsein

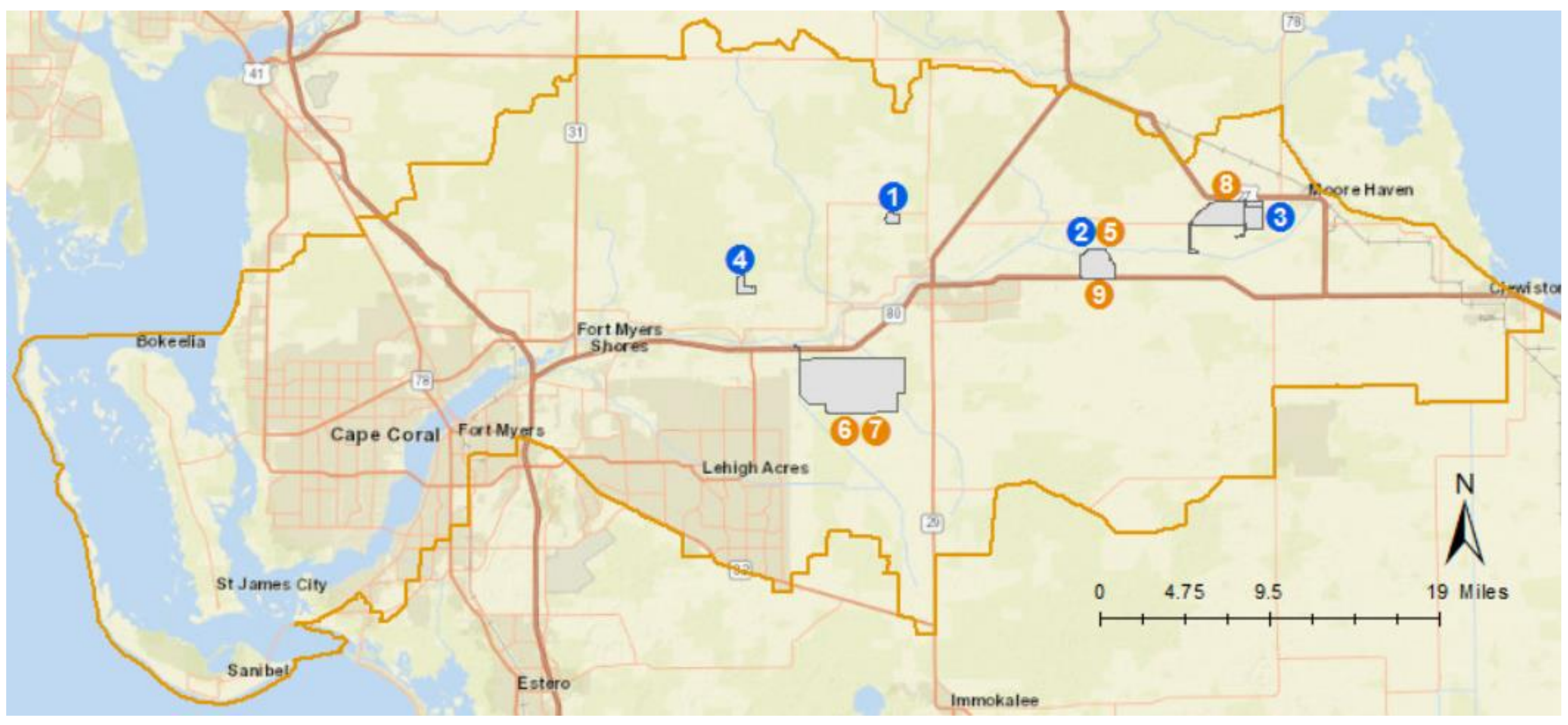
Planning and Project Management Section, Everglades and Estuaries Protection Bureau

Three operational projects in Water Year 2023 (WY2023) provided approximately:

- **5,000 acre-feet** (ac-ft) of storage
- **5.5 metric tons** (t) total phosphorus (TP) retention
- **29.3 metric tons** (t) total nitrogen (TN) retention

Four Corners Rapid Infiltration project completed construction and began operating in June 2023 (WY2024). This project will provide an additional estimated 20,000 ac-ft if storage and will retain 39.3 metric tons (t) of TN per year (t/yr).

Advancing Watershed Construction Projects



Operational Projects


Inspection at Mudge Ranch

1. Mudge Ranch

- Dispersed water management (DWM) public-private partnership
- Passive storage project
- Operational since WY2014
- **WY2023 storage: 362 ac-ft**


Pump at Boma Interim Storage

2. Boma Interim Storage

- Temporary storage until construction begins for the Boma Flow Equalization Basin (FEB)
- Operational since WY2019
- **WY2023 storage: 3,405 ac-ft**


Pump Station G-725 at LHHEP Phase I

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

- Enhances hydration of the historic Lake Hicpochee
- Phase I captures excess surface water from the C-19 canal
- Operational since WY2021
- **WY2023 storage: 1,222 ac-ft**


Ribbon cutting event at Four Corners Rapid Infiltration

4. Four Corners Rapid Infiltration

- DWM public-private partnership
- 366-acre above ground impoundment (AGI), including a 22-acre rapid infiltration area
- Operational since WY2024
- **Estimated storage: 20,000 ac-ft/yr**

Planned Projects


C-43 WQTT (Test Cells)

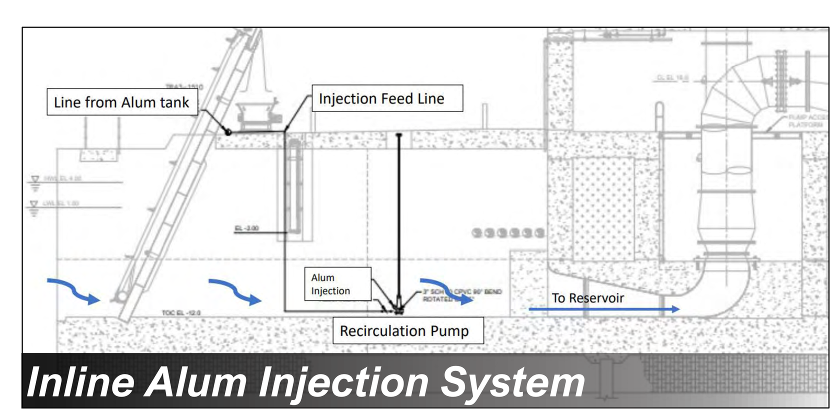
5. C-43 Water Quality Treatment and Testing (WQTT) Project – Phase II (Test Cells)

- Study evaluating the effectiveness of constructed wetland treatment systems in reducing TN at a test scale
- Status: Construction
- Expected to be operational by WY2025


Pump Station S-470 at C-43 WBSR

6. C-43 West Basin Storage Reservoir

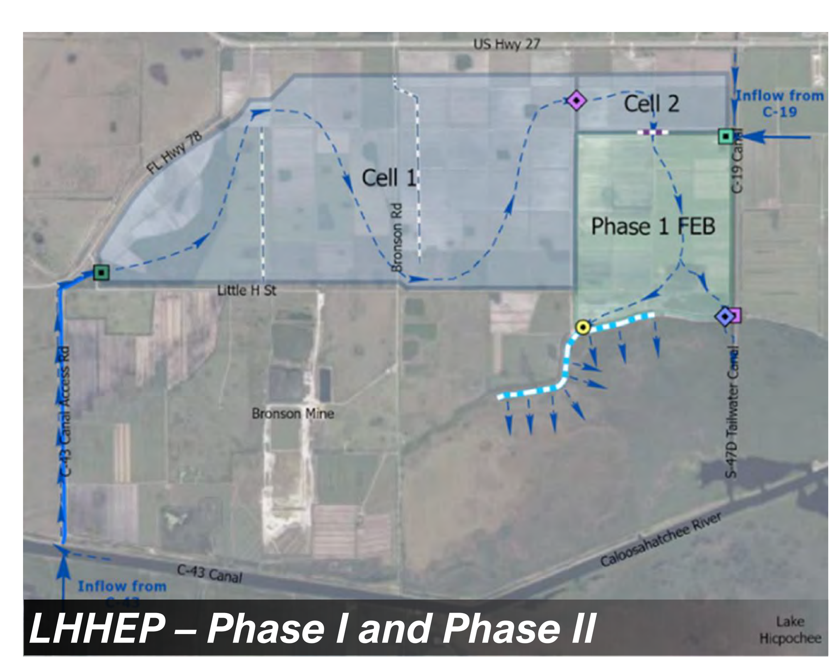
- Provides storage to reduce harmful discharges to the Caloosahatchee River Estuary during the wet season and provide freshwater flow during the dry season
- Status: Construction
- Expected to be operational by WY2026
- **Estimated static storage: 170,000 ac-ft**



Inline Alum Injection System

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

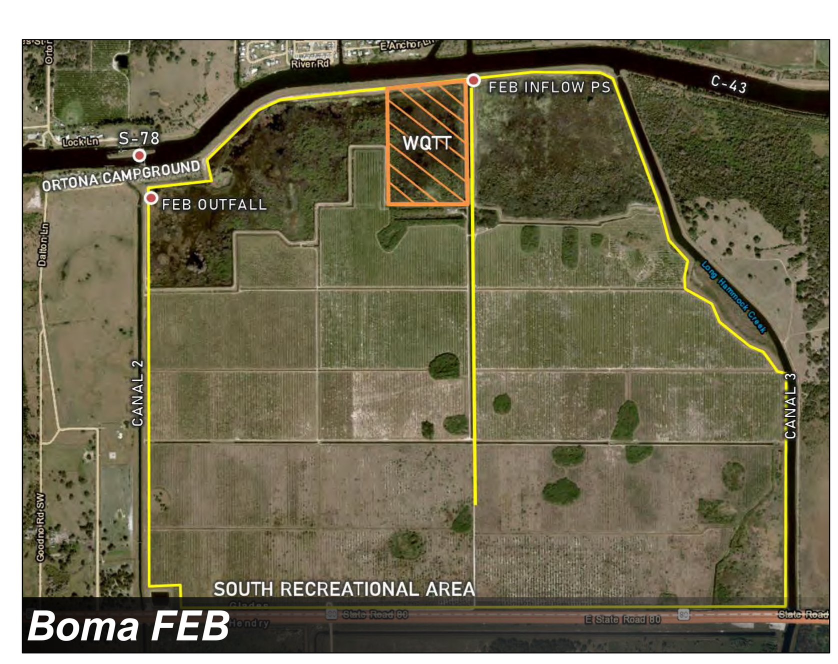
- Inline alum injection system at the C-43 WBSR project
- Status: Design
- Expected to be operational by WY2026



LHHEP – Phase I and Phase II

8. Lake Hicpochee Hydrologic Enhancement Project (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
- Expected to be operational by WY2027
- **Estimated static storage: 8,058 ac-ft**

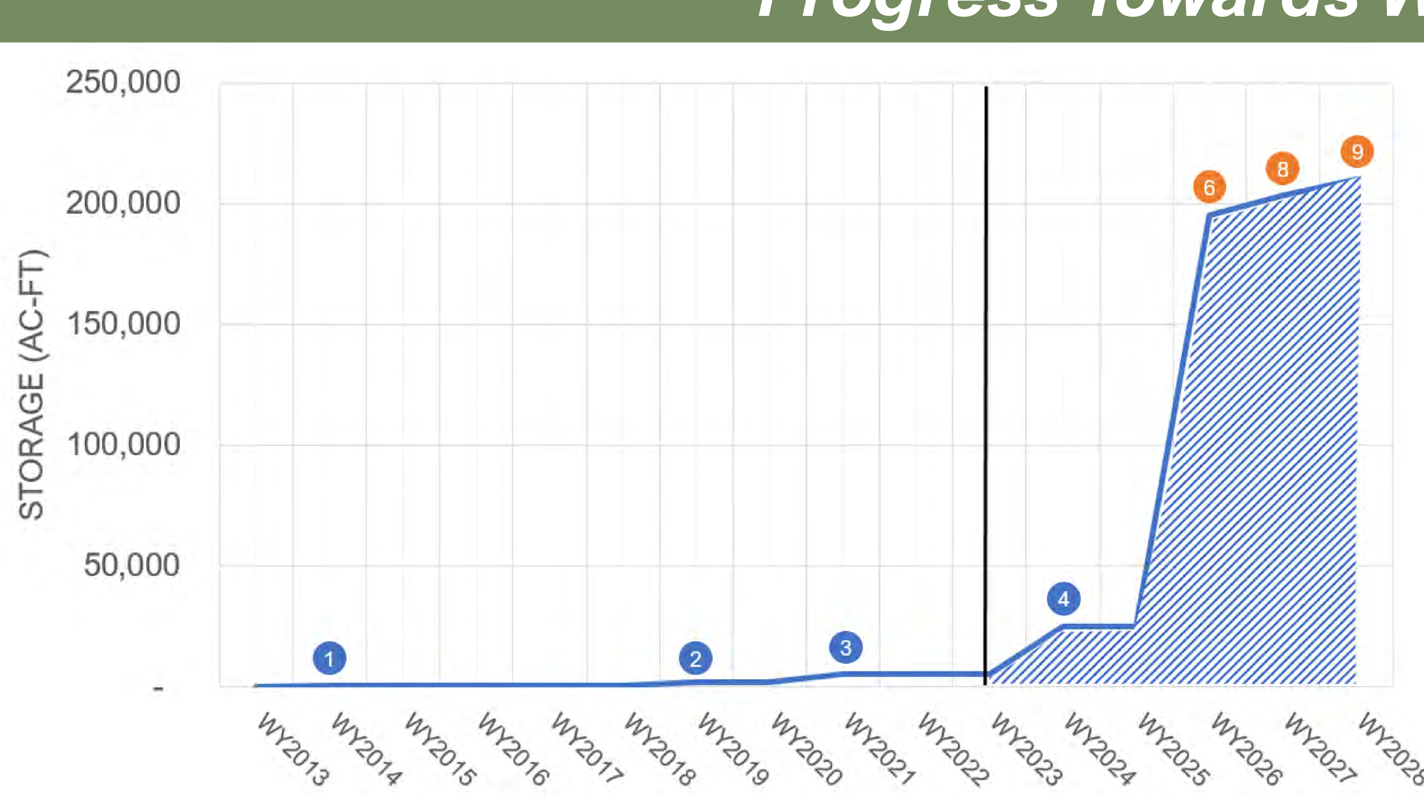


Boma FEB

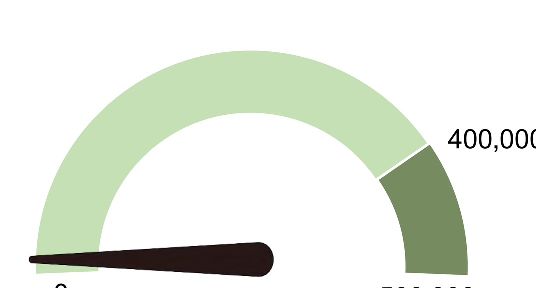
9. Boma Flow Equalization Basin (FEB)

- Provides storage to reduce harmful discharges to the Caloosahatchee River Estuary
- Status: Design
- Expected to be operational by WY2028
- **Estimated static storage: 7,200 ac-ft**

Progress Towards Water Quality and Storage Goals

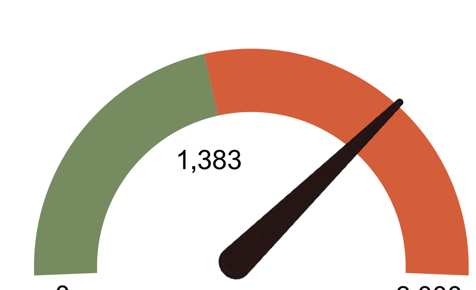


Total Storage



GOAL = 400,000 ac-ft
WY2023 = 4,989 ac-ft

TN Loading



GOAL = 1,383 t
5-Year Average = 2,219 t

For more information: SCAN ME

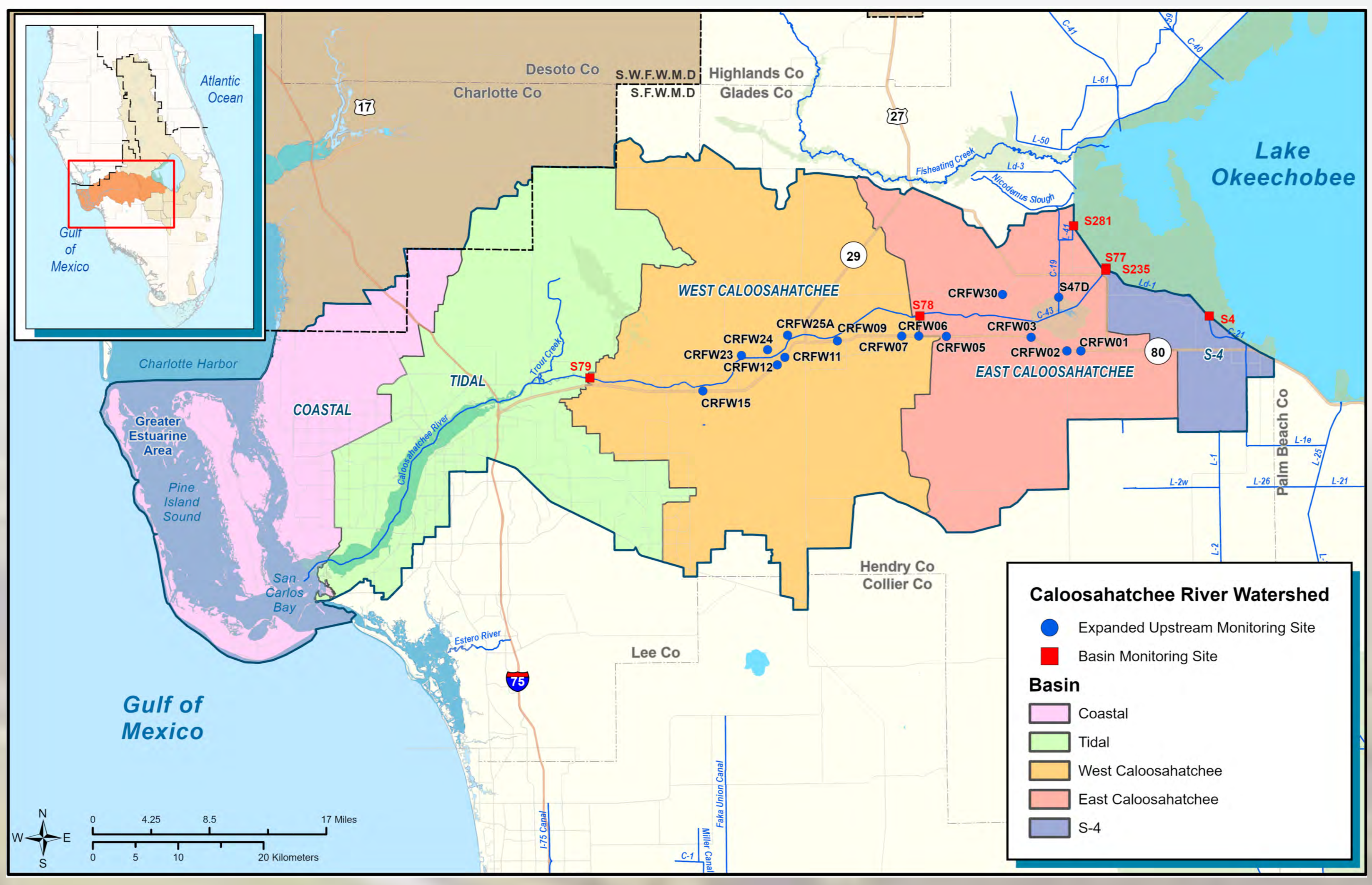
Appendix 8D-1: Water Year 2023 Caloosahatchee River Watershed Upstream Monitoring

Jacob Landfield, Steffany Olson, Amanda McDonald

Project Operations & Assessment Section, Everglades & Estuaries Protection Bureau

Purpose of Upstream Monitoring: ➢Highlight Areas of Concern ➢Prioritize Resources ➢Track Progress

Water Quality Monitoring Network



Acknowledgements: Thank you to the staff from the Water Quality Monitoring Section and Analytical Services Section. Without their efforts these data would not exist. Additionally, the maps were produced by Allison Lamb, Madelyn Rinka, and Edwin Rios of the Geospatial Services Section.

