

# Stormwater Treatment Areas: Constructed Wetlands for Everglades Phosphorus Removal

August 19, 2005

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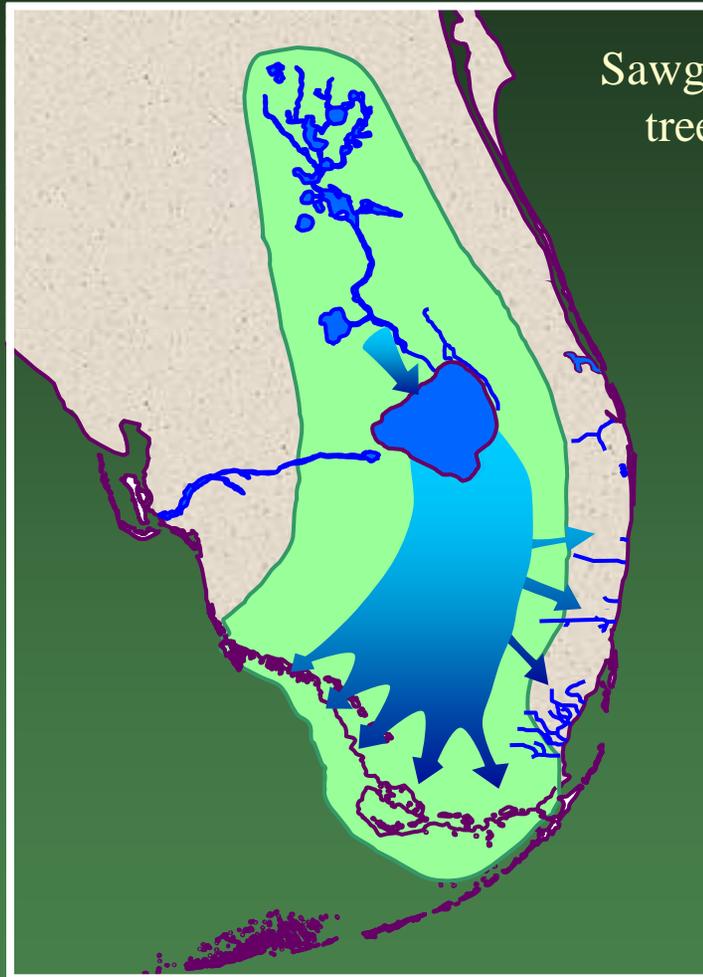
## Overview

- **Background**
- **Prototype constructed wetland**
- **Stormwater Treatment Areas (STAs)**
- **Future Water Quality Strategies**



# The Historic Everglades Ecosystem

## "River of Grass"



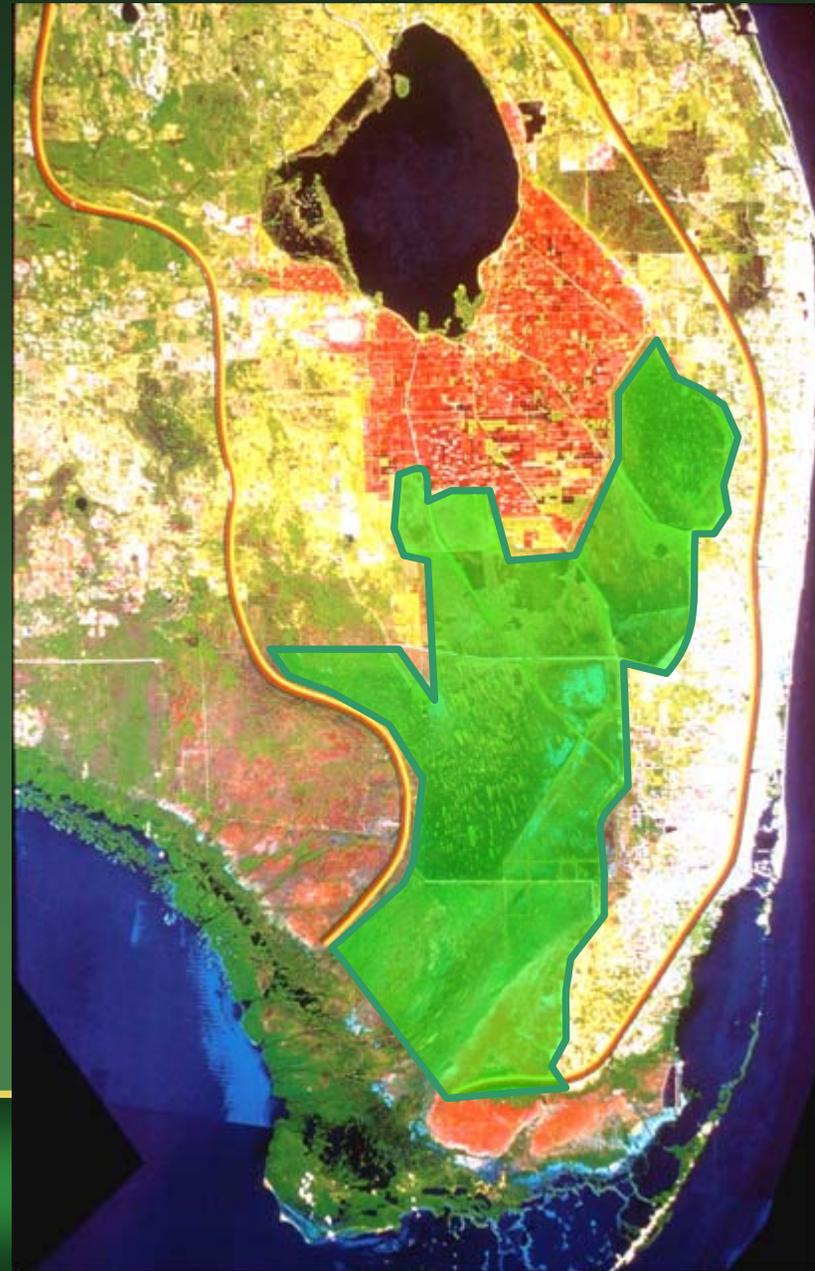
Sawgrass and  
tree islands



Sawgrass prairie &  
open water sloughs

## Major Problems Facing Everglades

- Loss of Everglades habitat
- Disruption of hydropatterns (i.e., timing, volume & distribution)
  - Repetitive water shortages and salt water intrusion
  - 1.7 billion gallons of water a day wasted to tide
- Degradation of water quality
- Exotic plant species



