Restoration Strategies

Science Plan Development Update

10th Annual Public Meeting on the Long Term Plan for Achieving Water Quality Goals for Everglades Protection Area Tributary Basins

February 12, 2013

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Science Plan: SFWMD Requirements (from Consent Order)

- SFWMD shall:
  - Convene the Technical Representatives to discuss the Science Plan within 6 months of permit issuance

    Deadline: March 10, 2013 ✓

    Meetings: November 6, December 5-6, December 17 2012, and January 15-17, 2013
  - Develop the Science Plan and an associated work plan within 9 months of permit issuance

    Deadline: June 10, 2013

    Draft Plan: February 28, 2013
  - Begin to implement the Science Plan within 12 months of permit issuance

    Deadline: September 10, 2013 ✓

Science Plan Development: Draft Schedule

Activity	Target Dates
Identify key questions, information gaps	August 3 – October 31, 2012
Develop Science Plan Outline/Table of Contents	October 1 – 31, 2012
Develop Draft Science Plan	November 1, 2012 – February 28, 2013
Prepare Initial Set of 9 Study Plans/Schedules/ Budgets for 5-year Project Work Plan (Appendices)	December 1, 2012 – February 28, 2013
Prepare Final Science Plan and Work Plan	March 1, 2013 – May 30, 2013
Develop SFWMD Internal Processes	June 1, 2013 – August 31, 2013
Initiate Science Plan	September 1, 2013

Science Plan: Progress to Date

Formulated six draft Key Questions for the Science Plan:

1. How can the FEBs be designed and operated to moderate and optimize **phosphorus concentrations, phosphorus loading rates and hydraulic loading rates entering the STAs**, possibly in combination with water treatment technologies, and/or inflow canal dredging/lining?

2. How can **internal loading of phosphorus** to the water column be reduced or controlled, especially in the lower reaches of the treatment trains?

3. What measures can be taken to enhance **vegetation-based treatment** in STAs and FEBs?

Science Plan: Progress to Date

4. How can the biogeochemical and/or physical mechanisms be managed to further reduce **soluble reactive, particulate and dissolved organic phosphorus concentrations at the outflow?**

5. What **operational and/or design refinements** could be implemented at existing STAs and future features (i.e. STA expansions, Flow Equalization Basins) to improve and sustain treatment performance?

6. What is the influence of **wildlife and fisheries** on the reduction of phosphorus in the STAs?

Science Plan: Progress to Date

- Further evaluated and expanded on key questions:
  - Performed preliminary literature and data review
  - Deliberated on what is known, what is not known and developed an expanded set of focused **sub questions** geared to filling information gaps
  - Reviewed the condition of each STA to inventory potential factors affecting phosphorus performance (good and bad)
  - Identified areas needing further studies or possible engineering refinements

Science Plan: Progress to Date

- Prioritized sub questions based on 4 criteria (testability, feasibility, timeliness and importance)

- Identified eight sub questions around which hypotheses were formulated and eight detailed study plans are being developed for inclusion in the Work Plan
  - Represents the initial suite of studies for the 5-year Work Plan
  - Work plan will be updated annually with new studies or study refinements through an adaptive management process

Restoration Strategies Science Plan – Study Index February 12, 2013

Key Question(s)	Study Name	Sub Question(s) Study Addresses
1, 5	Development of Operational Guidance for FEB and STA and Regional Operation Plans	1) How should storage in the FEBs be managed throughout the year so that water can be delivered to the STAs in a manner that allows them to achieve desired low outflow phosphorus concentrations?
5	Evaluation of the Influence of Canal Sediment on STA Inflow and Outflow Phosphorus Concentrations	2) Would canal sediment management improve STA performance?
3	Evaluation of phosphorus removal efficacy of water lily and sawgrass in a low nutrient environment of the Stormwater Treatment Areas	3) What is the role of vegetation in modifying P availability to the low P environment, including the transformation of refractory forms of P?
3	Establishing Sawgrass Vegetation in EAV and SAV Cells to Increase Plant Species Diversity and Nutrient Removal Performance	4) Can STA performance and sustainability be improved with increased plant species diversity or relative coverage of vegetation types?
4	Evaluation of Phosphorus Sources, Forms, Flux, and Transformation Processes in STAs	5) What are the sources (internal/external, plants, microbial, fauna), forms, and transformation mechanisms controlling the residual P pools within the different STAs and are they comparable to what is observed in the natural system? 6) What are the key physico-chemical factors influencing P cycling at very low concentrations?
2, 4	Investigation of PSTA technology performance, design, and operational factors (STA-3/4 PSTA)	7) What are the treatment efficacy, long-term stability, and potential impacts of floc and soil management? 5) What are the sources (internal/external, plants, microbial, fauna), forms, and transformation mechanisms controlling the residual P pools within the different STAs and are they the same as observed in the natural system? *(specific to soil-free system)* 6) What are the key physico-chemical factors influencing P cycling at very low concentrations? *(specific to soil-free system)*
3	Evaluation of Impacts of Deep Water Inundation Pulses on Cattail Sustainability	8) How do water depths, velocities, and soil characteristics affect sustainability of dominant vegetation?
2	Use of Soil Management/Amendments to Control P Flux	7) What are the treatment efficacy, long-term stability, and potential impacts of floc and soil management?