Nathan Moreo collecting data with YSI unit and sonde at S79

Governing Board Expansion of Upstream Network

- ➢Fully implemented in Water Year 2021 (WY2021)
- ➢Increased:
  - Number of sites
  - Collection frequency to bi-weekly
  - Parameters collected

Parameters	Definitions
TP	total phosphorus
OPO_4-P	orthophosphate
TN	total nitrogen
NH_3-N	ammonial nitrogen
NO_x-N	nitrate + nitrate
pH	potential of hydrogen
Temp	temperature
DO	dissolved oxygen
Conductivity	Measures the ability of water to pass an electrical current.

Monitoring Level	Total Number of Sites
Basin	6
Upstream	15

Upstream Monitoring Plan	
Frequency	Biweekly when flowing (some weekly)
Parameters	TP, OPO_4-P, TN, NH_3-N, NO_x-N, pH, Temp, DO, Conductivity

Michael Ruccolo collecting water sample with Nisken bottle at S79

Water Year 2023 Upstream Monitoring Network Results

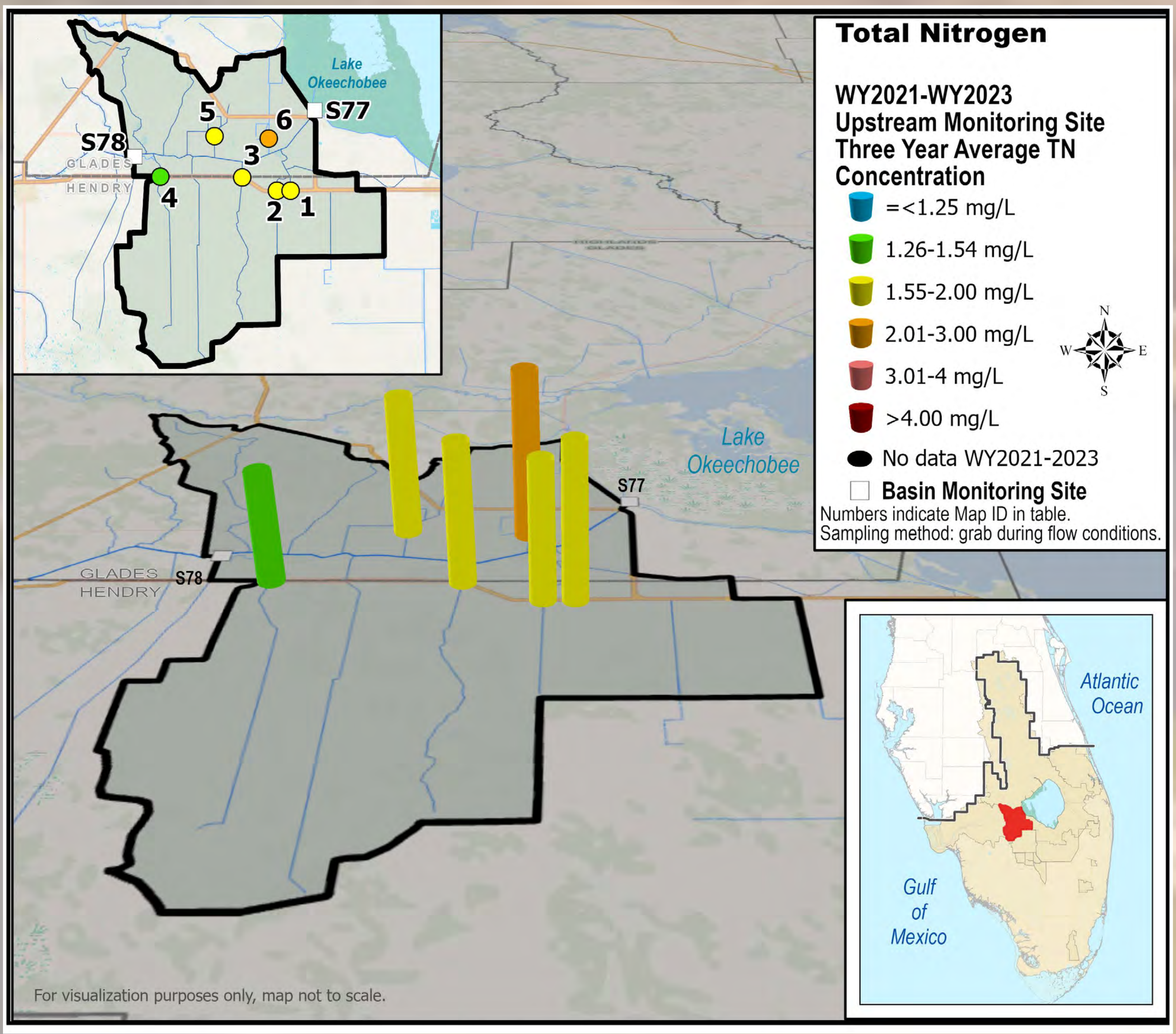
Focus on East Basin

- ➢ Five of the six sites have 3-year average annual TN concentrations > 1.54 mg/L (Florida Department of Environmental Protection [FDEP] numeric nutrient criteria).
- ➢ All six sites have 3-year average annual TP concentrations > 120 µg/L (FDEP numeric nutrient criteria).
- ➢ There was above average rainfall across the watershed.

CRFW25A Rapid Assessment

- ➢ One trigger for TP > 1,000 µg/L.
- ➢ Coordinating Agencies notified.
- ➢ Continuing to monitor.

East Basin Total Nitrogen



Unit of Measurement	Definitions
µg/L	microgram(s) per liter
mg/L	milligram(s) per liter

Nutrient Concentrations

East Caloosahatchee		WY2021-WY2023 TP (µg/L)		OPO_4-P (µg/L)		TN (mg/L)		NH_3-N (mg/L)		NO_x-N (mg/L)	
Map ID	Site	No.	Avg.	No.	Avg.	No.	Avg.	No.	Avg.	No.	Avg.
1	CRFW1	18	160	18	91	17	1.82	18	0.12	18	0.34
2	CRFW2	28	181	27	122	28	1.53	27	0.14	27	0.05
3	CRFW3	23	247	23	176	23	1.66	23	0.15	23	0.12
4	CRFW5	32	138	31	78	32	1.31	32	0.08	32	0.06
5	CRFW30	30	152	30	73	30	1.65	30	0.15	26	0.04
6	CRFW33 (S47D)	28	249	27	164	28	2.09	28	0.46	26	0.09

For more information: SCAN ME

FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

Everglades Protection Area
Total Phosphorus Criterion Assessment for Water Year (WY) 2023

Edward Smith and 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

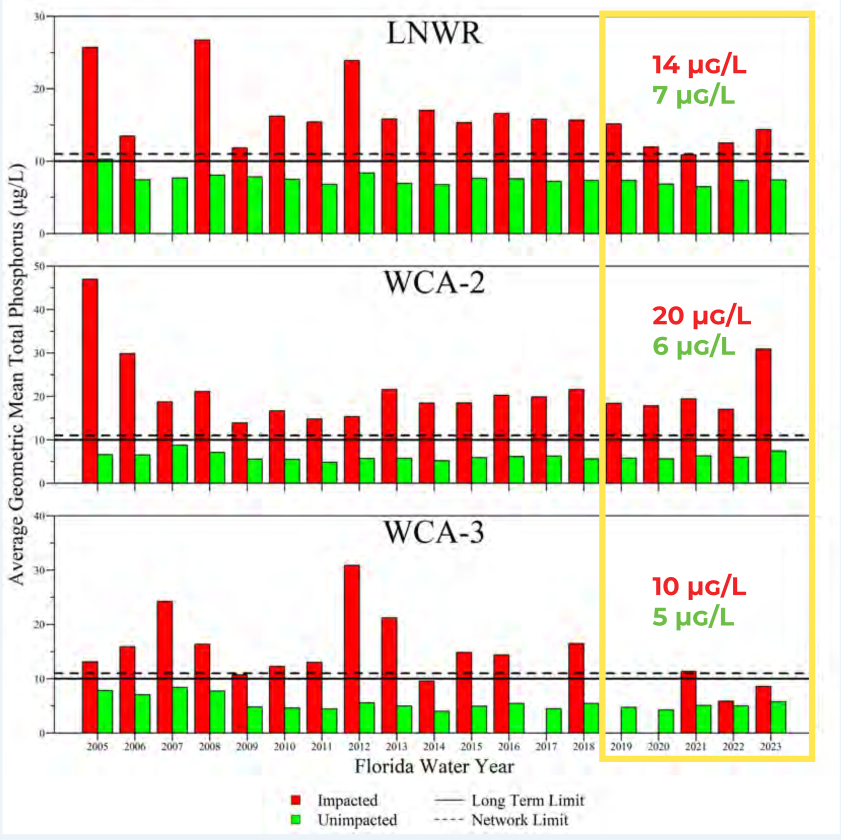


Figure 2. Network trends for LNWR, WCA-2 and WCA-3 during WY2005-2023 relative to the 10 µg/L long-term (5-year) and the 11 µg/L annual network limits for TP. The yellow bracket highlights the 5-year TP geometric mean average (WY2019-2023). (*) Not sufficient data.

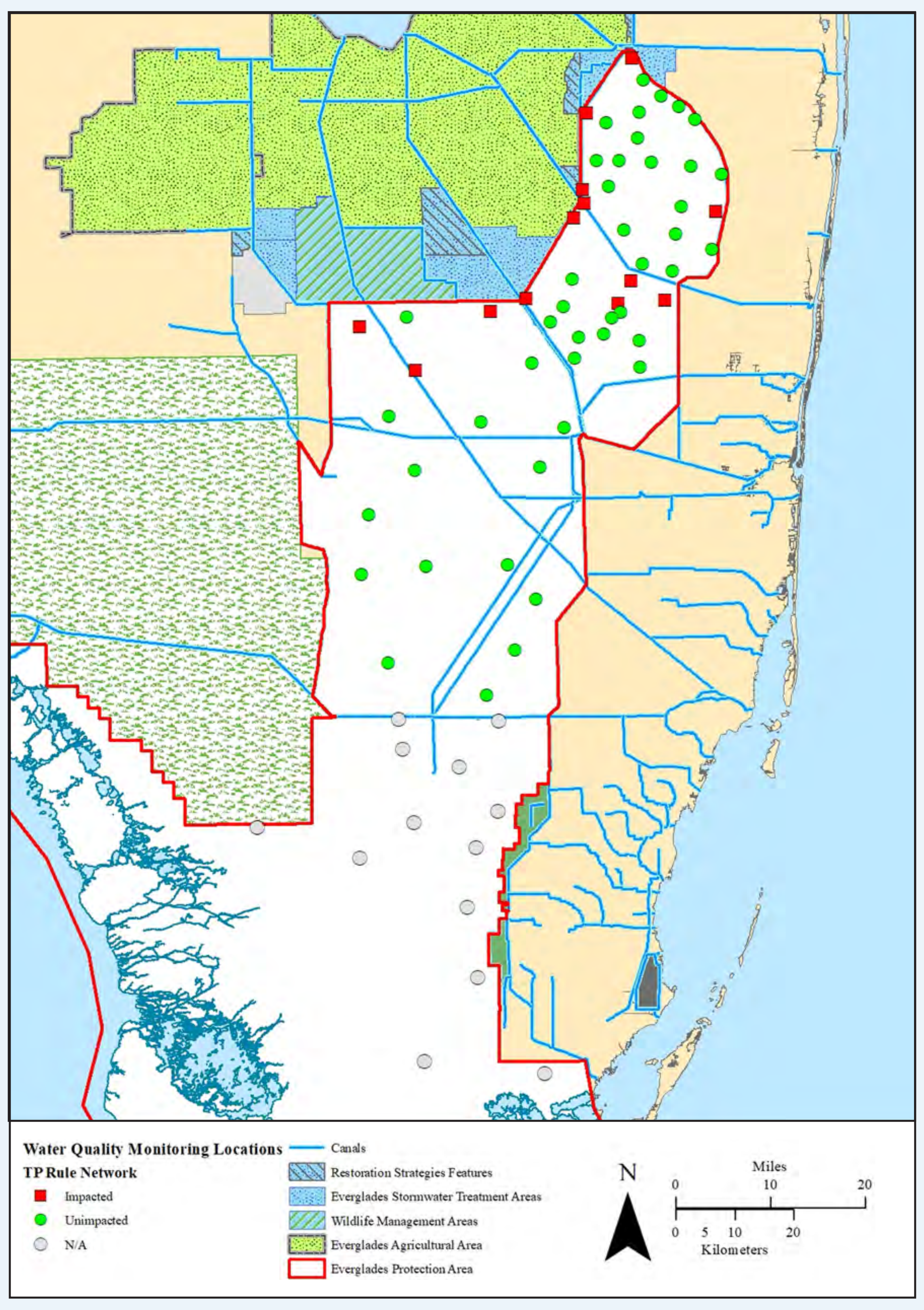


Figure 1. Location of TP criterion assessment monitoring stations and their respective classifications used in WY2019–2023 evaluations. (Note: N/A – not applicable)

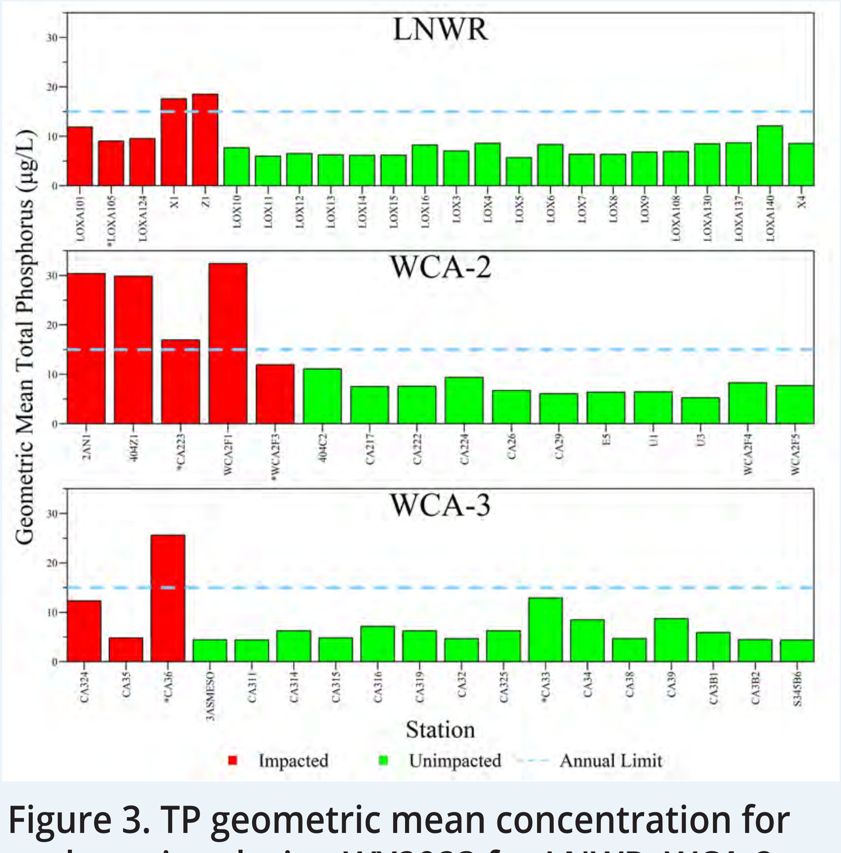


Figure 3. TP geometric mean concentration for each station during WY2023 for LNWR, WCA-2 and WCA-3 relative to the 15 µg/L annual limit. Stations with less than six samples are identified with an asterisk (*).

