STA 3/4
PSTA Cell Modifications

Long Term Plan Quarterly Communications Meeting

November 15, 2011

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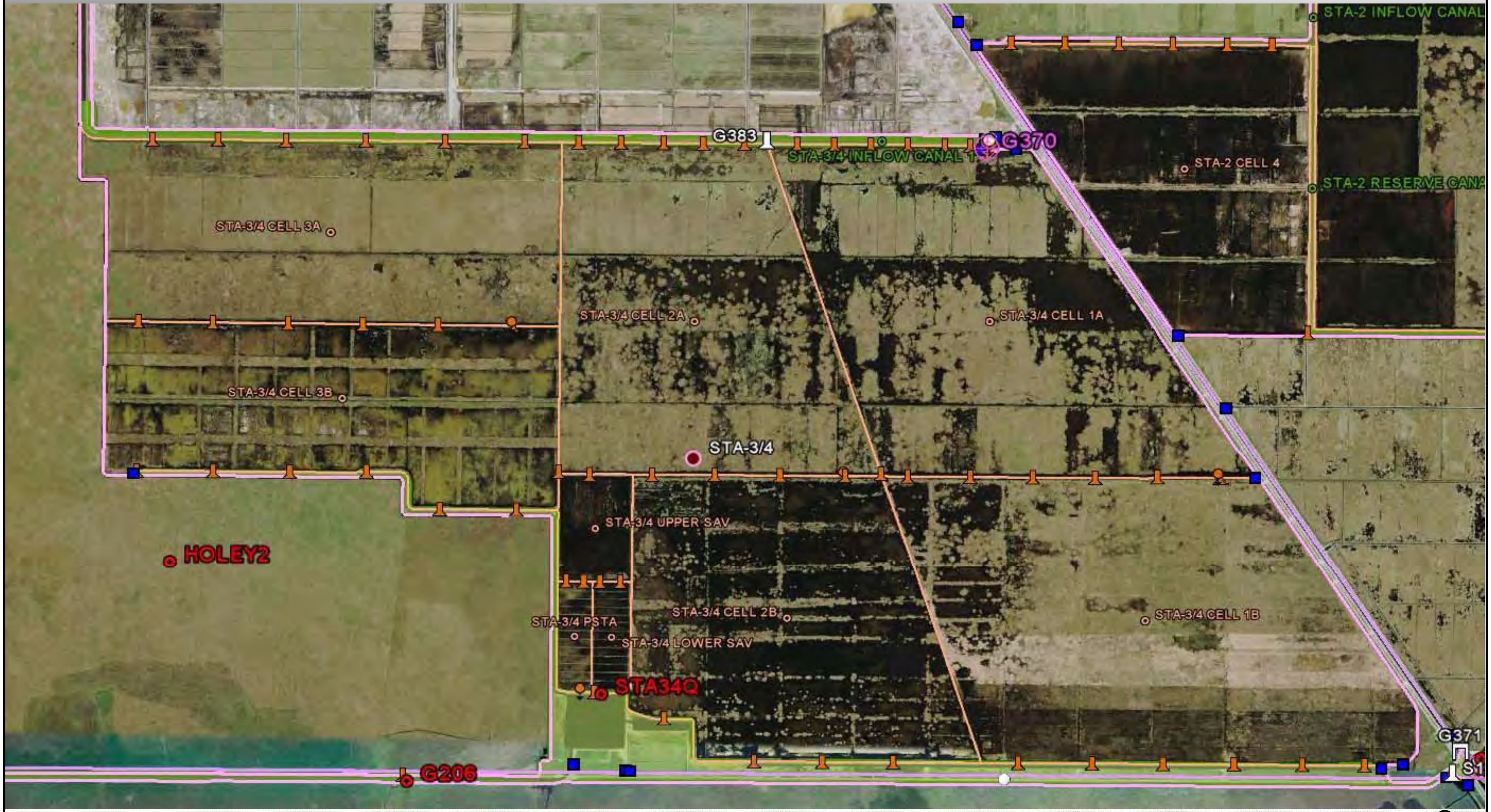
Water Quality Treatment Technologies