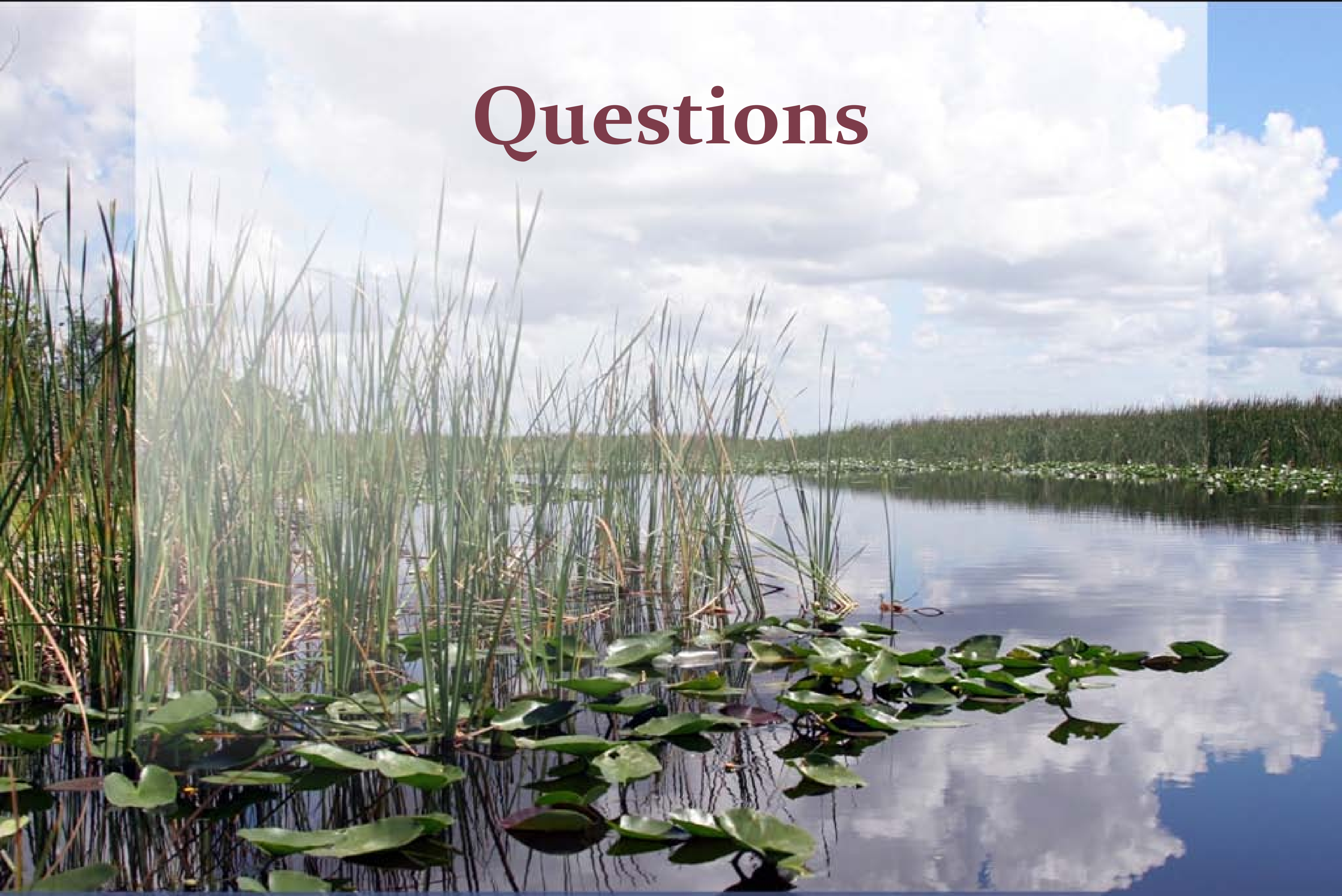
Science Plan: Progress to Date

- Includes two ongoing studies:
  - Evaluation of phosphorus removal efficacy of water lily and sawgrass in a low nutrient environment (mesocosm scale)
  - Investigation of PSTA technology performance, design, and operational factors (STA-3/4 PSTA)
- Identified two special areas requiring further investigation as part of the Plan:
  - Phosphorus Sampling Methodologies
  - STA Water Budgets
- Drafted Science Plan sections; currently undergoing technical editing
  - Added sections on Role of Modeling, Data Management and Quality Assurance

Path Forward

- Complete technical editing and internal review of draft Science Plan main document (February)
- Complete draft detailed study plans (including schedule and budget) designated for first phase of studies/ projects in draft 5-year Work Plan (February)
- Review of draft Science Plan documents by Tech Reps (March)
- Place draft documents on Restoration Strategies website (April)
- Update Long Term Plan Quarterly Communication attendees (early May)
- Finalize Science Plan /associated documents (on or before June 10)

Questions



PROPOSED INITIAL SUITE OF STUDIES FOR RESTORATION STRATEGIES SCIENCE PLAN 5-YEAR WORK PLAN

Development of Operational Guidance for Flow Equalizaton Basins and Stormwater Treatment Areas and Regional Operations Plans (Key Questions 1 and 5)

Study Coordinator: Akin Owosina

Description:
This study addresses how storage in the Flow Equalization Basins (FEBs) should be managed throughout the year so that water can be delivered to the STAs in a manner that allows them to achieve desired low outflow phosphorus (P) concentrations. The objective of this study is to integrate multiple considerations of regional hydrology and Stormwater Treatment Area (STA) performance dynamics into operational decision support tools. Restoration Strategies planning relied primarily on the Dynamic Model for Stormwater Treatment Areas (DMSTA) for water quality modeling, predicated on underlying hydrology provided by the South Florida Water Management Model (SFWMM). While this approach is appropriate for and will continue to be used for planning purposes, real time operations support will focus on consolidating multiple sources of information into a broader set of modeling and decision support tools including the Regional Simulation Model (RSM). This work includes, but is not limited to, development and application of hydrologic, hydraulic and water quality modeling to test guidance for operation plans. This three and a half year effort will include hydrologic, hydraulic and water quality modeling in support of the development of initial operational guidance for the A1, L-8 and C-139 Annex FEBs, associated STAs and the surrounding regional water management infrastructure. FEBs and STAs can be considered as engineering systems that are designed to provide a known quantifiable level of performance in terms of flood control, P treatment, other regulatory compliances and environmental sustainability. Information gathering, field testing and model hypothesis testing will be performed in order to improve the understanding of FEB/STA system dynamics in terms regarding response times, response delays, attenuation rates, and numerous other relationships between control variables (gate openings) and state variables (water level, P concentration). Development and implementation of analytic and computer models at varying temporal and spatial scales will help to incorporate improved understanding of the system dynamics into tools that can assist in analyzing infrastructure design and in optimizing operational control algorithms. This effort will at times support work that is being conducted by consultants and may also leverage work performed by consultants into operating protocols and decision support tools that clarify real-time operating protocols by integrating multiple system considerations with the goal of achieving consistent, sustainable low outflow P concentrations.

Evaluation of the Influence of Canal Sediment on STA Inflow and Outflow Phosphorus Concentrations (Key Question 5)

Study Coordinator: David Unsell

Hypotheses:

Physico-chemical characteristics of canal sediments influence total phosphorus (TP) concentrations at inflow and outflow waters from the STAs and FEBs.

P concentration in STA/FEB treated water can increase via sediment resuspension or P flux along the outflow collection canal and at the outflow structure.

Resuspension and transport of particulates and P at inflow and outflow canal waters during flow events may affect STA/FEB performance.