LONG-TERM GEOMETRIC MEAN FOR EPA

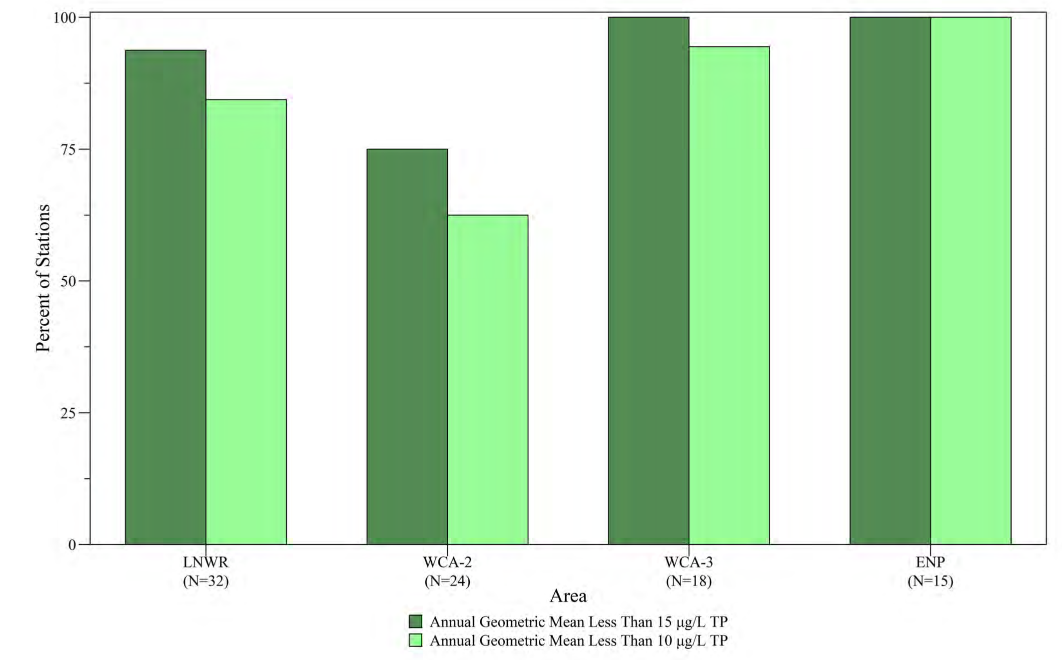


Figure 4. Percentage of stations within each region of the EPA with an annual geometric mean TP concentration less than 10 and 15 µg/L during WY2023. (Note: N – number of sites used in assessment with greater than six samples per year across the entire marsh monitoring network [TP Rule and ambient network]).

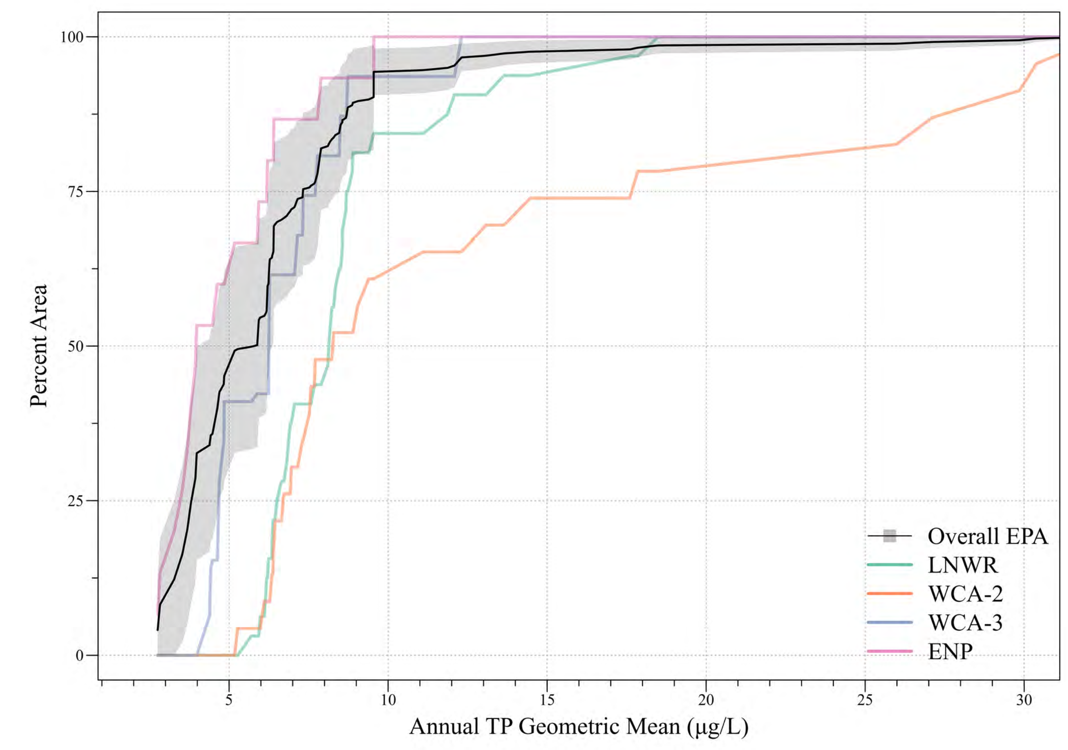


Figure 5. Cumulative distribution functions (CDFs) of annual geometric mean TP across the overall EPA and individual areas of the EPA in WY2023. Shaded region around the Overall EPA CDF represents the 95% confidence interval. (Note: CDF estimated for Everglades National Park [ENP] is based on four monitoring locations within Shark River Slough and may not be representative of all the freshwater portions of ENP.)

TOTAL PHOSPHORUS REDUCTION PROGRESS FROM WY 2005 - 2023

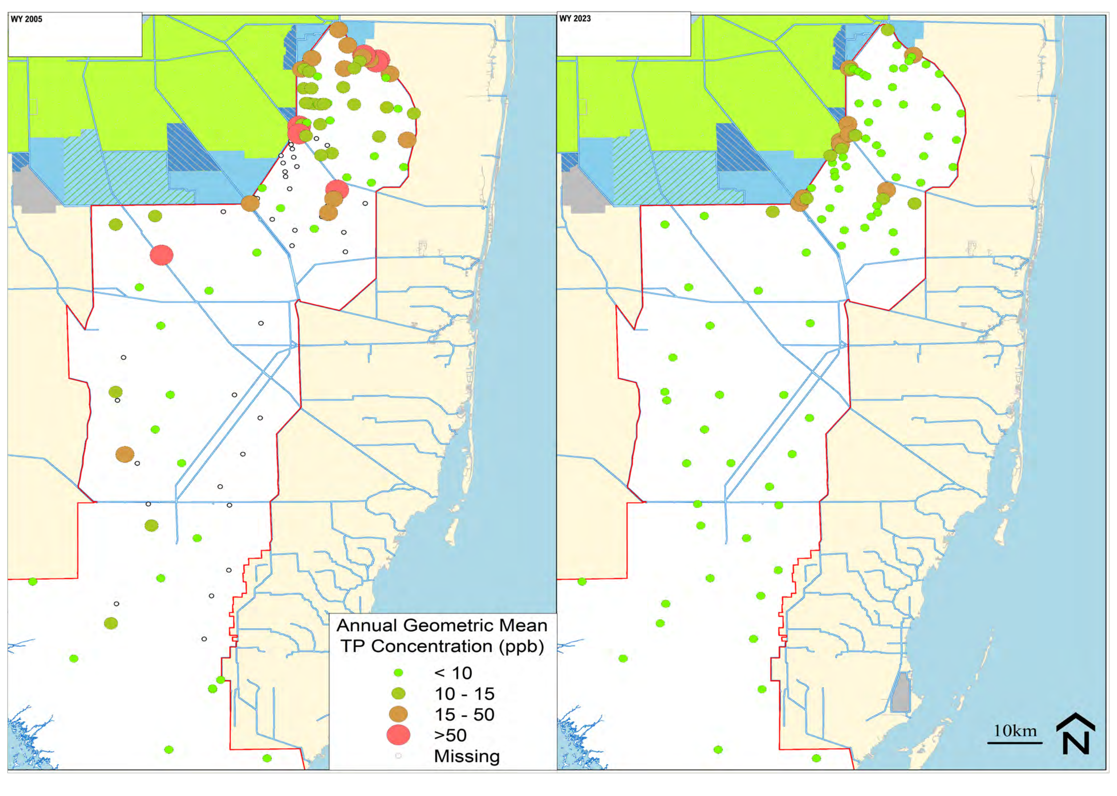


Figure 6. TP geometric mean concentration for each station during WY2005 (left) & WY2023 (right) for the EPA.

- 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 WY2023.
- Since the TP Rule came into effect in 2005, seven impacted stations across the EPA have transitioned from impacted to unimpacted. LOXA124 appear to meet the criteria to move from the impacted to unimpacted network in WY2023. Additional analyses will be conducted to verify the transition to unimpacted.

SUMMARY

- For WY2023, 53 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 comply 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 98% of the interior EPA is below 15 ppb and nearly 95% is below 10 ppb in WY2023. 100% of the ENP and WCA-3 is below 15 µg/L; 97% of LNWR is below 15 µg/L and 74% of WCA-2 is below 15 µg/L.

For more information:

SCAN ME

Chapter 4: Southern Everglades Nutrient Source Control Program

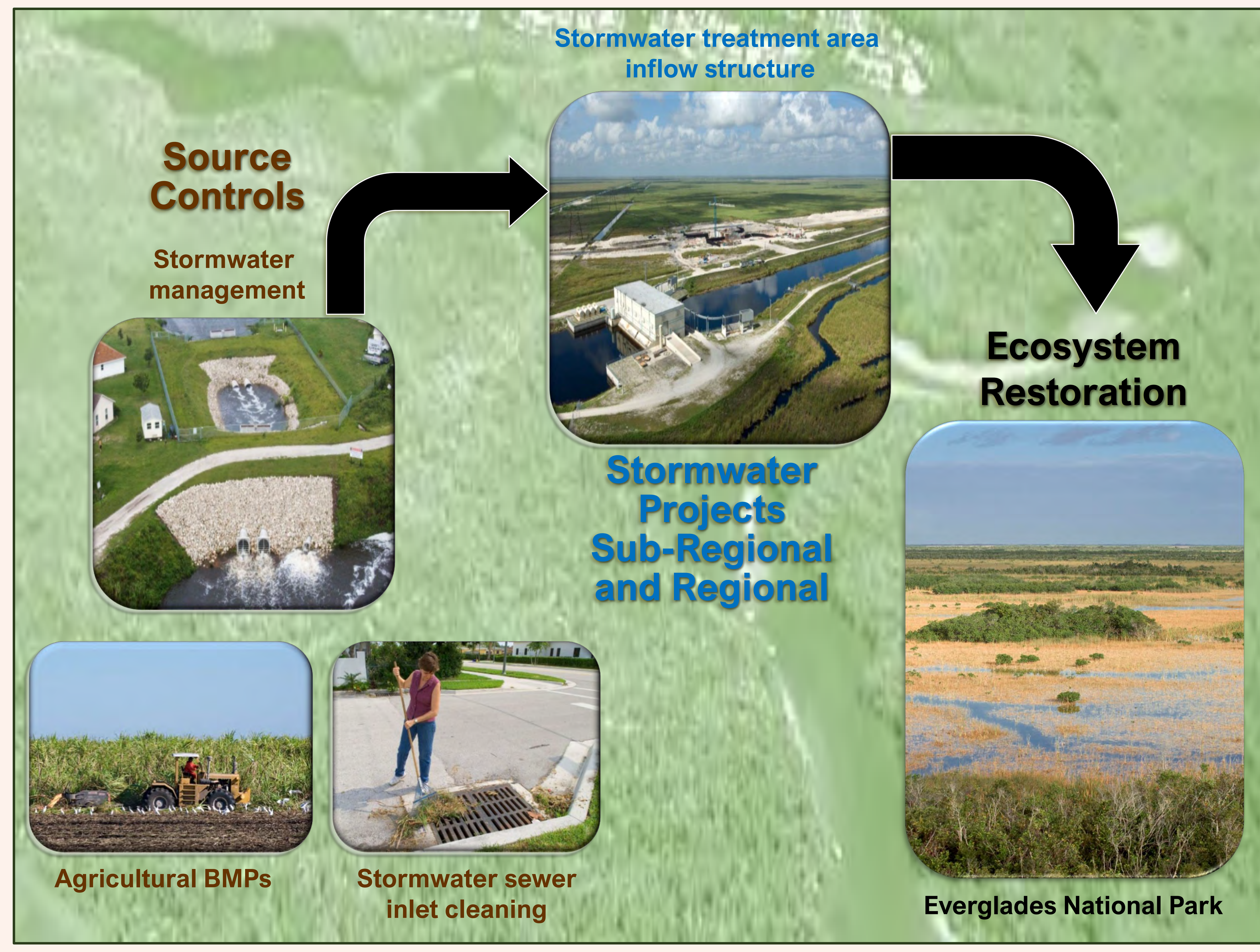
Youchao Wang, Mehrnoosh Mahmoudi, Christian Avila

Project Operations & Assessment Section, Everglades & Estuaries Protection Bureau

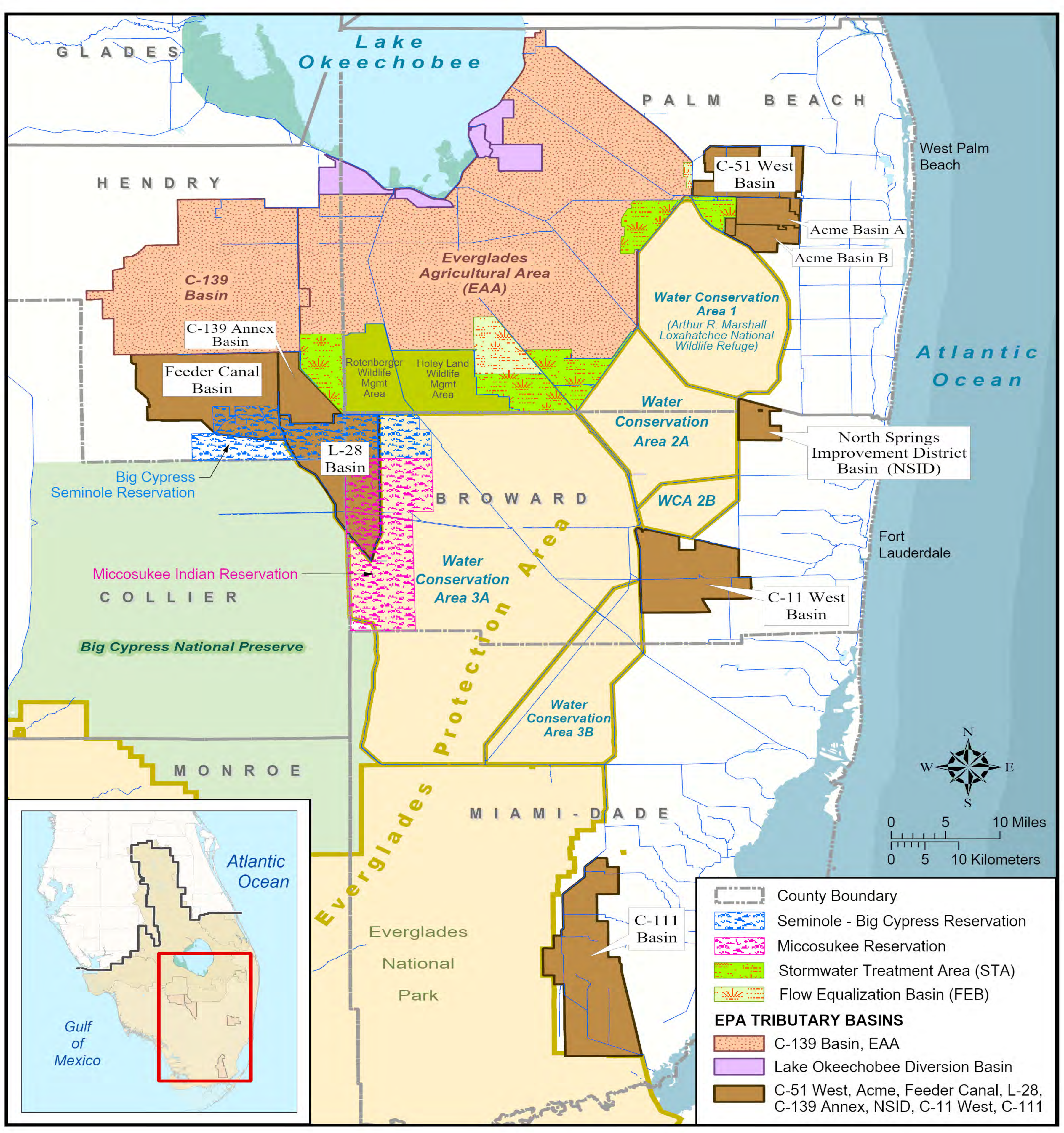
Purpose: Implement regulatory and cooperative programs for basins discharging to the Everglades

Mandatory Requirements

- Appendix E of the United States Settlement Agreement
- Everglades Forever Act, Section 373.4592, F.S.
- Regulatory Best Management Practices (BMP) program under Chapter 40E-63, Florida Administrative Code
- Environmental Resource permits conditions and local cooperative agreements



Basins Tributary to the Everglades Protection Area (EPA)



WY2023 Total Phosphorus (TP) Runoff and Target by Basin

Basin	TP Load (metric tons)	TP (µg/L)	Target TP Load (metric tons)
Everglades Agricultural Area (EAA)	138	118	283
C-139	56	272	71
C-51 West (incl. Acme Improvement District)	13	111	-
Feeder Canal	10	121	-
L-28	10	96	-
C-11 West	6	19	-
C-111	4	9	-
North Springs Improvement District (NSID)	0	-	-

Comprehensive Best Management Practices (BMPs)

BMP point system: Ensures equivalent level of effort among permittees (SFWMD 1991)

Works of the District permits require a minimum of 25 equivalent BMP points for each permittee