# Everglades Nutrient Removal Project

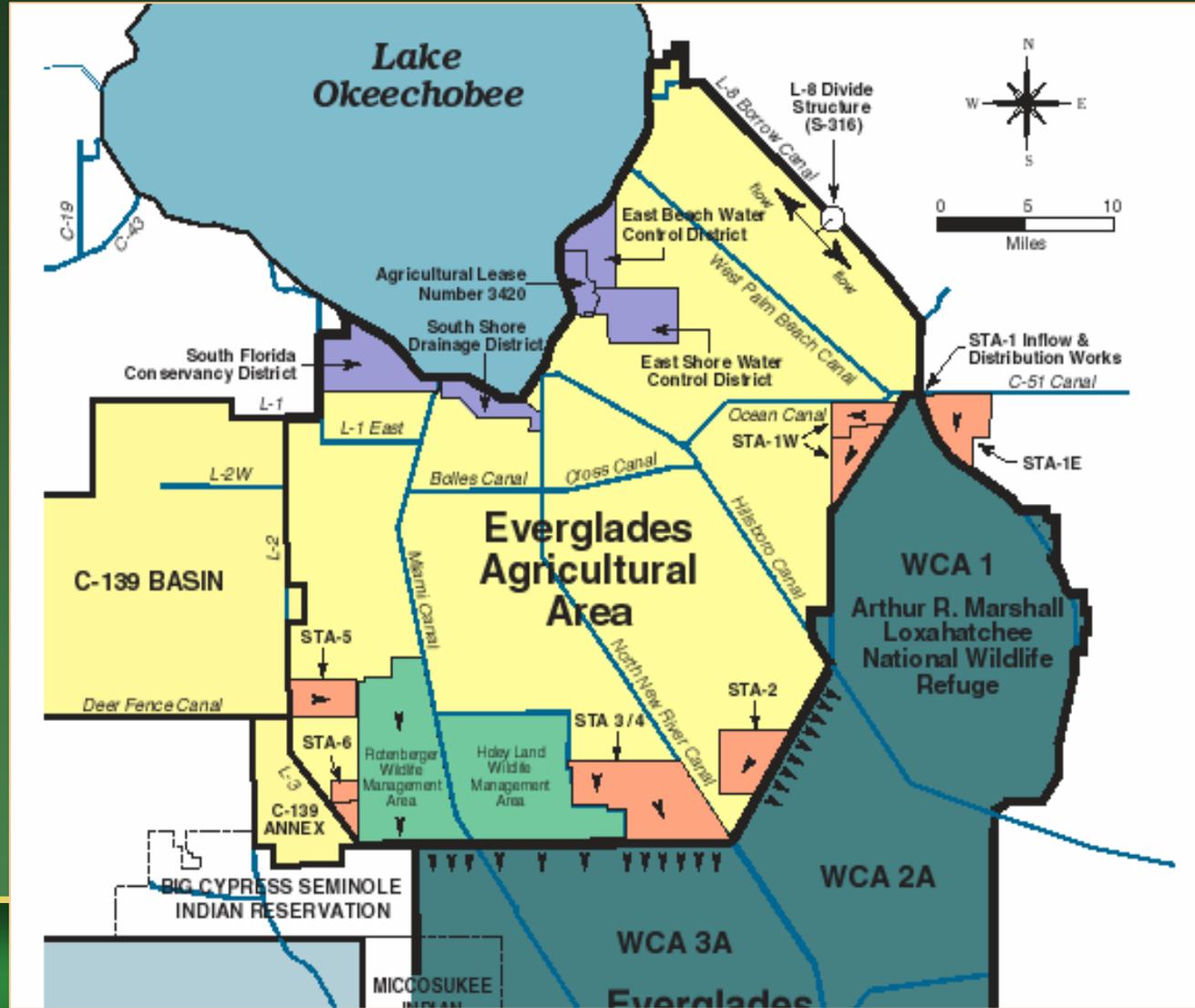


- Design target 50 ppb
- Model was unharvested cattail marsh in WCA 2A
- 2 flow paths compare performance of emergent vegetation with algae-dominated community
- Some planting; largely volunteer recruitment of vegetation
- Consistently reduced phosphorus to <25 ppb



# Everglades Construction Project

6 constructed wetlands  
>40,000 acres  
1.5 million AF/yr  
\$700 million  
>167 tons/yr TP removal



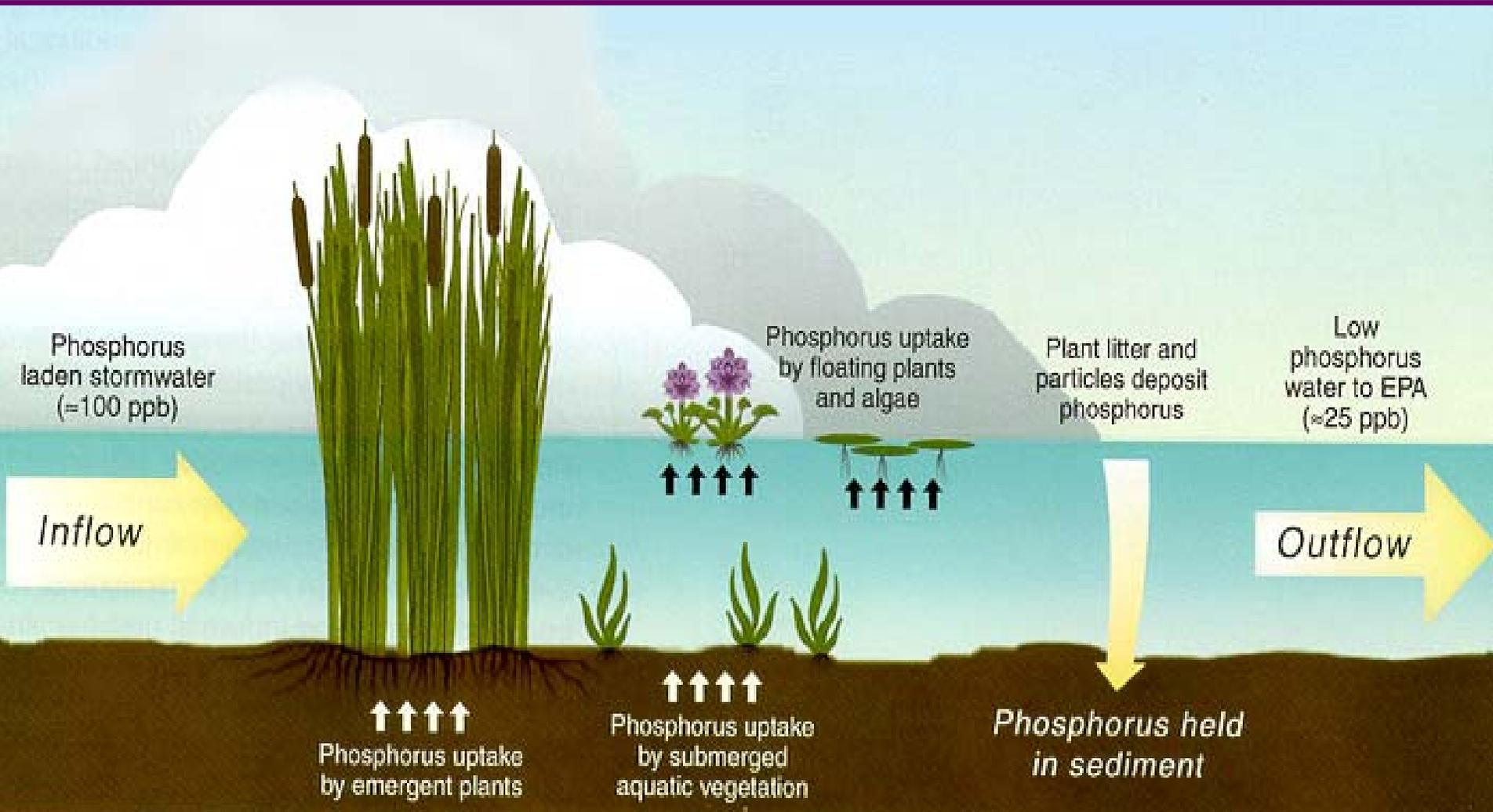
## Everglades Construction Project - Objectives

- Reduce phosphorus levels, in conjunction with EAA BMPs, to an average of 50 ppb
- Increase supply of water into Everglades
- Improve distribution of inflows to Everglades
- Maintain flood protection for tributary basins; improve flood protection in C-51W basin
- Reduce discharges of freshwater to estuaries
- Reduce local phosphorus loading to Lake Okeechobee



# Stormwater Treatment Areas

STAs are constructed wetlands that remove and store nutrients through plant growth and the accumulation of dead plant material in a layer of peat.