Seepage to or from adjacent water bodies or groundwater is conveying additional P to or away from inflow and outflow canals connected to STAs and FEBs.

Description:

Changes in P concentration have been observed in inflow canals in STAs 2 and 3/4. P concentrations have been observed increasing and decreasing from the STA inflow pump stations to the inflow structures at the upstream side of the STA flow-ways. There is also evidence that P concentrations may increase as water moves from the treatment cell flow-ways to the permit compliance discharge structures in some STAs. Particulates are a component of stormwater and are present in STA inflow and outflow canals. During times when velocities are high, sediment re-suspension could result in elevated P in STA inflow water and/or elevated P in the STA outflow collection canals. During severe droughts, water levels in some canals are significantly lowered to the extent that portions of the canal sediments are exposed for periods of time. When re-wetted, the effects of sediment P flux to the overlying water column or release of P from wetting/drying cycles of portions of canal sediment could also influence the water P concentrations observed at the STA inflow and outflow structure sampling locations. Seepage of water into or out of STA canals to or from adjacent water bodies or groundwater might also be a contributing factor in changes in P concentration. Other influences may be considered as well. These conditions will equally apply to conveyance of water to and from FEBs, especially from FEBs to STAs. This study will involve an examination of historical data (data mining) and canal sampling for areas with potential issues. Depending on the particular issue, canal sampling may include transect water quality, flow measurements and sediment sampling.

PROPOSED INITIAL SUITE OF STUDIES FOR RESTORATION STRATEGIES SCIENCE PLAN 5-YEAR WORK PLAN

Evaluation of Phosphorus Removal Efficacy of Water Lily and Sawgrass in a Low Nutrient Environment of the Stormwater Treatment Areas (Key Questions 3 and 4)

Study Coordinator: Shili Miao

Hypotheses:

Water lily and sawgrass vegetation will reduce concentrations of the recalcitrant P fractions of the outflow to levels lower than what are achieved via SAV treatment

The water lily treatment will result in quicker reduction in outflow TP than sawgrass treatment

A combination of greater extracellular phosphatase enzyme activities, high P storage in belowground rhizomes, and slow decomposition of the rhizome are major mechanisms of P removal for both species

P reduction in sawgrass or water lily treatment areas is optimal at water depth and flow rate of 40-50 centimeters (cm) and 3-5 cm per day, respectively

Description:

STAs have achieved significant P reduction since their construction, but further reductions in outflow P concentrations are required. Further P removal, however, is increasingly difficult and challenging. Some of the critical obstacles are: 1) outflows consist of extremely low SRP (soluble reactive phosphorus) with a significant amount of organic P and particulate P, and 2) SAV has a quick turnover time and high decomposition rates. It is imperative to search for alternative vegetation types that are capable of growing in a low P condition, as well as possess specific P uptake mechanisms. Thus, a three-year proof-of-concept mesocosm study is underway to investigate nutrient removal efficacy and P uptake of native macrophytes found in the pristine Everglades, including sawgrass and water lily. The key objectives of the study are to: 1) evaluate nutrient removal efficacy of water lily and sawgrass under very low P conditions; and 2) examine major processes and mechanisms in water, soil and plants underlying P assimilation functions. The preliminary data are promising and a one-year extension of the ongoing study should indicate whether these species have potential for reducing phosphorus outflow concentrations in SAV cells. The expansion of this study to another platform will be dependent on results of the mesocosm study. If positive, the results can be validated at a larger scale. The information obtained by the study will support management actions that promote use of water lily and sawgrass stands near the STA outflows to achieve lower outflow P concentrations.

PROPOSED INITIAL SUITE OF STUDIES FOR RESTORATION STRATEGIES SCIENCE PLAN 5-YEAR WORK PLAN

Establishing Sawgrass Vegetation in EAV and SAV Cells to Increase Plant Species Diversity and Nutrient Removal Performance (Key Question 3)

Study Coordinator: Lou Toth/Shili Miao

Hypothesis:

Increasing plant species diversity or relative coverage of different vegetation types, particularly native Everglades vegetation, may promote the long term sustainability of STA vegetation community and thus improve STA performance.

Description:

The vegetation in the STAs has been, in general, naturally recruited from the system after the lands were converted to wetlands. As a result, mono-specific cattail stands are the dominant vegetation in the emergent aquatic vegetation (EAV) cells, while limited submerged aquatic vegetation (SAV) species thrive in the SAV-designated cells. Increasing plant species diversity or relative coverage of different vegetation types, particularly native Everglades vegetation, may promote the long-term sustainability of STA vegetation community and thus improve STA P performance. Our existing knowledge indicates that sawgrass (*Cladium jamaicense*), the dominant plant species of the pristine Everglades, has the ability to adapt to a low P environment. Sawgrass plants are also capable of growing at high nutrient environments, where their height can reach as high as 2-3 m, approximately one or two folds taller than sawgrass growing in low nutrient habitats. An ongoing mesocosm study includes testing sawgrass' ability to reduce outflow P concentrations to levels lower than what have been achieved by SAV. If the results from the mesocosm study confirm this hypothesis, a large-scale field study will be implemented to further test nutrient removal efficacy of sawgrass and water lily under a low P condition. However, large-scale sawgrass planting and establishment in field may be difficult. The objective of the study is to determine whether large-scale sawgrass planting in STA cells is feasible. The study will also evaluate planting methodologies and optimal growth conditions including optimum location, water depth, hydroperiod, etc.

Evaluate Phosphorus Sources, Forms, Flux, and Transformation Processes in the STAs (Key Question 4)

Study Coordinators: Delia Ivanoff and Sue Newman

Hypotheses:

The residual P composition at the outflow varies among the different STAs and is less recalcitrant than those observed in similar trophic zones in the natural areas.

Because of greater productivity, the biological sources of P to the outflow cells of the STAs are proportionally greater and less tightly coupled than those within mesotrophic and unenriched areas of the natural ecosystem.

Biotic transformations of residual DOP and PP will be maximized by increased vegetative and microbial activity.

Breakdown of residual organic P will be enhanced by increased UV radiation within the cells.

Shallow conditions with dominant SAV communities will increase the proportion of P precipitated as Ca-phosphates.

Increased water column phosphomono and phosphodiester activity will result in greater turnover of the water column DOP pool, and greater turnover of floc DOP.

Enzyme activity will be optimized in the areas with greater divalent cation concentrations and during higher seasonal temperatures.

The lowest TP concentrations in the outflow cells will be accomplished via a vegetative mosaic of emergent and SAV/periphyton communities.

Description:

Biogeochemical cycling of phosphorus within the STAs is controlled by various mechanisms and influenced by several physical, chemical, and biological factors. While there have been numerous previous publications addressing these mechanisms and factors in both natural and constructed wetlands, little is known on what the key influencers are or the magnitude of their influence in low phosphorus treatment wetland systems. We believe that a better understanding on the nutrient cycling/spiraling and key factors affecting the relevant mechanisms and processes can be useful in formulating management strategies to further reduce and sustain low outflow TP concentrations in the STAs. This study has multiple objectives: 1) characterize the different P forms and cycling along the inflow to outflow gradient, 2) understand the composition of the residual P at the outflow, 3) determine the factors affecting P cycling along the transect, 4) understand the differences in P forms, factors, and processes among different flow-ways (good-performing versus poor performing systems), and 5) compare the findings with natural areas (WCAs) to determine what desirable condition in the natural marsh can be replicated in the STA cells. The study will involve a review of existing information, detailed transect studies, and core/mesocosm studies.

Investigation of the Periphyton Stormwater Treatment Area (PSTA) Technology Performance, Design and Operational Factors (Key Questions 2 and 4)

Study Coordinator: Delia Ivanoff

Hypothesis:

Long-term ultra low outflow P concentrations in PSTA are achieved primarily as a combined effect of low P loading rate into the cell, minimized flux due to soil-less system and presence of calcareous layer, and biota uptake.

Description:

The continuation of the PSTA study will help address the following Science Plan key question: How can internal loading of phosphorus to the water column be reduced or controlled? The STA-3/4 PSTA Project, in operation since WY2008, is continuing in order to conduct a more accurate assessment of PSTA performance and to determine design and operational factors that contribute to performance and to assess the potential for full scale implementation. In earlier years, difficulty in hydraulic measurements prevented an accurate assessment of the performance of the PSTA cell. In WY2012, various efforts were initiated to improve understanding of the performance of the PSTA cell, including structural, monitoring, and operational changes, as well as improvements to data evaluation and research efforts. Aside from addressing the STA Science Plan questions, the PSTA project has the following goals: 1) determine important design elements and biogeochemical characteristics that enable the PSTA cell to achieve ultra-low outflow TP levels, 2) identify optimal operational criteria that enable the PSTA cell to achieve ultra-low outflow TP levels, and 3) identify management practices that are required to sustain performance in the PSTA cell. The project involves evaluation of surface water, groundwater, soil, vegetation, periphyton, and microbial activity, laboratory incubations, and a mesocosm study.

Evaluation of Impacts of Deep Water Inundation Pulses on Cattail Sustainability (Key Question 3)

Study Coordinator: Delia Ivanoff

Hypothesis:

The survival, growth and propagation of cattail community are influenced by deep inundation in the STAs.

Description:

This study will help address the key question: What measures can be taken to enhance vegetation-based treatment in STAs and FEBs? Water stages for different STA cells are currently managed based on one target depth of ~1.3 feet. However, peak flows in the wet season, particularly during and/or following storm events, often occur and cause water level pulsing up to >3.0 feet. Previous mesocosm studies indicated that six-week continuous inundation at >3.0ft water depths negatively impacted cattail health. Although deep water level pulsing often occurs in the STAs, there is limited scientific information available on the impact of these events on cattail community sustainability in large-scale treatment wetlands. The objective of this study is to examine the growth, photosynthesis, reproduction, and nutrient (nitrogen, P) uptake of cattail growing in a range of deep water pulses, similar to what is experienced in the STA cells. We hypothesize that the survival, growth, and propagation of cattail community are influenced by the length and frequency of deep water pulsing. In this proposed study, we will first establish healthy cattail communities in constructed wetlands, allow them to mature, and then assess the response of the cattail communities to water level pulsing. Inflow and outflow P concentration in the test cells will be measured to determine effects of cattail stress on cell P uptake performance.

PROPOSED INITIAL SUITE OF STUDIES FOR RESTORATION STRATEGIES SCIENCE PLAN 5-YEAR WORK PLAN

Use of Soil Amendments/Management to Control Phosphorus Flux (Key Question 2)

Study Coordinator: Mike Chimney

Hypotheses:

Reducing the flux of dissolved P from the soil in an operating STA will lead to a reduction of P concentration in surface water at the outflow

Reducing the flux of dissolved P from the soil during startup of a new STA will shorten the time required for the wetland to achieve its start-up criteria.

Description:

Biogeochemical cycling of nutrients in wetlands is mediated by a number of factors, one of which is the flux of dissolved material from the soil to the overlying water column. It is believed that if the flux of dissolved P from the soil in the STAs is reduced then the concentration of P in surface water at the outflow will correspondingly decease. It is also hypothesized that reducing soil P flux during STA startup will shorten the time required for the wetland to achieve its startup criterion. The District and DB Environmental, Inc. have investigated a number of approaches to reducing soil P flux in the STAs including: removing all soil down to the caprock layer, covering the soil with a layer of low-P material (such as limerock) and deep tilling the soil surface horizon down into the underlying soil layers and adding soil amendments, either by broadcasting on top of or incorporation into the soil. This study will start with an initial effort to 1) summarize data and findings of past District and DB Environmental, Inc. studies on controlling soil P flux in wetlands, 2) expand the preliminary literature review on technologies for controlling soil P flux in wetlands that was produced for a Science Plan subcommittee and 3) assess the engineering and logistical feasibility of applying any of these technologies in the STAs. A stop/go decision will be made based on this information/assessment as to whether to continue with the study. If there is a decision to continue, investigations could begin at a small scale using soil cores or small mesocosms to screen different soil amendments, soil management methods and amendment application methods. Work would then move to field-scale enclosures using the most promising product/soil management methods/application method combinations. Trials focused on reducing outflow P concentration in existing STAs could be conducted in the STA-1W Test Cells or in new facilities constructed within an operating STA. Trials investigating reducing soil P flux during STA startup would, by necessity, have to be conducted within the footprint of a new STA or FEB prior to inundation.

Evaluation of Sampling Methods for Total Phosphorus

Study Coordinator: Peter Rawlik

Description:
In general, the District uses three methods to collect and analyze water quality samples for TP: Grab samples and autosamplers, both of which use a central laboratory to conduct analysis, and remote analyzers, which have built in micro-laboratories. In all of these methods, sample collection may be initiated in response to flow conditions, a specified span of time, or a combination of the two, such as a weekly grab if flow is observed, or, a weekly grab regardless of flow conditions. Historically, a significant difference in TP concentrations has often been observed between results from autosamplers and those from grab samples. While some of this has been shown to be the result of differences in the collection period, other data suggests large masses of solids, such as mats of vegetation and other organic material, may have significant impacts on sampling results. The ephemeral and sometimes submerged nature of such events may serve to explain some of the short-term elevations observed in data collected using autosamplers and remote analyzers. Additionally, the possibility of biofouling of the deployed equipment and its impact on TP data must be investigated. Other factors, such as the criteria for triggering an autosampler in response to flow, and the relation to structure operation and analytical results must be examined. Other issues that must be evaluated for each method are the costs of installation and maintenance, the cost-benefit, and the potential for contamination and failure.

ID#	Restoration Strategies: Science Plan for the Everglades Stormwater Treatment Areas – Sub Questions
1	What is the treatment efficacy, long-term stability, and potential impact of floc and soil management?
2	Can *Cladium jamaicense*, *Nymphaea odorata* and periphyton mats enhance phosphorus (P) uptake and removal in submerged aquatic vegetation (SAV) cells?
3	What are the sources (internal/external, plants, microbial, wildlife), forms and transformation mechanisms controlling the residual P pools within the different STAs and are they comparable to what is observed in the natural system?
4	How should storage in the flow equalization basins (FEBs) be managed throughout the year so water can be delivered to the Stormwater Treatment Areas (STAs) in a manner that allows them to achieve desired low outflow phosphorus concentrations?
5	What are the key physico-chemical factors influencing P cycling at very low concentrations?
6	What is the role of vegetation in modifying P availability to the low P environment, including the transformation of refractory forms of P?
7	Would canal sediment management improve STA performance?
8	How do water depths, velocities, and soil characteristics affect sustainability of dominant vegetation?
9	What is the effect of the size and distribution of emergent vegetation strips on SAV sustainability?
10	What is the cost-benefit of adding more operational flexibility to transfer water between cells and flow-ways or to deliver supplemental water during droughts?
11	What are the direct and indirect effects of wildlife communities on P cycling at temporal and spatial scales (e.g., are they net sinks or sources)?
12	What are the best structural design features for delivering water to and from STAs and FEBs?
13	What is the appropriate relative cover of emergent vegetation in the SAV cells?
14	Can upward diffusion of phosphorus in SAV cells (or portions of cells) be reduced by inducing downward advection flow?
15	What factors determine spatial and temporal variability of SAV community structure (species composition, cover, density)?
16	Will rotation of SAV and emergent vegetation cover enhance sustainability of SAV cells?
17	Will P uptake processes in emergent aquatic vegetation (EAV) cells be reestablished within one month of reflooding after a controlled drawdown?
18	Does pumping at lower STA inflow and outflow rates over 16 or 24 hours in a day, versus 8-hour day shifts, improve STA performance?
19	What is the best period within a 24-hour day to discharge water from an STA in order to achieve the lowest phosphorus concentrations?
20	What chemical treatment technologies should be evaluated in conjunction with FEBs?
21	How do water depths and soil characteristics affect sustainability of dominant vegetation?
22	Can STA performance and sustainability be improved with increased plant species diversity or relative coverage of vegetation types?
23	Can *Potamogeton illinoensis* ,*Vallisneria americana,* and floating leaved species such as *Nelumbo lutea* and *Nuphar lutea*, survive in deeper portions of SAV cells and complement P uptake by dominant SAV species?
24	How do water depths and soil characteristics affect sustainability of dominant vegetation?
25	How critical is topography in STA treatment performance?
26	What are the short and long-term impacts of herbivory by wintering waterfowl on SAV cover, community structure, and sustainability or P uptake of SAV cells?
27	How do water depths and soil characteristics affect sustainability of dominant vegetation?
28	Are the rates of reestablishment of cover and associated P uptake processes of dominant SAV species (*Chara* spp. and *Najas guadalupensis*) dependent on the duration and intensity (water table depth) of dry out events?
29	Will dry outs result in changes to relative cover of *Chara* spp. and *Najas guadalupensis*?