PARTICIPANT BMPs	POINTS	SUGAR CANE	VEGETABLE	CORN	SOD
NUTRIENT CONTROL PRACTICES					
Nutrient Application Control	2.5	2.5	2.5	2.5	2.5
Nutrient Spill Prevention	2.5	2.5	2.5	2.5	2.5
Soil Testing	5.0	5	5	5	5
Plant Tissue Analysis	2.5				
Split Nutrient Application	5				5
Slow Release P Fertilizer	5				
No Nutrients Imported via Direct Land Application	15				
PARTICULATE MATTER AND SEDIMENT CONTROLS					
Particulate Matter and Sediment Controls (2)	2.5				
Particulate Matter and Sediment Controls (4)	5				5
Particulate Matter and Sediment Controls (6)	10	10	10	10	
WATER MANAGEMENT PRACTICES					
Water Management (0.5-inch)	5	5	5	5	5
Water Management (1.0 -inch)	10				
Water Management (1.5-inch)	15				
Water Management (> 1.5-inch)	15				
Improved Infrastructure	5				
Reduced Flow Through Water Table Management	5				
PASTURE MANAGEMENT					
Pasture Management	5				
TOTALS (minimum 25 points)		25	25	25	25

Program Implementation:

- Issue Works of the District (WOD) permits to landowners
- Comprehensive BMP plan
- Post-permit compliance activities
- Discharge (water quality and quantity) monitoring plan
- Evaluation of program performance
- Research and education to improve the BMP program

For more information:

SCAN ME

Appendix 4-1: Everglades Agricultural Area Source Control Monitoring and Performance

Youchao Wang, Mehrnoosh Mahmoudi, Christian Avila

Project Operations & Assessment Section, Everglades & Estuaries Protection Bureau

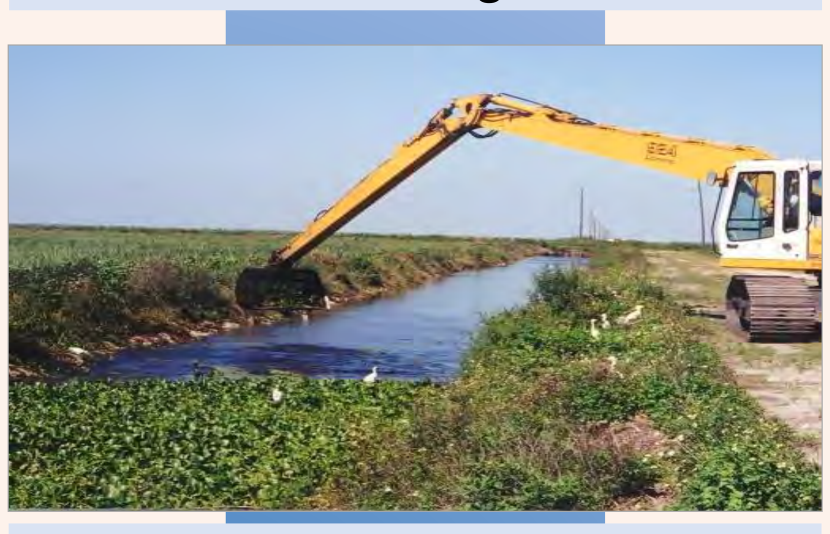
Since 1996, a total of 4,671 metric tons of Total Phosphorus (TP) load has been prevented from being discharged directly from the Everglades Agricultural Area (EAA).

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

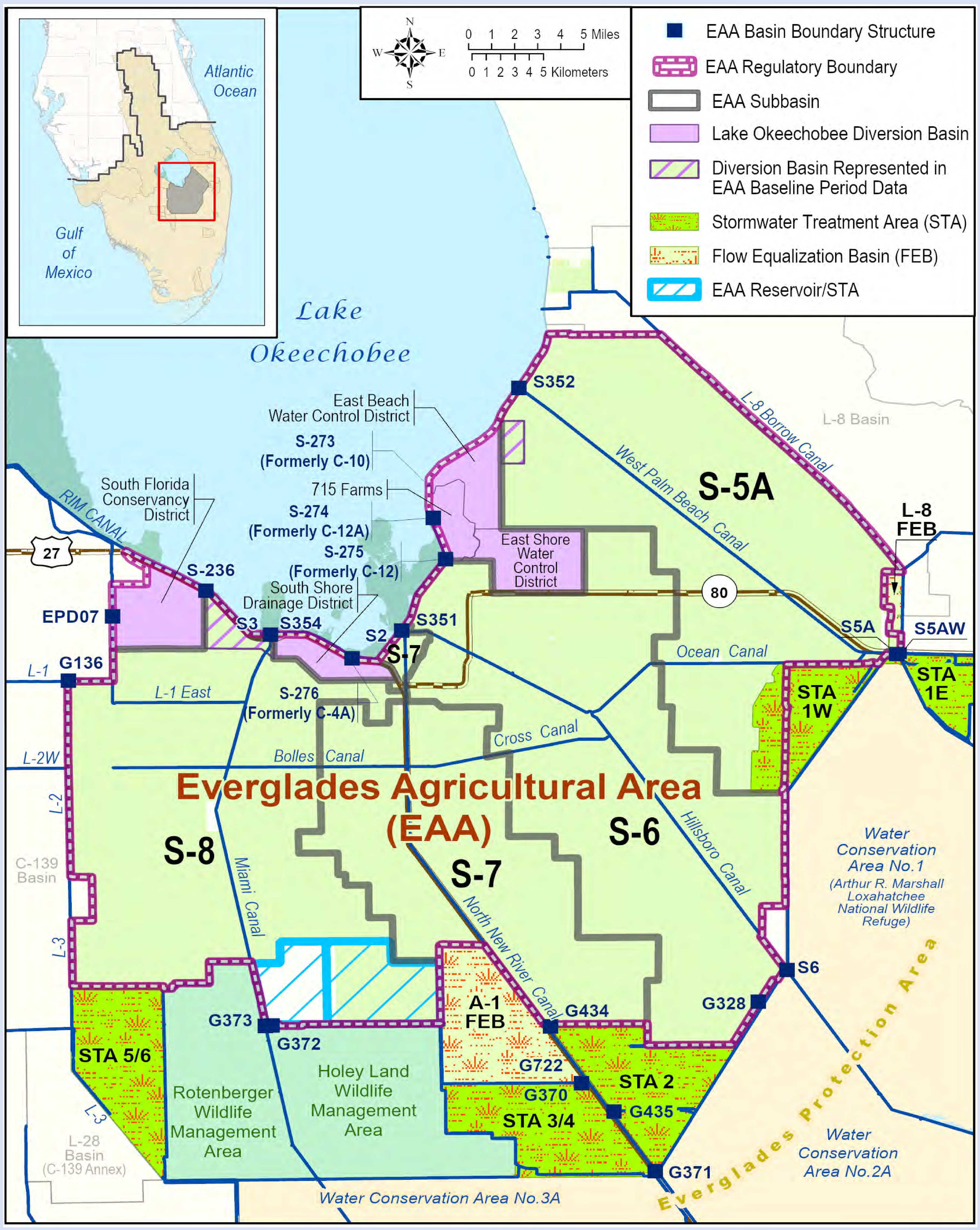


Particulate Matter and Sediment Controls

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.

The regulatory source control program requires permittees to achieve a 25 percent TP load reduction from pre-BMP baseline period in their stormwater discharges to the Everglades.

EAA Boundaries and Monitoring Stations

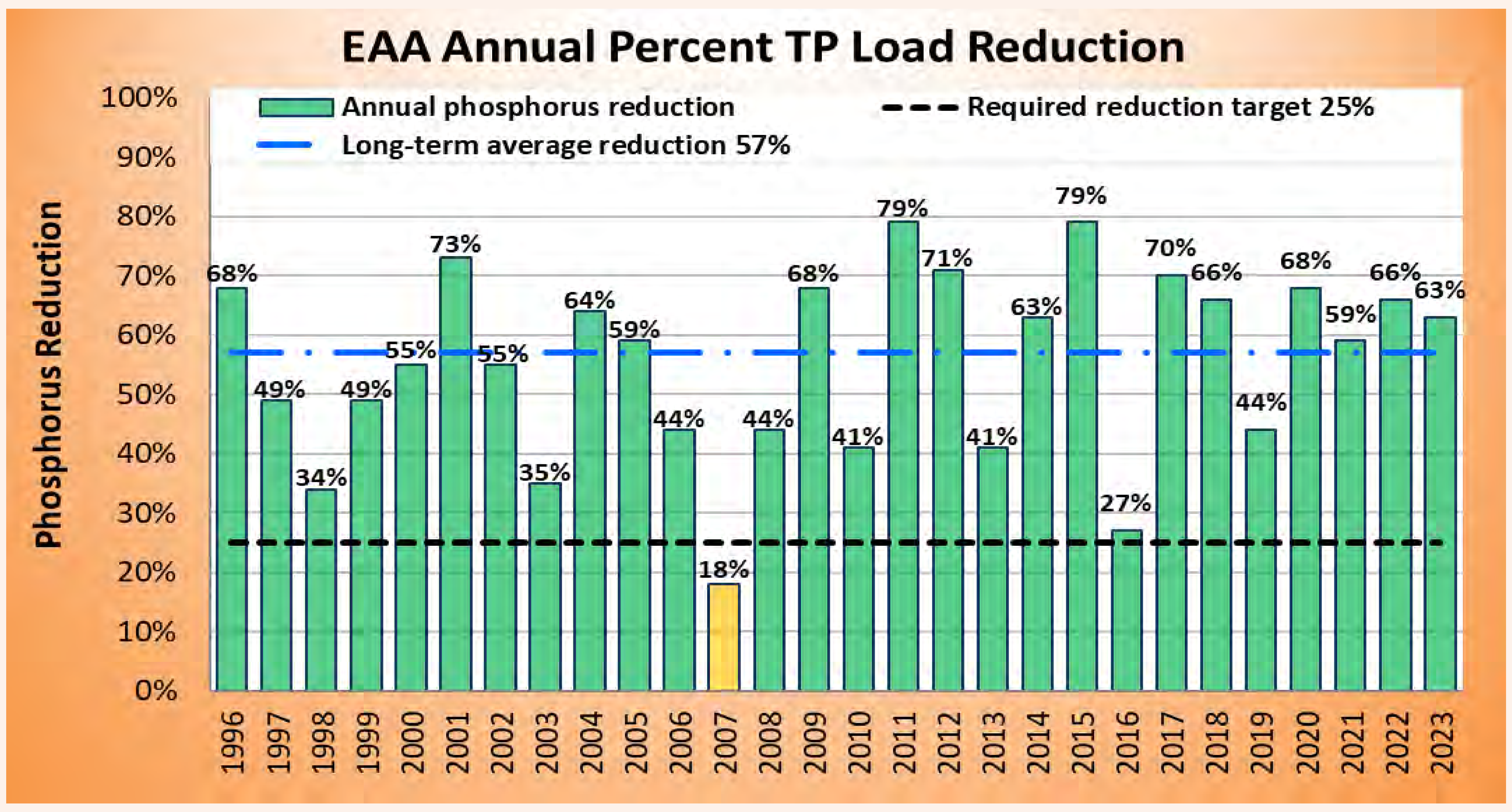


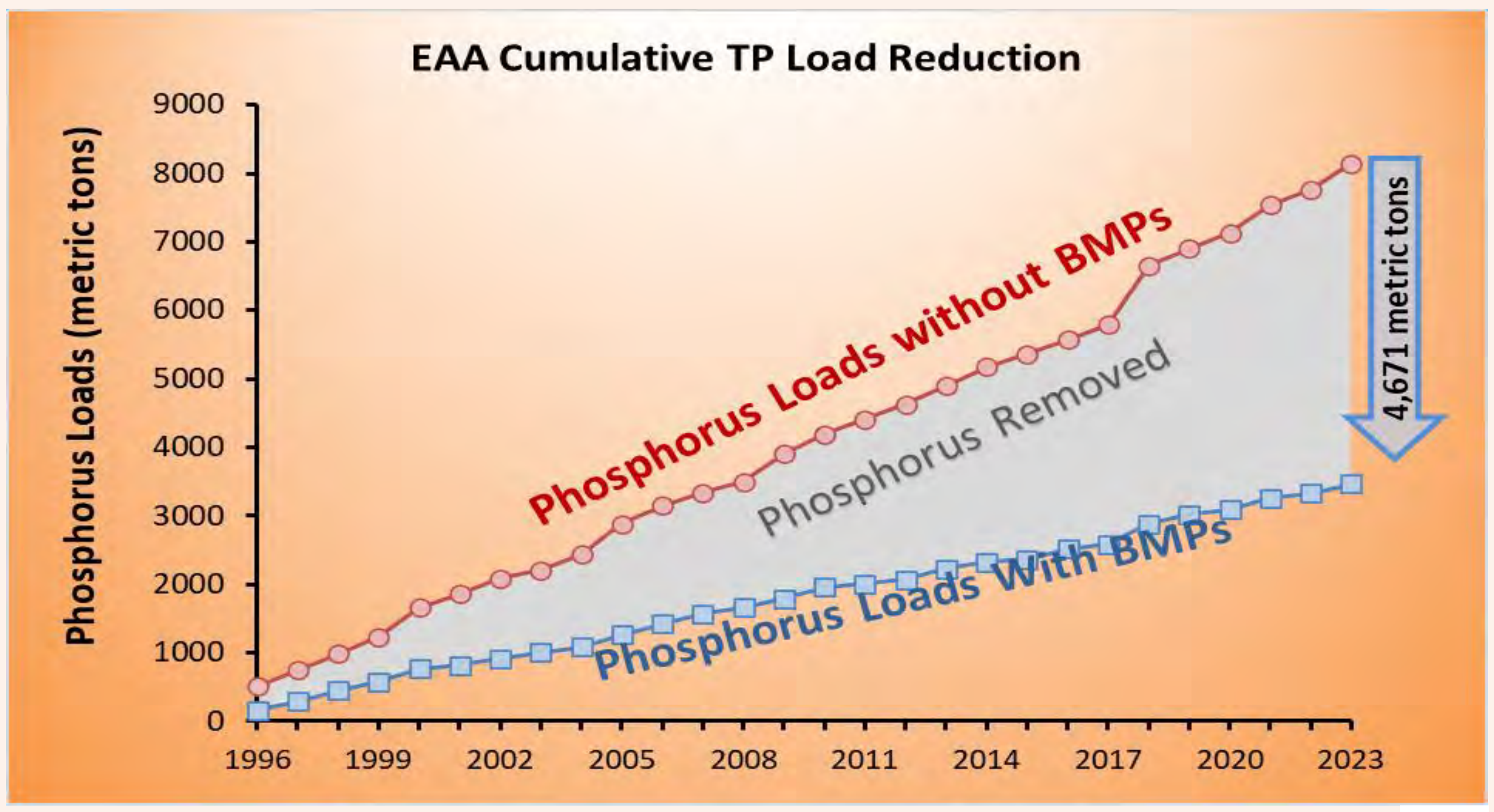
MONITORING & ASSESSMENT

- 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 "apple-to-apple" comparison between the two periods.

Autosampler at S-3 Pump Station

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





For more information:

SCAN ME

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

Michael J. Chimney, Ph.D.
Water Quality Treatment Technologies Section, Applied Sciences Bureau

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

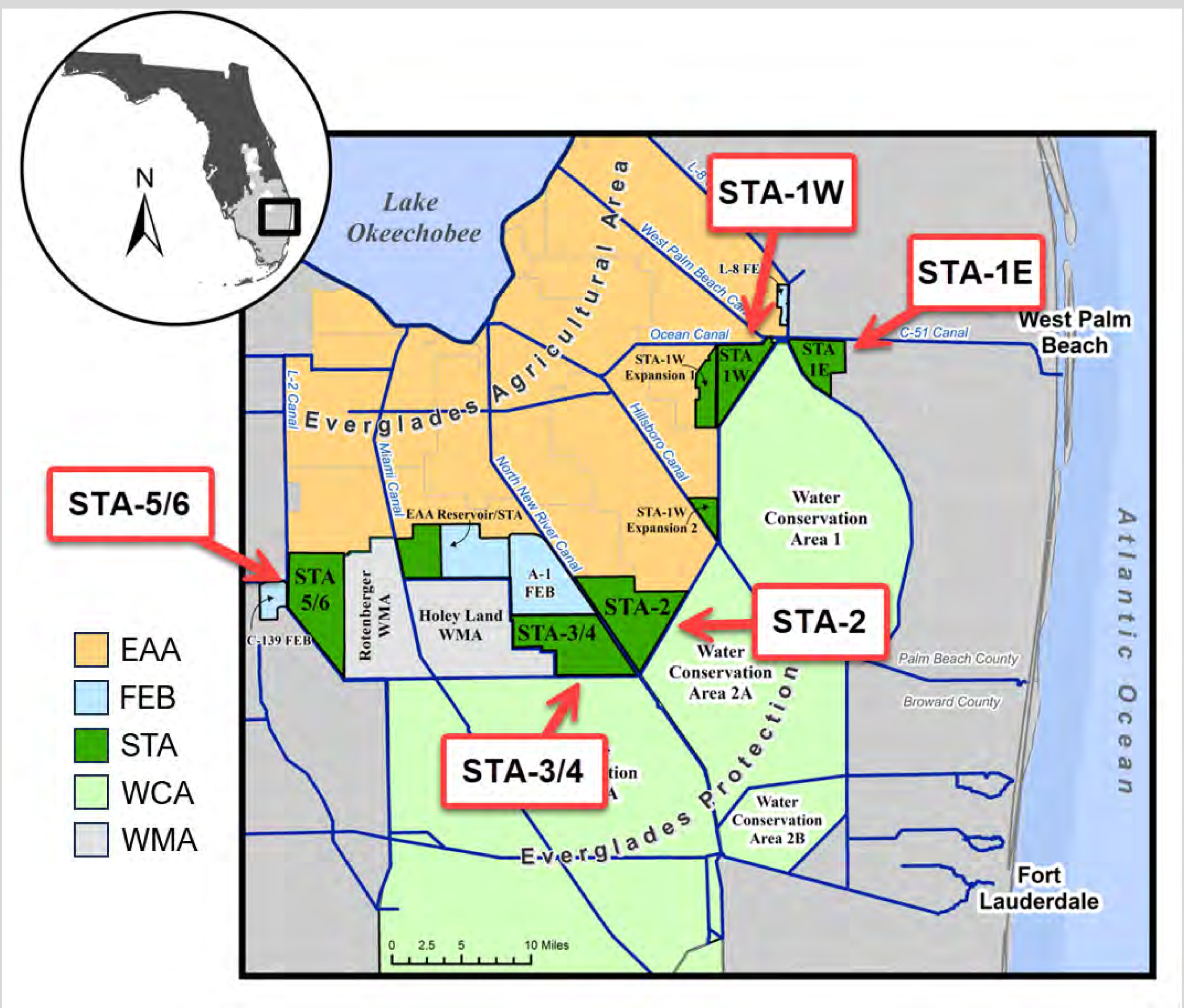


Figure 1. Location of the STAs in relation to the EAA, WCAs, flow equalization basins (FEBs) and other land features in South Florida.