PSTA Cell Improvements



G390B
G390A
G389B
G389A
STA-3/4 PSTA
STA-3/4 LOWER SAV
G379E
G388
STA34Q

G-390B Modification

G-390B Modification

G-388 Modifications

STA 3/4 PSTA Cell Modifications

- Objective: Flow/load measurement improvements
- Modify G-390B to improve flow measurements
- Modify one pump at G-388 to reduce pump flow rate
- Resurvey all stage sensors in the flow path in a single loop
- Utilize existing wells/piezometers on east and west levees
- Other future work to include is improved gauging at S378 and S389 structures

PSTA Modifications
Start Up Options

- Start using existing flow/stage criteria
- Plan to move to higher stage and/or flow rates after vegetation has stabilized/recovered from dry down

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Transition to Science Plan

STA 3/4 PSTA Research Plan

Prepared for the

Long Term Plan Quarterly Communications Meeting

November 15, 2011

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Background: PSTA Concept

- The PSTA "concept" generally refers to:
  - Treatment wetland with a lime rock (LR) substrate, achieved either through muck removal or LR cover placed over muck
  - Deployed as a "back end" STA community
  - Low inflow P concentrations/loadings desired
  - Subsequent colonization with calcareous periphyton may occur, but it is not always the dominant plant type

Background: Prevailing theory as to how PSTA achieves outflow TP levels of ~10 ug/L

- The lime rock provides a stable substrate, and therefore minimizes potential sediment P contribution to water column via diffusive flux, bioturbation and/or macrophyte mining
- Vegetation that develops/persists is adapted to low P conditions, and can support microbial communities that contribute to removal of relatively recalcitrant P forms (e.g., dissolved organic P [DOP])

PSTA: Potential constraints to scale-up

- Only a small subset of the PSTA projects performed in past 12 years have attained the 10 ug/L TP target
- High cost of muck removal or lime rock placement
- Presumed requirement of operating at very shallow water depths
- Water balance of many prior PSTA projects potentially compromised by undocumented seepage
- Considerable speculation about additional requisite PSTA design and operational features
  - Certain LR types superior to others?
  - Routine drydown needed to obtain best performance from calcareous periphyton communities?

Example PSTA Projects that did not achieve the 10 ug/L TP target

STA-2 Field Scale Facility

- ~2’ LR over soils; or muck scraped
- Unit sizes of 0.5 ha

STA-1W Test Cell Facility

- ~1’ LR over soils
- Unit sizes of 0.22 ha

Despite a poorly characterized water balance, the STA 3/4 PSTA facility has provided key information on the technology

- The 40 ha STA 3/4 PSTA cell is the largest individual platform deployed in 12 years of PSTA research
- Achieved the mean 10 ug/L TP target for several years in succession
- Successfully operated at a water depth comparable to "typical" SAV cells, with no drydown until summer 2011

STA 3/4 PSTA Cell: TP loading and inflow/outflow TP concentrations for WYs 2008 - 2011

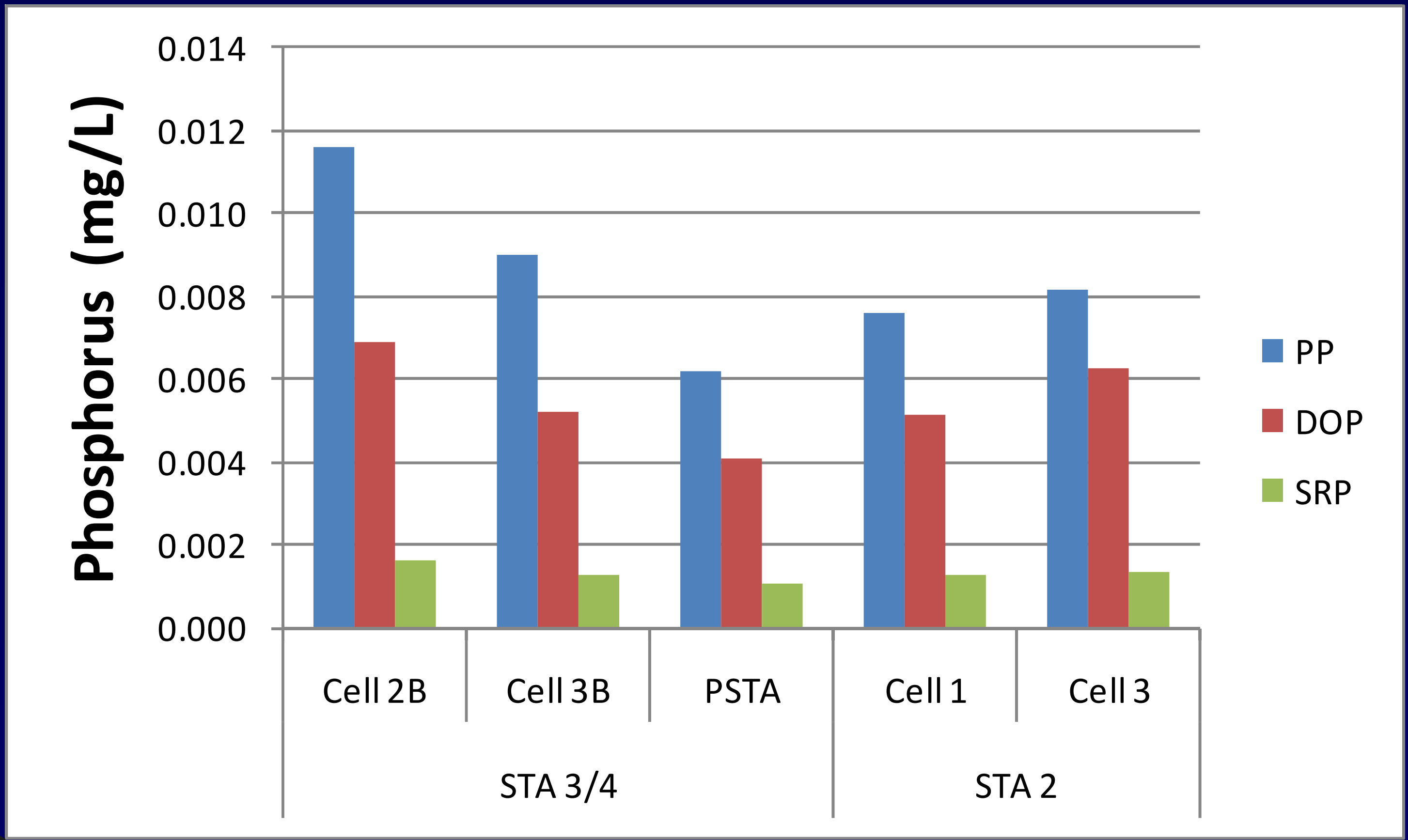
	Days of Operation	HLR (cm/day)	TP Load (g P/m^2/yr)	TP Inflow (µg/L)	TP Outflow (µg/L)
WY2008	161	6.3	0.63	28	12
WY2009	168	7.1	0.37	14	8
WY2010	341	7.1	0.52	20	10
WY2011	159	7.4	0.52	20	11

Values from draft SFER 2012

The STA-3/4 PSTA cell offers a useful platform for evaluating critical questions that should be addressed prior to scale-up

- What characteristics of the PSTA wetland facilitate low-level outflow P concentrations?
- Are the P removal processes sustainable, or will system performance decline as new sediments accumulate over time?
- Under what P loading and inflow P levels does PSTA remain sustainable?
- How critical is the scraping of muck (or addition of a LR soil cover) to support these key processes, and to achieve low outflow TP levels?
- Are there less expensive alternatives to achieving low P levels than muck scraping or LR addition?

Outflow chemistry comparisons among well-performing STA flow paths provides insight into the unique characteristics of PSTA cell discharges

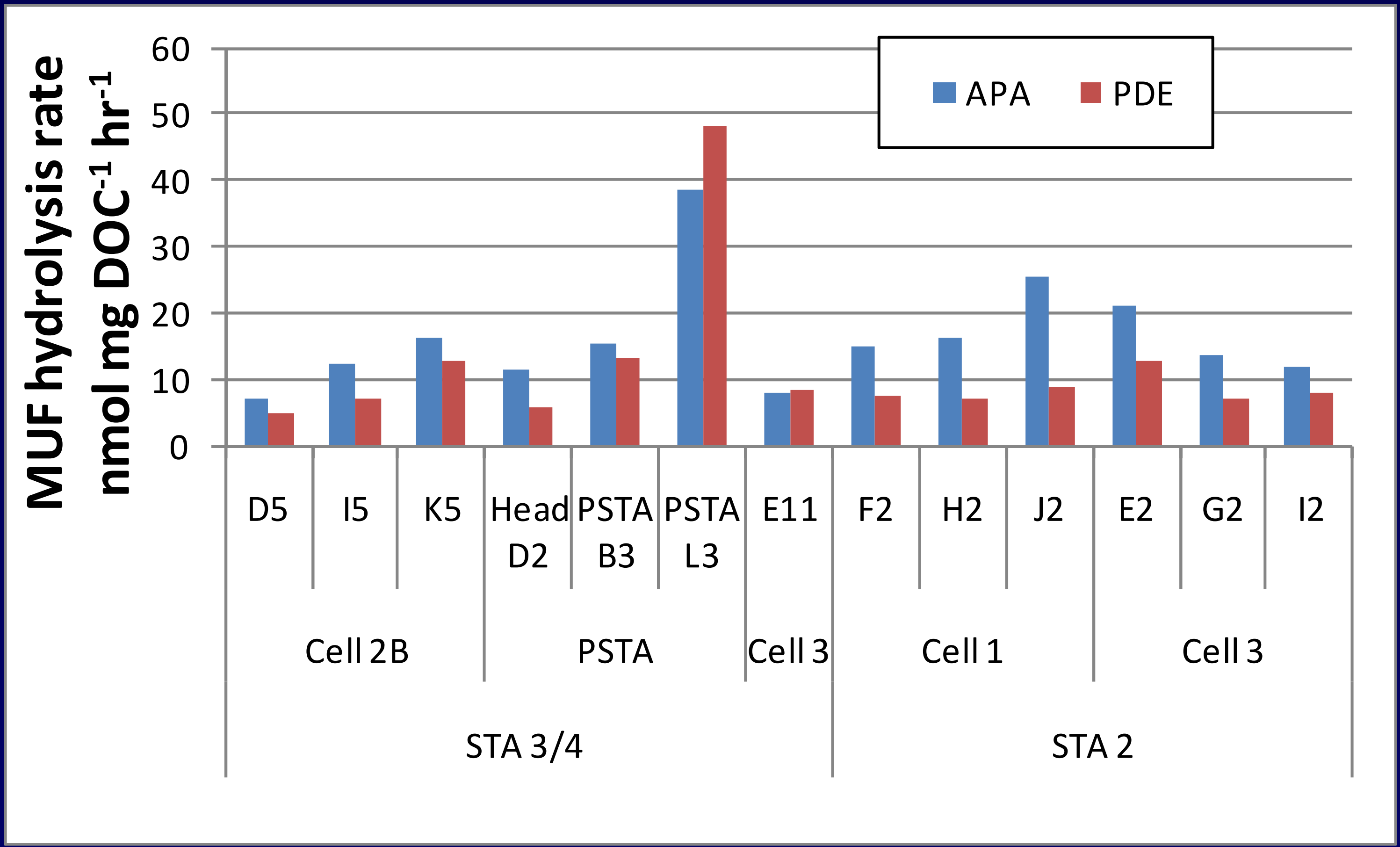


Mean values, Sept 2009 – Aug 2010

Phosphatase enzymes probably play a key role in the PSTA cell's low outflow P concentrations

- Enzymes liberate phosphate from larger DOP molecules
  - Phosphate can pass through cell walls, membranes into bacteria, algae cells
  - Dissolved organic P compounds typically are too large for direct biological uptake
- Phosphatase activity increases P available for uptake, reduces DOP levels, and may also reduce PP concentrations

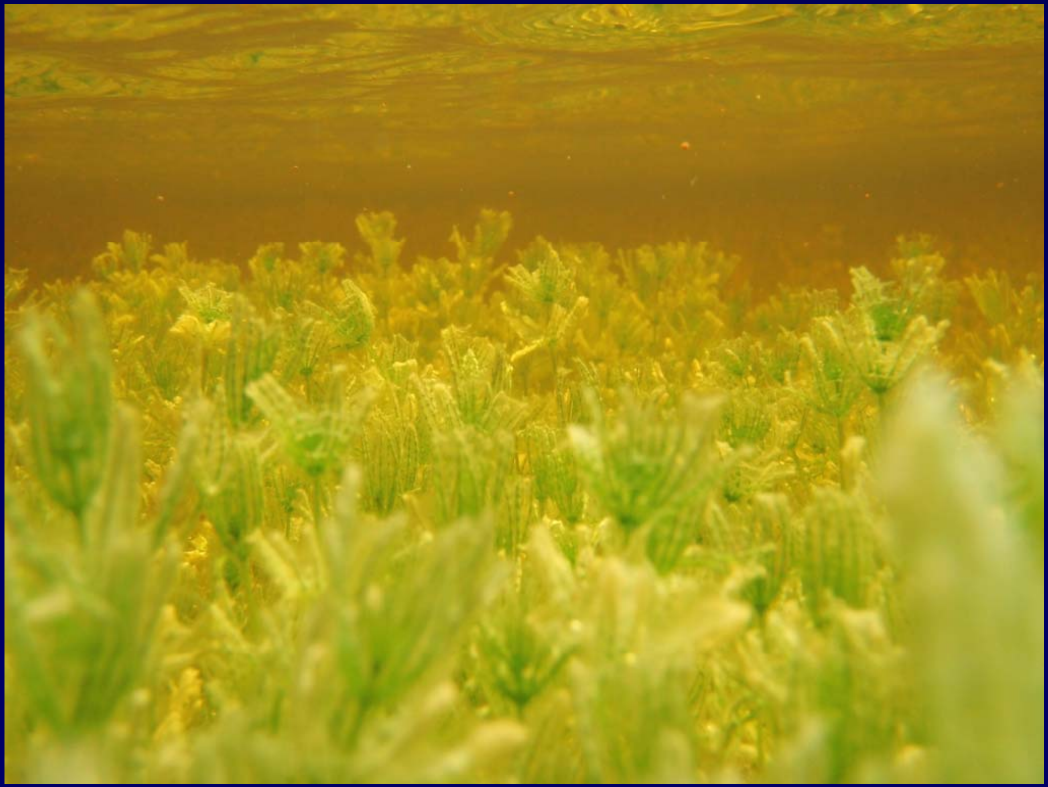
Our initial survey demonstrated enhanced phosphatase activity in portions of the PSTA cell



Samples collected late summer 2010;
APA – alkaline phosphatase, PDE – phospho-diesterase

UV radiation also may play a role in DOP breakdown. This process may be enhanced in regions of sparse vegetation, or in areas where SAV is not “topped out”. Conversely, high dissolved organic matter levels can inhibit this process by minimizing UV penetration into the water column.

Dense Chara meadow



PSTA Research Plan

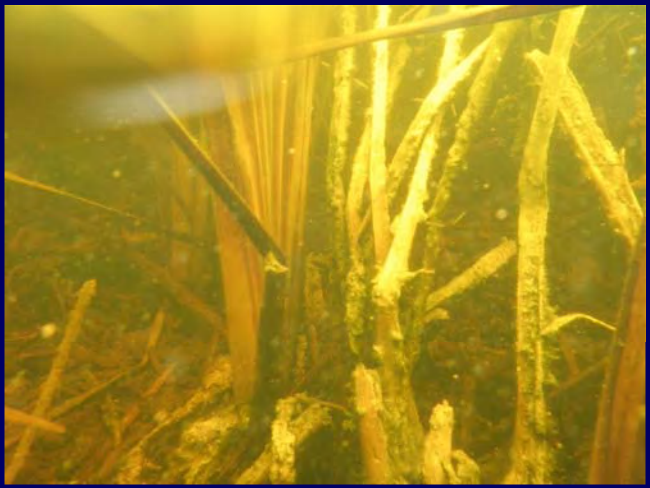
- Anticipated 2 – 3 year effort
- Flexible – we will modify activities over time as findings suggest
- Spatial and temporal internal transect sampling of surface waters
  - Perform under varying P loading rates and if possible, variable inflow P concentrations
  - Assess enzyme activity, P species, N species, DOC quantity and quality, + other analytes
  - Evaluate regions of particularly effective (or ineffective) treatment; relate to cell operational conditions and/or site-specific vegetation characteristics

PSTA Research Plan

- Spatial sediment characterization
  - survey accrued sediments: assess depth, enzyme activity, TP, TN, TC and Ca contents and size of P pools available for flux or macrophyte “mining”
- Sediment core or flask lab incubations to assess potential P release
  - comparisons to be made with underlying LR and with sediments from outflow regions of other well-performing STA cells
- These sediment analyses are critical to assess PSTA long-term sustainability
  - i.e., are sediments that accrue along the cell flow path as “P stable” as the original underlying LR?

PSTA Research Plan

- Spatial vegetation assessments
  - characterize SAV and periphyton speciation, standing crop and whether or not plants are “topped out”; compare to plant characteristics in muck-based SAV flow path outflow regions
  - assess potential role of EAV on vegetated strips
  - measure enzyme activity and elemental composition of algae and macrophyte tissues

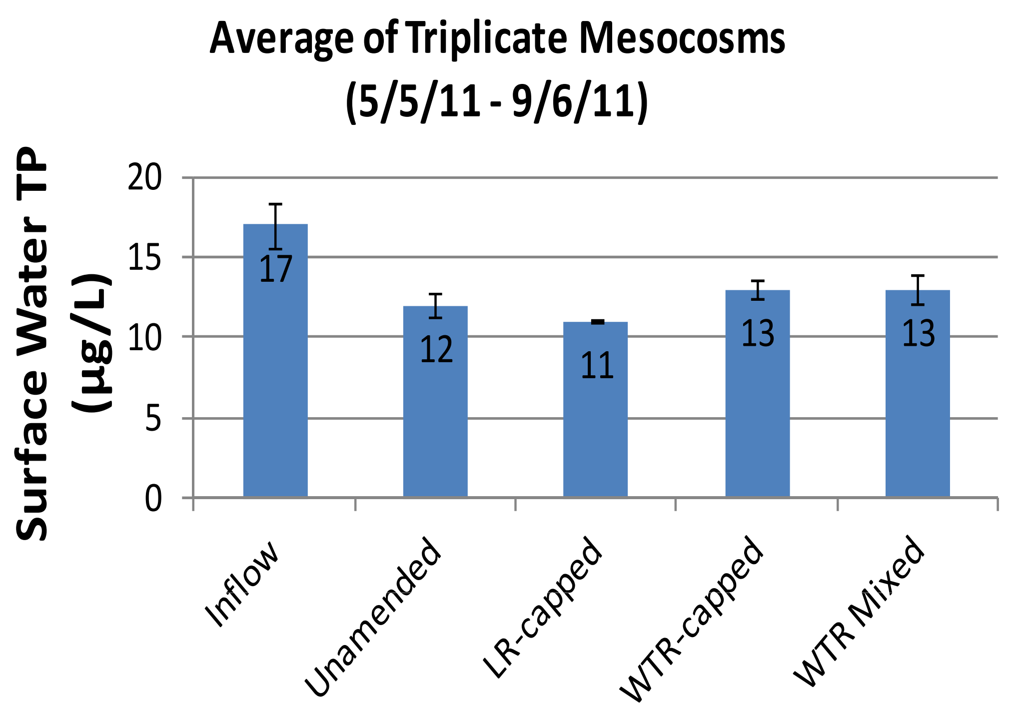


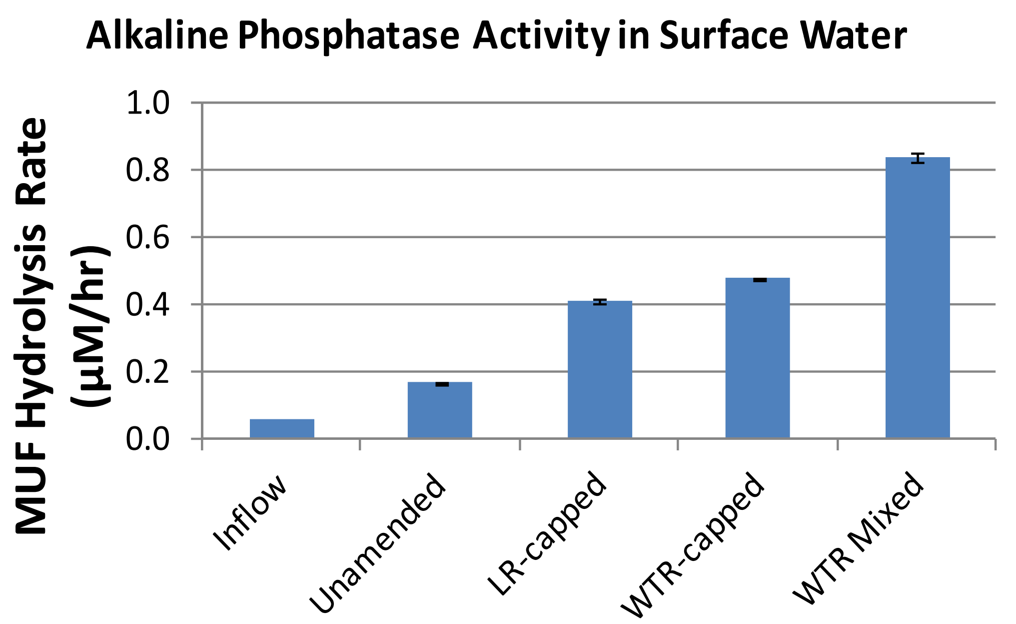
PSTA Research Plan

- Mesocosms and enclosures
  - mesocosms (containing soils/amendments and vegetation) will be used for selected studies to characterize vegetation – sediment interactions (e.g., P mining, enzyme activity)
  - Intact soil + vegetation + water “cylinder” studies, at scales ranging from intact cores to *in situ* enclosures, will be used to evaluate key processes
- Other assessments
  - Stable isotope analyses to determine sources of dissolved organic matter
  - Periodic sampling of levee wells for P species to help characterize potential contribution of seepage to the wetland P balance

Example mesocosm effort: current study at STA-1W outflow region, comparing LR substrate with another P-sorbing (but non-calcium) substrate

Lime rock and water treatment residual (WTR) amendments. Both were used as a 4 cm “cap” over muck to attenuate soil P release. The WTR also was blended in with top 4 cm of muck soil.





Initial P removal performance and phosphatase enzyme activity in unamended muck mesocosms and those amended with LR and a WTR

Summary

- Outflow data demonstrate that the STA-3/4 PSTA cell achieves slightly better reductions in both DOP and PP compared to well-performing SAV cells.
- Water column sampling has revealed high phosphatase enzyme activity in the PSTA cell.
- A multi-year research effort has been initiated to identify and optimize the key DOP and PP removal processes, and to better define operational boundaries
- This effort will include spatial and temporal water column, vegetation and sediment assessments
- Initial efforts will focusing on identifying regions (and substrates) with greatest phosphatase enzyme activity, and on characterizing stability of P in the accrued sediments.