# STAs: Constructed Wetlands for Everglades Phosphorus Removal

Emergent Vegetation



Submerged Aquatic Vegetation



Periphyton-based Stormwater Treatment Area (PSTA)



## 1st Generation Design Model

$$d(QC) / dA = p C_p - S$$

Where Q = flow

C = water column phosphorus concentration

A = effective treatment area

p = precipitation

C<sub>p</sub> = atmospheric deposition of phosphorus

S = sediment accretion rate

Long-term phosphorus storage mechanism in the STAs



## Simplifying Assumptions

- Apparent background TP conc = atmospheric deposition TP conc
- Sediment accretion rate, assumed to be represented by first-order equation:
  - $S = K_e F_w C$
  - $K_e$  = effective settling rate
  - $F_w$  = wet period fraction (%)
- Effective settling rate ( $K_e$ ) is constant and independent of hydraulic and nutrient loading rates
- Area remains wet all year long ( $F_w = 100\%$ )
- Plug flow, no hydraulic short circuiting
- Negligible interaction with groundwater
- Used 10-year average annual values



## Sizing of the STAs

$$A = \frac{Q \left\{ \frac{(N C_i + K C_i - P C_p)}{(N C_o + K C_o - P C_p)} \right\} [1/(1 + K/N)]}{N} - Q$$

Where: A = effective treatment area

Q = 10-yr average annual flow

C<sub>i</sub> = 10-yr average annual inflow phosphorus concentration

C<sub>o</sub> = 10-yr average annual outflow phosphorus concentration (50 ppb)

K = effective settling rate (10.2 m/yr)

P = 10-yr average annual rainfall (1.233m/yr)

N = 10-yr average annual (rainfall - evapotranspiration) (0.083m/yr)

C<sub>p</sub> = 10-yr ave annual atmospheric deposition of phosphorus (50 ppb)



## Summary of STA Sizes

STA	Flow AF/yr	Load MT/yr	Size acres	Removal MT/yr
STA 1E	125,000	29	5,350	23
STA 1W	143,000	38	6,670	31
STA 2	175,000	34	6,430	25
STA-3/4	600,000	87	16,480	53
STA 5	78,000	25	4,118	21
STA 6	54,000	13	2,280	10



# Treatment Area Hydraulics

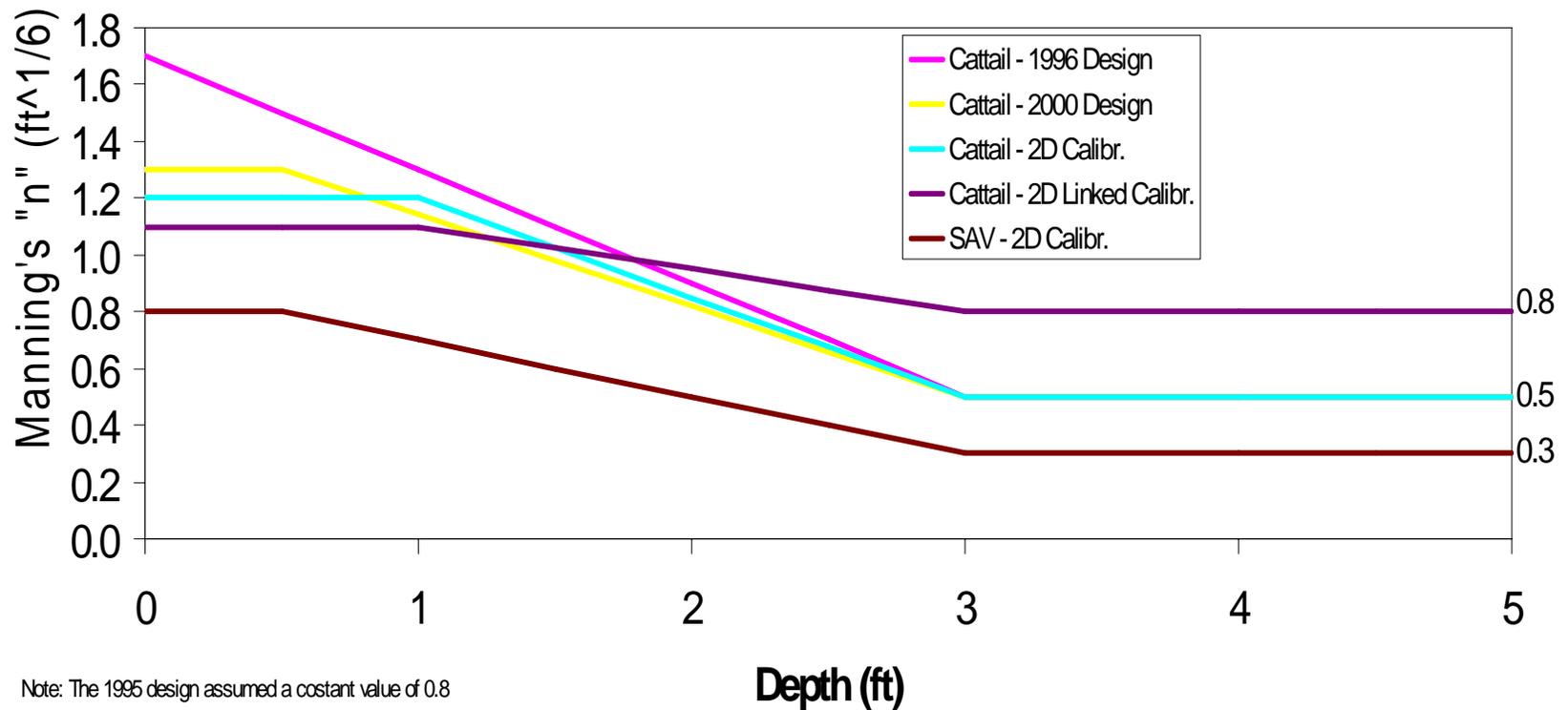
- **Minimum depth of 6 inches to prevent dryout**
  - Prevent oxidation and mobilization
  - Requires supplemental water
- **Target depths designed to mimic depth exceedence relationship in WCA 2A**
- **Initial - average depth of 2 feet**
  - Problems with large areas of floating cattails
  - Recently lowered to 1.25 and 1.5 ft
- **Maximum depth of 4.5 feet**
- **Hydraulic residence times of 2-3 weeks**



# STAs: Constructed Wetlands for Everglades Phosphorus Removal

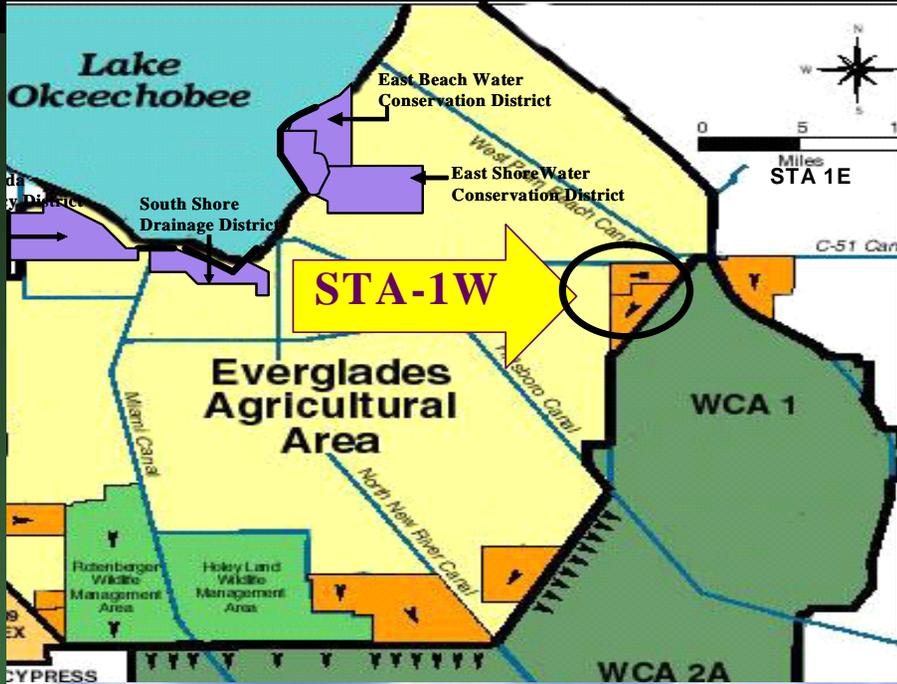
Vegetation resistance - Manning's "n" depth dependent; long flow paths (up to 5 miles) with dense vegetation

## Estimates of Manning's "n"



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**Inflow structure  
for STA 1W**



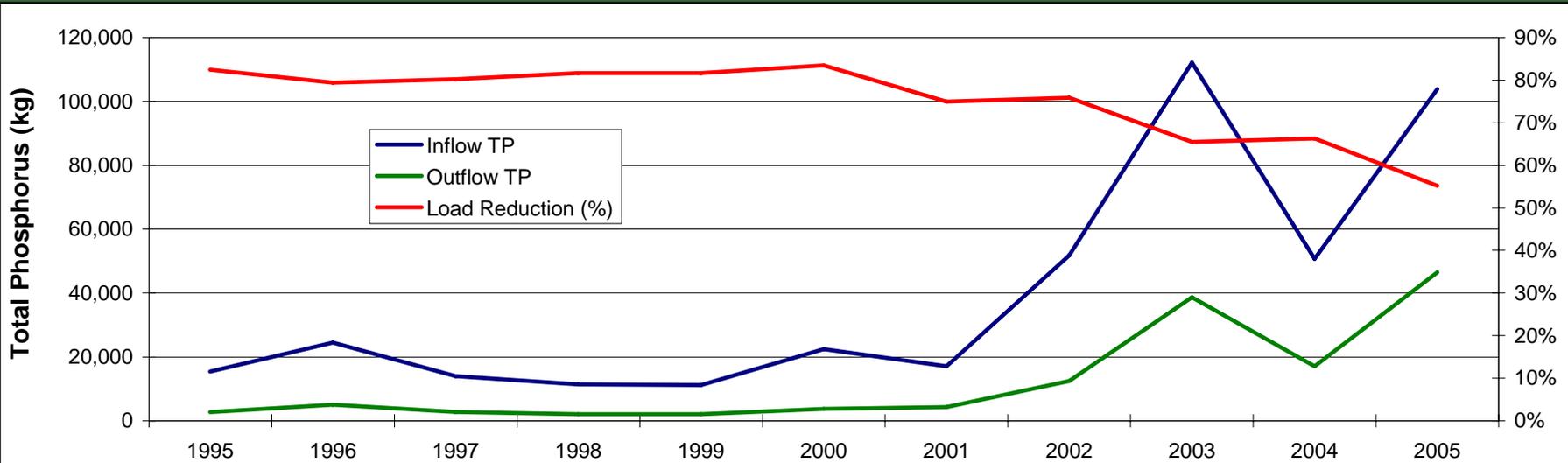
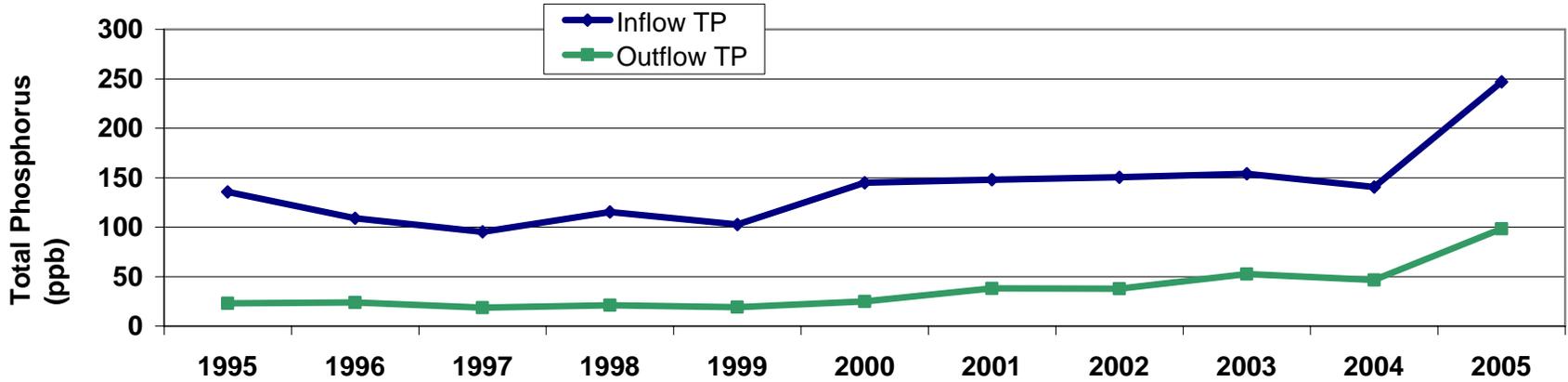
**Limerock berm**



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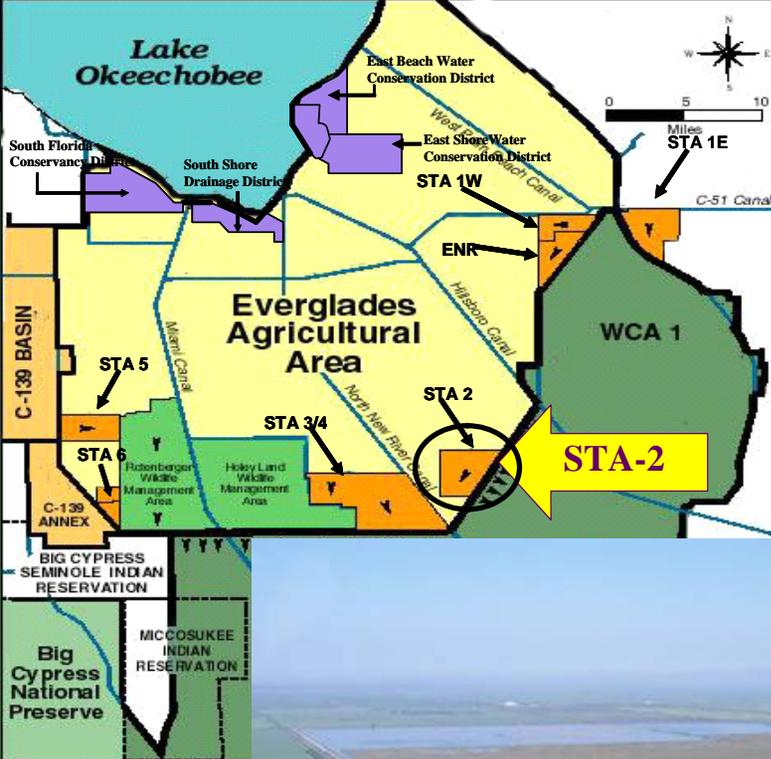
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## STA-1W Phosphorus Concentrations



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# Plans for Everglades Phosphorus Removal



**STA-2**  
**6,430 acres**  
**3 parallel flow-ways**

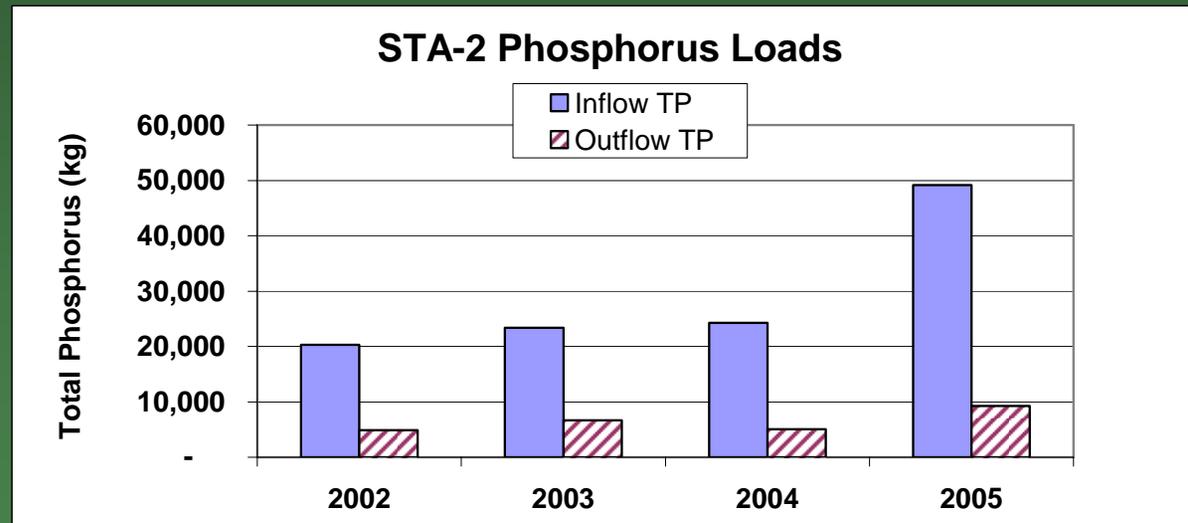
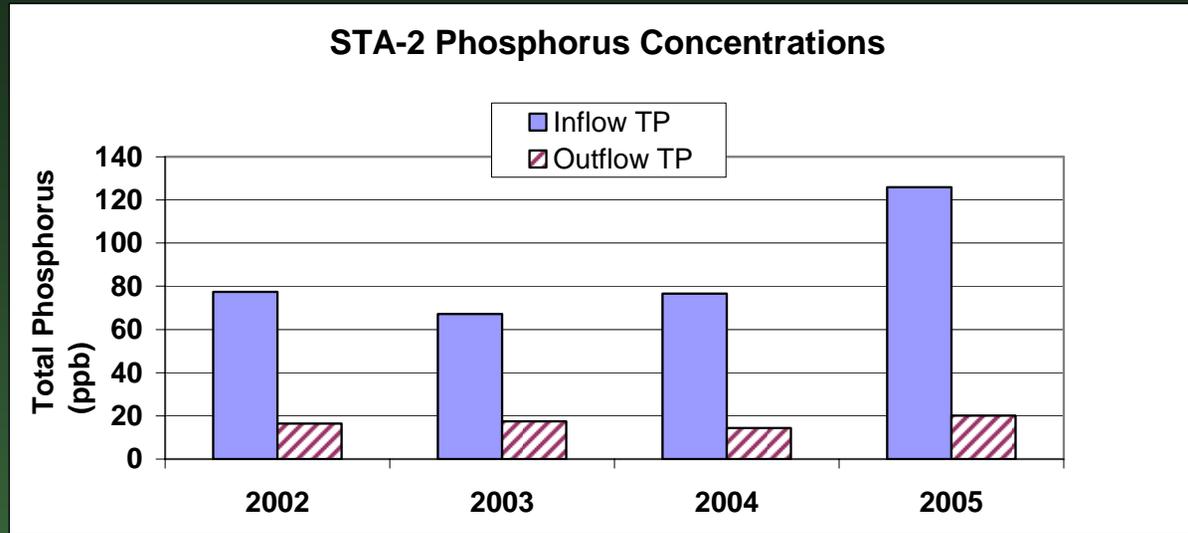


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STA-2 has a mixture of emergent & submerged vegetation



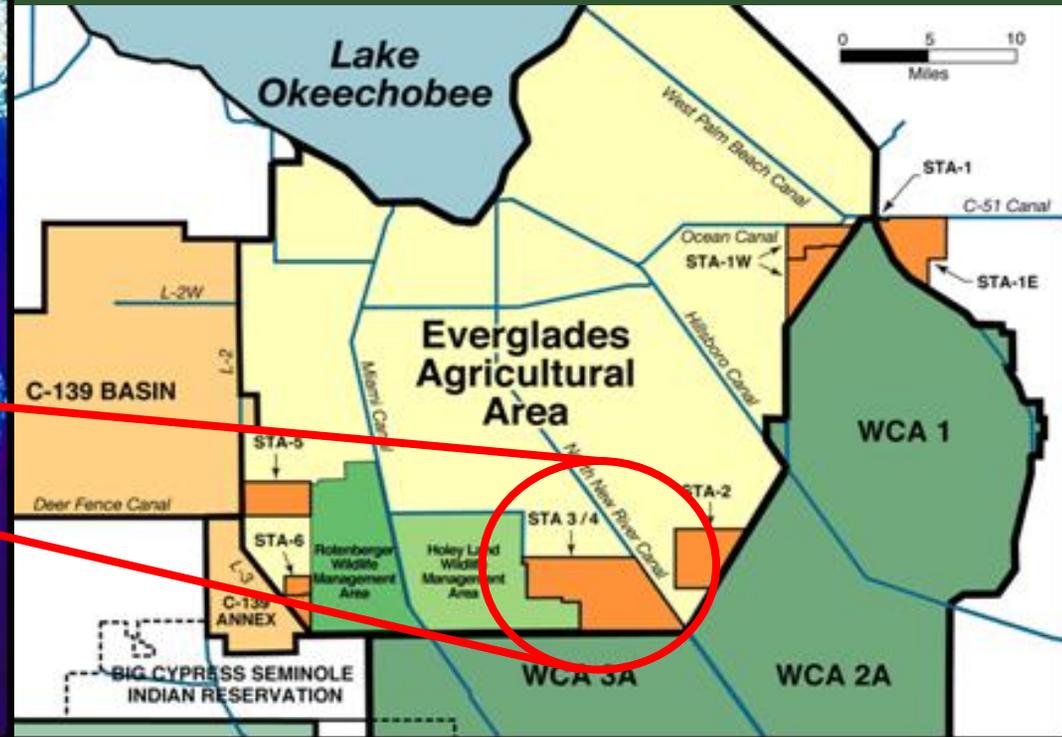
# STAs: Constructed Wetlands for Everglades Phosphorus Removal



# STAs: Constructed Wetlands for Everglades Phosphorus Removal



**Stormwater Treatment Area 3/4** is the world's largest constructed wetland! Over 16,500 acres of former agricultural land has been converted to a biological treatment system designed to remove over 55 tons per year of phosphorus from water entering the Everglades.



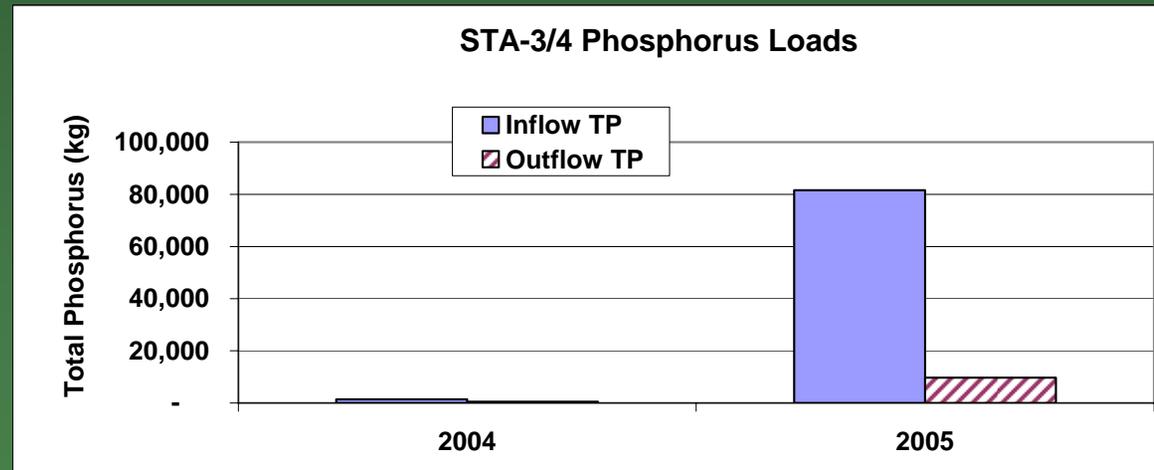
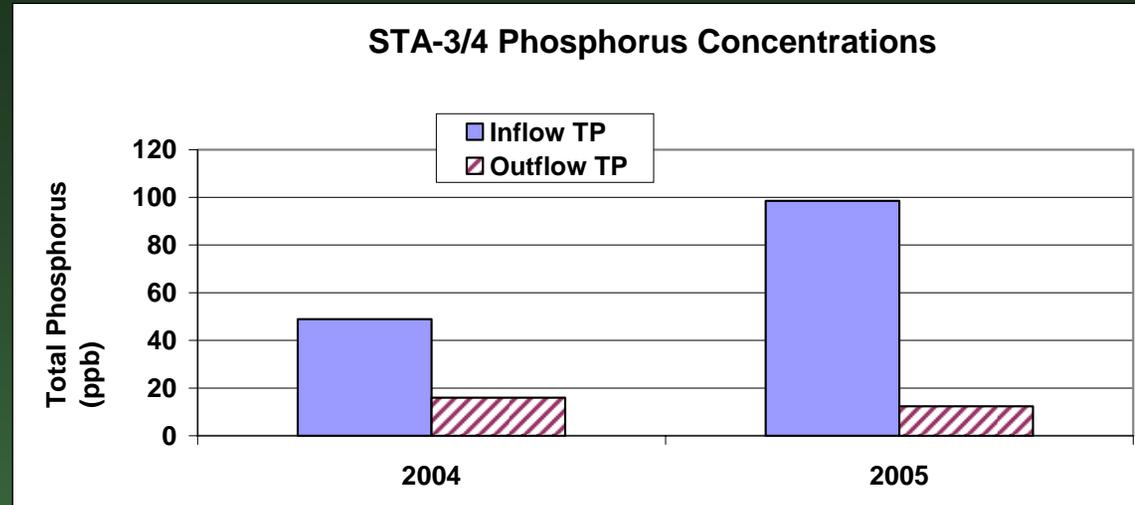
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# STA-3/4 – 3 parallel flow-ways with emergent vegetation followed by SAV

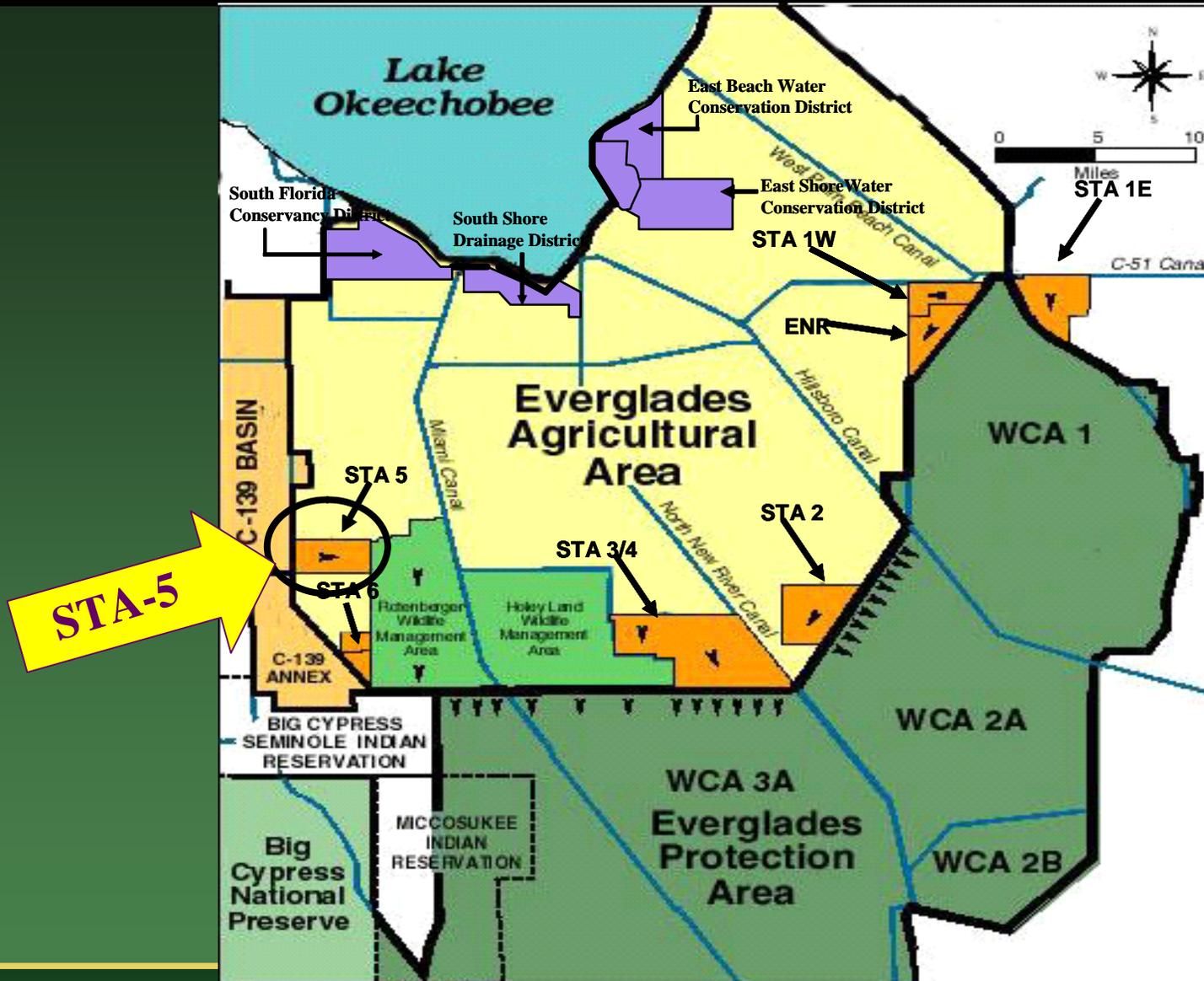


# STAs: Constructed Wetlands for Everglades Phosphorus Removal

**Performance during the initial 15 months has been incredible:**  
**695,000 AF**  
**13 ppb**  
**>72 tons removed!**



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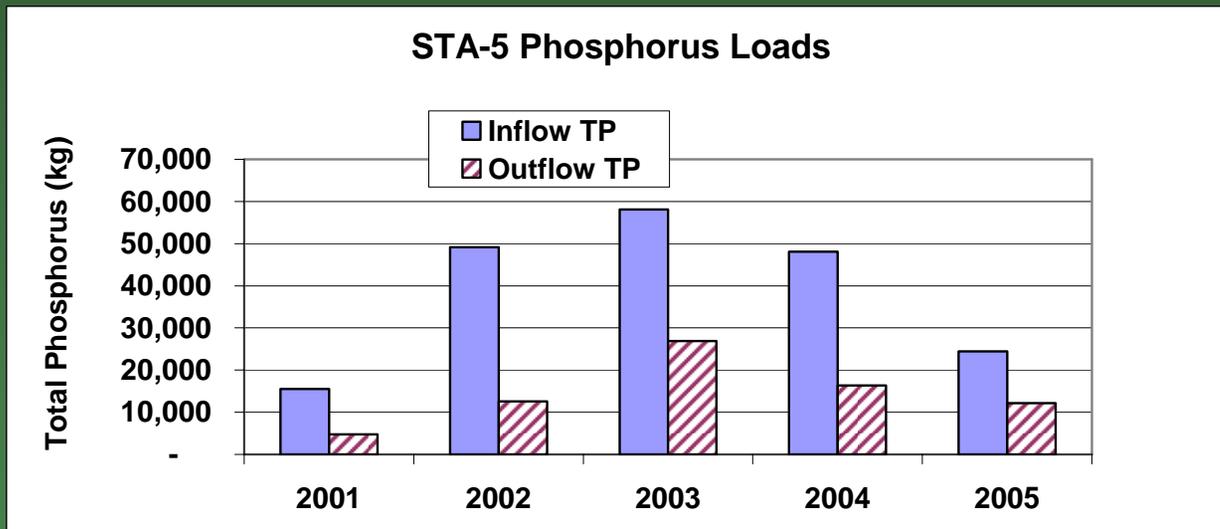
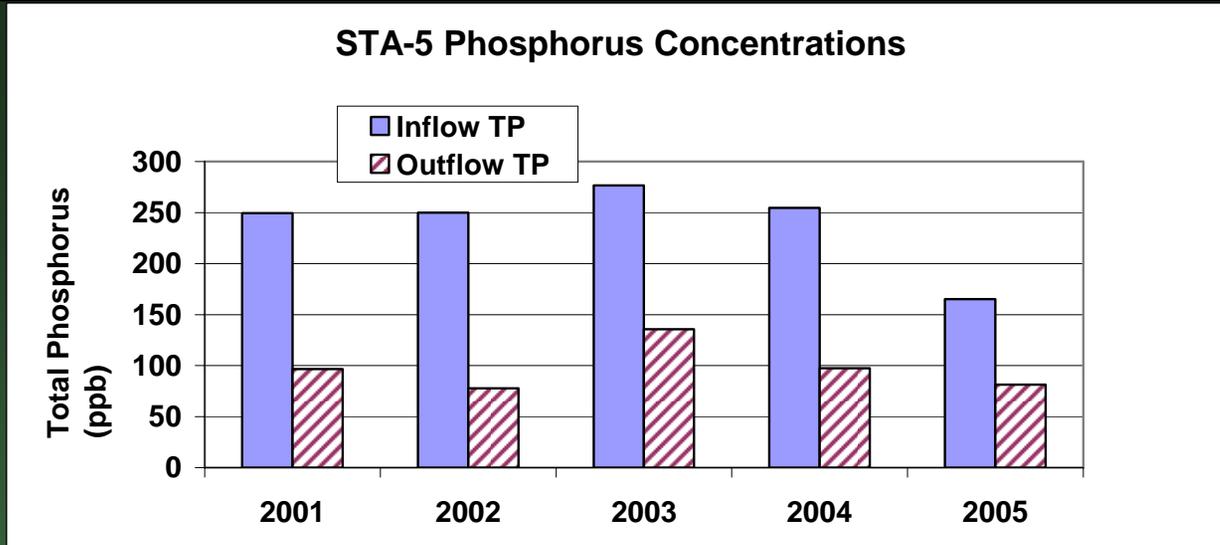


## STA-5

- **4,118 acres of effective treatment area**
- **Parallel flow-ways: emergent and the emergent followed by SAV**



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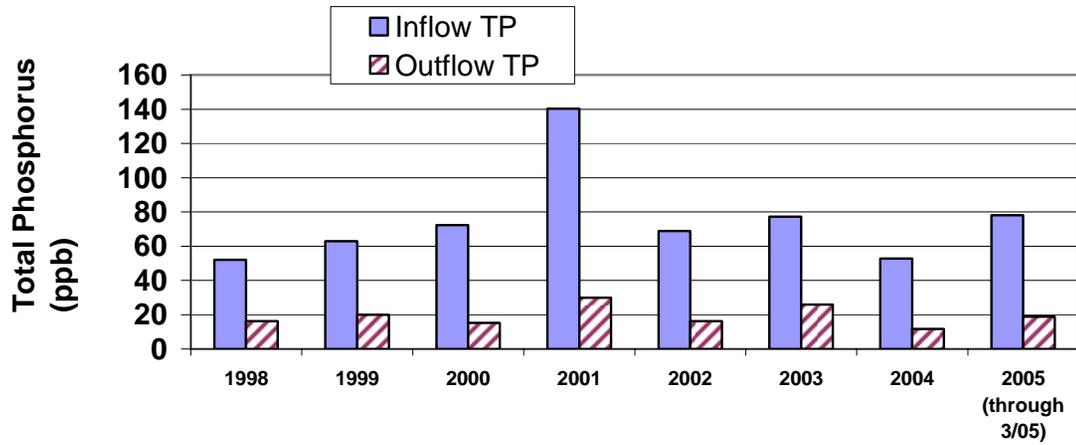
**STA-6**



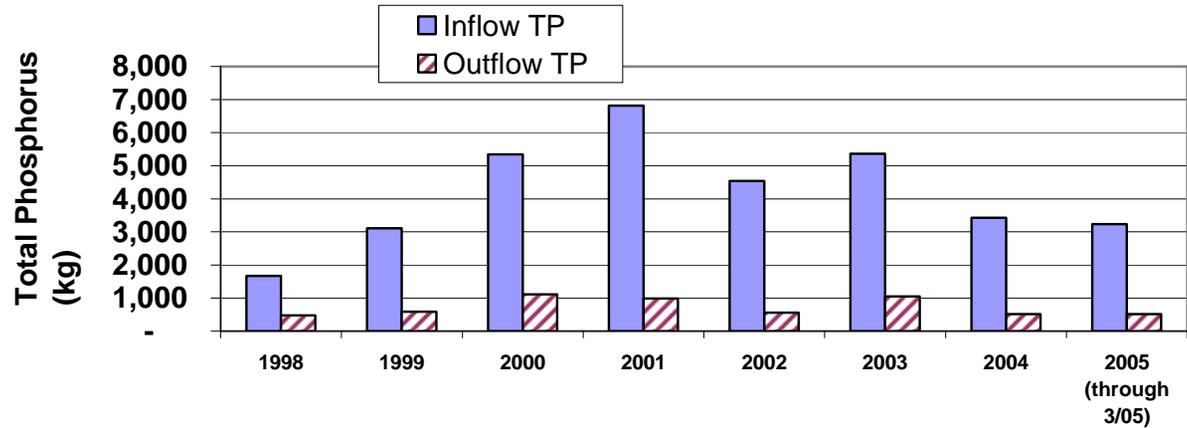
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## STA-6 Phosphorus Concentrations



## STA-6 Phosphorus Loads

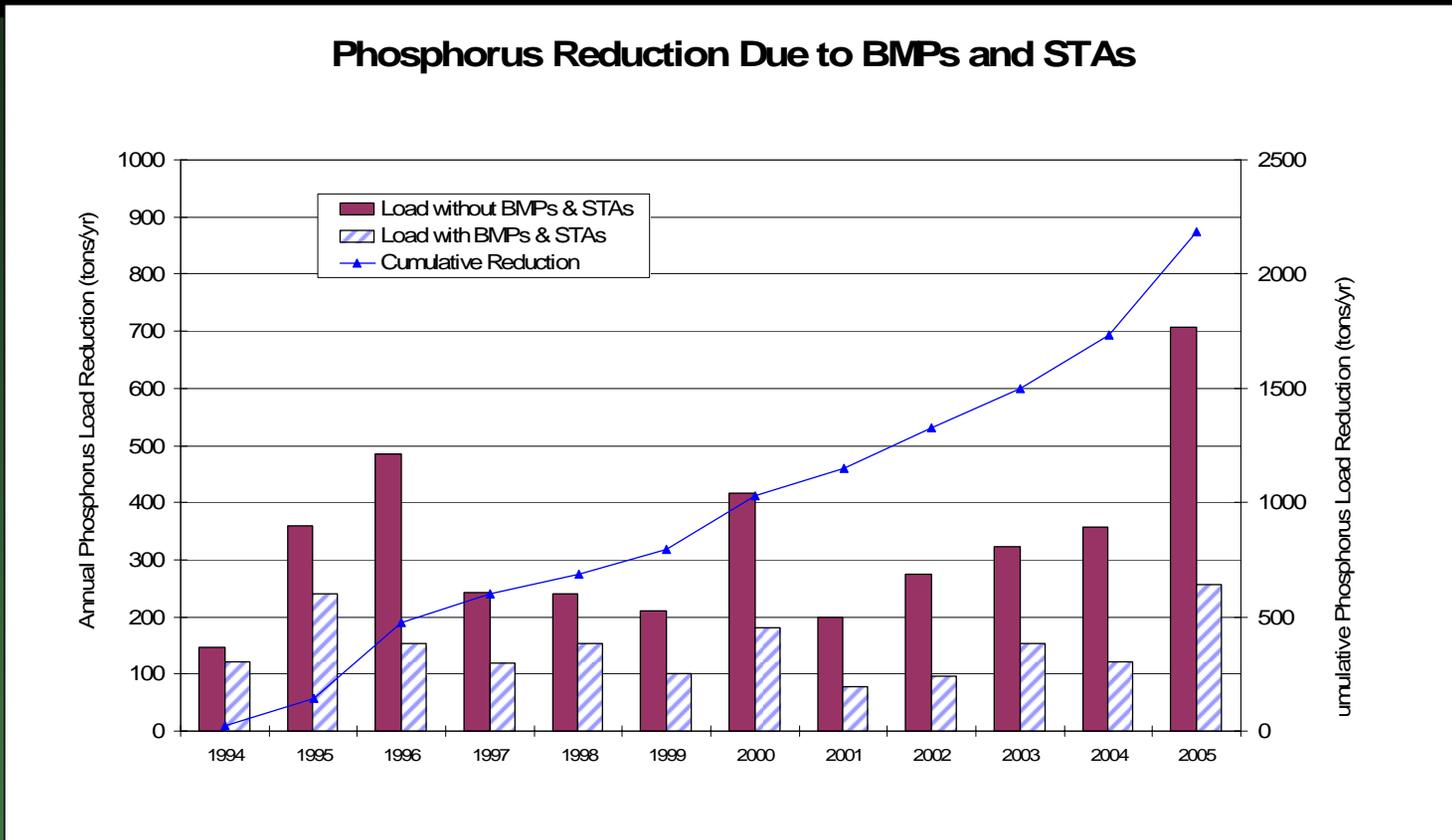


## Summary of Performance (through May 2005)

- In general, performance has exceeded expectation – outflow has averaged 41 ppb
  - STA-1W: 48 ppb – severely impacted by hurricanes
  - STA-2: 17 ppb
  - STA-3/4: 13 ppb
  - *STA-5: 100 ppb*
  - STA-6: 19 ppb
- 611 metric tons removed; 71% removal
- Removal influenced by nutrient loading rate, inflow concentrations, soils, vegetation and hydraulic loading rate, depth



# STAs: Constructed Wetlands for Everglades Phosphorus Removal



**Despite success of EAA BMPs and STAs, need additional water quality improvement measures to achieve compliance with phosphorus standard by Dec. 31, 2006**



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# STA Optimization Research

- **Advanced treatment technologies**
  - **Narrowed down from dozens to less than 10**
  - **Supplemental Technology Standard of Comparison**
- **Results used by basin feasibility studies in evaluating alternative enhancements**
- **Continues today with full-scale monitoring and PSTA demonstration projects**



# Additional Water Quality Solutions

- Expansion of BMPs (esp. urban basins)
- Expansion of STAs
- Enhancement of STAs
  - Vegetation conversion to SAV
  - Compartmentalization
  - Operations to balance flow and loads
  - Continue strong science-based program to optimize performance
- Synchronization with CERP projects
- *ADAPTIVE MANAGEMENT*
- *Collectively referred to as “Long-Term Plan”*



# STAs: Constructed Wetlands for Everglades Phosphorus Removal



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## For More Information:

- **www.sfwmd.gov**
  - Everglades Restoration
  - Everglades Construction Project
  - Long-Term Plan ([sfwmd.gov/org/erd/longtermpplan/index.shtml](http://www.sfwmd.gov/org/erd/longtermpplan/index.shtml))
- **South Florida Environmental Report**
  - Summary of all available data
  - <http://www.sfwmd.gov/org/ema/everglades/index.html>
- **Gary Goforth**
  - [www.garygoforth.net](http://www.garygoforth.net)



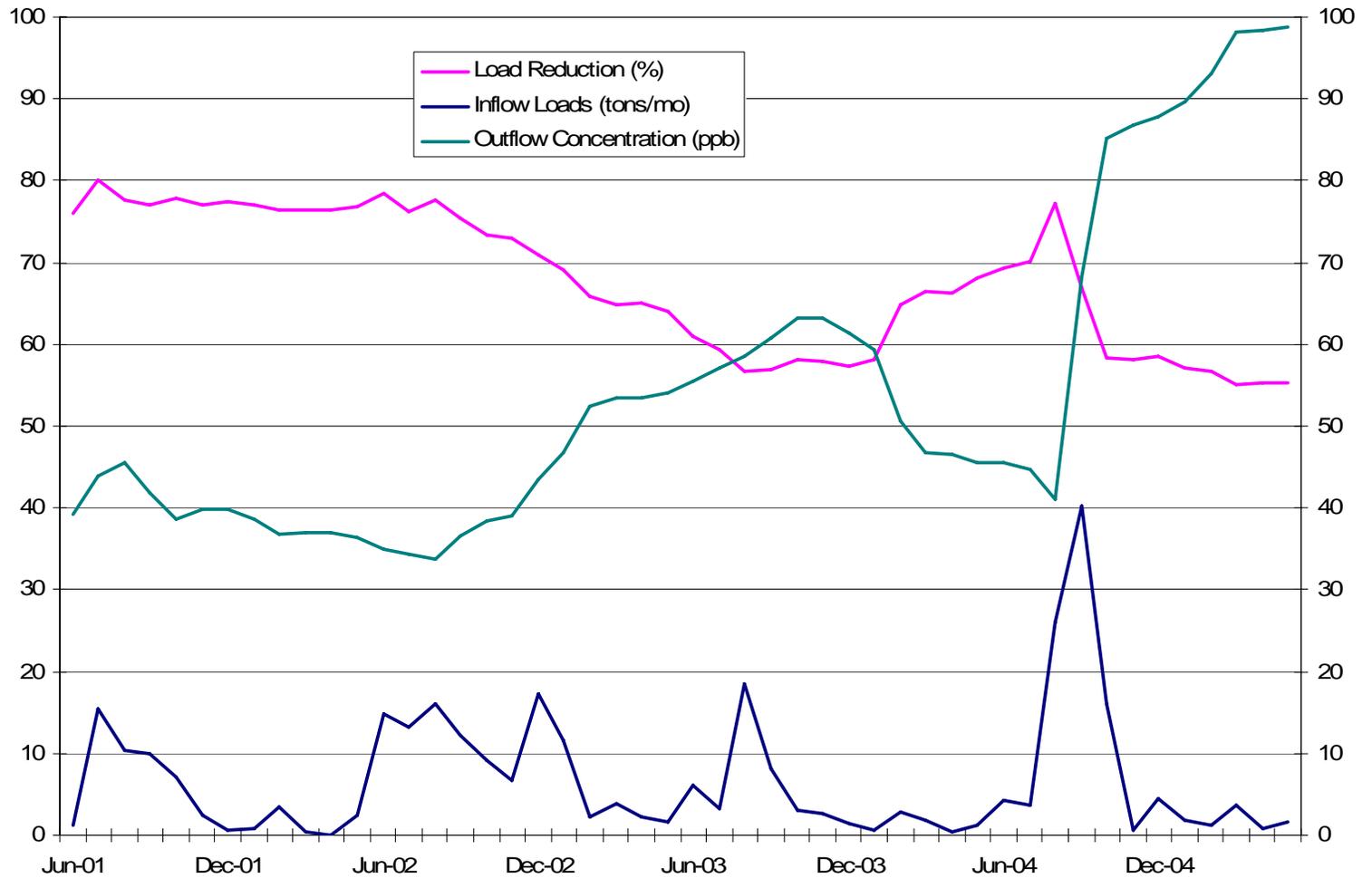
# Hurricane Impacts – Sept. 2004

- **Glancing blows from Hurricanes Frances, Ivan and Jeanne**
- **In general, STAs performed well**
  - **Inflow: 411,000 acre feet & 95 tons of phosphorus**
    - 30% of annual flows; 60% of annual loads
  - 65 m tons removed (68%); average outflow = 54 ppb
  - **STA-1W**
  - **Inflow: 70% of annual flows; 150% of annual loads**
  - 20 m tons removed; average outflow = 127 ppb
  - **Recovery Plan being implemented**
    - **Divert flows to other STAs**
    - **Restricted inflows to 5% of maximum – diversion to Refuge**
    - **Additional monitoring and assessment**



# STAs: Constructed Wetlands for Everglades Phosphorus Removal

## STA-1W Phosphorus Removal Performance



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