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	19
STA-1W	10,810	Oct 1993	29
STA-2	15,495	Jun 1999	22
STA-3/4	16,327	Oct 2003	20
STA-5/6	14,338	Dec 1997	26
All STAs	61,964		29

*Complete District water years with flow-through operation

Table 2. Summary of treatment performance in each STA and all STAs combined during WY2023 for each STA and all STAs combined.

Parameter	STA-1E	STA-1W	STA-2	STA-3/4	STA-5/6	All STAs
WY2023						
Inflow Water Volume (ac-ft)	124,454	152,330	326,940	326,784	153,410	**1,083,919**
Mean Inflow TP (µg/L)	115	199	113	93	288	**144**
P Loading Rate (PLR) (g/m²/yr)	1.5	0.9	0.9	0.9	1.0	**0.9**
Mean Outflow TP (µg/L)	26	20	29	16	40	**25**
TP Load Reduction (%)	82%	89%	72%	84%	87%	**83%**

Note: ac-ft = acre-feet; µg/L = micrograms per liter; g/m²/yr = grams per square meter per year.

SUMMARY

- Table 5B-2 in the 2024 South Florida Environmental Report summarizes the operational status of all 25 flow-ways for the 2023 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 29-year period-of-record (POR):
  - Treated 26.3 million acre-feet (ac-ft) of runoff
  - Retained 3,380 metric tons of TP
  - TP load reduction = 77%
  - Outflow mean TP = 30 µg/L
- STA-3/4 over its 20-year POR:
  - Treated the most water = 8.6 million ac-ft
  - Retained the most TP load = 907 metric tons
  - Highest inflow-to-outflow TP load reduction = 85%
  - Lowest mean outflow TP conc. = 15 µg/L

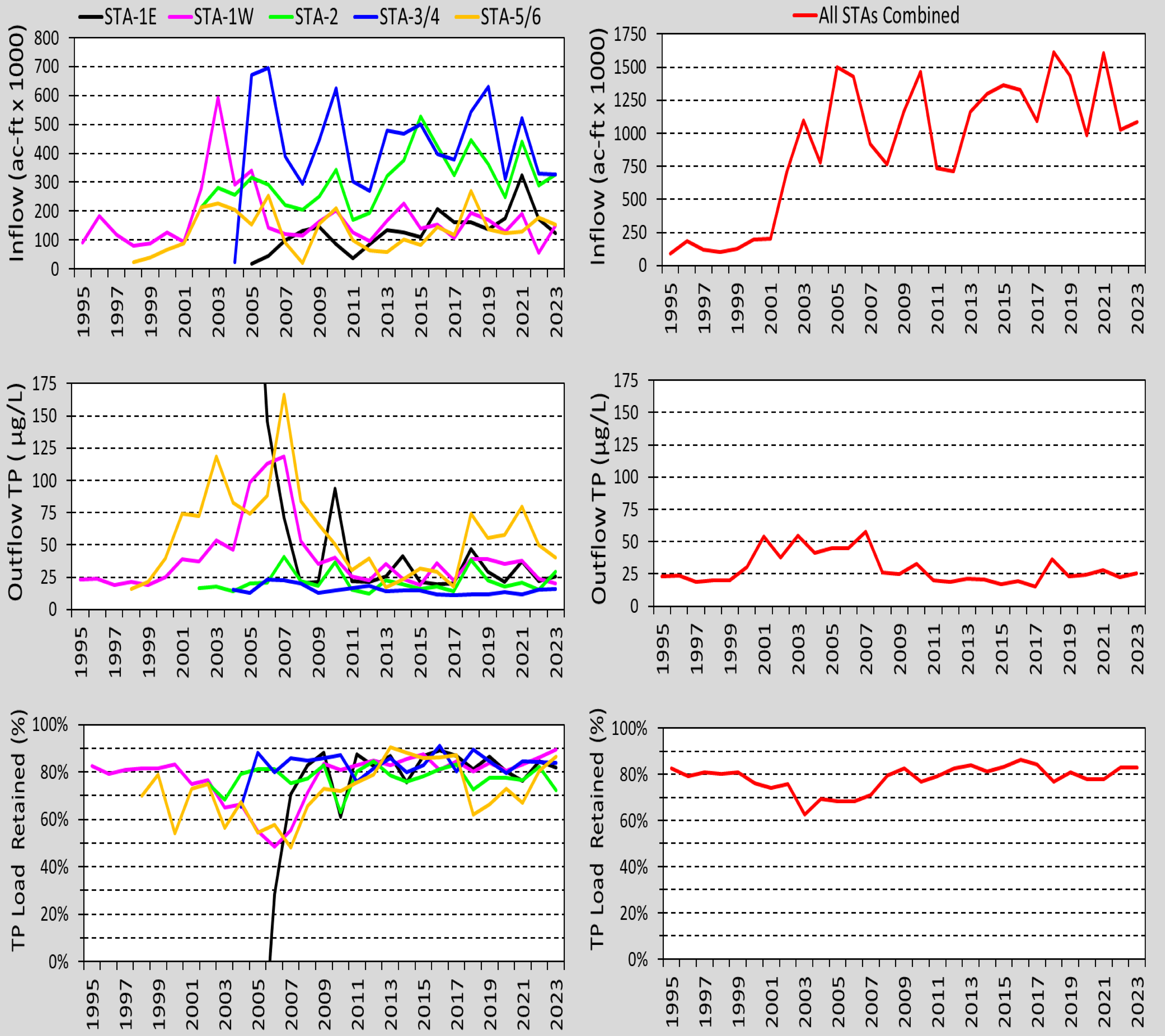


Figure 2. Annual time-series plots (WY1995—WY2023) for each STA and all STAs combined.
Top Panels = total inflow water volume; **Middle Panels** = mean outflow TP concentration; **Bottom Panels** = percent inflow-to-outflow TP load reduction.

For more information: SCAN ME

Appendix 5B-4: Submerged Aquatic Vegetation Coverage in the Stormwater Treatment Areas

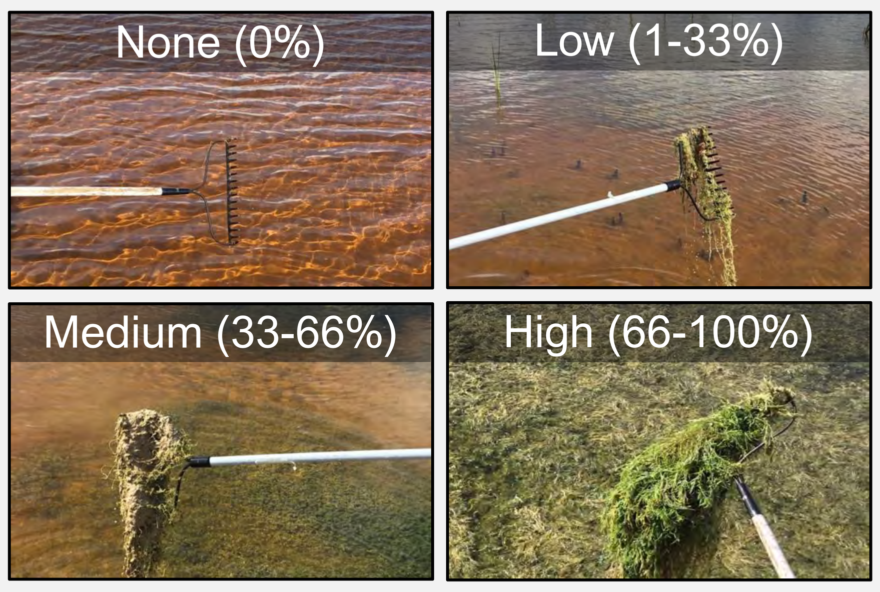
Ryan Goebel, Jacob Dombrowski, Camille Herteux
Water Quality Treatment Technologies Section, Applied Sciences Bureau

Introduction

- The Everglades Stormwater Treatment Areas (STAs) are constructed wetlands designed to reduce phosphorus (P) concentrations entering the Everglades Protection Area
- P retention occurs through mechanisms such as particulate settling, soil sorption, plant and microbial uptake, and eventual biomass accretion
- STAs are divided into emergent aquatic vegetation (EAV) and mixed EAV/submerged aquatic vegetation (SAV) cells
- Surveys of EAV/SAV cells document SAV taxa aerial coverage to provide insights on marsh structure, vegetation health, and efficacy of management practices

Methods

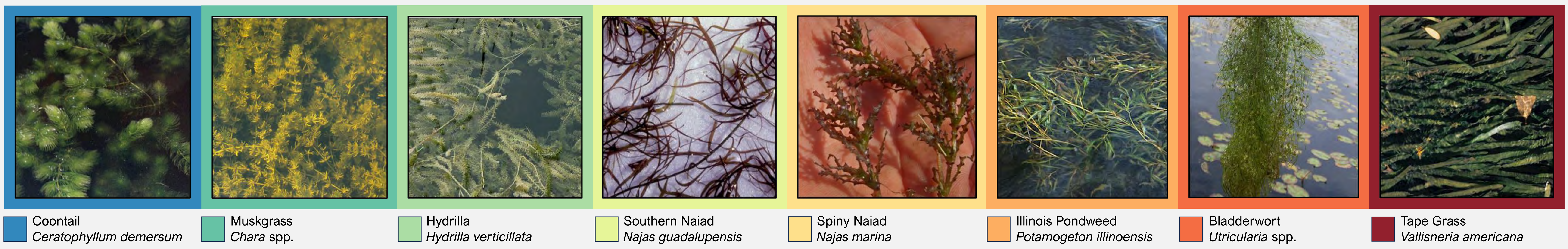
- Surveys use a grid pattern of geo-referenced sites within EAV/SAV cells, where SAV coverage is estimated within 50 ft of each point
- Coverage is recorded on a 4-point ordinal scale: *None* – no plants; *Low* – 1-33% coverage; *Medium* – 33-66% coverage; *High* – >66% coverage (Right)
- Frequency of occurrence is calculated as the number of sites where SAV is present to total sites visited
- Ground survey coverage maps and frequency of occurrence figures below correspond to Water Year 2023 (WY2023; May 1, 2022 – April 30, 2023)



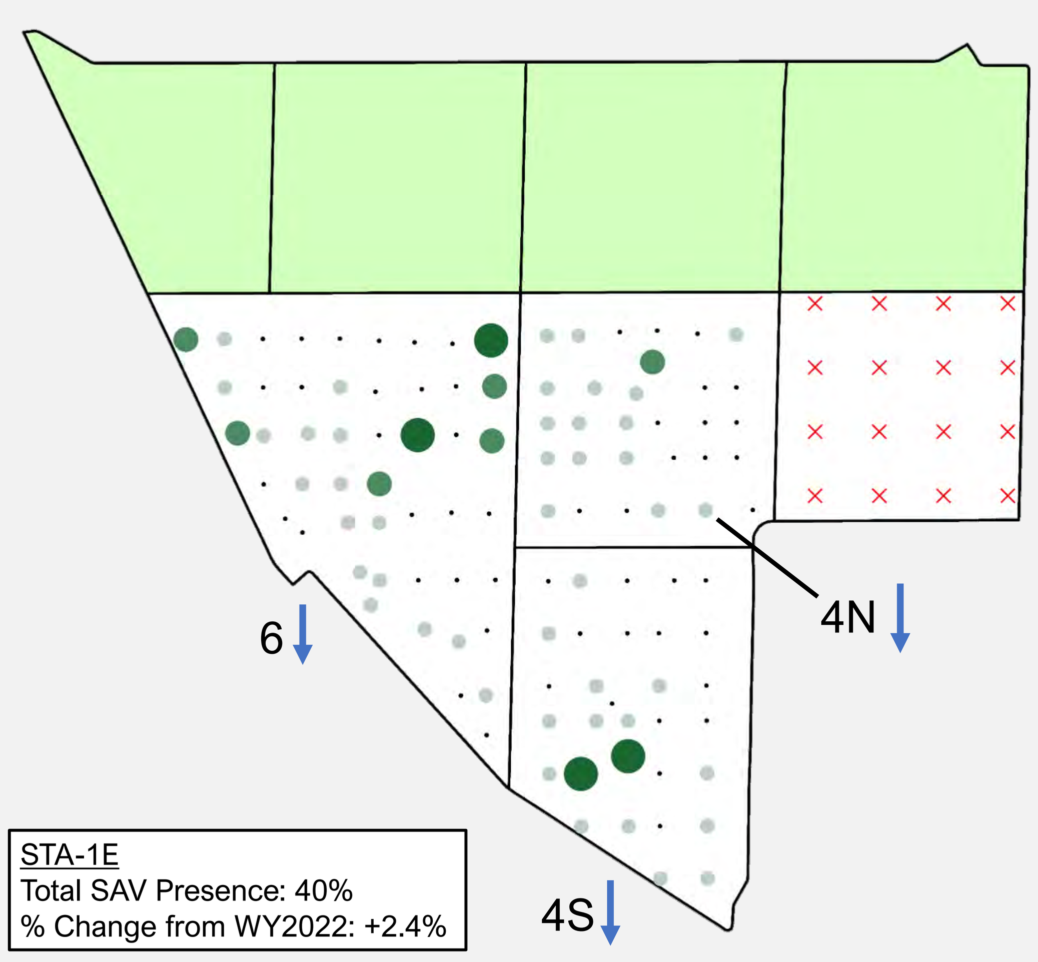
Coverage Map Legend:

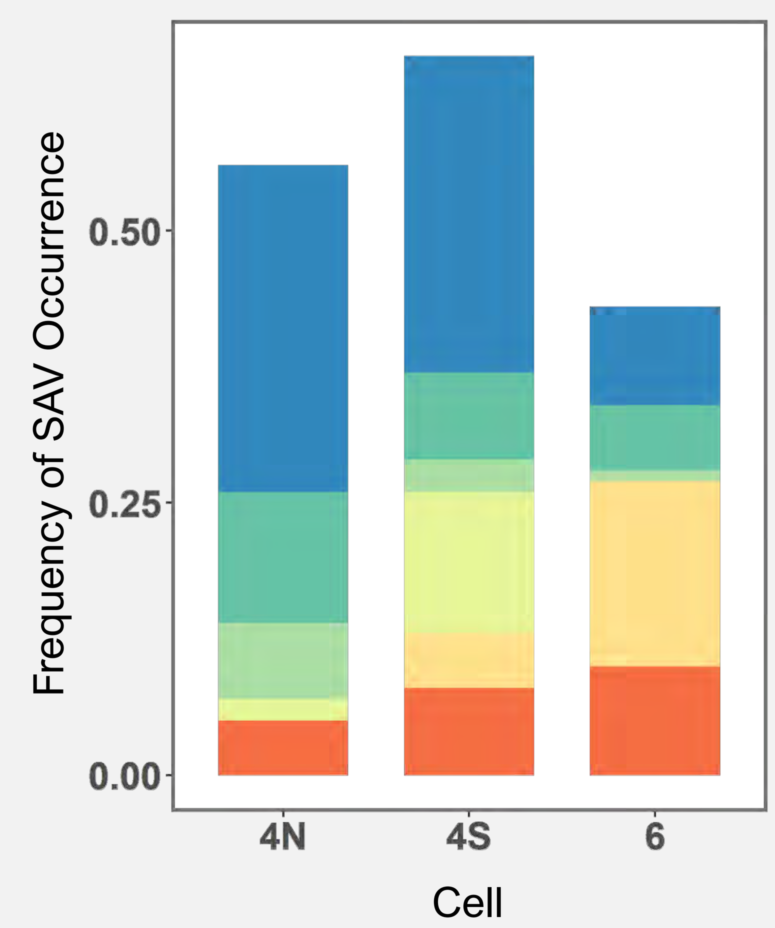
- None
- Low
- Medium
- High
- Not Surveyed
- EAV
- EAV/SAV
- Structures
- Dense Cattail
- Flow Direction

Species Key for Frequency of Occurrence Figures:

