Long-term phosphorus removal performance by a large-scale constructed wetland treating lake water

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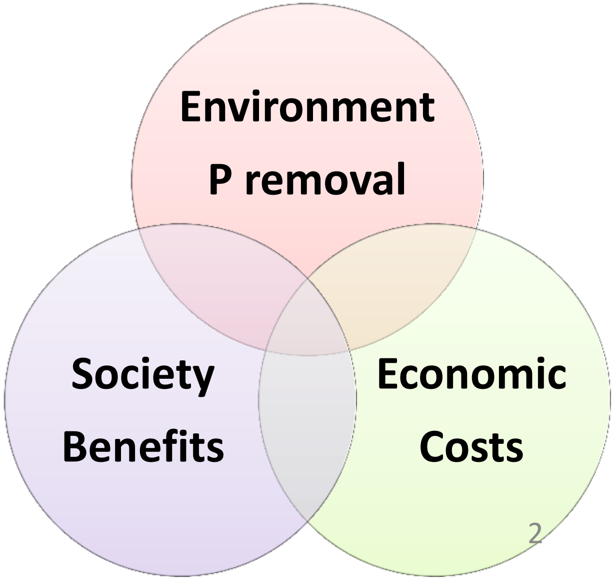
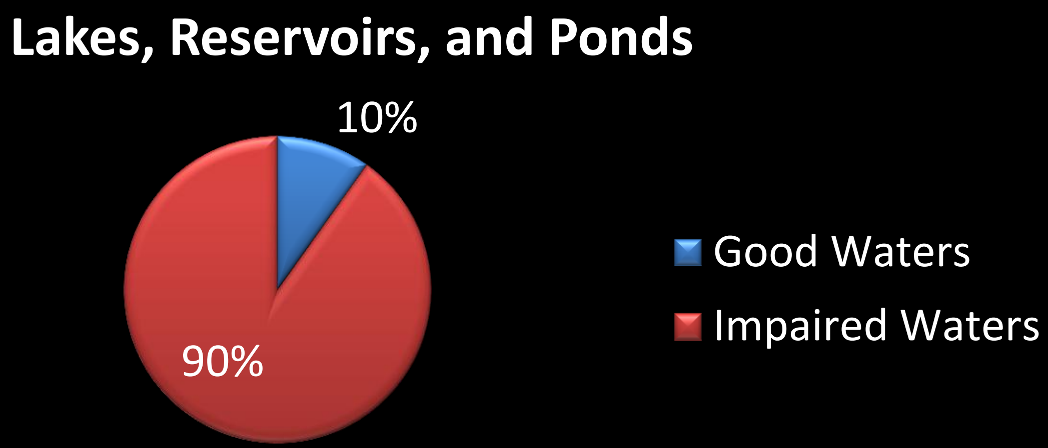
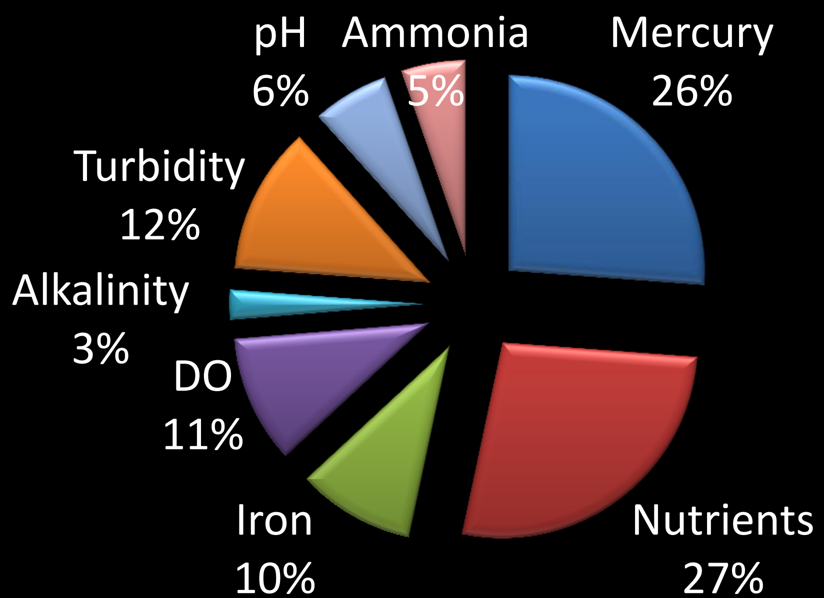
Overview and context

- **Goals and Objectives**
- **System characteristics, location, and site description**
- **Performance**:
  - Inflow characteristics
  - Short-term: release
  - Long-term: removals, transformations, and patterns
- **Sustainability**:
  - P removal
  - Economic Costs
  - Cost ($)/removal (kg)
  - Benefits: Ecosystem services



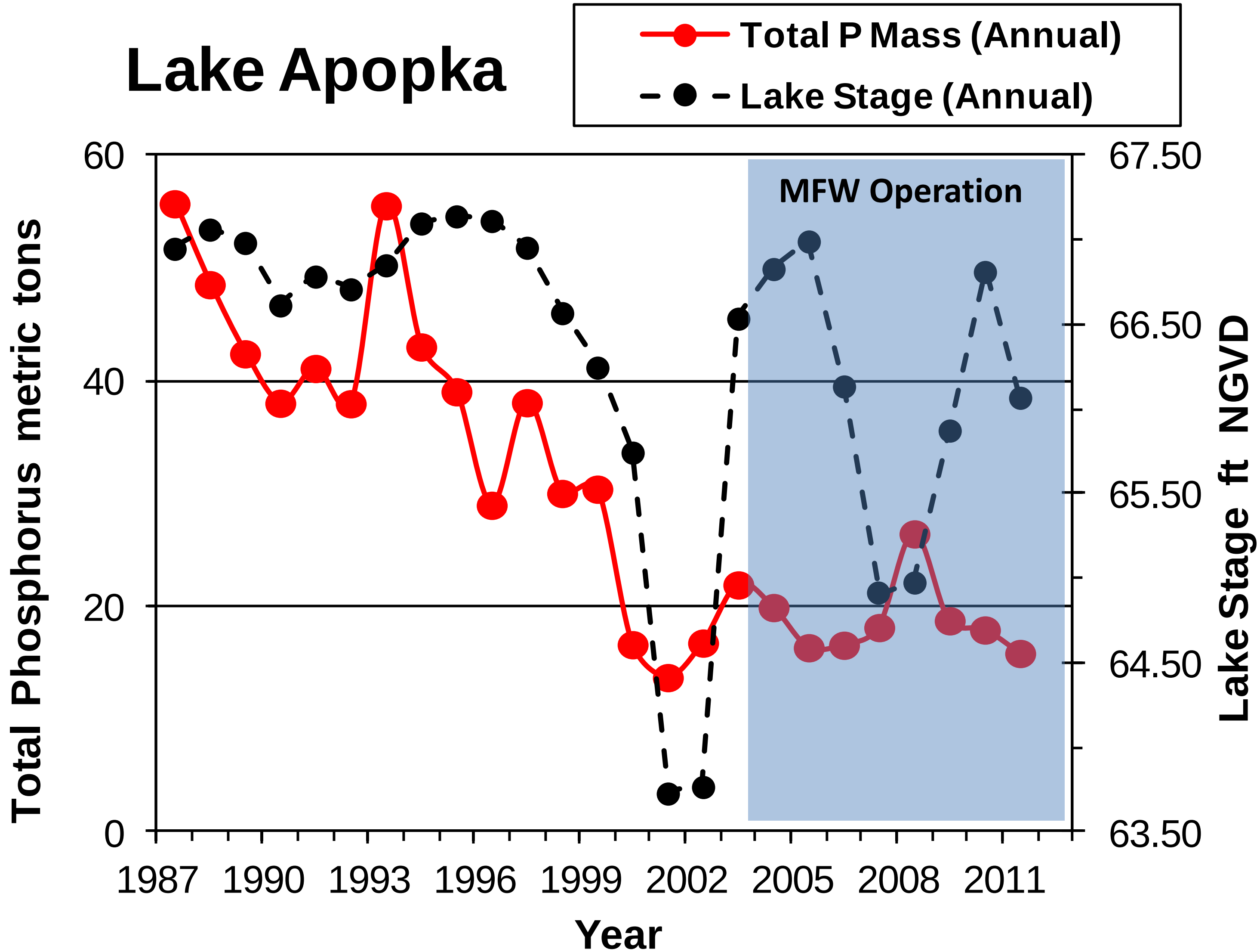
Florida 2010
Lakes, Reservoirs, and Ponds 2010



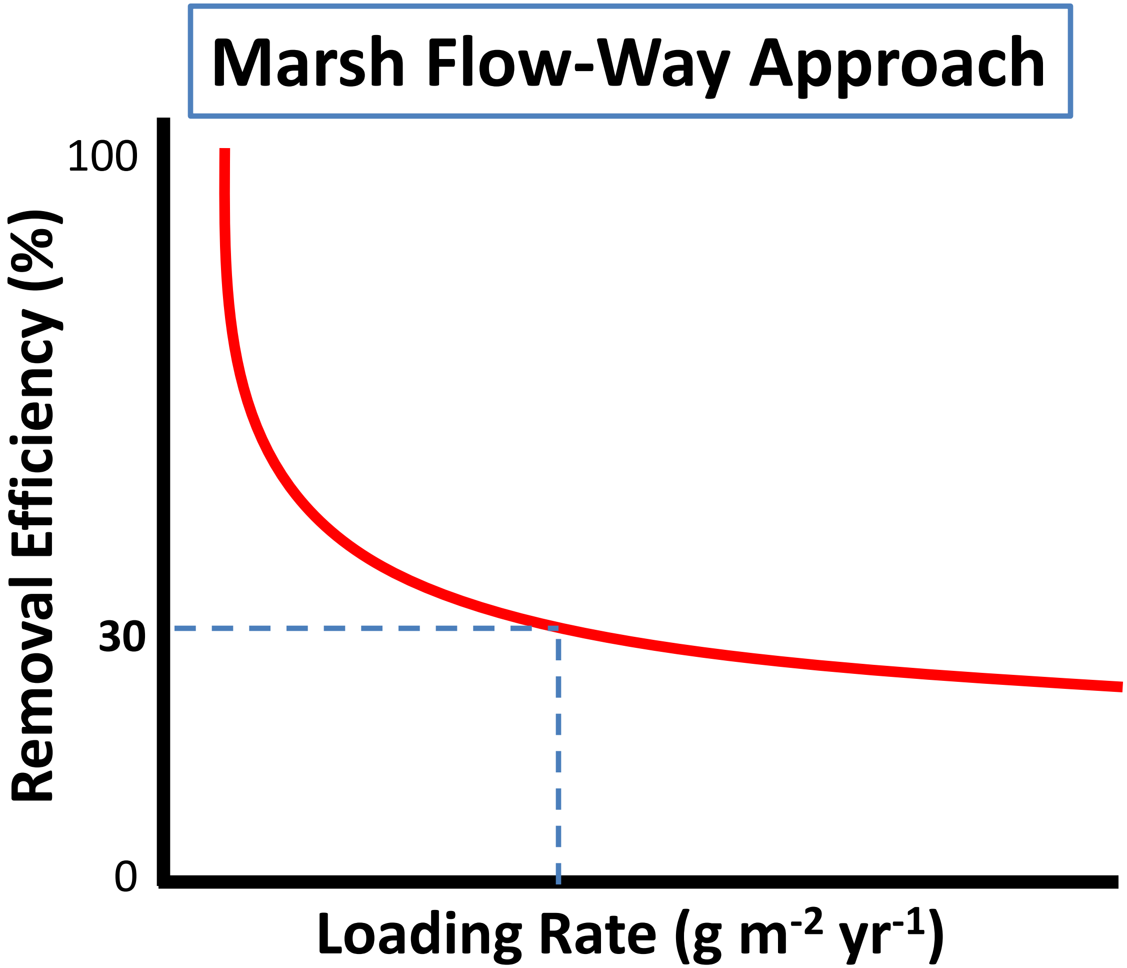


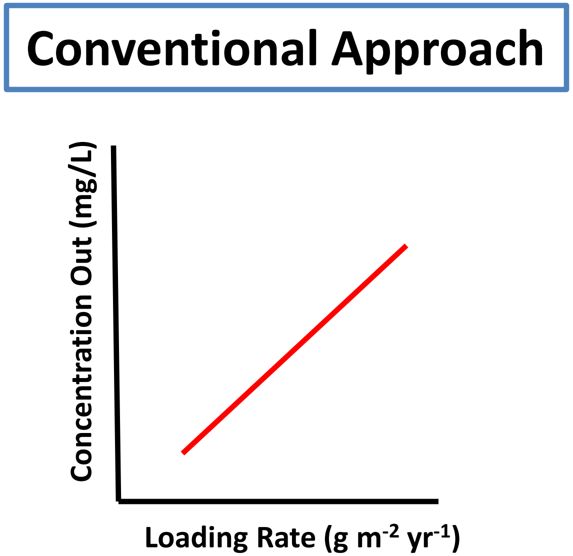
Source:http://iaspub.epa.gov/waters10/attains_state.control?p_state=FL#total_assessed_waters

Goal of Marsh Flow-Way:
Reduce phosphorus inventory already in Lake Apopka



Goal of Marsh Flow-Way: Optimize removal rate

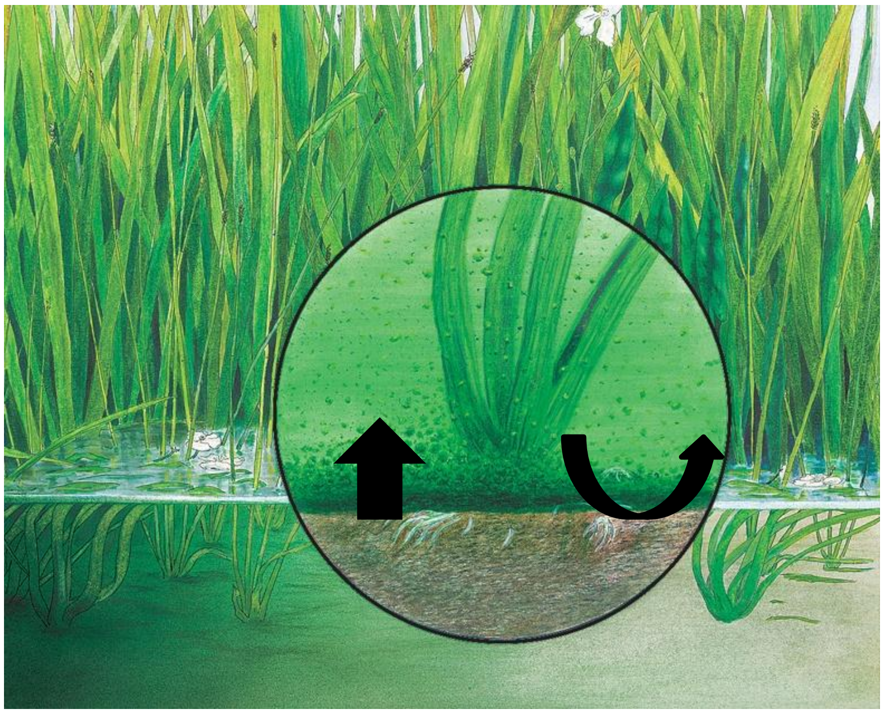




Source: Nichols, 1983

Dominant ***physical*** and biogeo***chemical*** processes governing phosphorus dynamics

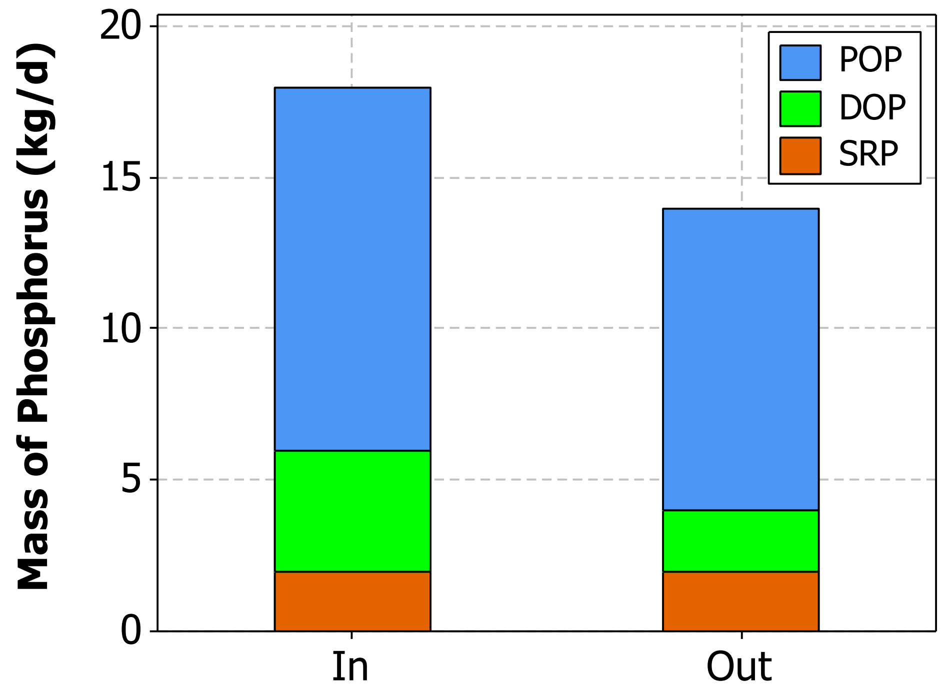
Removing phosphorus laden particles



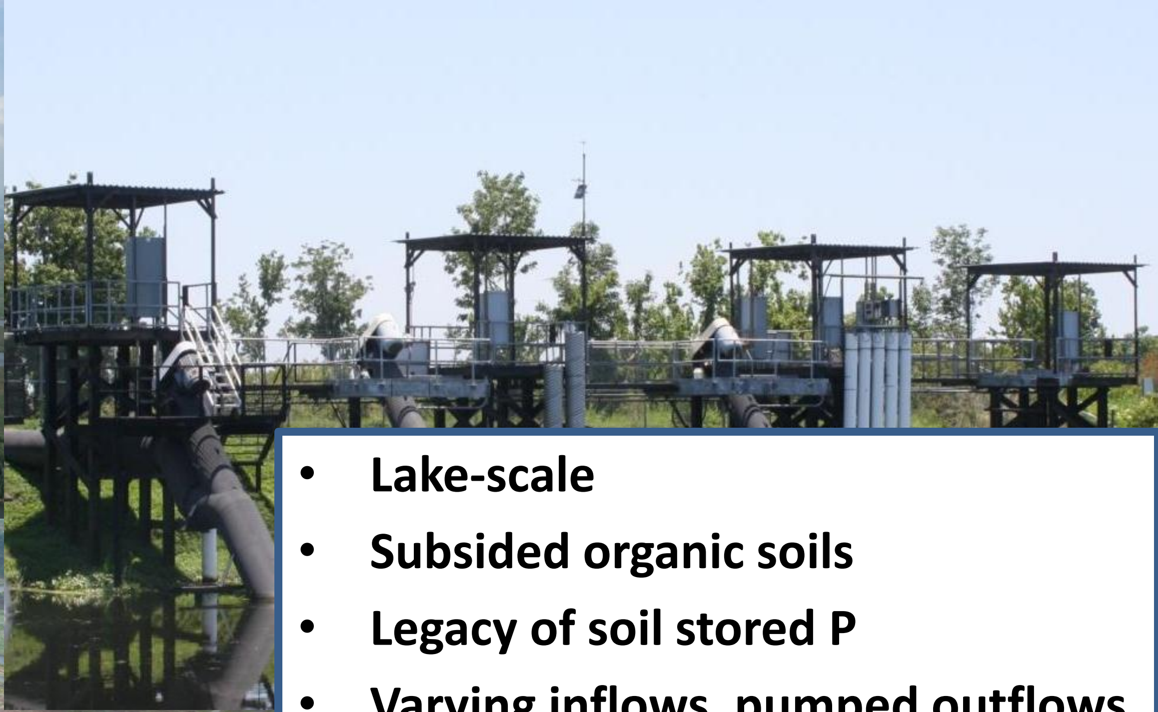
Vertical accretion of new soil material

Resuspension

Removal &Transformations

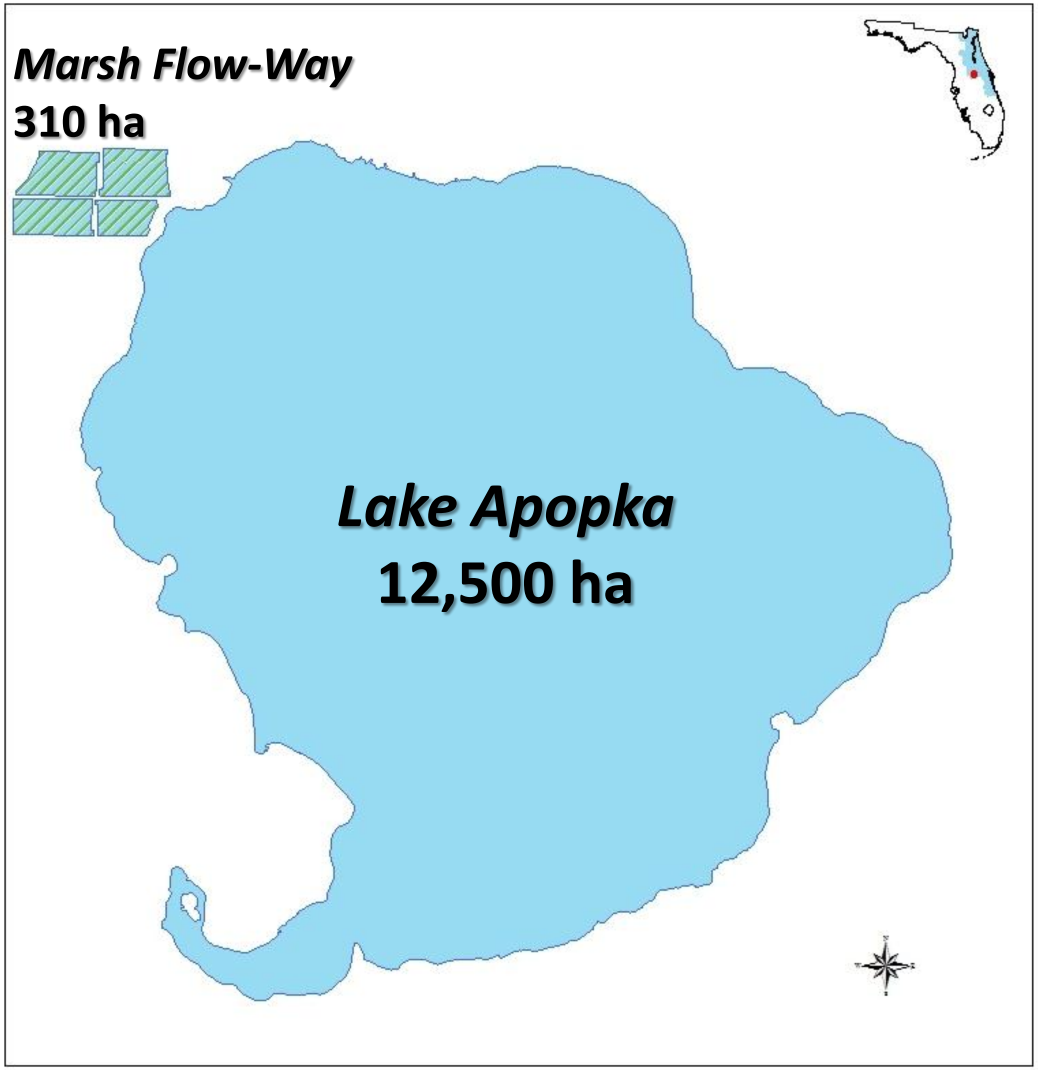


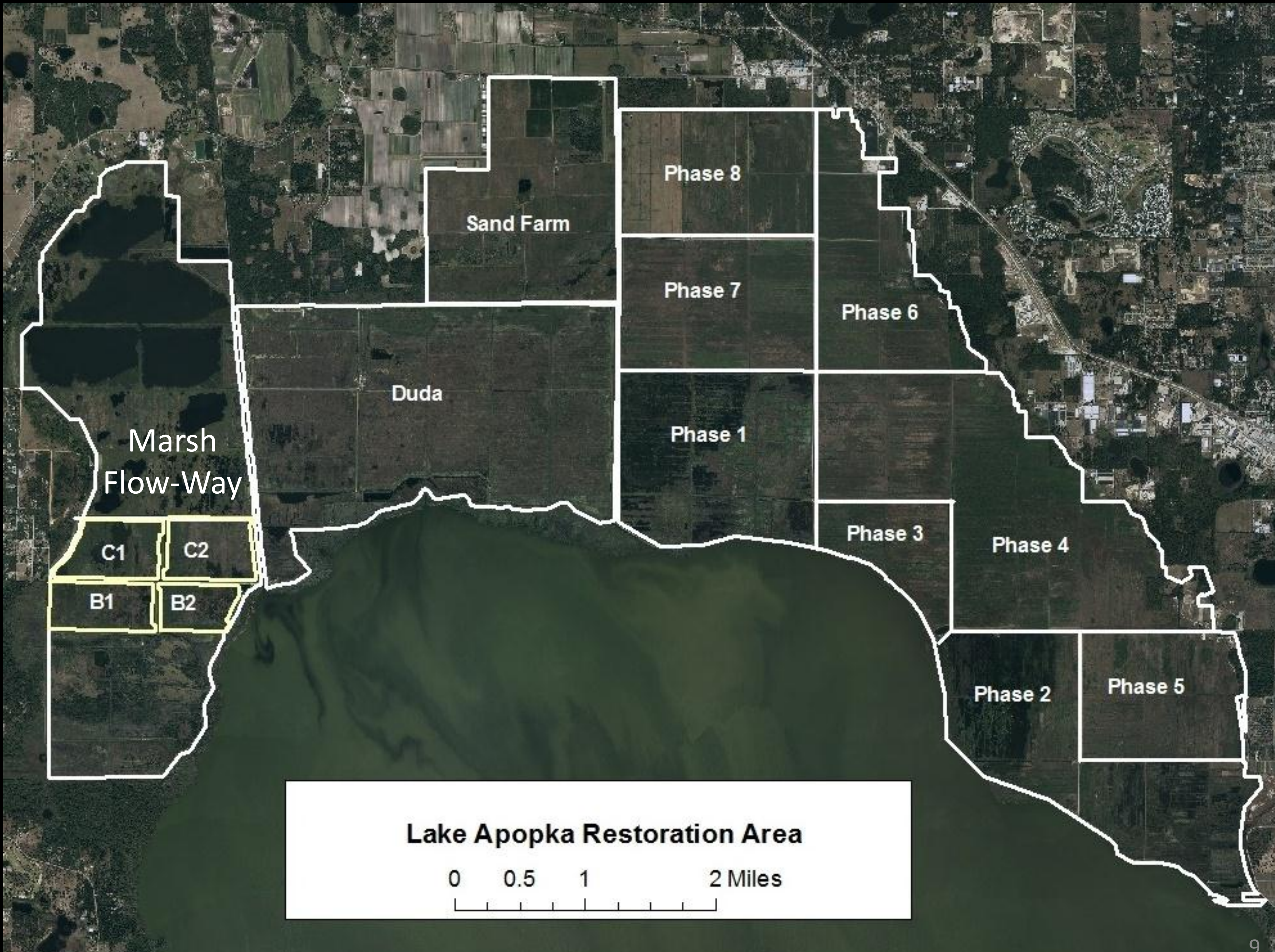
Marsh Flow-Way characteristics



- Lake-scale
- Subsided organic soils
- Legacy of soil stored P
- Varying inflows, pumped outflows
- Varying inflow concentrations
- Do not have to attain outflow water quality criteria

Location and scale of wetland approach

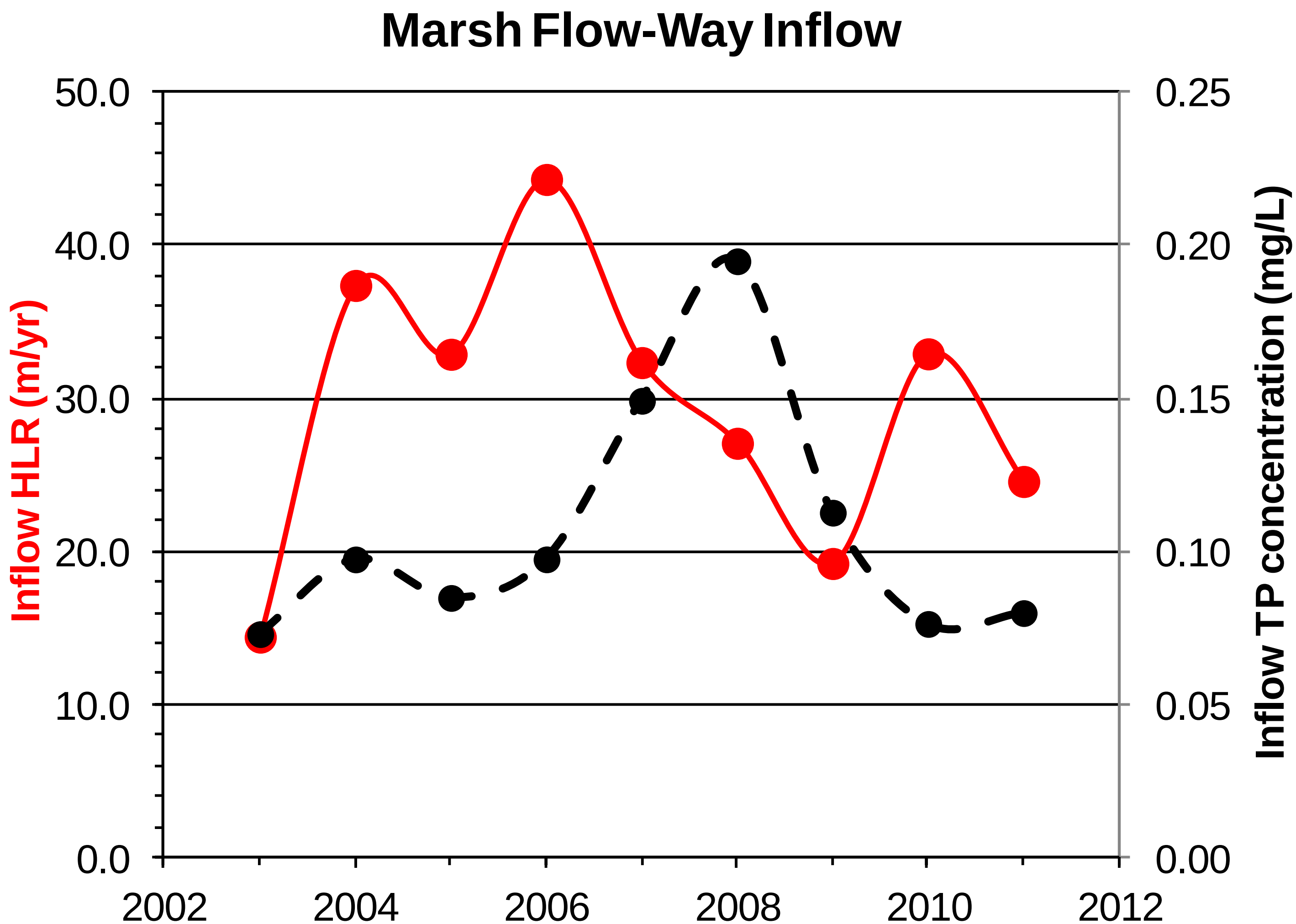




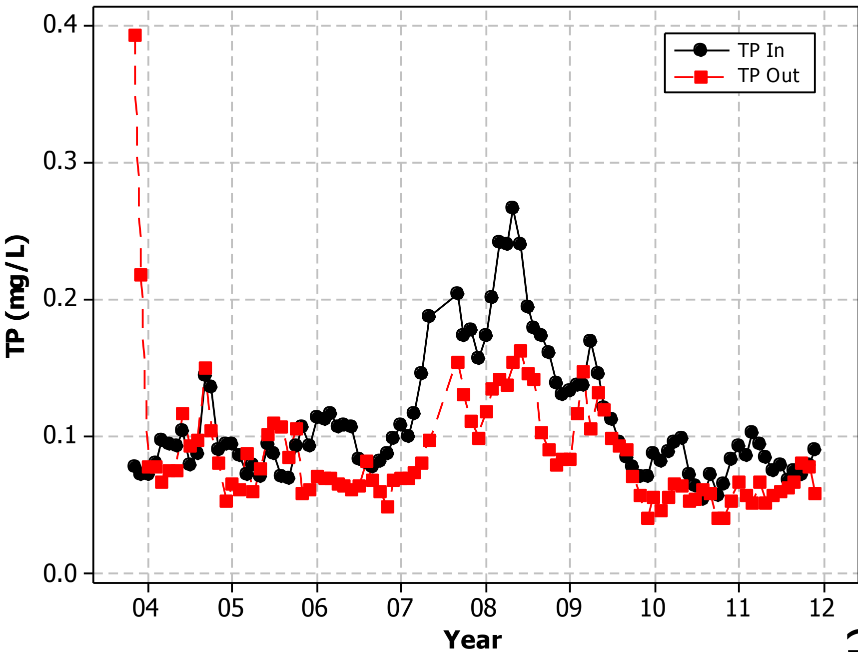
Map created by P. Bowen

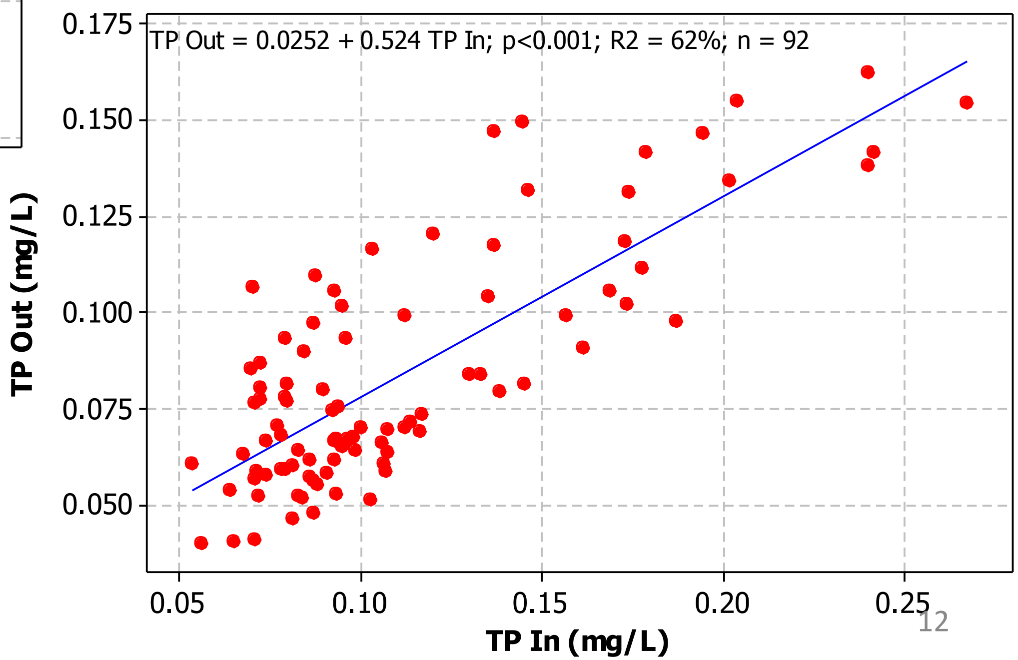

East
South
Lake Apopka
MFW Inflow
North
West
Apopka Beauclair Canal
Pump Station
B2
49 ha
C2
76ha
C1
78 ha
C2
76 ha
Photo taken by J. Stenberg on 2010_12_10

Controlling factors in marsh flow-way performance

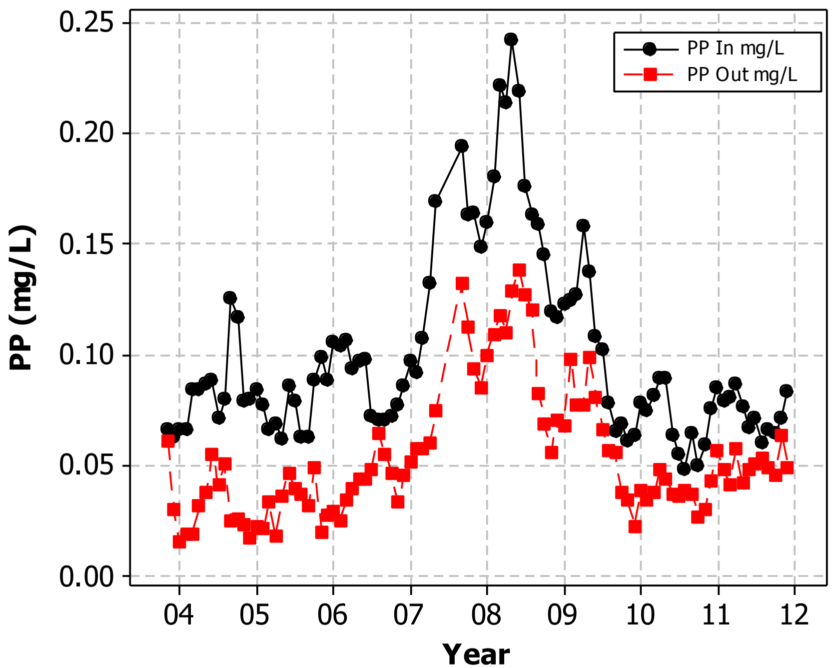


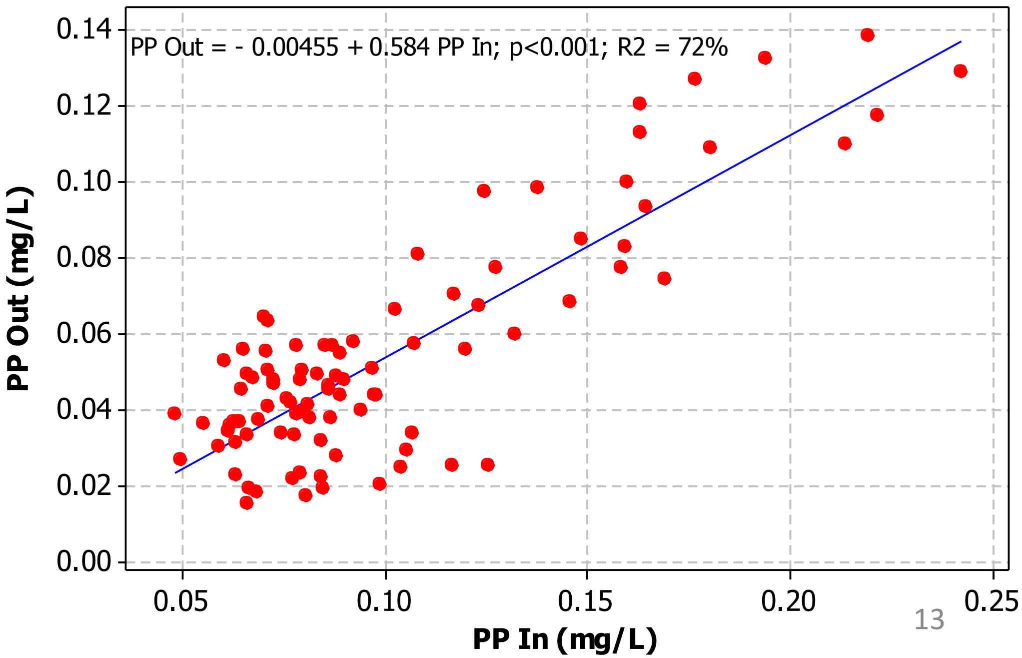
Long-term performance
Total phosphorus





Long-term performance
Particulate phosphorus

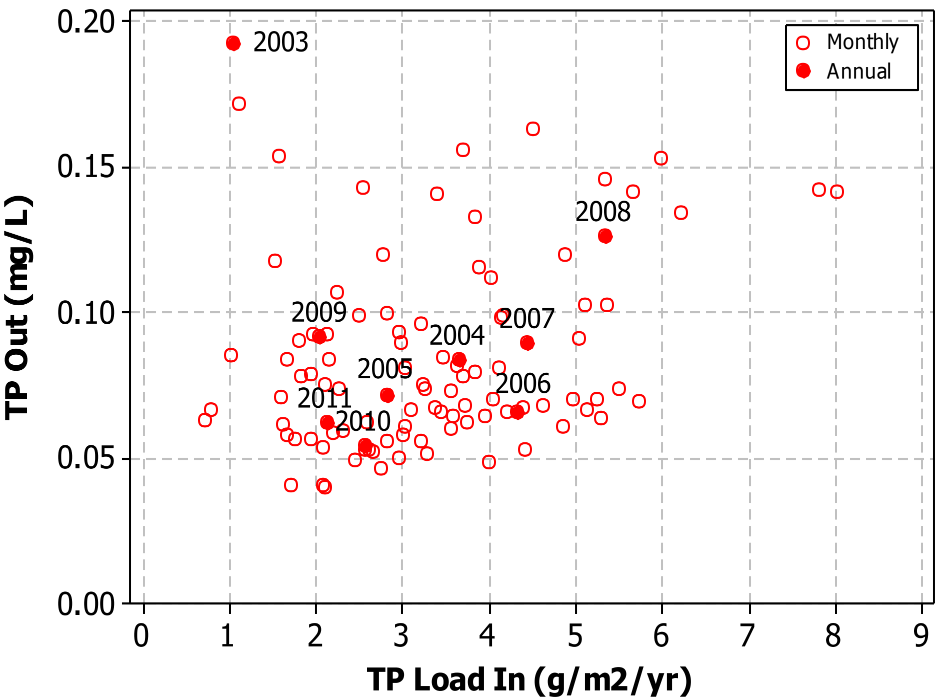




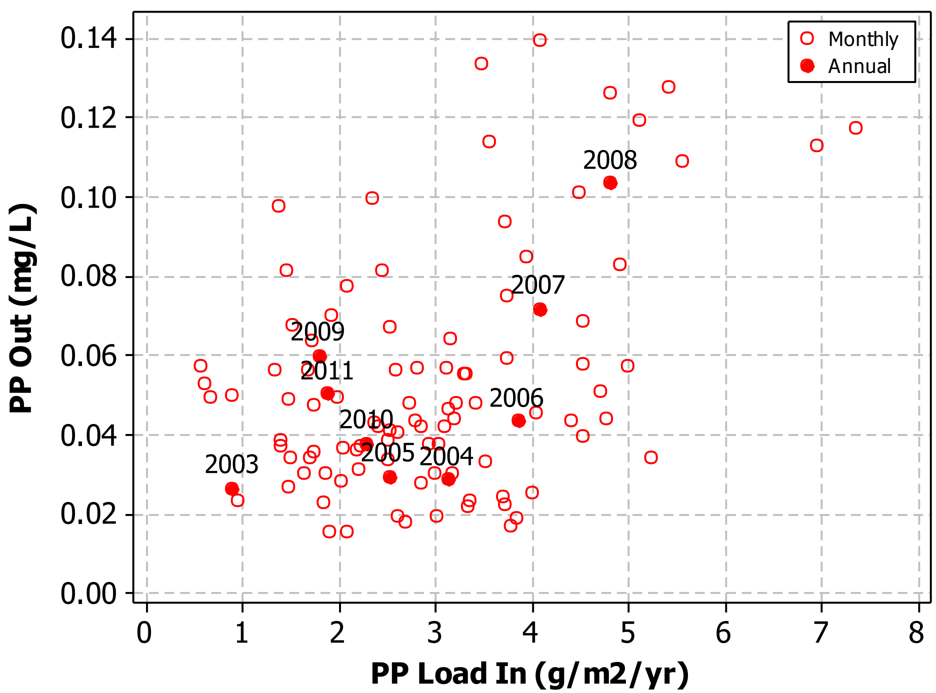
Long-term performance

Outlet concentrations versus inlet loadings

Total phosphorus



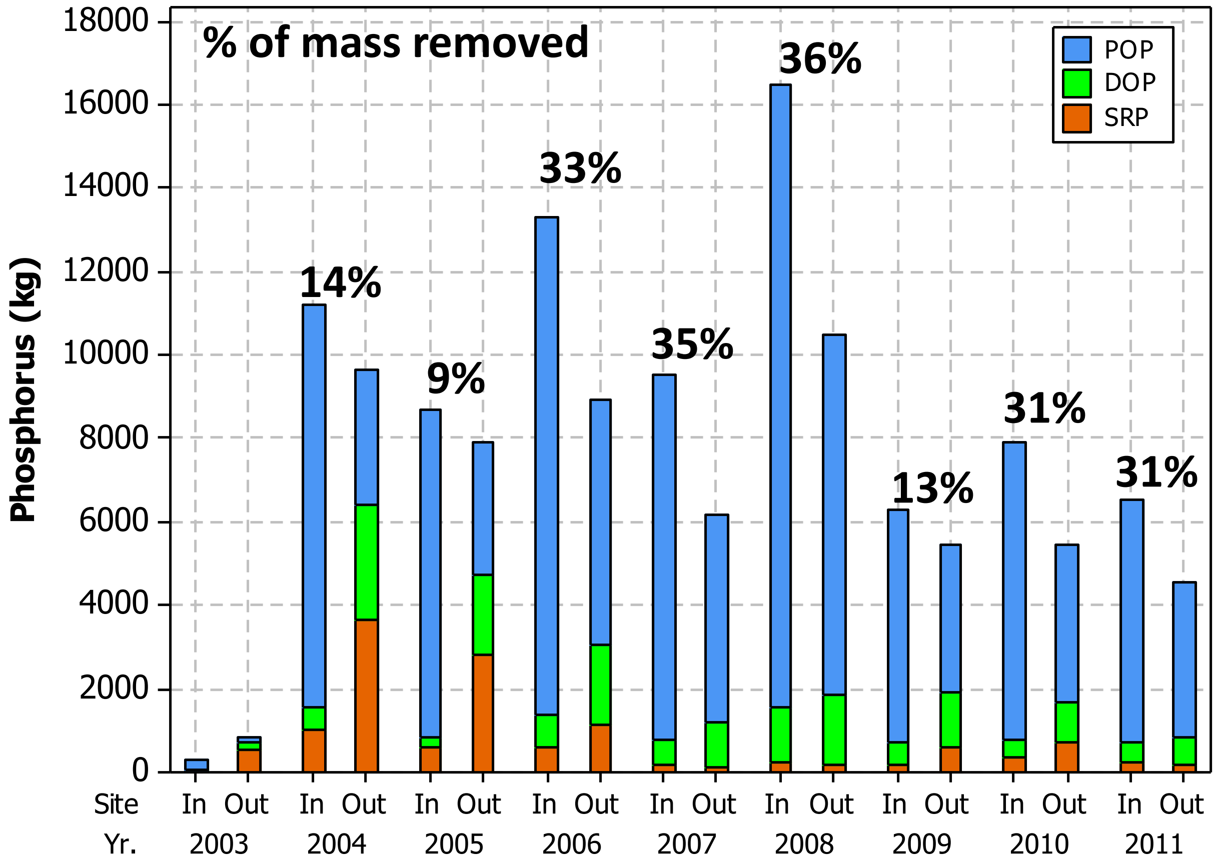
Particulate phosphorus



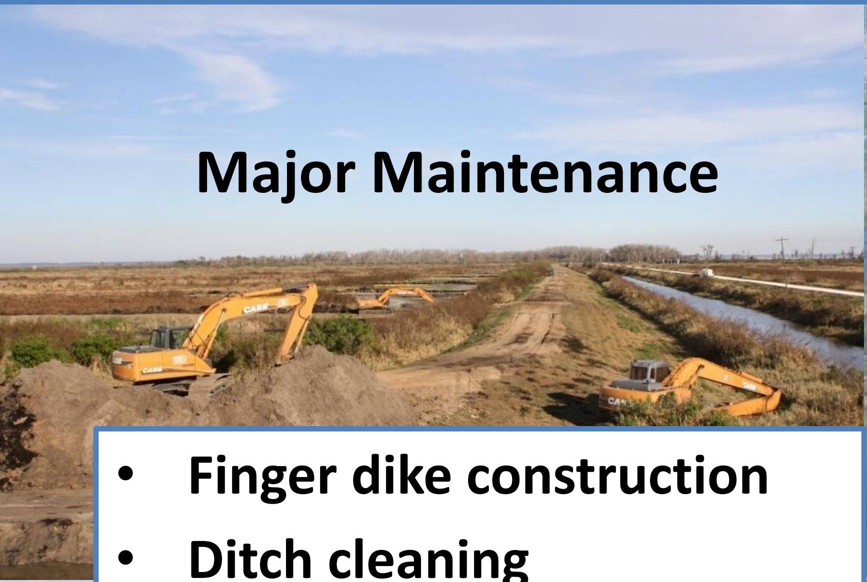
Long-term performance
Mass removal and efficiency

Short-term release

Long-term retention



Dynamic management to sustain performance



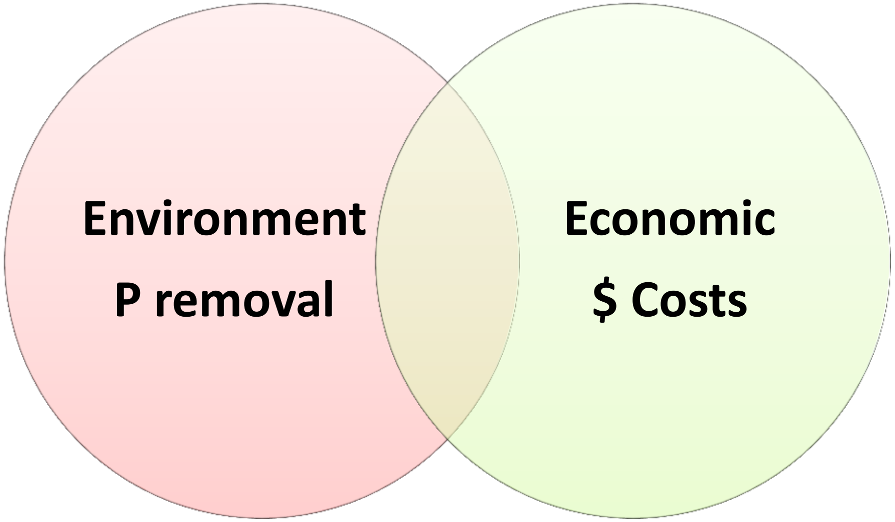
Major Maintenance

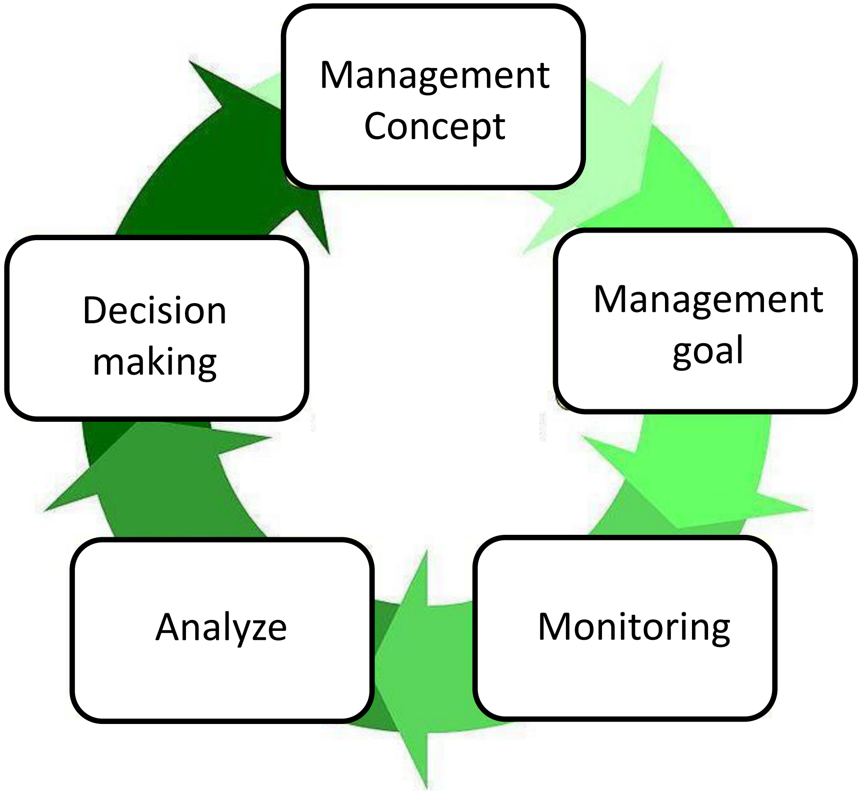
Minor Maintenance & Operation

- Finger dike construction
- Ditch cleaning
- Mowing
- Alum injection

- Manipulating water levels and flows
- Drawdown, resting
- Turning off/on cells
- Planting

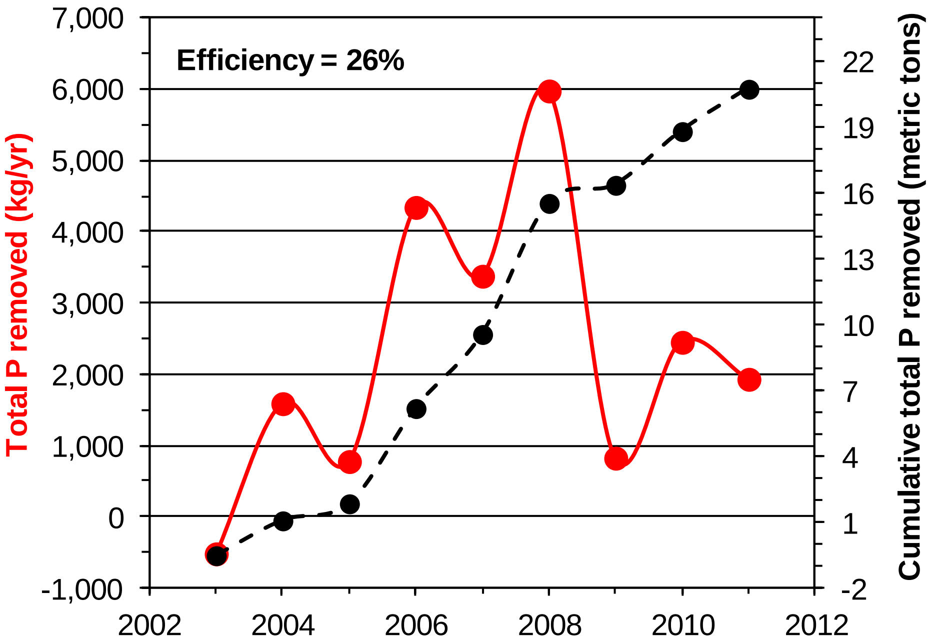
Incorporating sustainability into decision making and management





Components of sustainability

Phosphorus Removal

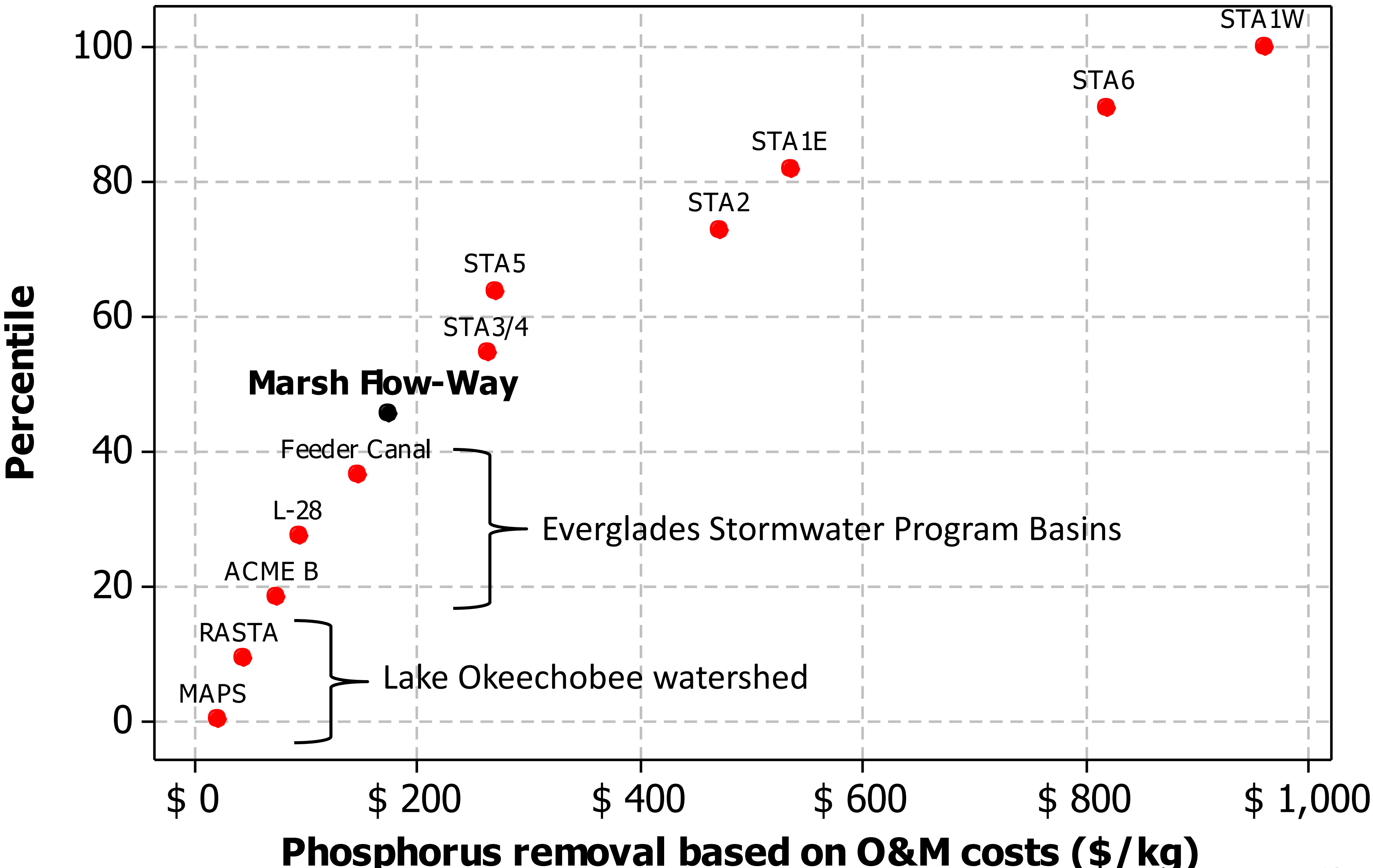


O&M cost ($/kg)
$173/kg of total phosphorus removed

Capital and O&M Costs

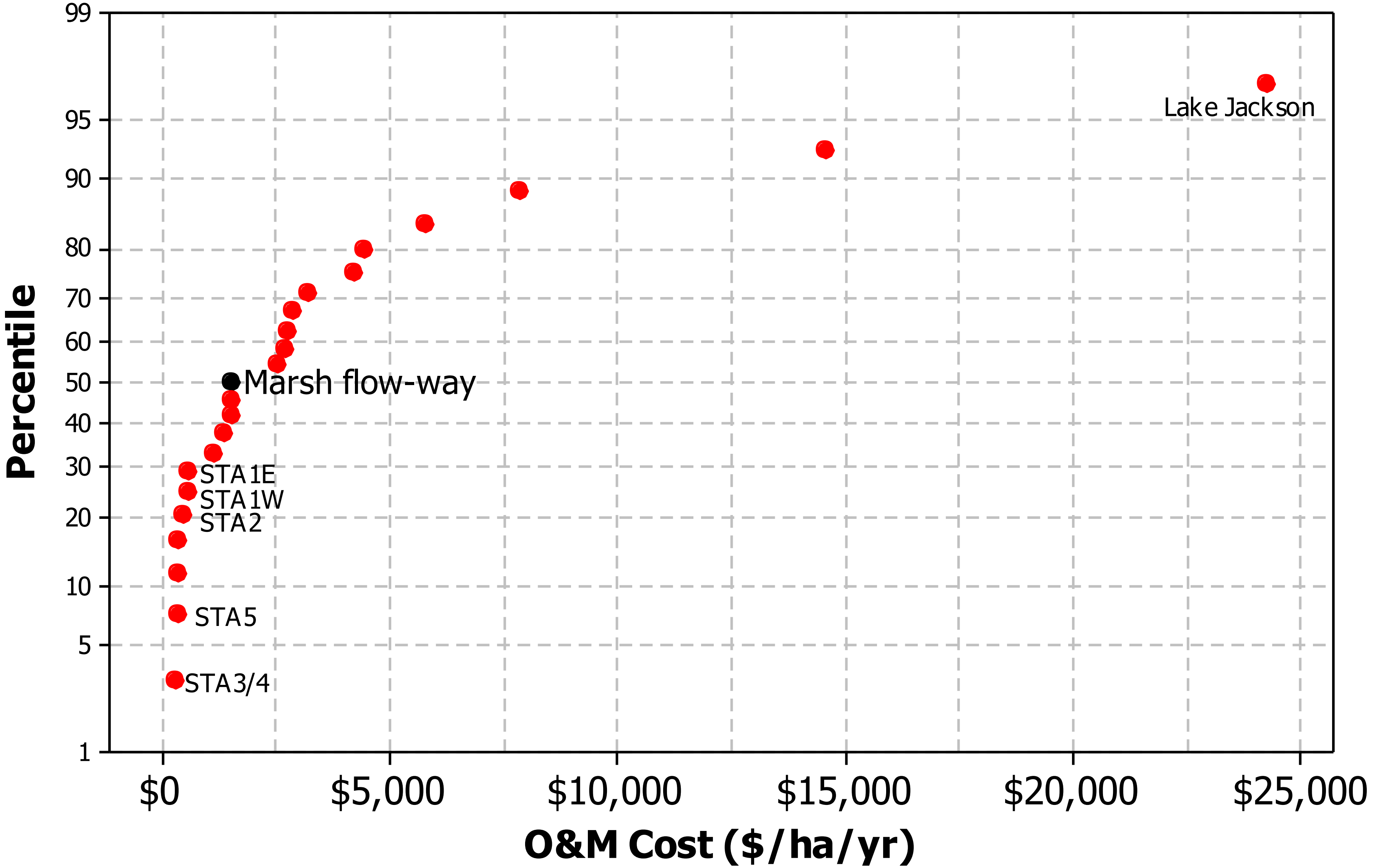
Capital costs		In 2011 ($)
Construction	$	3,568,951
Design and Engineering	$	491,326
Pumps	$	606,648
Settlement	$	1,687,718
Soil amendment	$	130,695
Injection system, tanks and telemetry	$	28,320
Earthwork	$	132,018
Total capital costs	**$**	**6,645,675**
O&M Costs		
Pumping	$	1,036,233
Alum	$	493,710
Personnel	$	1,797,376
Contracts and purchases	$	434,026
Total O&M costs	**$**	**3,761,345**
O&M cost ($/yr)	**$**	**470,168**
Total Project Costs	**$**	**10,407,021**

Comparing phosphorus removal systems in Florida



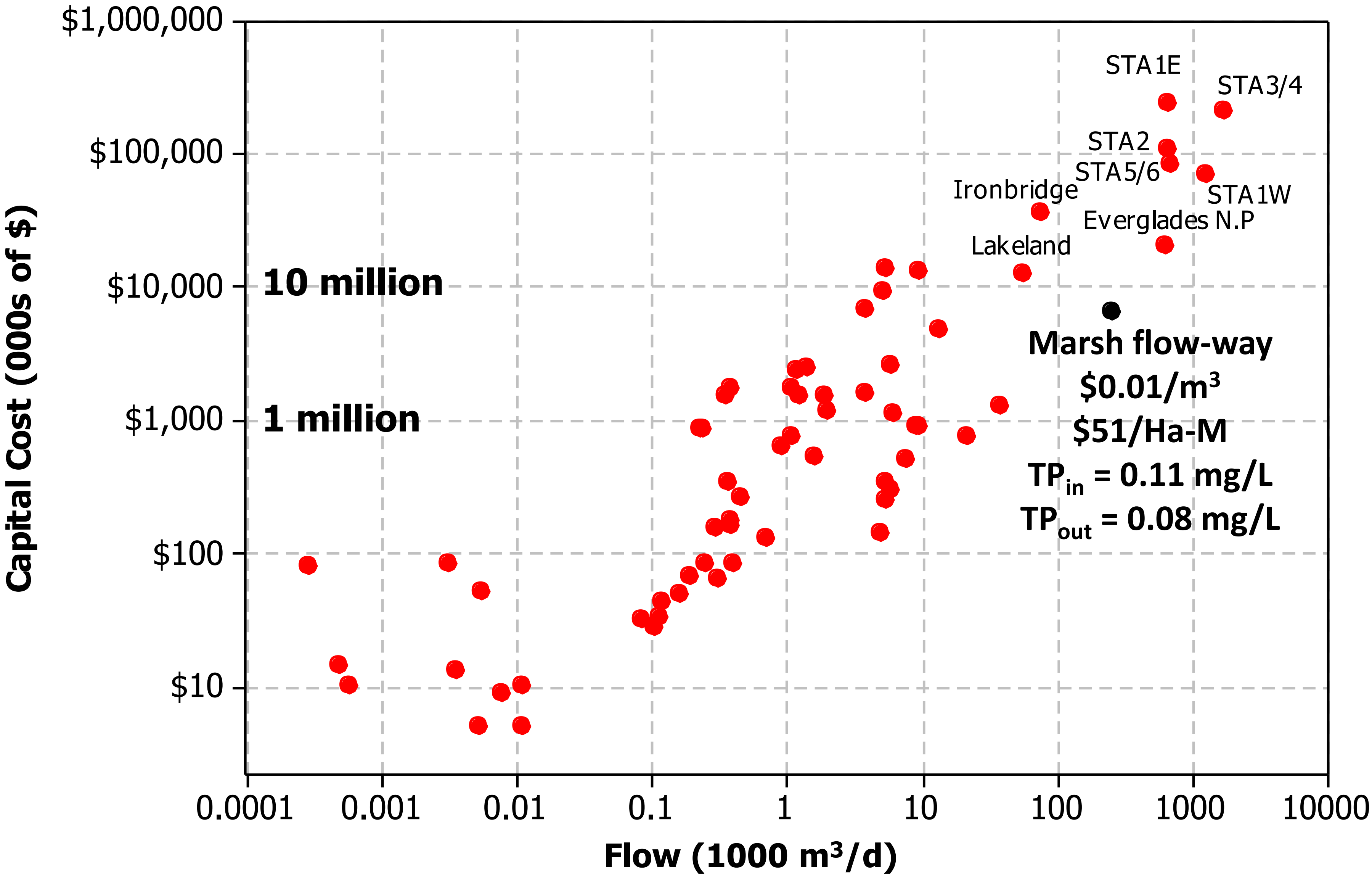
Data source from: Sano, Hodges, and Degner, 2005. Monetary values expressed in 2011 dollars.

Annual O&M costs for treatment wetlands



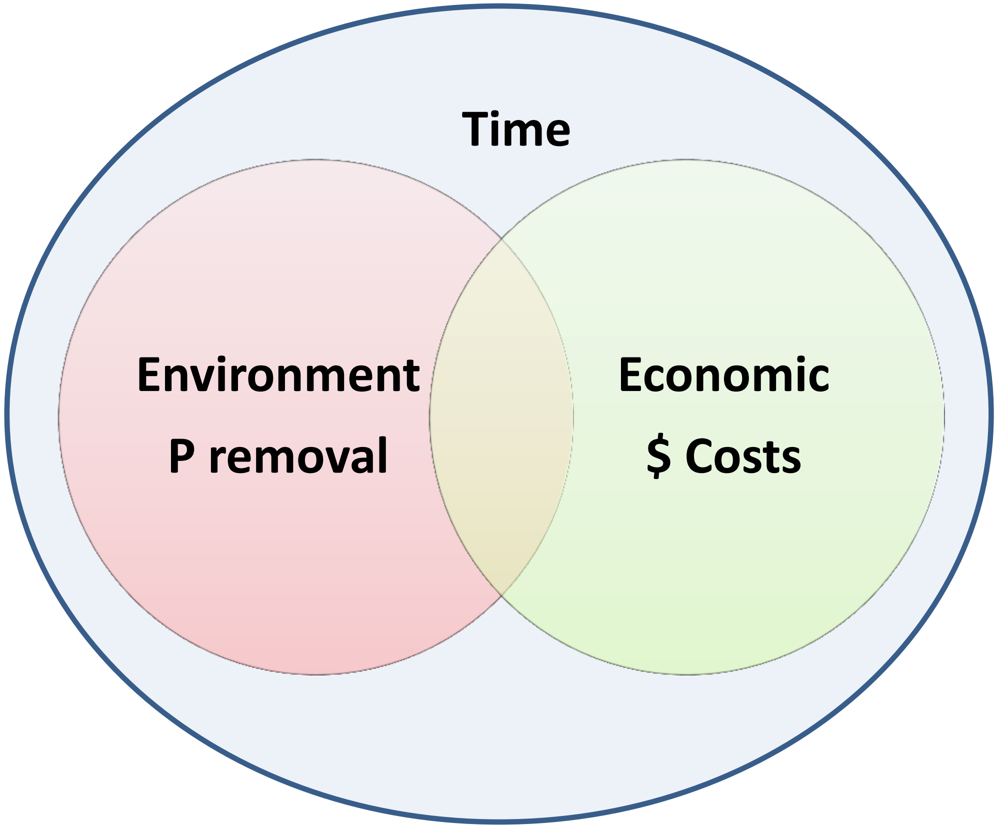
Data source and modified from: B. Kadlec; Kadlec and Wallace, 2008.

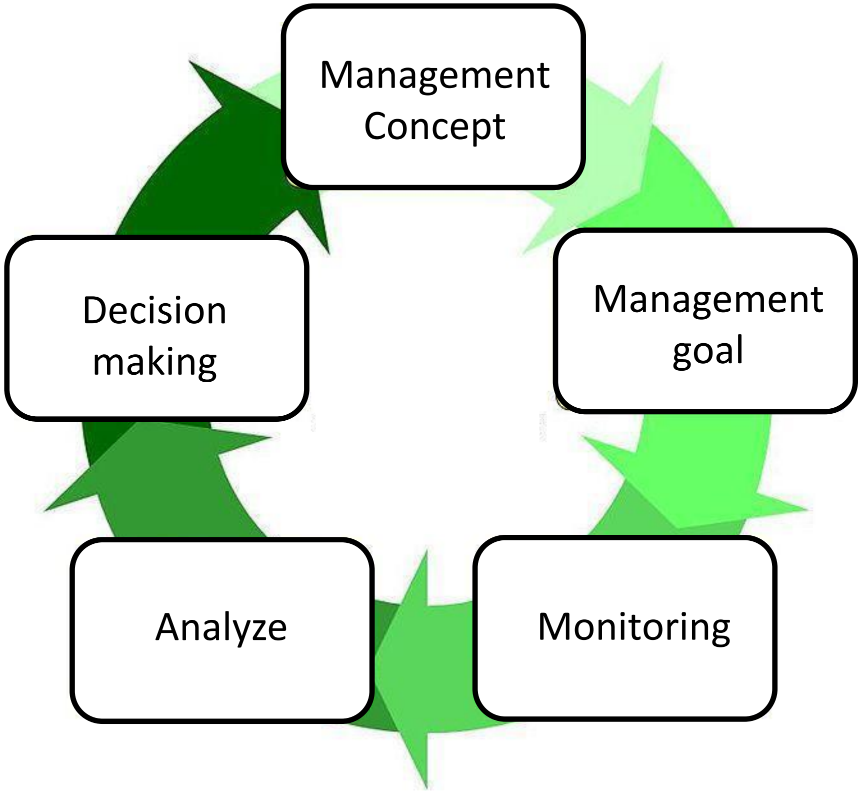
Capital costs for treating water



Data source and modified from: B. Kadlec; Kadlec and Wallace, 2008.

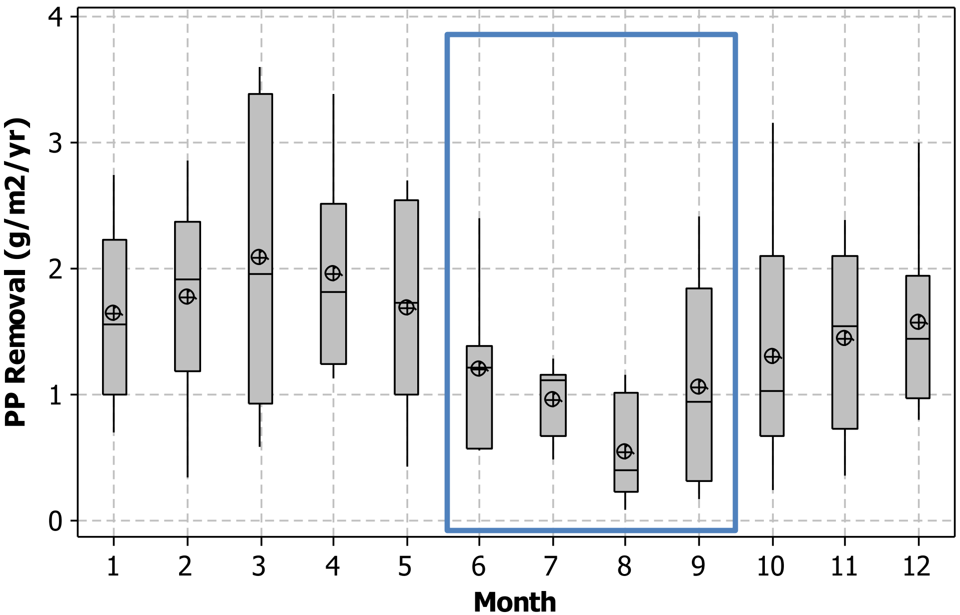
Incorporating sustainability into dynamic management of system





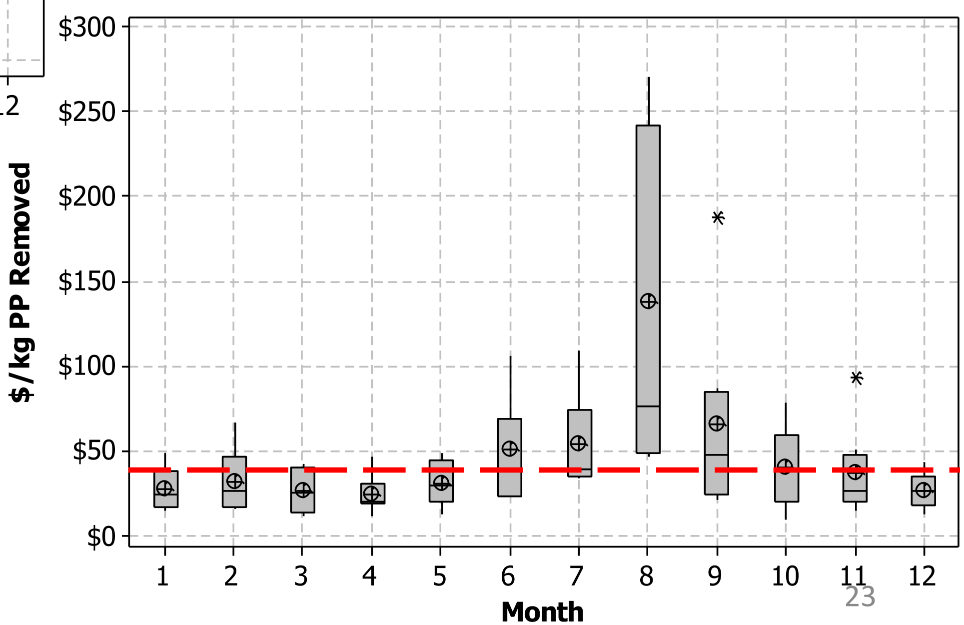
Patterns in MFW cost effective performance: How much is too much?

PP removal



Poor performance and increased cost during summer periods

Pumping Cost Per kg Removed



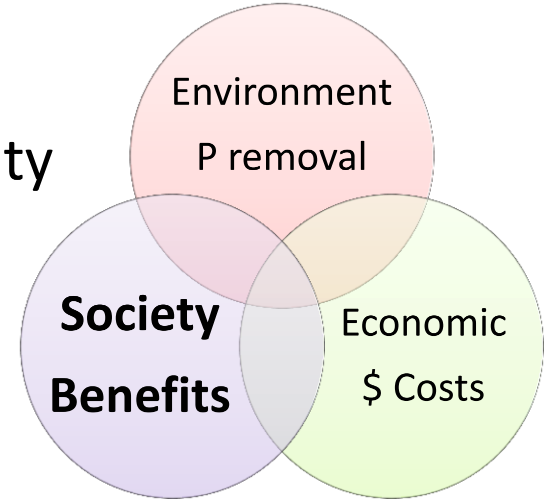
Management Scenario	TP Removed (kg yr^{-1})	Pumping Costs $ yr^{-1}	Cost $ kg^{-1}
All cells	2,900	$ 115,000	$40
No summer	2,700	$75,000	$28

Benefits of a wetland approach: *Ecosystem services*






- Provisioning
  - food, water, habitat
- Regulating
  - water quality
- Cultural
  - recreation
- Supporting
  - nutrient cycling, soil formation




Questions?