Restoration Strategies Science Plan

R. Thomas James
Principal Scientist
Applied Sciences Bureau

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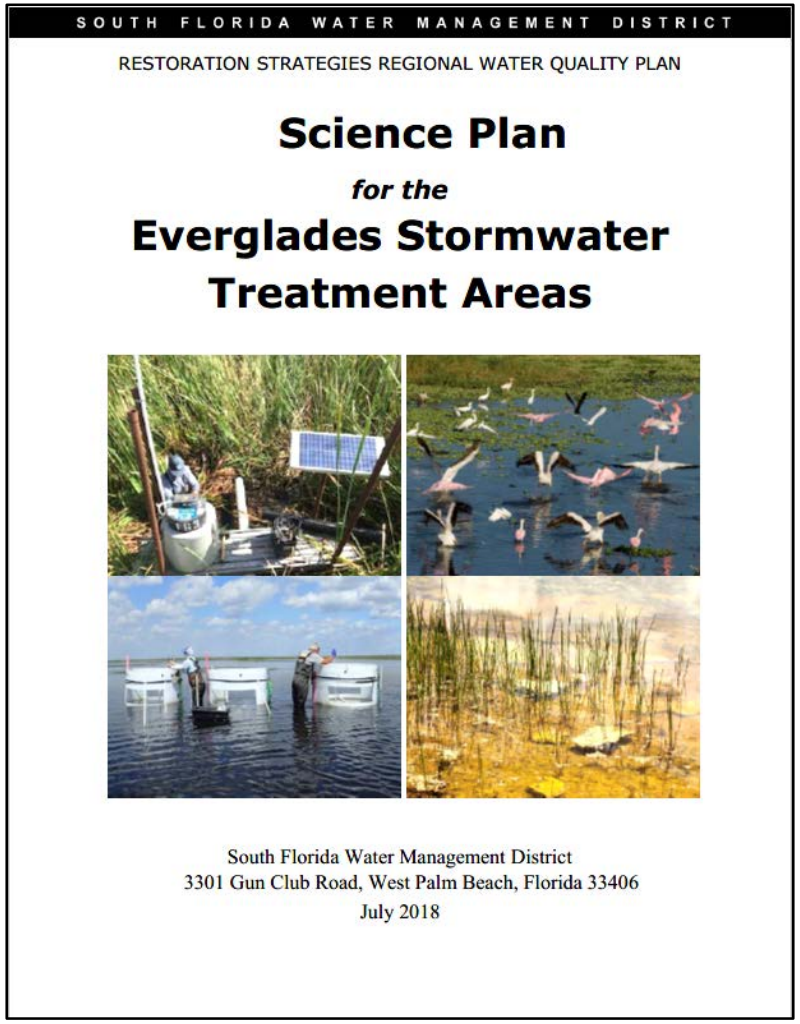
Overview of the Science Plan

- Specified in Restoration Strategies and required by STA permits and consent orders
- Study key factors and processes that affect phosphorus removal in the STAs
- Use results to aid design, operation, & management of STAs to achieve Water Quality-Based Effluent Limits (WQBEL)
- Originally developed in 2013, updated in 2018


SOUTH FLORIDA WATER MANAGEMENT DISTRICT

RESTORATION STRATEGIES REGIONAL WATER QUALITY PLAN

Science Plan

for the

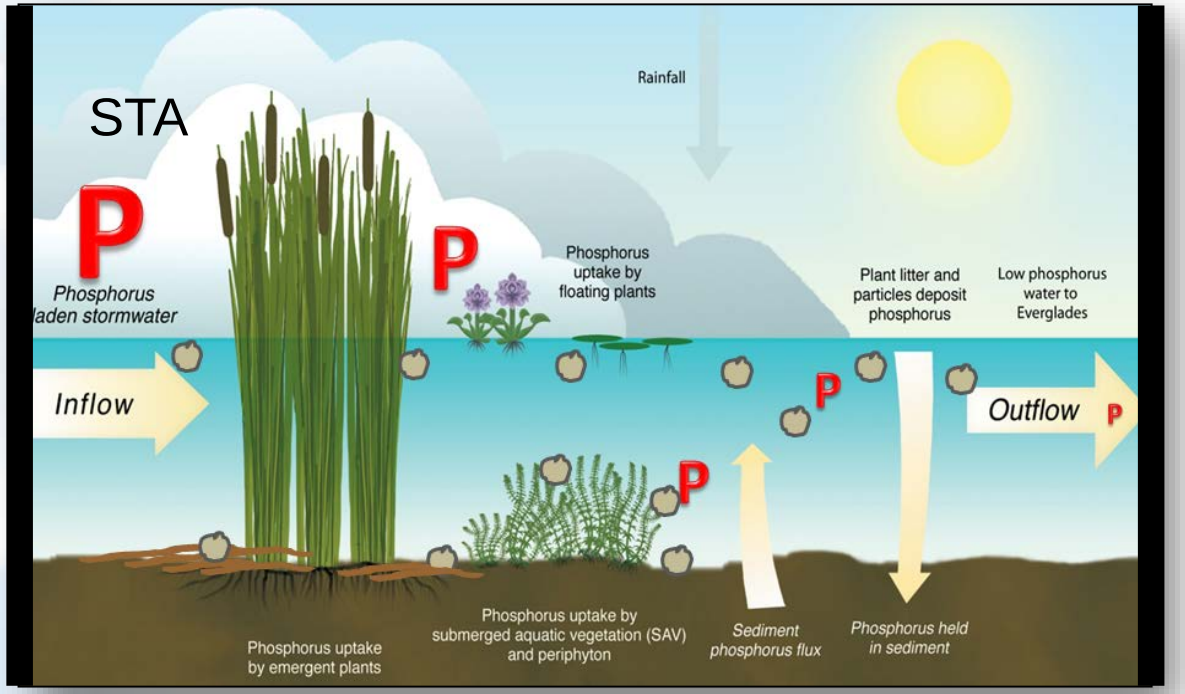
Everglades Stormwater Treatment Areas

South Florida Water Management District
3301 Gun Club Road, West Palm Beach, Florida 33406
July 2018

Areas of Investigation

6 Key questions and 18 subquestions on these topics

FEB



1. Design and operation of FEBs
2. Design and operation of STAs
3. Vegetation improvement
4. Internal loading of phosphorus
5. Biogeochemical and physical mechanisms
6. Role of fauna

Completed Studies and Results

Study Title	Major Findings

Evaluation of the Role of Rooted Floating Aquatic Vegetation (rFAV) in STAs (rFAV Study)	• rFAV does not enhance P reduction
	  • In outflow region
	  • Compared to submerged aquatic vegetation

Investigation of STA-3/4 Periphyton-based Stormwater Treatment Area (PSTA) Technology Performance, Design, and Operational Factors (PSTA Study)	• Annual flow weighted mean discharge of TP ≤ 13 ppb for last 12 years. • Continue monitoring to evaluate performance.

Development of Operational Guidance for Flow Equalization Basin (FEB) and STA Regional Operation (Operation Study)	• Wave tests within the STAs
	  • Equations for flow, slope and resistance
	  • Equations support STA operations
	• Developed iModel for Restoration Strategies Operational Protocol
	  • FEB operations can be optimized to meet the WQBEL.

Influence of Canal Conveyance Features on STA and FEB Inflow and Outflow P Concentrations (Canal Study)	• Canals can remove or export TP • Export related to high flow events and increase of particulate P • Use of FEBs to reduced peak should reduce TP export.

Evaluation of Sampling Methods for TP (Sampling Study)	• Time-based autosampler, grab sample and flow-based auto samplers
	  • Time and grab more reliable for low flow gated structures,
	  • Autosamplers vulnerable to plant and animal contamination.

Current Studies

Study Title	Initiated	Completed
Evaluation of P Sources, Forms, Flux and Transformation Processes in the STAs (P Flux Study)	2015	2019
Evaluation of Inundation Depth and Duration Threshold for Cattail Sustainability (Cattail Study)	2013	Ongoing
Evaluation of Factors Contributing to the Formation of Floating Tussocks in the STAs (Tussock Study)	2018	Ongoing
Improving Resilience of SAV in the STAs (SAV Resilience Study)	2018	Ongoing
Periphyton and Phytoplankton P Uptake and Release (Periphyton Study)	2019	Ongoing
Investigation of the Effects of Abundant Faunal Species on P Cycling in the STAs (Faunal Study)	2018	Ongoing
Use of Soil Amendments and/or Management to Control P Flux (Soil Management Study)	2013	Ongoing
STA Water and P Budget Improvements (Water and P Budget Study)	2013	Ongoing
L-8 FEB Operational Guidance (L8-FEBOG Study)	2019	Ongoing
Quantifying the Recalcitrance and Lability of Phosphorus (P) to Optimize P Retention Within STAs (Biomarker Pilot Study)*	2018	2019

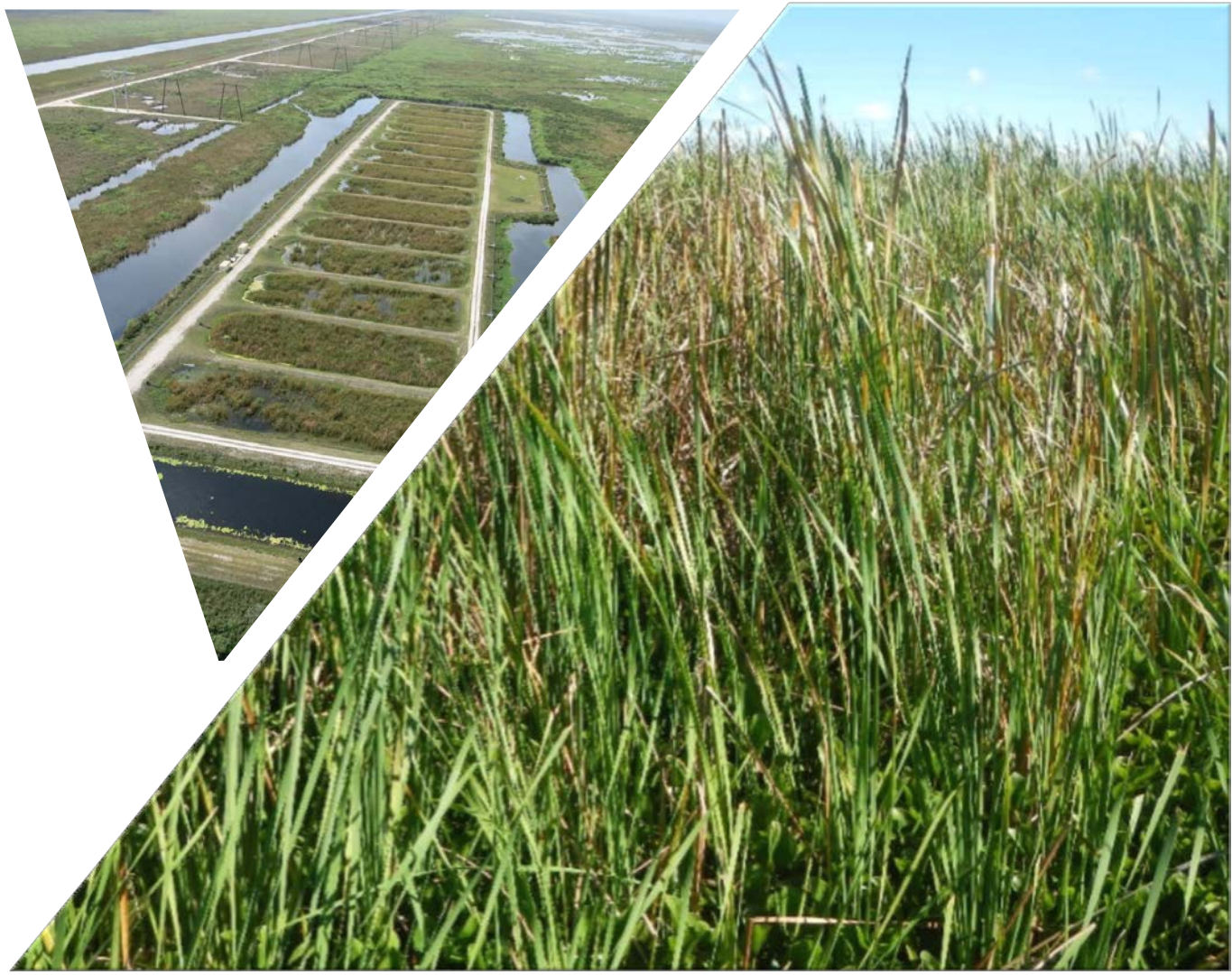
P Flux Study Objectives

Objective

- Investigate the mechanisms and factors affecting P treatment performance, especially at the lower reaches of the treatment flow-ways

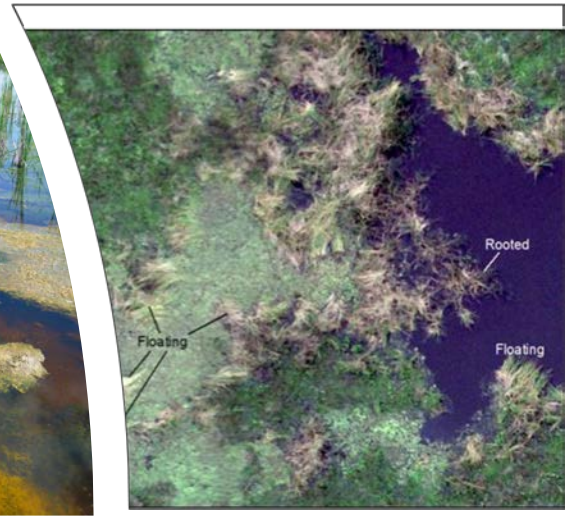
Cattail Study

- **Objective**
  - Identify the water depths, duration of inundation, and frequency that affects the health of cattail communities
- **Field Monitoring Study**
  - When water depths > 3 feet (91 cm) for more than 100 days cattail density and below ground biomass declined
- **Test Cell Study**
  - Cattail stands were established in 15 half-acre Test Cells
  - Water depth was set to constant levels between 1.3 ft to 4.1 ft in each cell
  - Water quality, cattail density, biomass and photosynthesis have been monitored since July 2019
  - Continues until plants show stress



Tussock Study

- **Objective**
  - Evaluate potential causes of floating cattail (Typha sp.) formation
- **Definition**
  - Defined floating wetlands based on size, substrate and connectivity
- **Unmanned Areal Vehicle (UAV)**
  - Images identified floating vegetation that was not apparent in satellite imagery
  - UAV scans of STA-1W Cell 2A & STA-2 Cell 7 completed
- **Further research**
  - Evaluate Historical Data for relationships to floating wetlands
  - Refine UAV methods
  - Develop a Buoyancy Model



SAV Resilience Study

- **Objective**
  - Evaluate factors that may adversely affect SAV health
- **Soils/sediment studies**
  - Altered nutrient availability to the SAV standing crop occurs as STAs “age”
  - Marl sediments did not hinder root production of vascular SAV
- **Higher nutrient loads**
  - Increased biomass, light limitation
  - Reduced dissolved oxygen at sediment surface
  - Potential conditions for SAV crash
- **Moderate nutrient loads**
  - Lowest TP outflow concentration
  - Increased dissolved oxygen, pH
- **Further research**
  - Enclosure studies in STA-2 Cell3 to evaluate SAV growth and Faunal effects
  - Dryout effects

Low Load (0.3 g P/m^2/yr) Moderate Load (0.7 g P/m^2/yr) High Load (2.1 g P/m^2/yr)

Periphyton Study

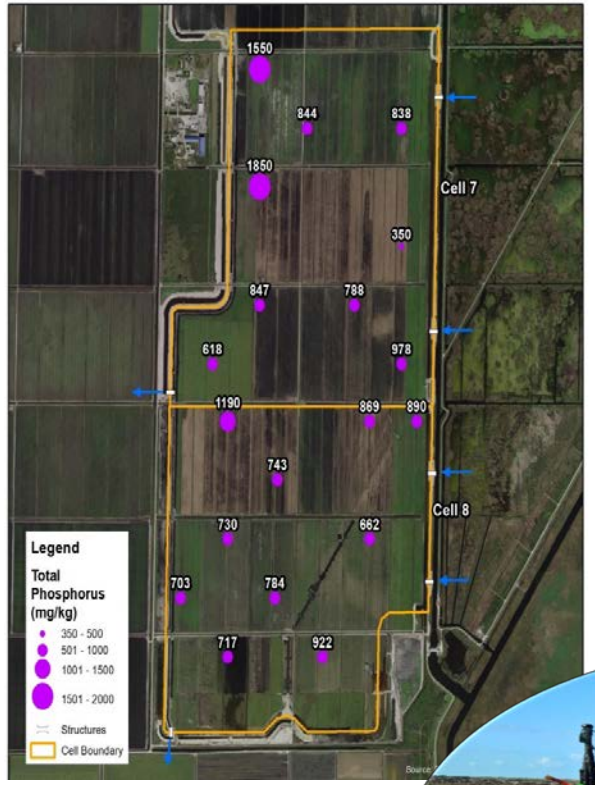
- **Objective**
  - Evaluate periphyton and phytoplankton biological processes in downstream STA treatment flow ways under various flow conditions
- **Literature review**
  - Methods to measure periphyton community structure, productivity, decomposition and senescence have been reviewed
- **Further research**
  - To be determined

Faunal Study

- **Objective**
  - Evaluate effects of abundant fauna on P removal within STAs, particularly near the outflow
- **Biomass**
  - STA fish contain a greater proportion of P in body tissues than Everglades fish
  - STAs support 2 to 15 x higher biomass of fish & invertebrates than Everglades
- **Water Column P effects**
  - Bioturbation experiments showed fish doubled TP in water column
  - Fish P content in STA 2 is greater than 1 metric ton
  - Estimates of excretion from six species of fish was equivalent to 53% of the P that enters the STAs per day
- **Further Research**
  - Surveys, excretion, bioturbation, (continued)
  - SAV herbivory and electrofishing sample bias experiments

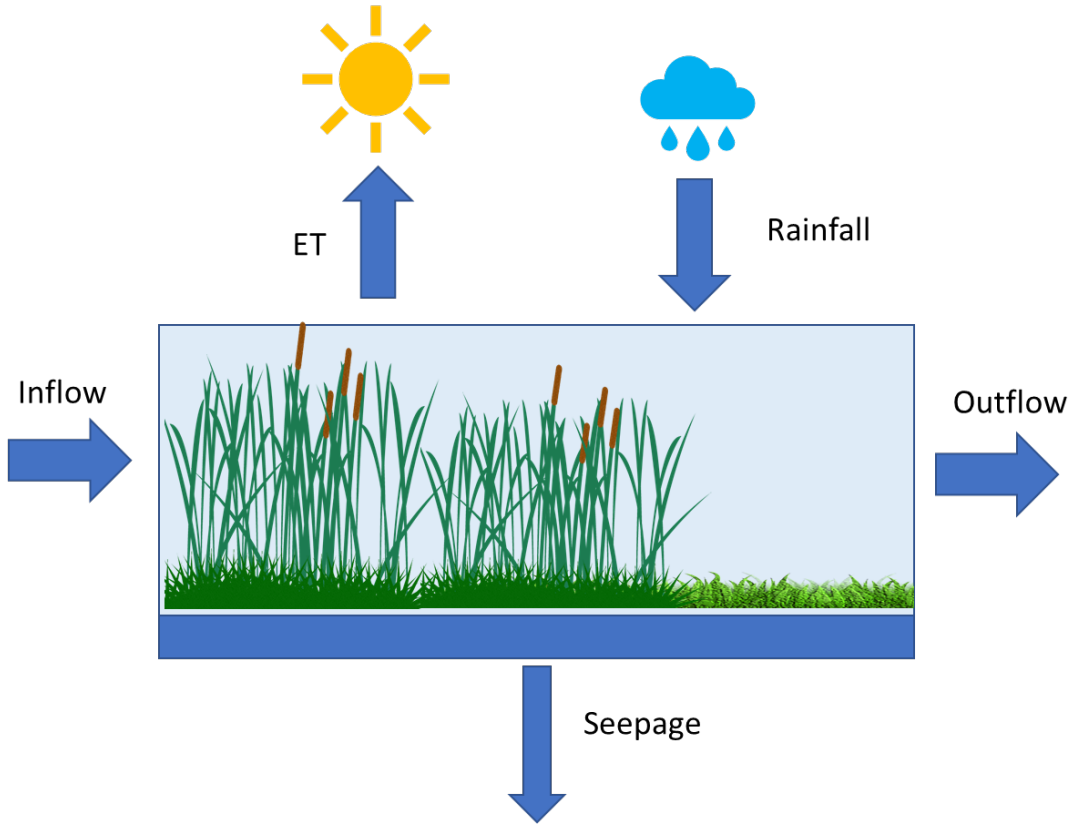
Soil Management Study

- **Objective**
  - Determine if soil amendments and/or soil management methods can improve STA treatment performance
- **Evaluation of Technologies**
  - A number of technologies potentially could lower P availability in STA soils
  - High costs to implement at full-scale in STAs
  - Unknown effects of chemical amendments to downstream Everglades
  - No plans to do further testing of chemical amendments
- **Soil Inversion STA-1W Expansion Area**
  - Soils in Cell 7 inverted to reduce effect of copper
  - Soils in Cell 8 were not inverted
  - Area flooded, but not operational
  - Soil TP content more variable in Cell 7 than in Cell 8, but not significantly different
  - Water-column TP concentrations varied spatially



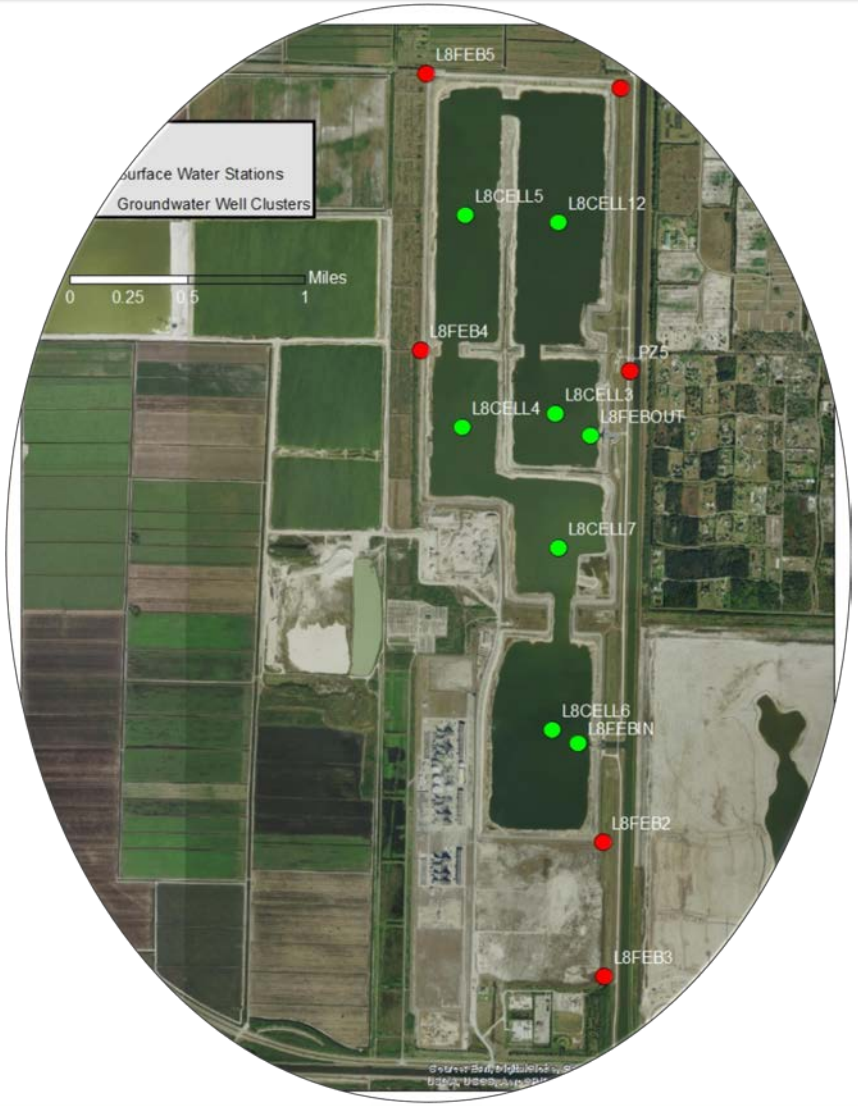
Water and Phosphorus Budget Study

- **Objective**
  - Improve annual water and phosphorus (P) budgets for selected Stormwater Treatment Area (STA) treatment cells and flowways
- **Water budgets**
  - Improved flow data at all structures (external and internal) greatly improved water budgets (reduced residuals)
  - Rainfall, ET, change in storage, and seepage were minor contributors
- **Phosphorus budgets**
  - Period of record TP budgets were developed for STA-2 Flow-ways 1, 2 and 3, and all cells of STA-3/4
  - Manuscript documenting results were published in Ecological Engineering
- **Future research**
  - Additional structures will be QA/QC'd in FY2020



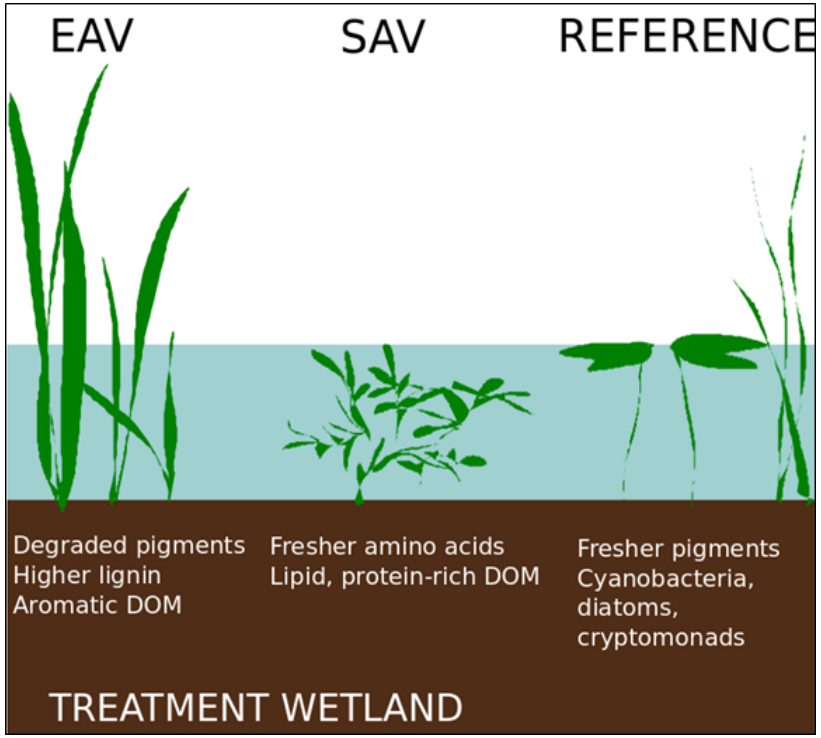
L-8 FEBOG Study

- **Objective**
  - Evaluate relationships between L-8 FEB water quality and stage and flow conditions, and the potential for groundwater interaction
- **Groundwater and surface water sampling**
  - Nutrients in groundwater and L-8 FEB water column indicates groundwater is not a major source of P
  - Particulate P resuspended from sediments during inflow events may cause increases TP in water column
- **Future research**
  - Investigation of particulate P sources
  - Event based sampling (under flowing conditions)
  - Autosampler and sonde deployment
  - Sampling of benthic and alluvial sediments



Biomarker Pilot Study

- **Objective**
  - Determine origins and fate of particulate organic matter (POM) within STAs using biomarkers to track sources, such as vascular plants and algae
- **STA and Reference Sites**
  - Biomarkers indicated differences in organic matter sources
  - Organic matter “freshness” and microbial biomarkers were positively correlated
  - Significant correlation between organic matter quality and bacterial abundance with distinct differences among EAV, SAV and Reference sites
  - Degradation indices tracked organic matter (OM) decay
  - Manuscript documenting results was published in Water Research Journal
- **Further Research**
  - Full project to evaluate biomarkers will begin in FY2020



Acknowledgements

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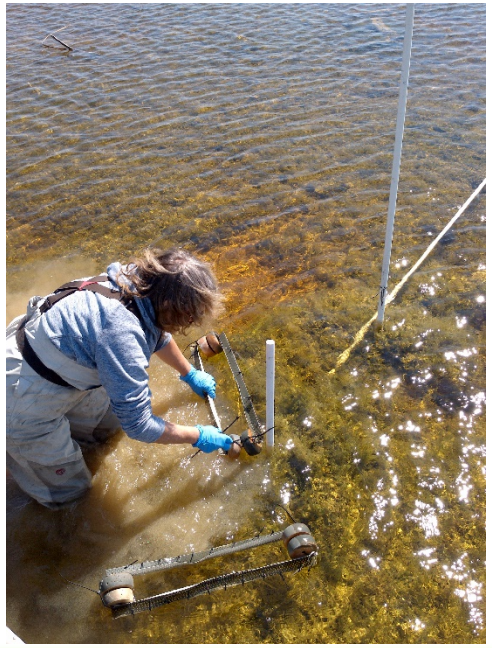

Questions

R. Thomas James
tjames@sfwmd.gov