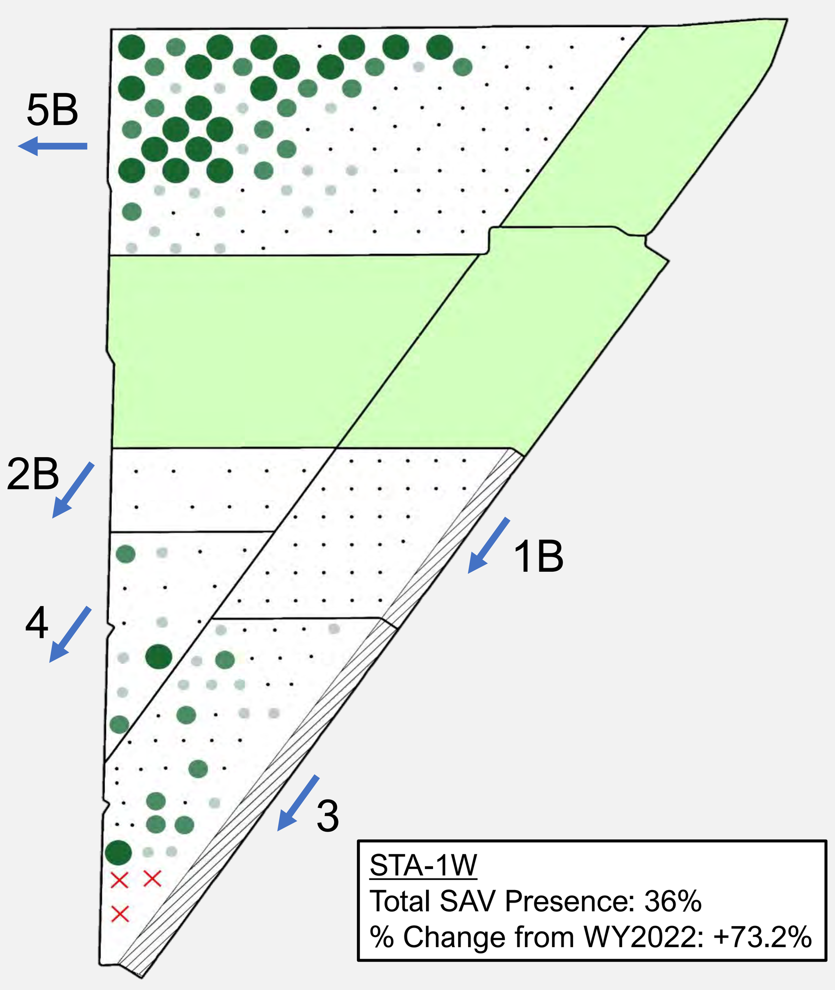


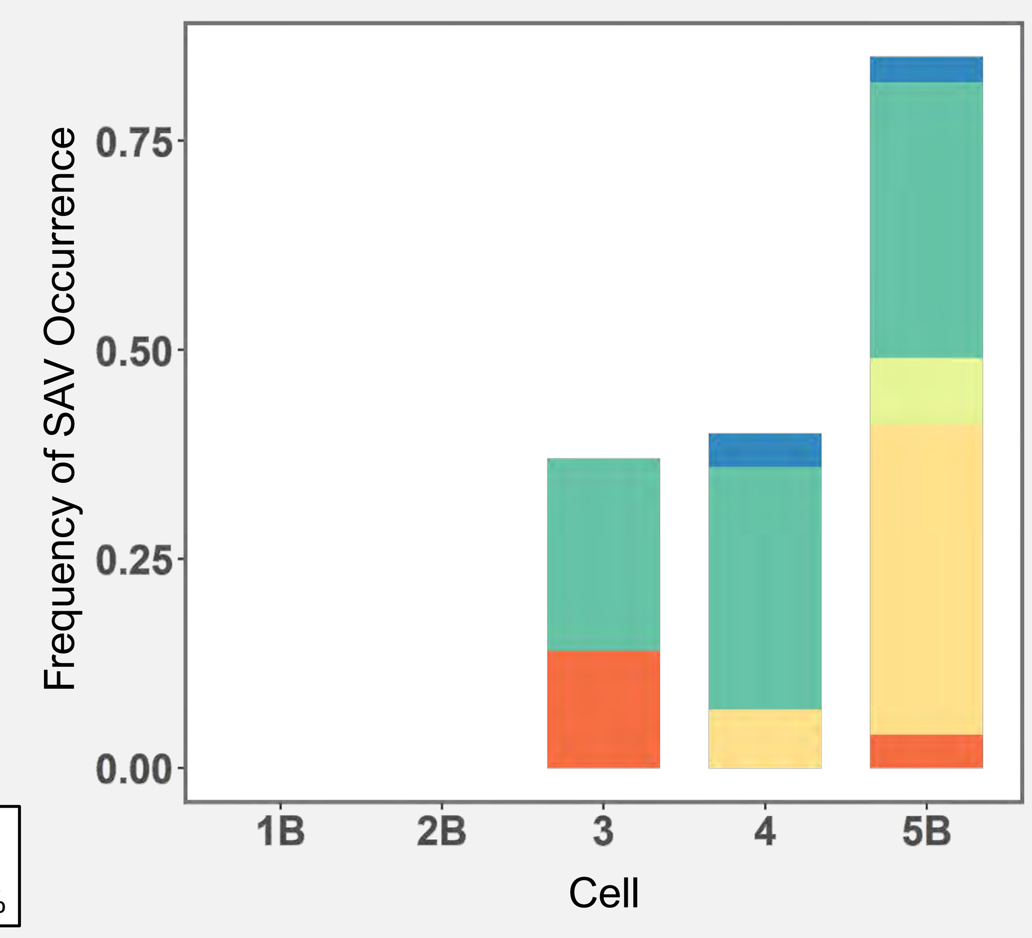
STA-1E



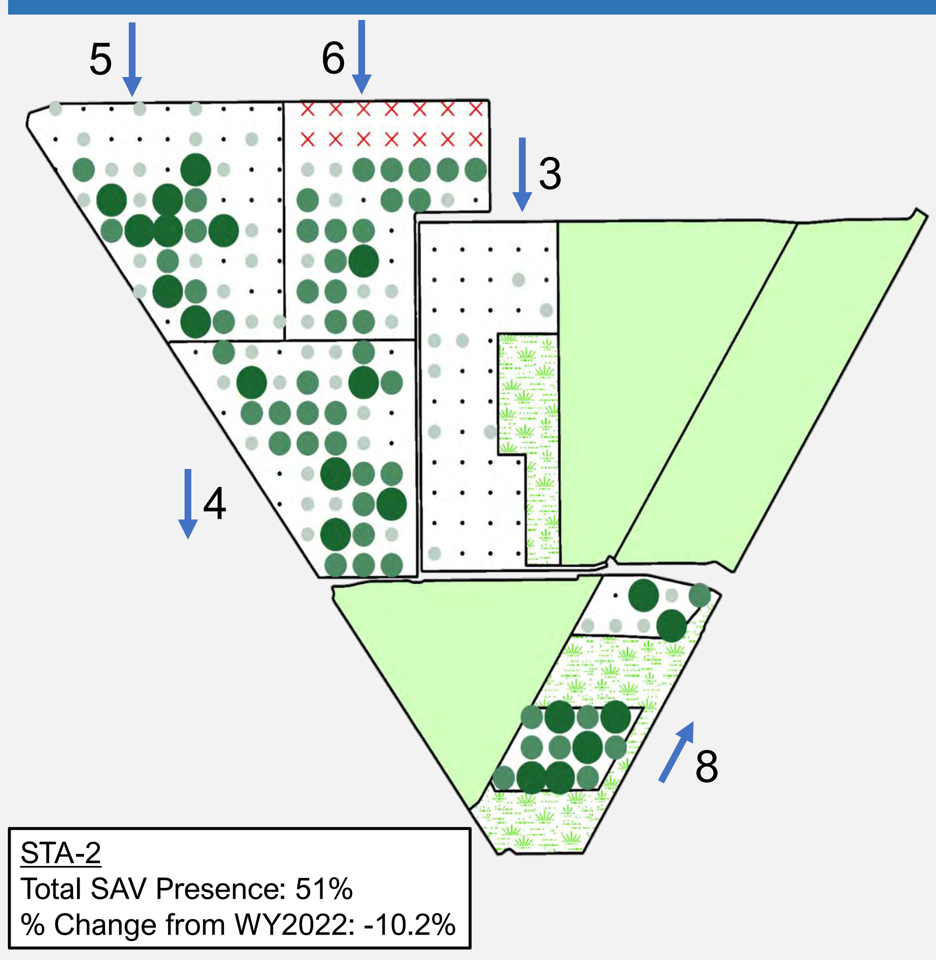


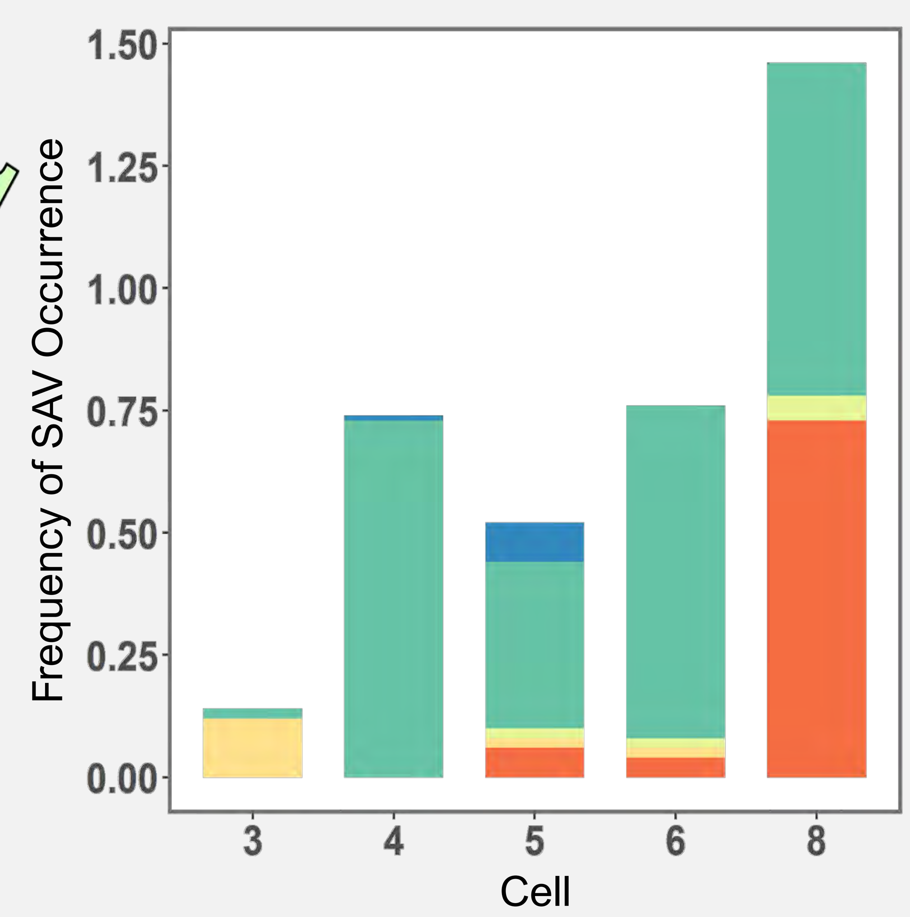
STA-1W



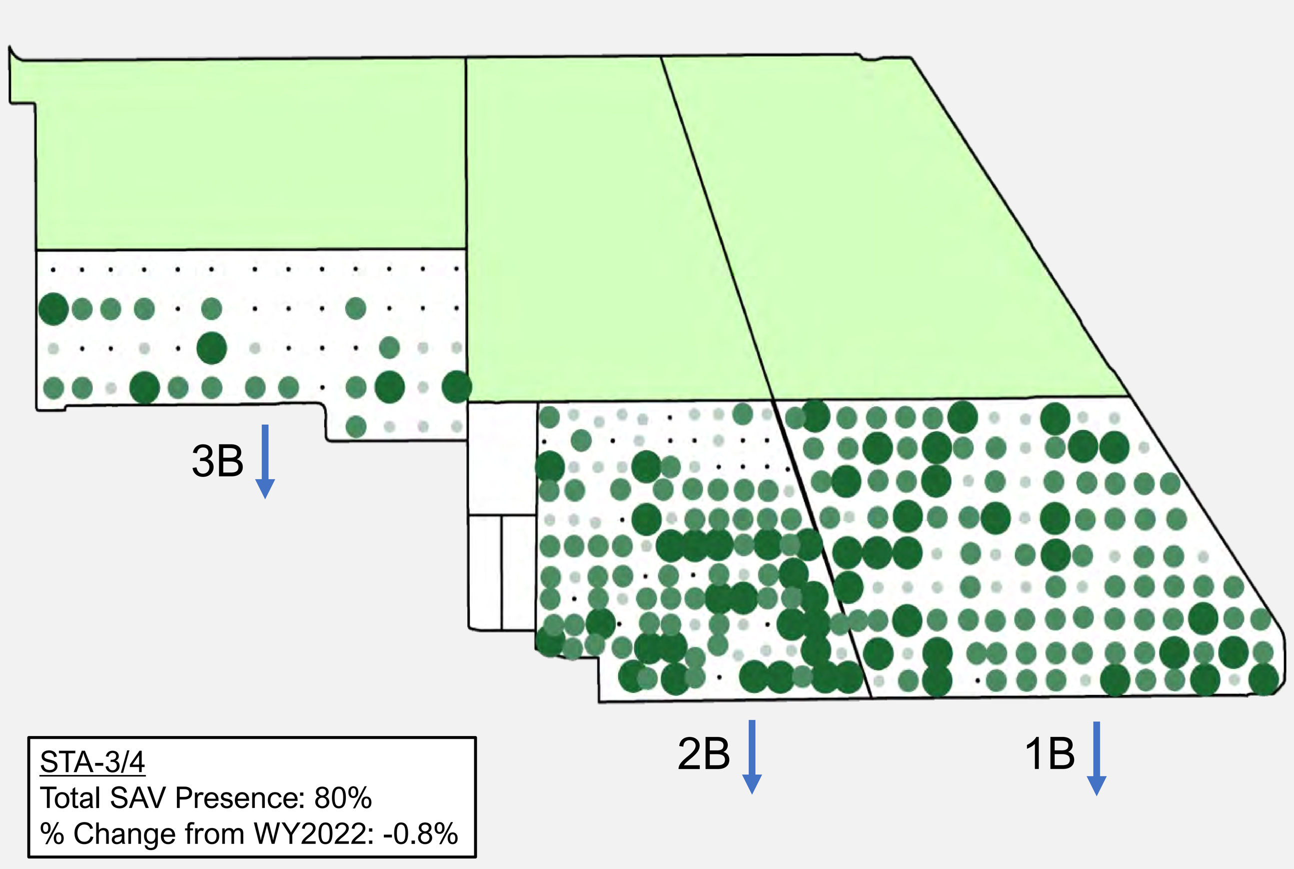


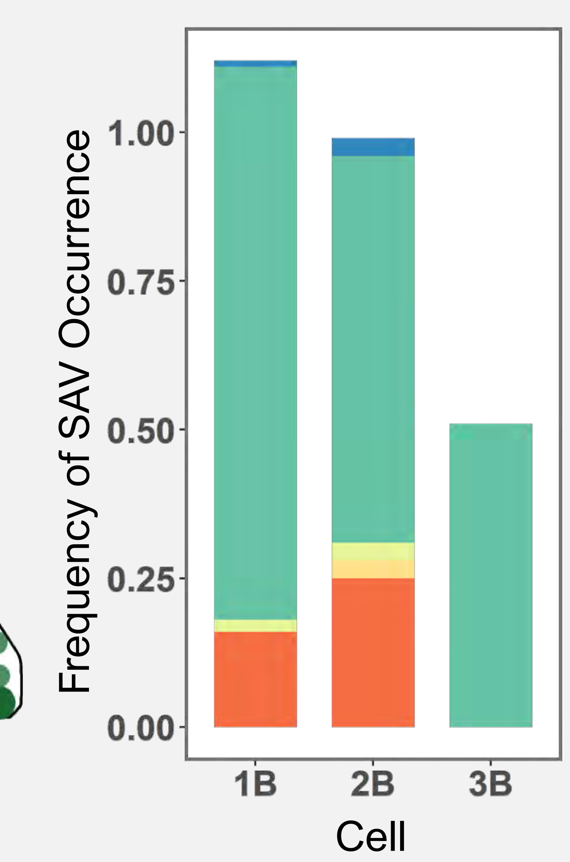
STA-2



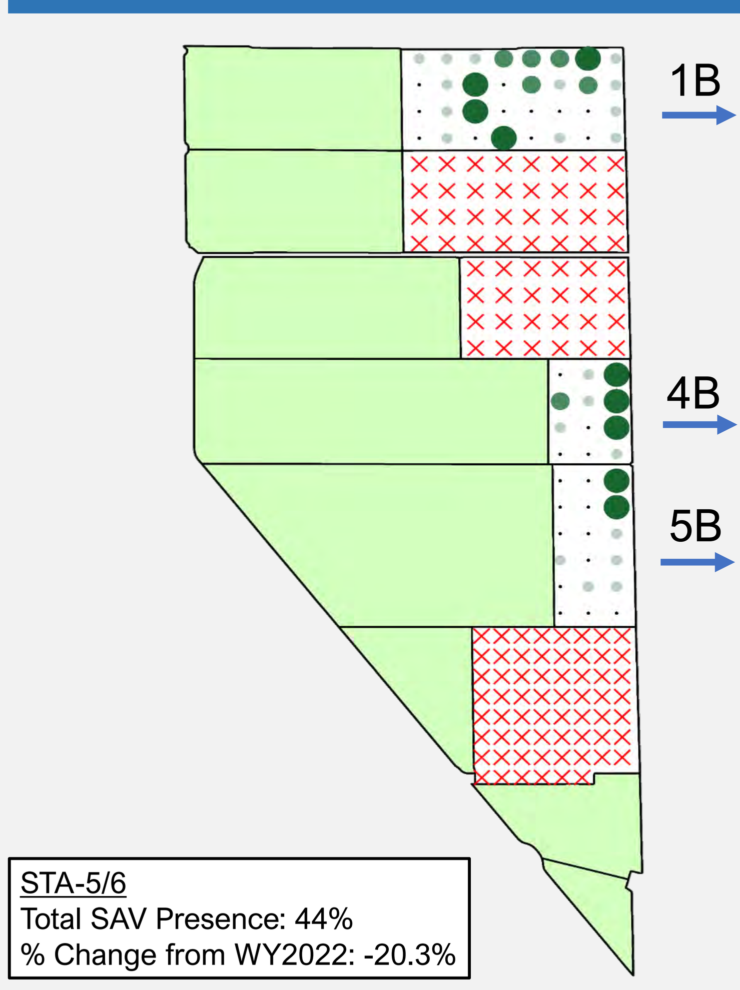


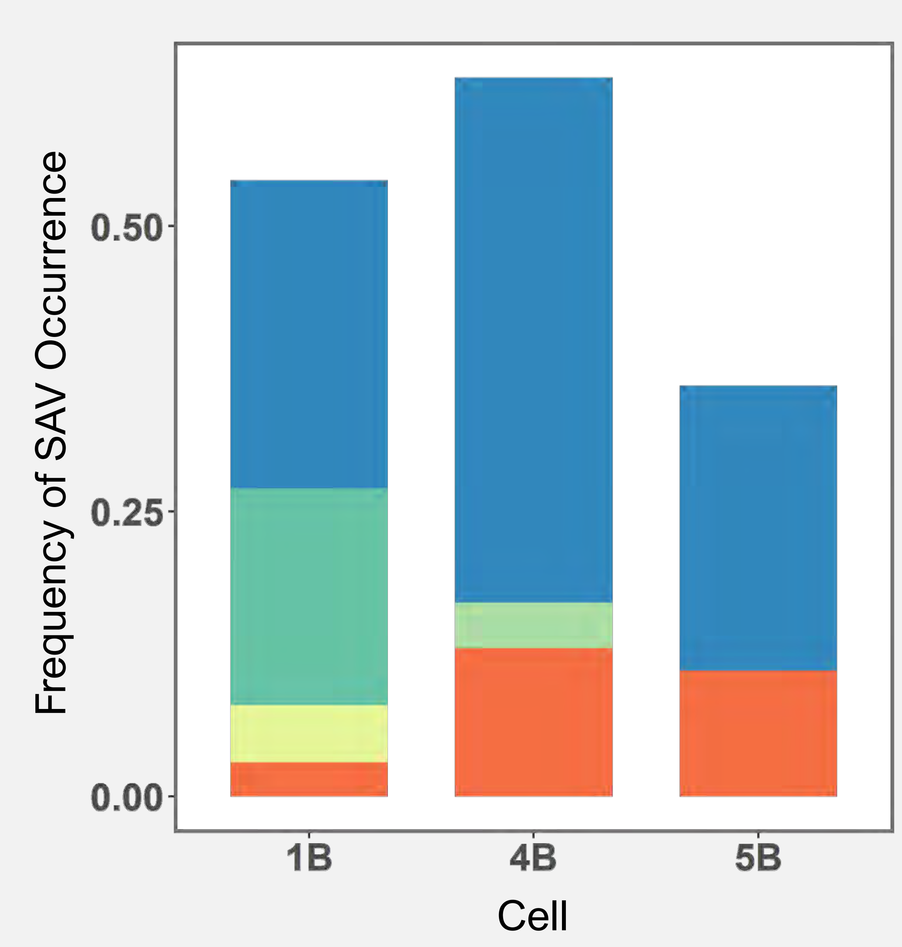
STA-3/4





STA-5/6





Water Year 2023 Trends

STA-1E

- Coontail is the most common taxon out of six total SAV taxa identified:
  - Observed at 21% of sites
- Surveys in the Eastern Flow-way were restricted due to vegetation maintenance activities

STA-1W

- Muskgrass is the most common taxon out of five total SAV taxa identified:
  - Observed at 23% of sites
- Expansion cells (not depicted) were not surveyed due to ongoing vegetation establishment
- Resurgence of SAV observed following WY2022 construction

STA-2

- Muskgrass is the most common taxon out of five total SAV taxa identified:
  - Observed at 44% of sites
- Notable SAV reduction in Cell 3 outflow region

STA-3/4

- Muskgrass is the most common taxon out of five total SAV taxa identified:
  - Observed at 75% of sites

STA-5/6

- Coontail is the most common taxon out of five total SAV taxa identified:
  - Observed at 30% of sites
- Surveys limited due to EAV dominance and low water levels
- Increase in EAV and floating vegetation abundance potentially displacing SAV

Total STAs

- Highest SAV coverage observed in STA-2 and STA-3/4
- Ongoing EAV reduction efforts in STA-2 and STA-3/4 promote SAV expansion
- Continued surveys add to 20+ year STA SAV database

For more information: SCAN ME

Chapter 5C: Restoration Strategies Science Plan

R. Thomas James, Jill King
Water Quality Treatment Technologies Section, Applied Sciences Bureau

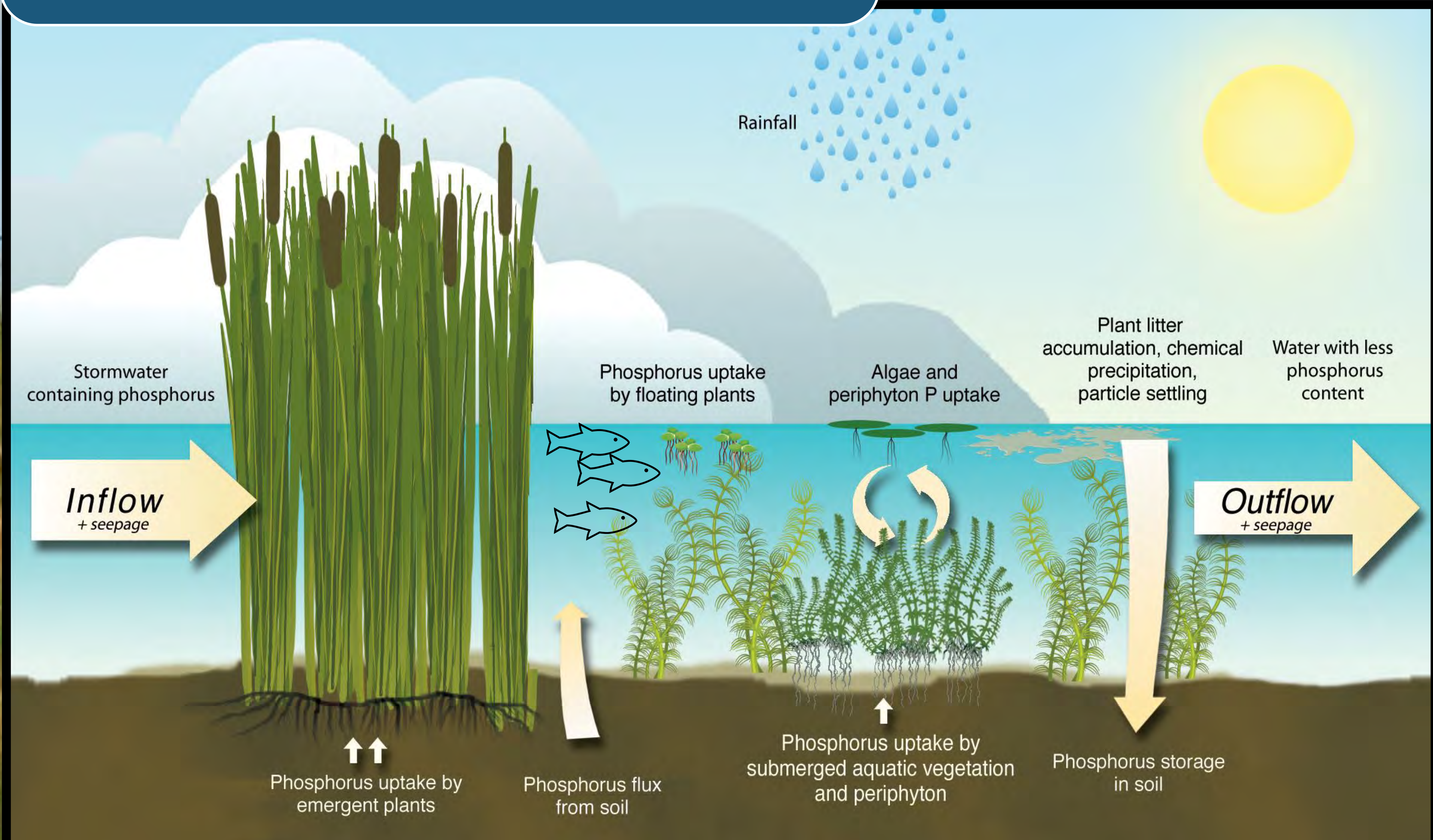
Introduction

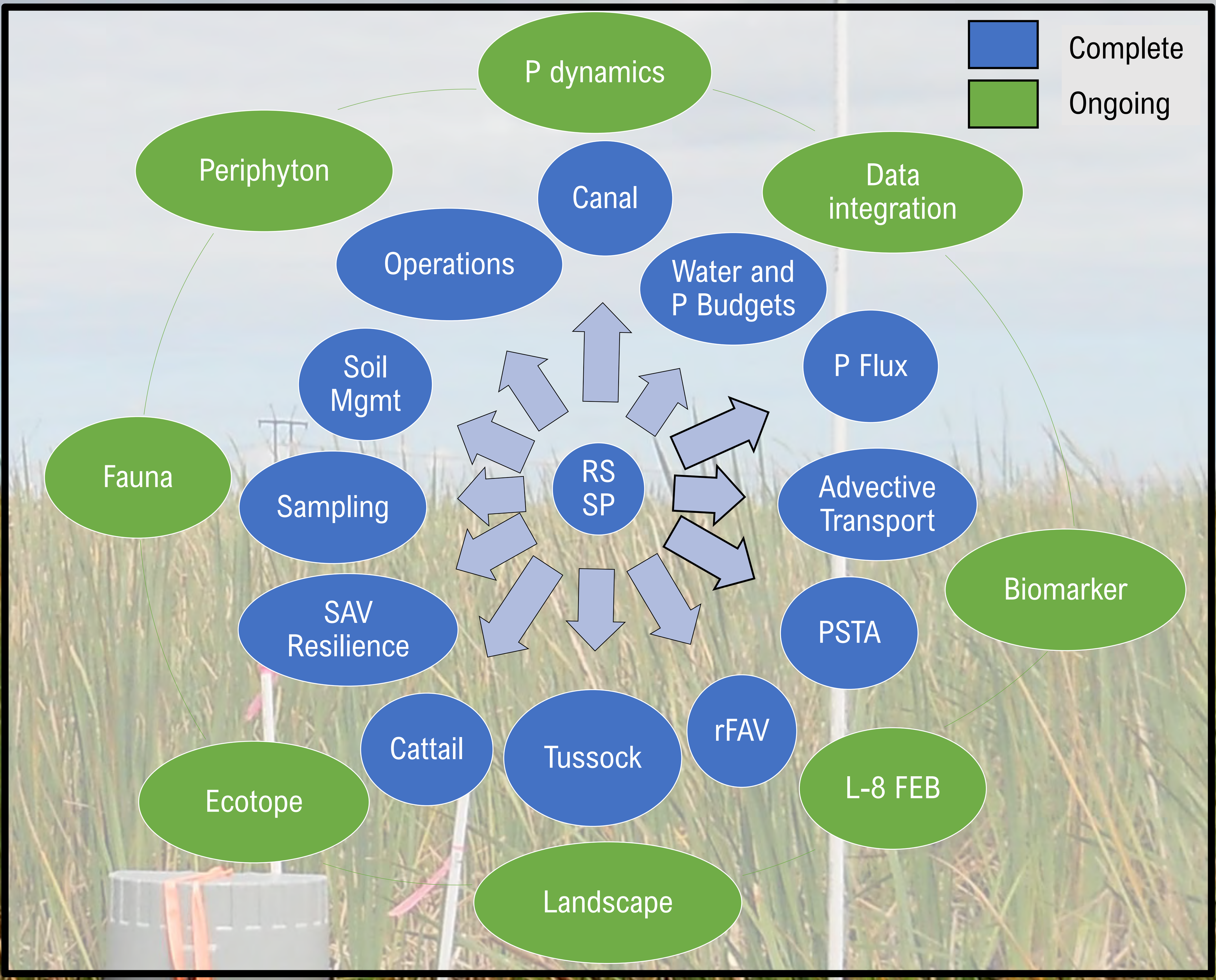
The Restoration Strategies Science Plan (RSSP) is a framework for studies in the Everglades Stormwater Treatment Areas (STAs) to evaluate phosphorus (P) cycling within the STA wetlands with a focus on processes that affect retention at low Total P (TP) concentrations (< 20 micrograms per liter, or µg/L). The RSSP is part of the Restoration Strategies for Clean Water for the Everglades, which was 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 exceedance of the State of Florida's numeric P criterion for the Everglades Protection Area.

As of 2023, 13 studies have been completed (blue) and 8 studies 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 submerged (SAV) aquatic vegetation and periphyton. The status and results from the ongoing studies are presented in this poster including the Data Integration Study, which incorporates information from all the studies. These ongoing studies will be completed in 2024.

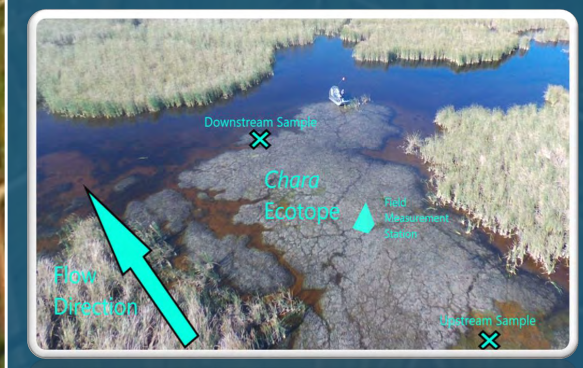
Data Integration Study

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





Ecotope Study



- Evaluate P retention in SAV communities within outflow regions of the STAs
- *Chara* retained the most P based on lowest P concentration; the difference was small
- Wet season concentrations less than dry season
- P was primarily dissolved organic, followed by particulate; inorganic P was at detection limits

Periphyton Study

- Evaluate periphyton (microbial community) functions affecting P cycling and retention
- DNA analysis of periphyton
  - Demonstrated seasonal difference in community and activated processes
- All sampling and experiments complete

P Dynamics Study

- Study of underperforming flow-ways
- Under performance related to disturbances of dry out, storm events, construction and poor vegetation conditions
- All sampling complete

L-8 FEB

- Study TP sources and sinks
- TP increases with inflow
  - Resuspension and load
- TP decreases after major inflows
  - Sinking
- Alum treatment feasible but expensive per pound of P removed

Landscape Study

- Evaluate water mixing based on plant density, water height, and flow
- Two flumes constructed 1 – straight, 1 – v-shaped (allows simultaneous evaluation of different flow velocities)
- Cattail planted and continues to grow and expand
- Experiments underway

Biomarker Study

- Identify sources and turnover of P forms in soil/plant material to improve understanding of P cycling
- Use advanced methods to measure organic P components
- Dissolved organic material in water column primarily from litter

Fauna Study

- Evaluate fauna effects in low P environment
- Substantial recycling of P by fish
  - Excretion is higher than P loading to STA flow-way
- Bioturbation (fauna mixing soils into water column) is localized and species-specific
  - Sailfin catfish and tilapia are major contributors
- Herbivory
  - Experiments excluding fish allowed SAV to germinate and grow

For more information:
SCAN ME

Chapter 6: Everglades Research and Assessment

The Everglades Multiverse: Alternate Ideas of Flow

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The Decomp Physical Model (DPM) was constructed to test what happens when flow is restored to the Everglades. We learned many lessons from DPM, but three were unexpected and caused us to reexamine how the historic Everglades might have worked.

Decreased sheetflow

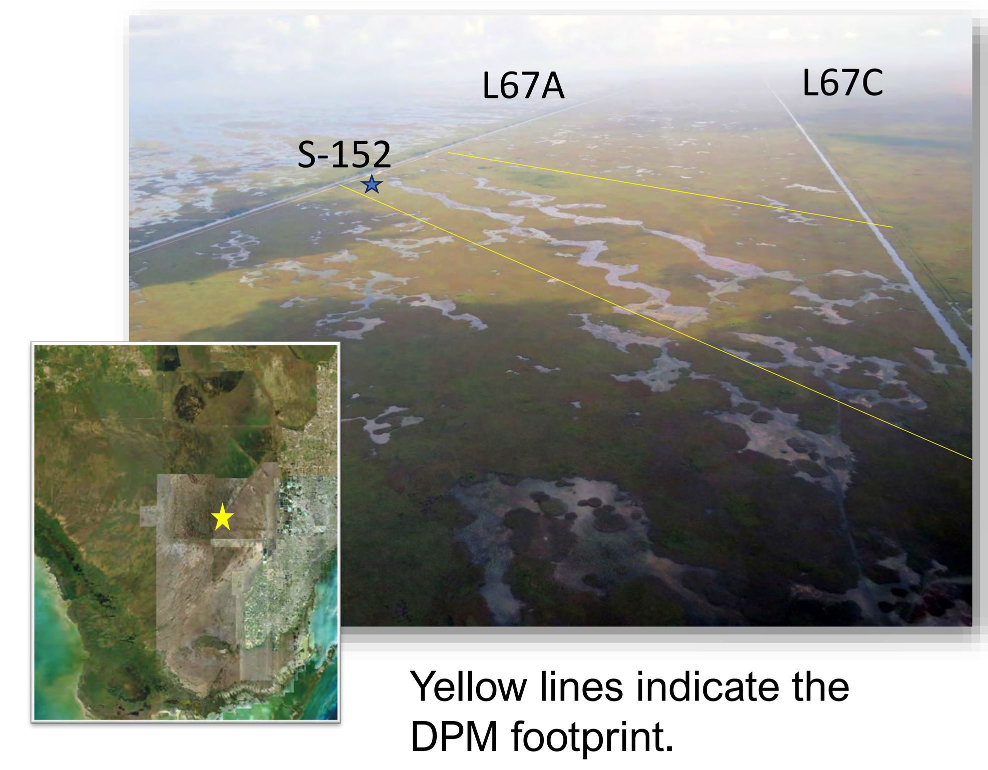
Faster flow did not extend very far into the experimental area. Even at full S-152 capacity (700 cubic feet per second or cfs), we did not get historic flows more than 1 kilometer (km) from inflows.

Periphyton clearing

Periphyton (a mix of fungus, bacteria, and algae) is very important to the Everglades system. When faster flows were introduced, periphyton sunk and disappeared. If historic flow speeds caused periphyton to disappear, how did it work in the historic Everglades?

More nutrients

We expected more nutrients because more water was passing through the system, but the enrichment was faster than anticipated even with ≤10 parts per billion (ppb) phosphorus concentrations. How did higher historic flows not cause enrichment?



Yellow lines indicate the DPM footprint.

DPM results and other evidence* is changing our understanding of the historic Everglades:

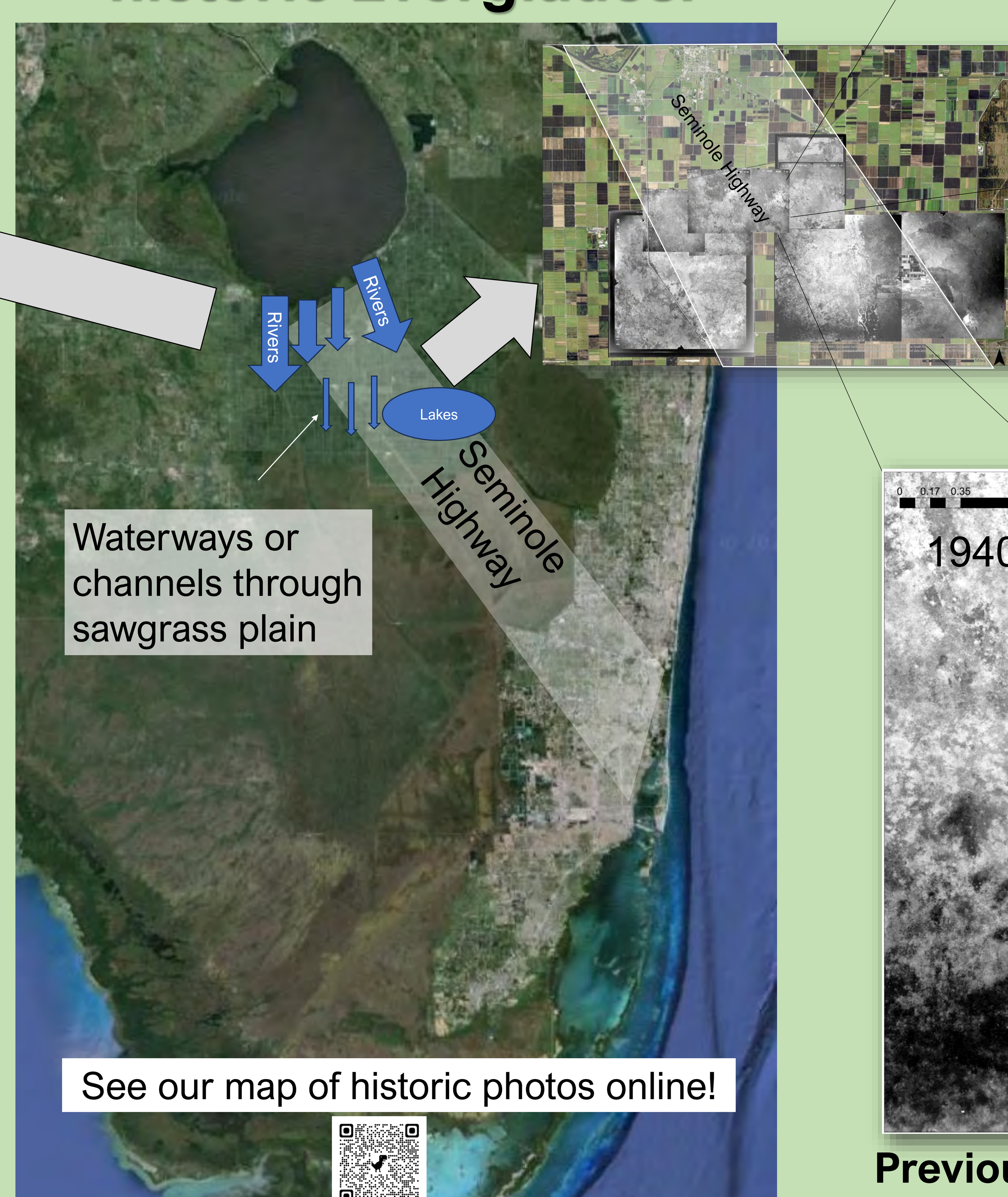
Previous Hypothesis

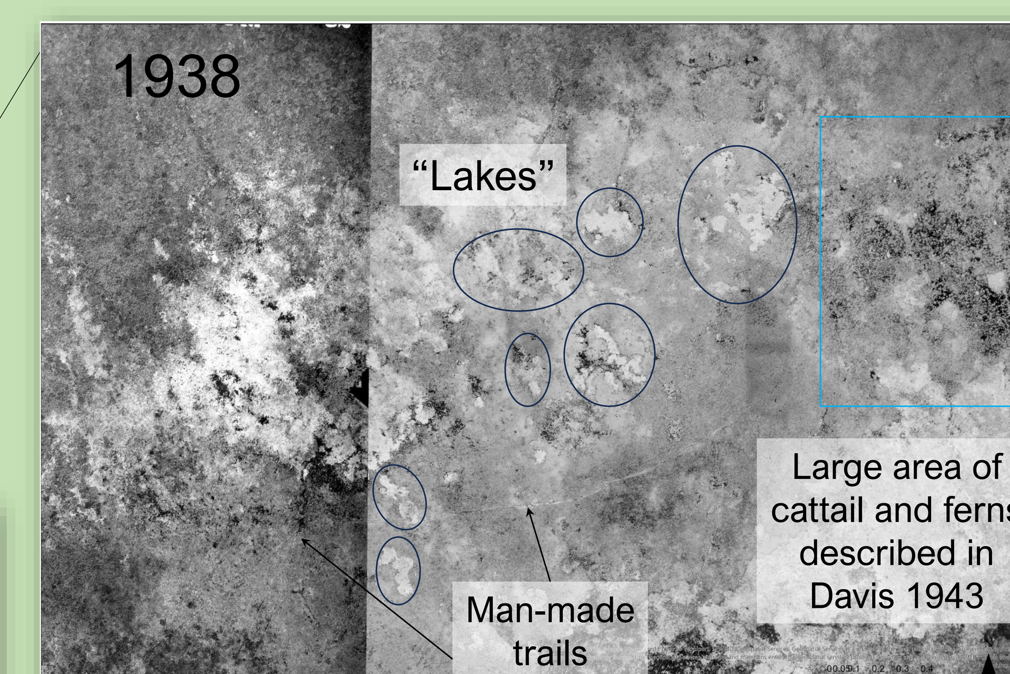
- Lake Okeechobee connected to the Everglades during the wet season when it overflowed.

Revised Hypothesis

- Constant inflow from Lake Okeechobee to the Everglades from distributaries.

The yellow lines outline the location of "ghost" rivers and distributaries in the southern regions of Lake Okeechobee around 1938-1940.



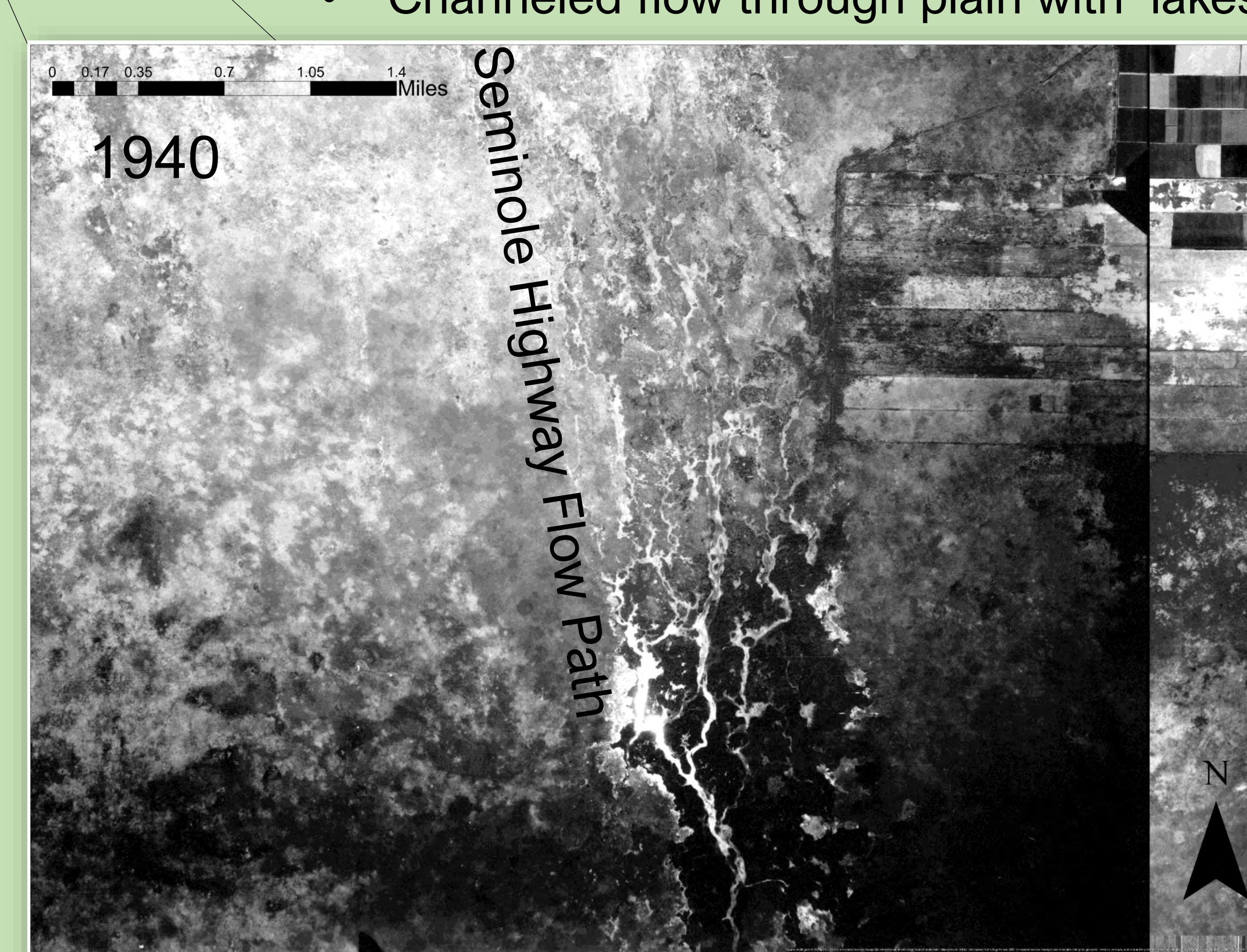


Previous Hypothesis

- A dense sawgrass plain existed, unbroken, from Lake Okeechobee to the ridge and slough landscape.

Revised Hypothesis

- Channeled flow through plain with 'lakes'.



Previous Hypothesis

- Sheetflow was evenly distributed across the landscape.

Revised Hypothesis

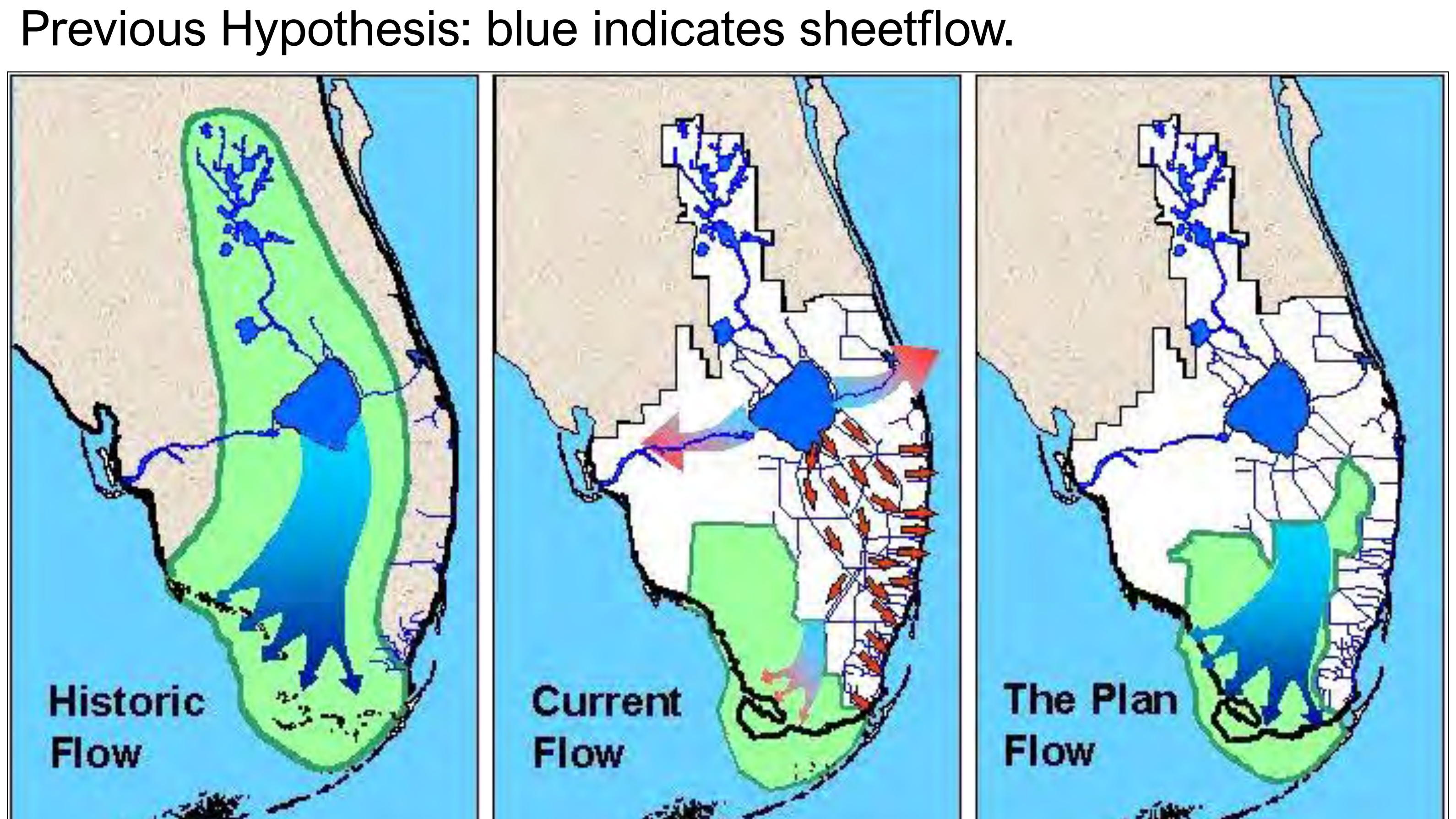
- The landscape had flow paths that moved around over time (flow-load-clog-redirect).

Why this matters

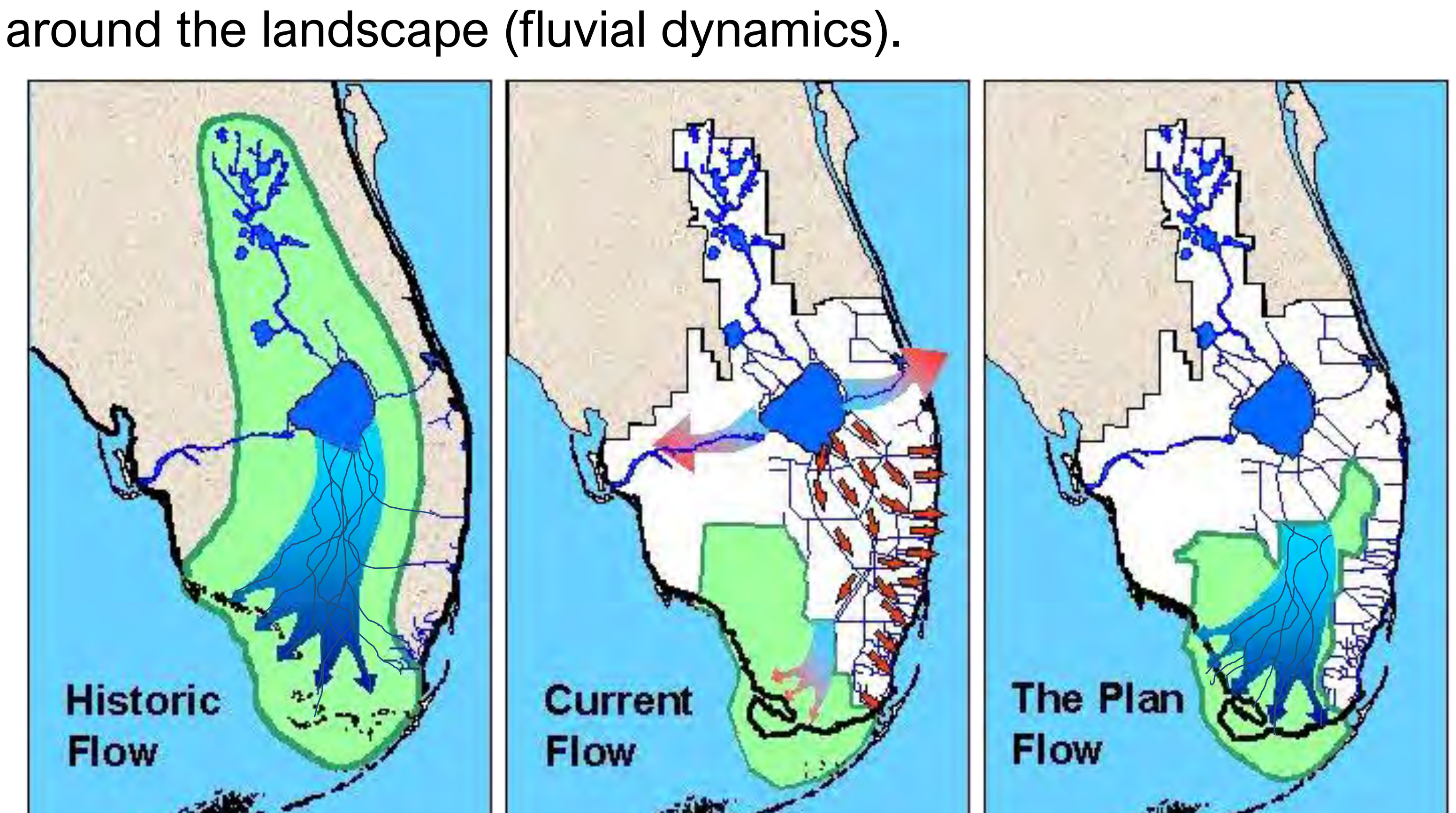
A change in our idea of how the historic Everglades worked can change how we plan to operate a restored system.

A visual example:

Previous Hypothesis: blue indicates sheetflow.



Revised Hypothesis: blue lines are flow paths that naturally move around the landscape (fluvial dynamics).



*Evidence: historical accounts, Seminole Highway, surveys, fluvial dynamics, aerial photography - lakes, channels, and "ghost distributaries".

For more information: