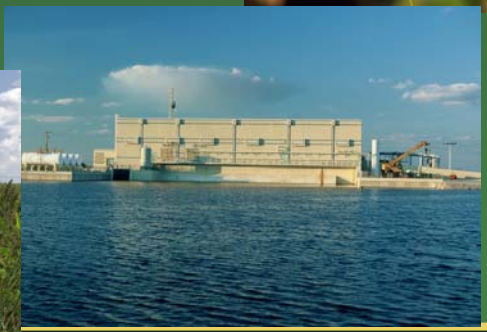
10-year Summary of the Performance of the Everglades Stormwater Treatment Areas

February 18, 2005

Gary Goforth, P.E., Ph.D.



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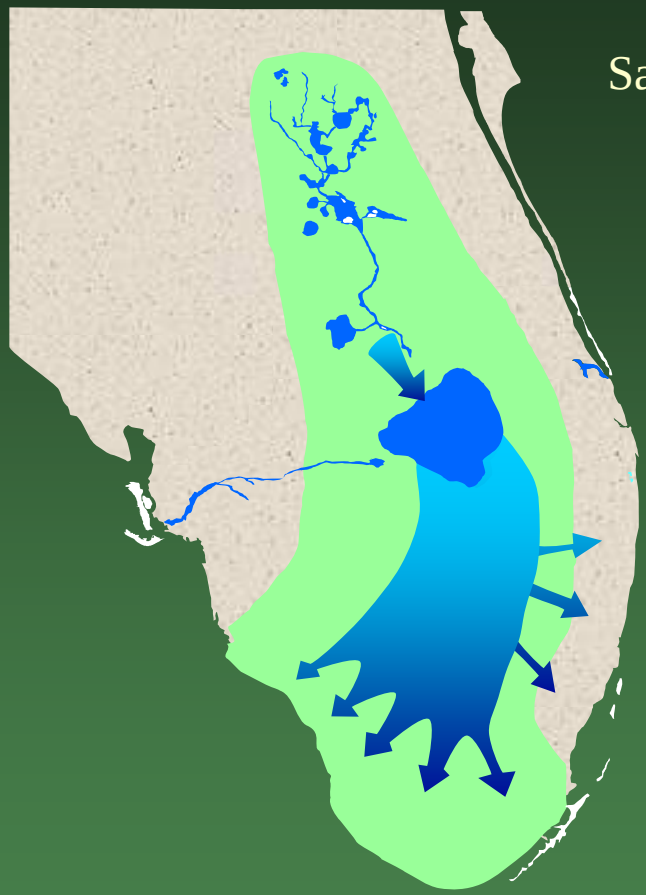
Overview

- Everglades Restoration Background
- Everglades Construction Project
- Stormwater Treatment Area Performance

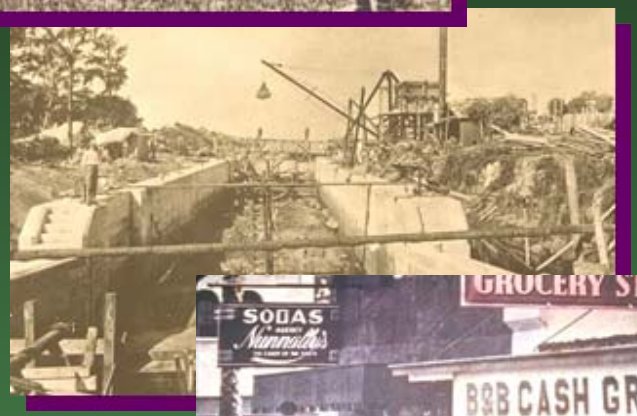
The Historic Everglades Ecosystem

"River of Grass"



Sawgrass and tree islands

Sawgrass prairie & open water sloughs

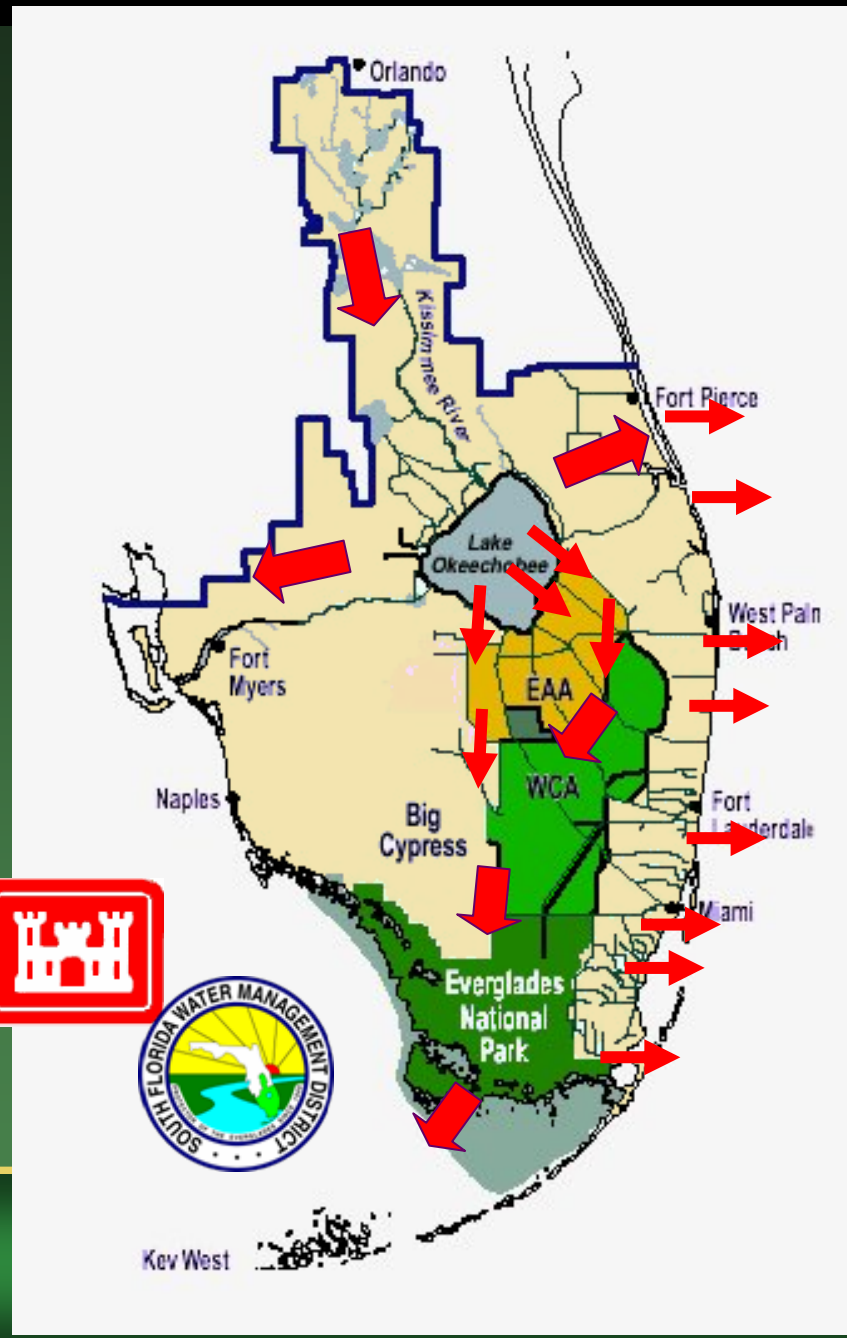


History

- Settlement in south Florida increased in the late 1800's
  - Navigation Improvements
- Everglades Drainage District
  - Initial drainage works improved development opportunities
  - Severe floods & droughts persisted

The Central and South Florida Project

- Early drainage projects began in late 1880s
- Storms of 1920s and 1940s highlighted deficiencies
- Initially authorized in 1948
- Constructed between 1950's and 1970's
- Operated in accordance with USACE criteria



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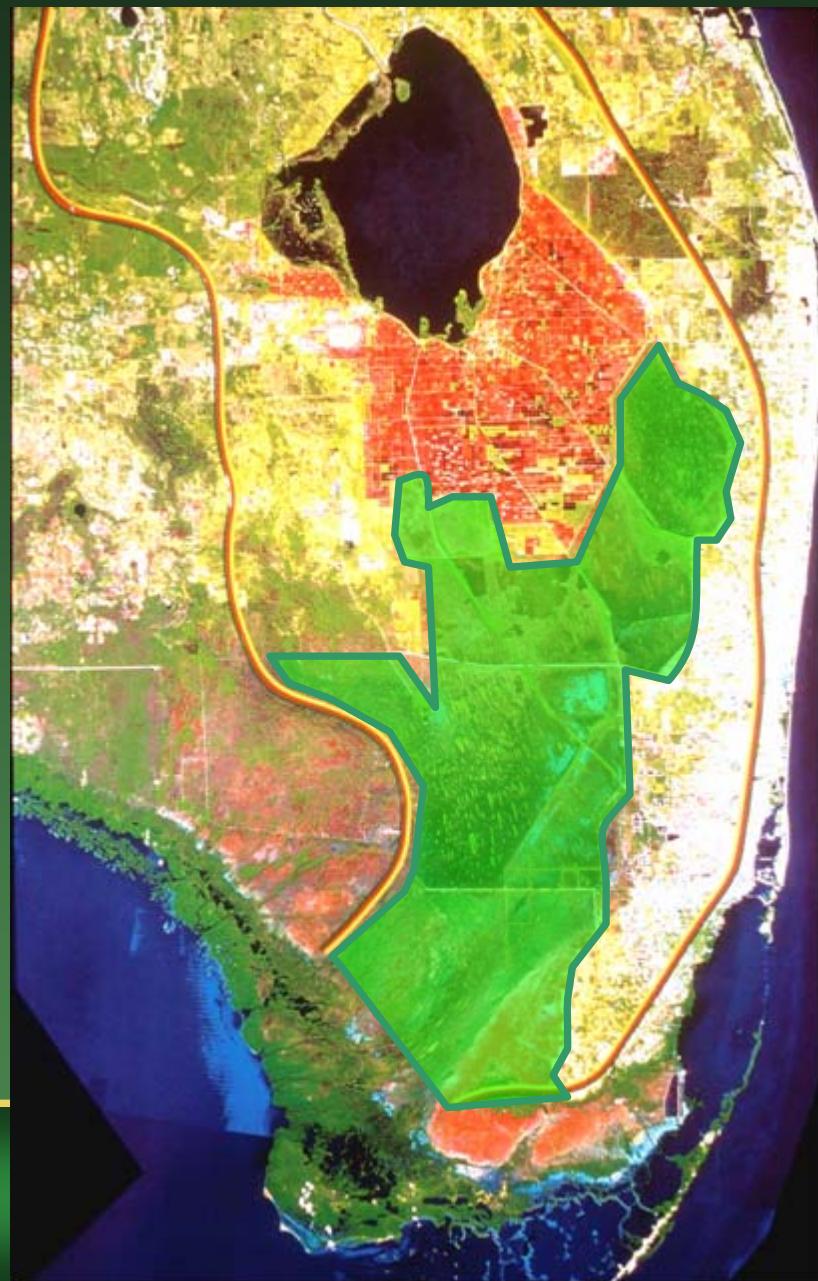
Major Problems Facing Everglades

- 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 Restoration

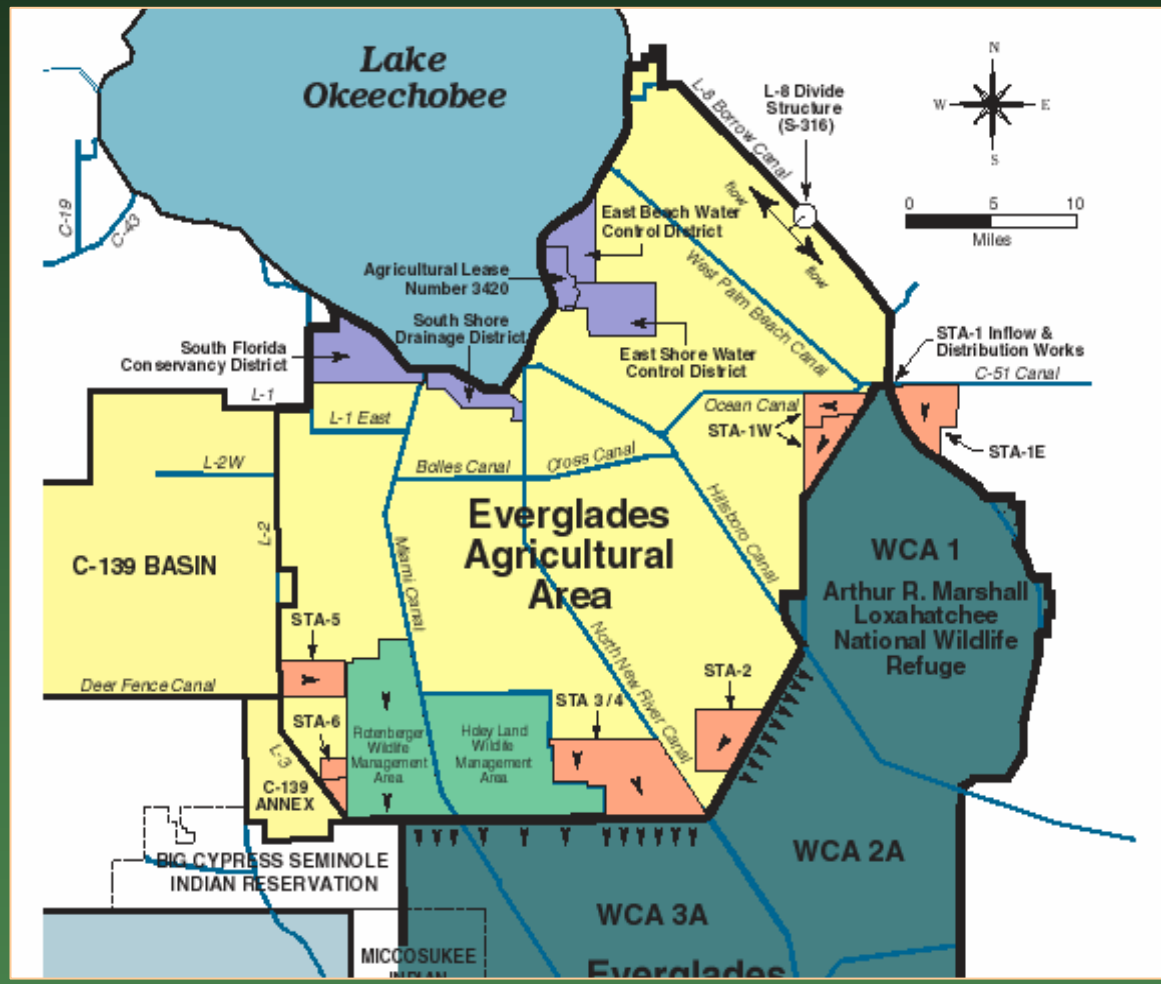
- Two initiatives:
  - Everglades Forever Act – primary focus is water quality, with some quantity and distribution features
  - Comprehensive Everglades Restoration Plan – primary focus is water quantity and distribution, with some water quality features
- This presentation will cover the Everglades Forever Act restoration program

Everglades Forever Act

- 1991, amended 1994 and 2003
- Achieve state water quality standards by 12/31/06
- Construction
  - *Stormwater Treatment Areas*
  - Diversion and hydropattern restoration
- Research
  - Phosphorus criterion research
  - Advanced treatment technology research
- Regulation
  - *Best Management Practices (BMPs)*

Everglades Construction Project

- 6 STAs
- Over 40,000 acres of constructed wetlands
- Capture and treat 75% of the water entering the Everglades



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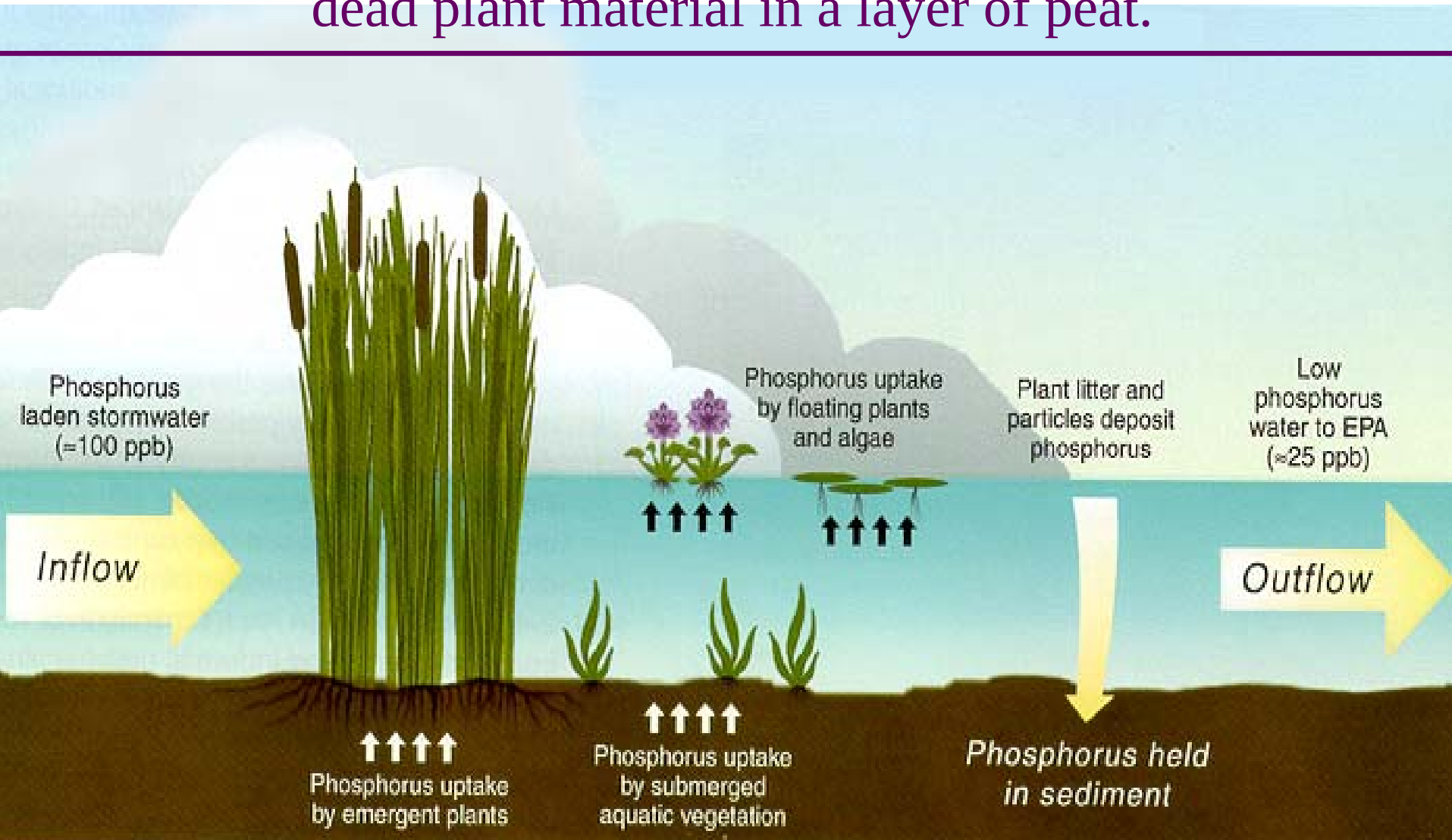
Everglades Construction Project - Objectives

- 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.

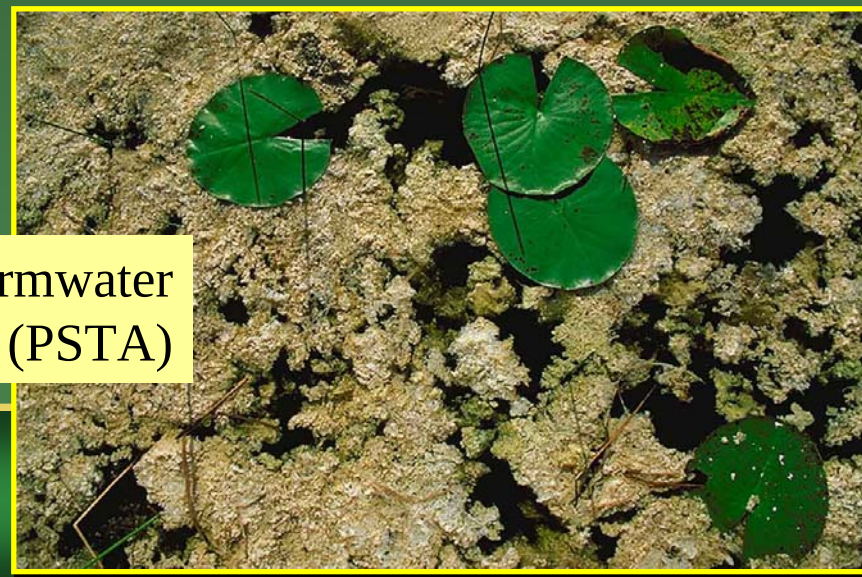


Summary of 10 Years of STA Performance

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_p = atmospheric deposition of phosphorus

S = sediment accretion rate

S = 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 faction (%)
- 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

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

Where: **A** = effective treatment area

Q = 10-yr average annual flow

$\mathbf{C_i}$ = 10-yr average annual inflow phosphorus concentration

$\mathbf{C_o}$ = 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)**

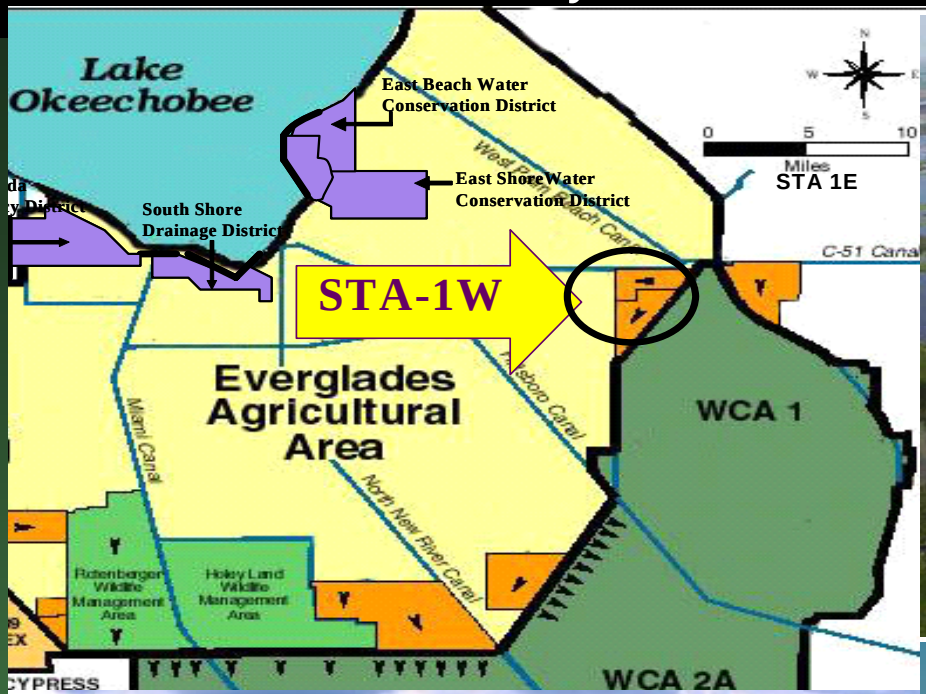
N = 10-yr average annual (rainfall - evapotranspiration) **(0.083m/yr)**

$\mathbf{C_p}$ = 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

Summary of 10 Years of STA Performance



Summary of 10 Years of STA Performance

Inflow structure for STA 1W

Limerock berm

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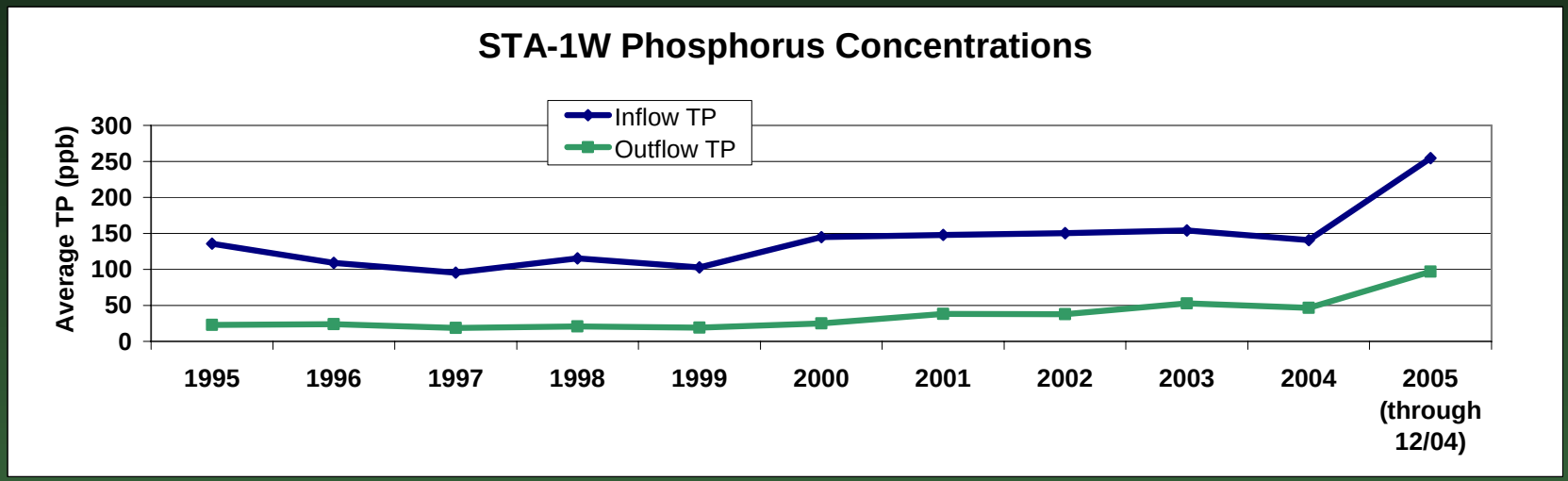
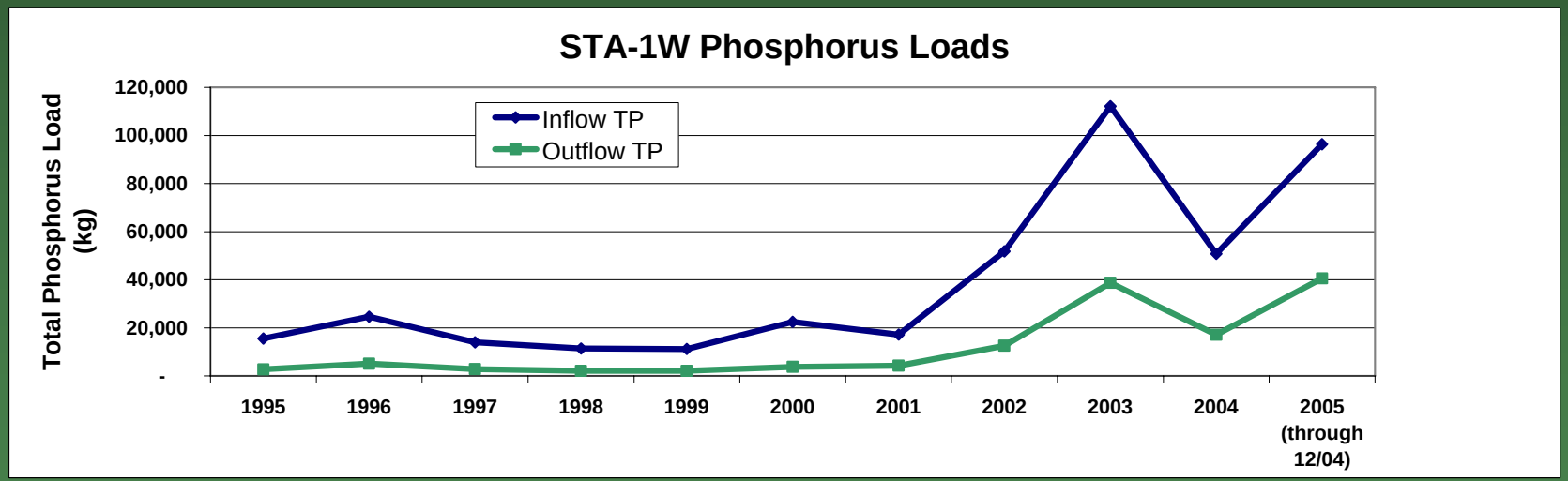
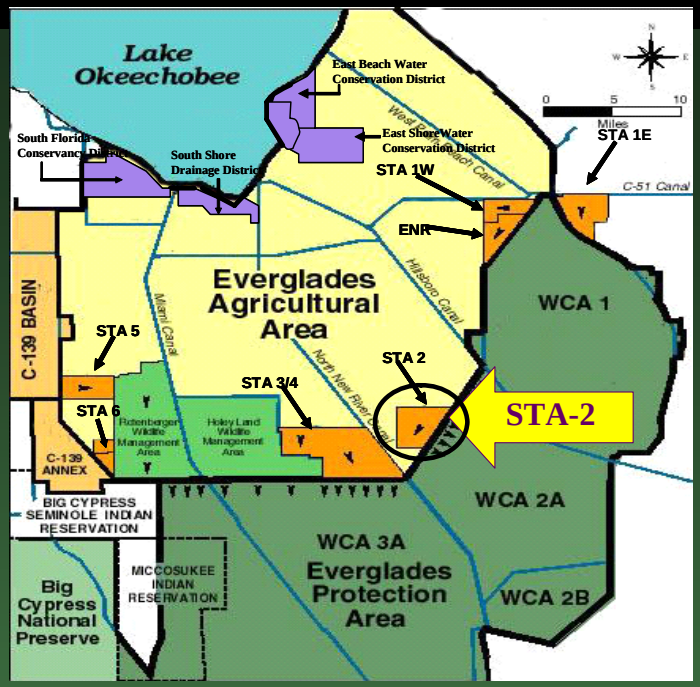
Summary of 10 Years of STA Performance





Summary of 10 Years of STA Performance



STA-2

- 6,430 acres of effective treatment area
- Parallel flow-ways: emergent followed by SAV

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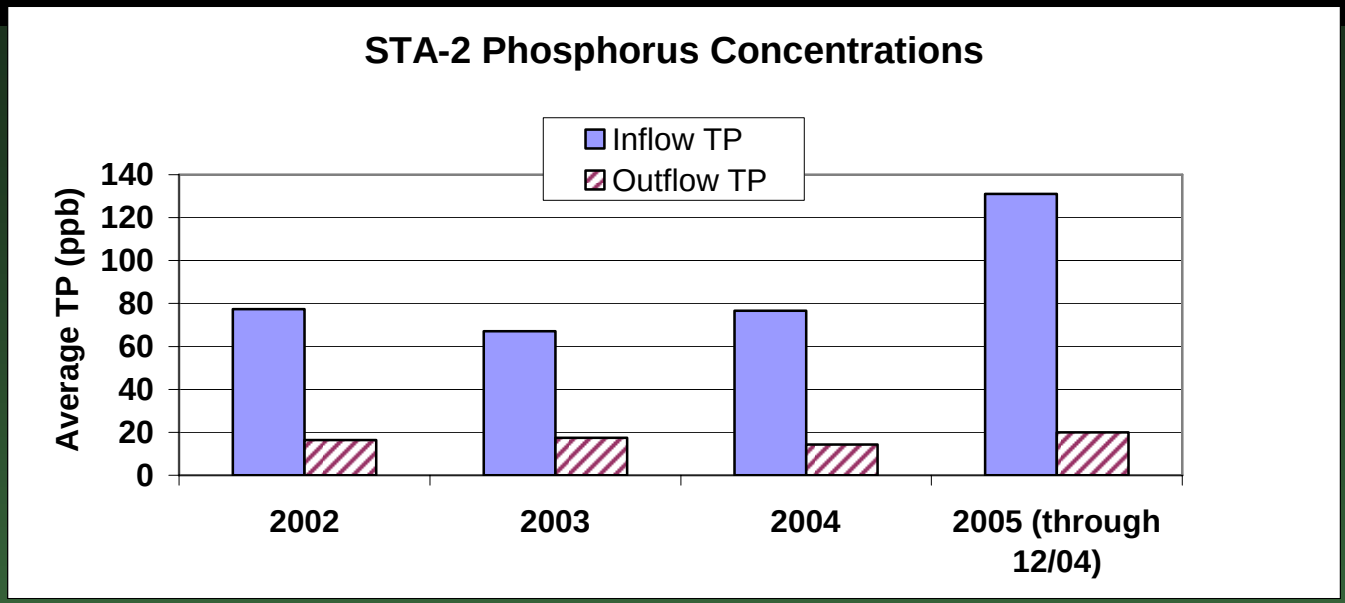
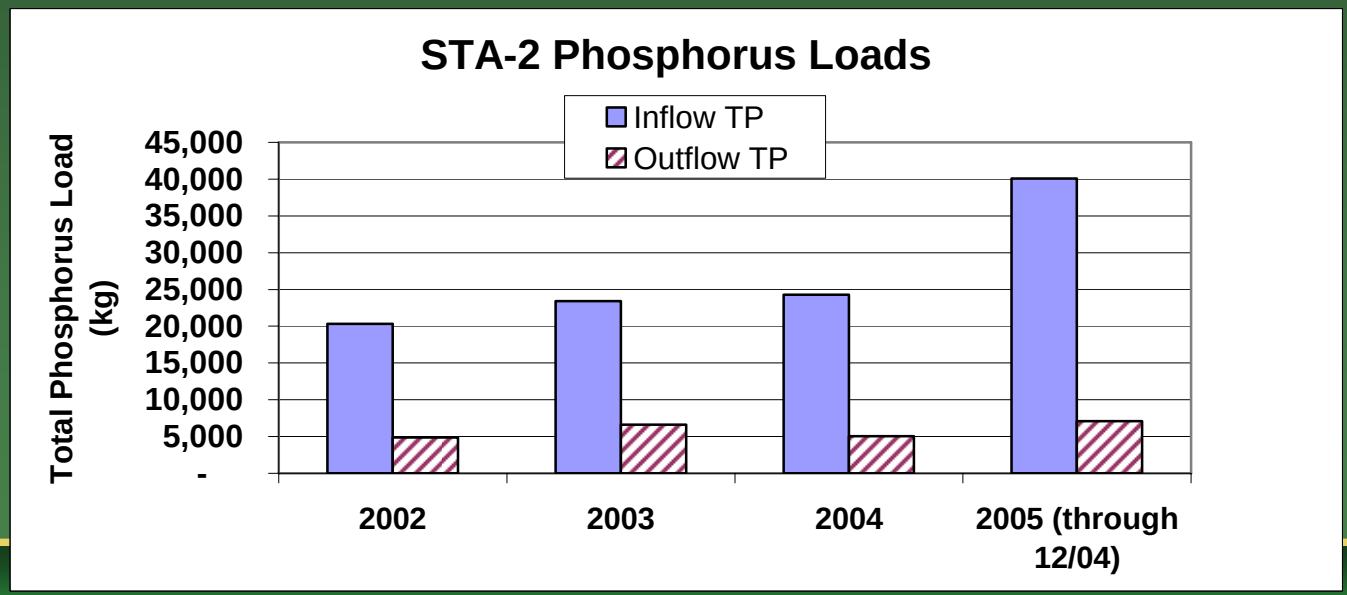
Summary of 10 Years of STA Performance





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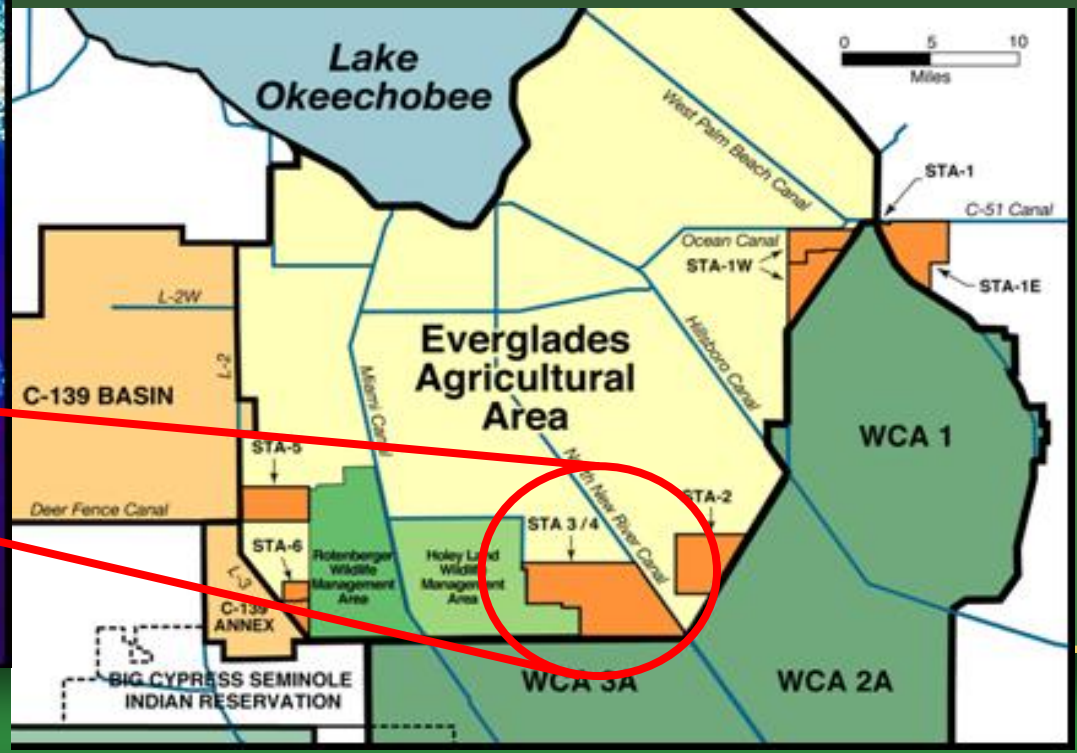
Summary of 10 Years of STA Performance

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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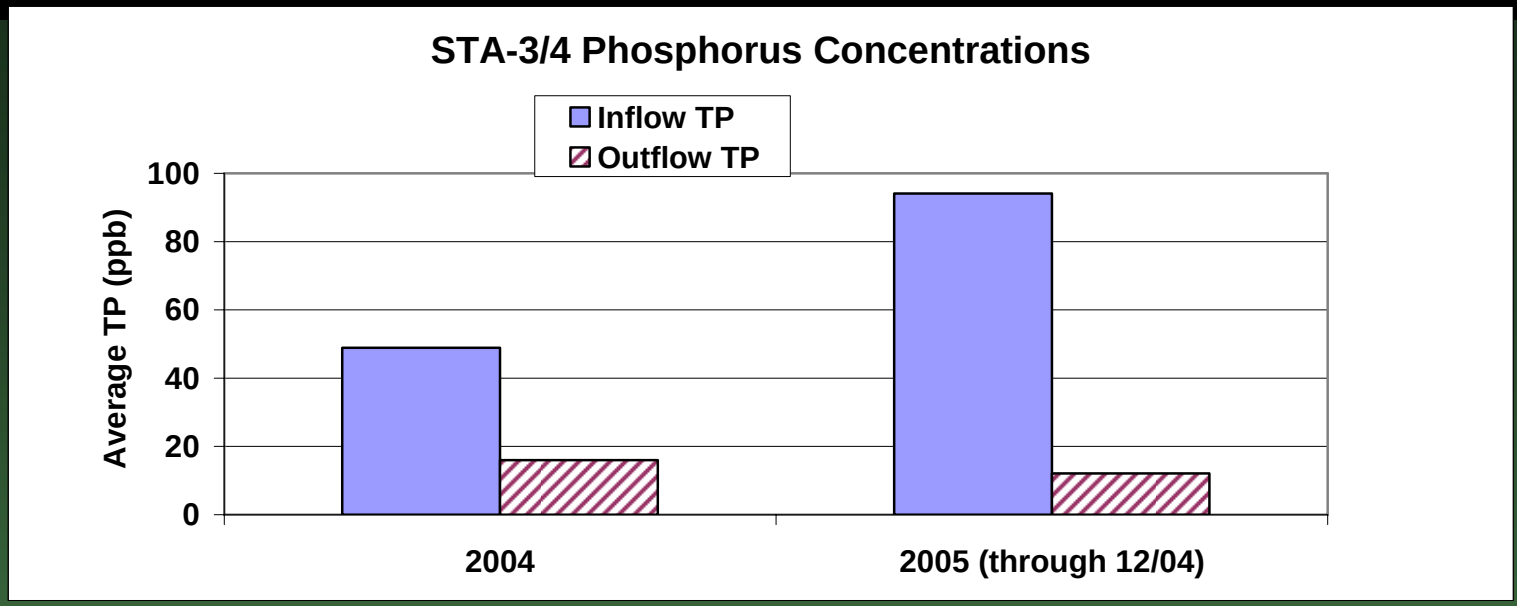
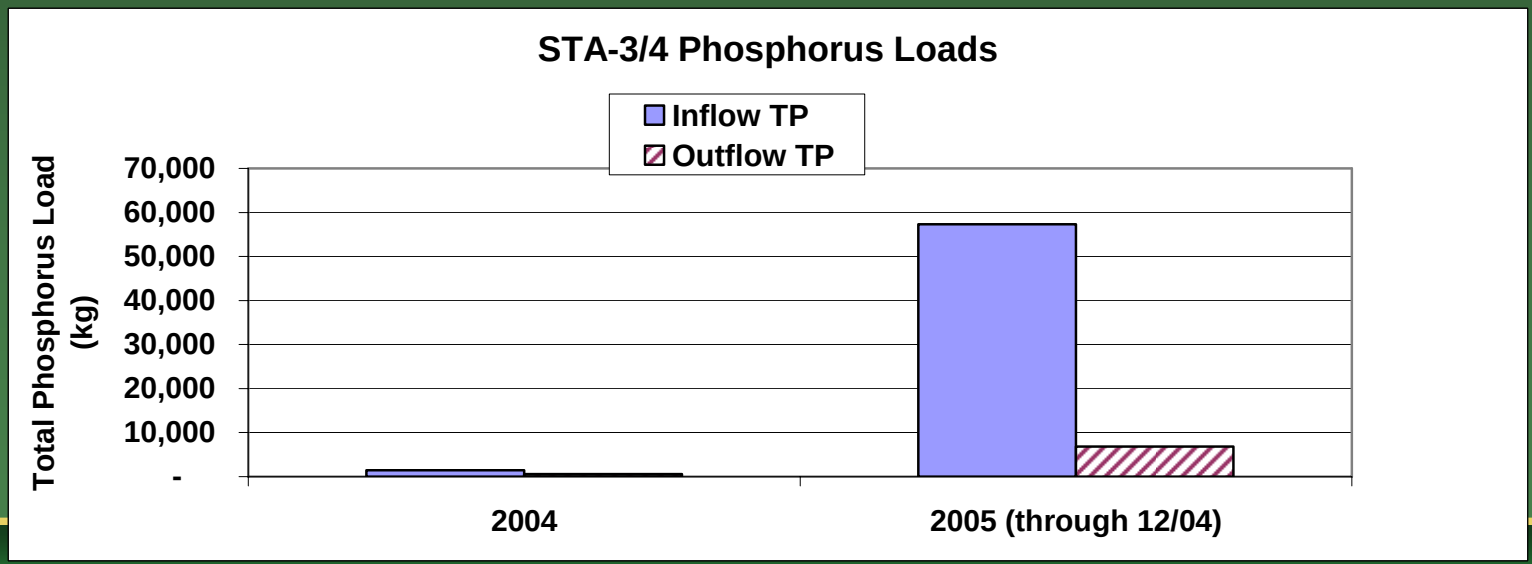
STA-3/4

- 16,530 acres of effective treatment area
- Lessons learned from other STAs applied to design and construction
- Parallel flow-ways: emergent vegetation

Summary of 10 Years of STA Performance





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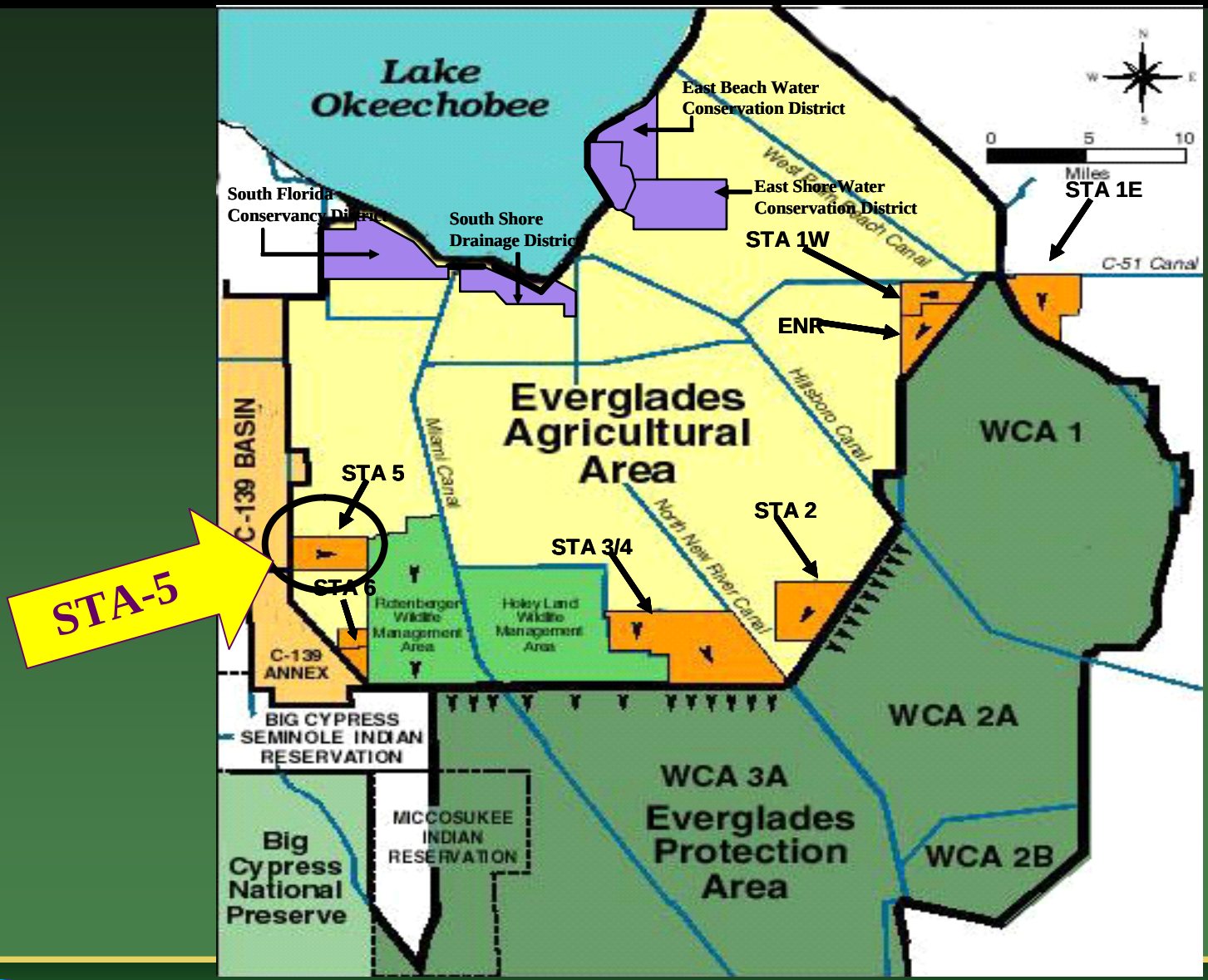
Summary of 10 Years of STA Performance



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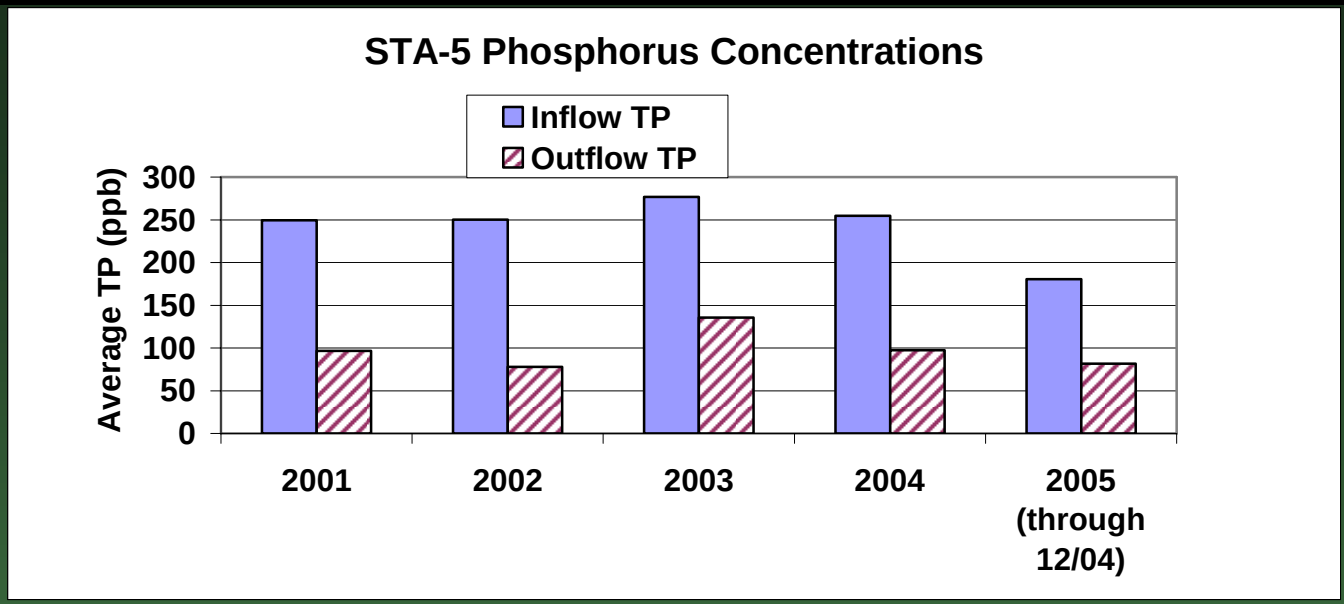
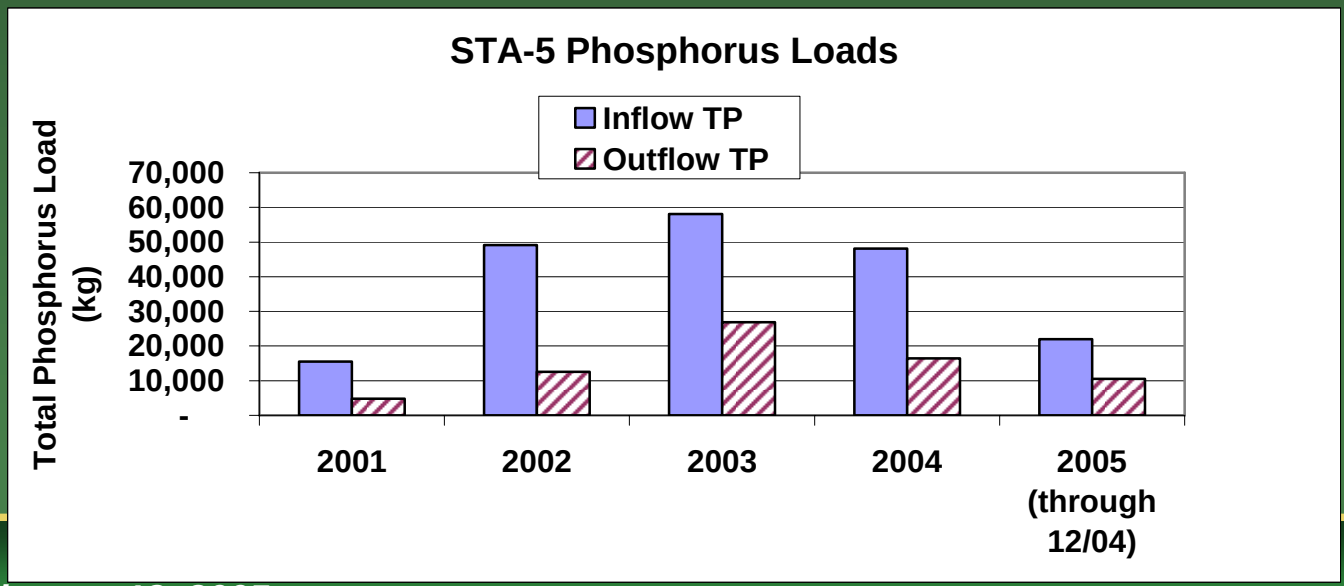
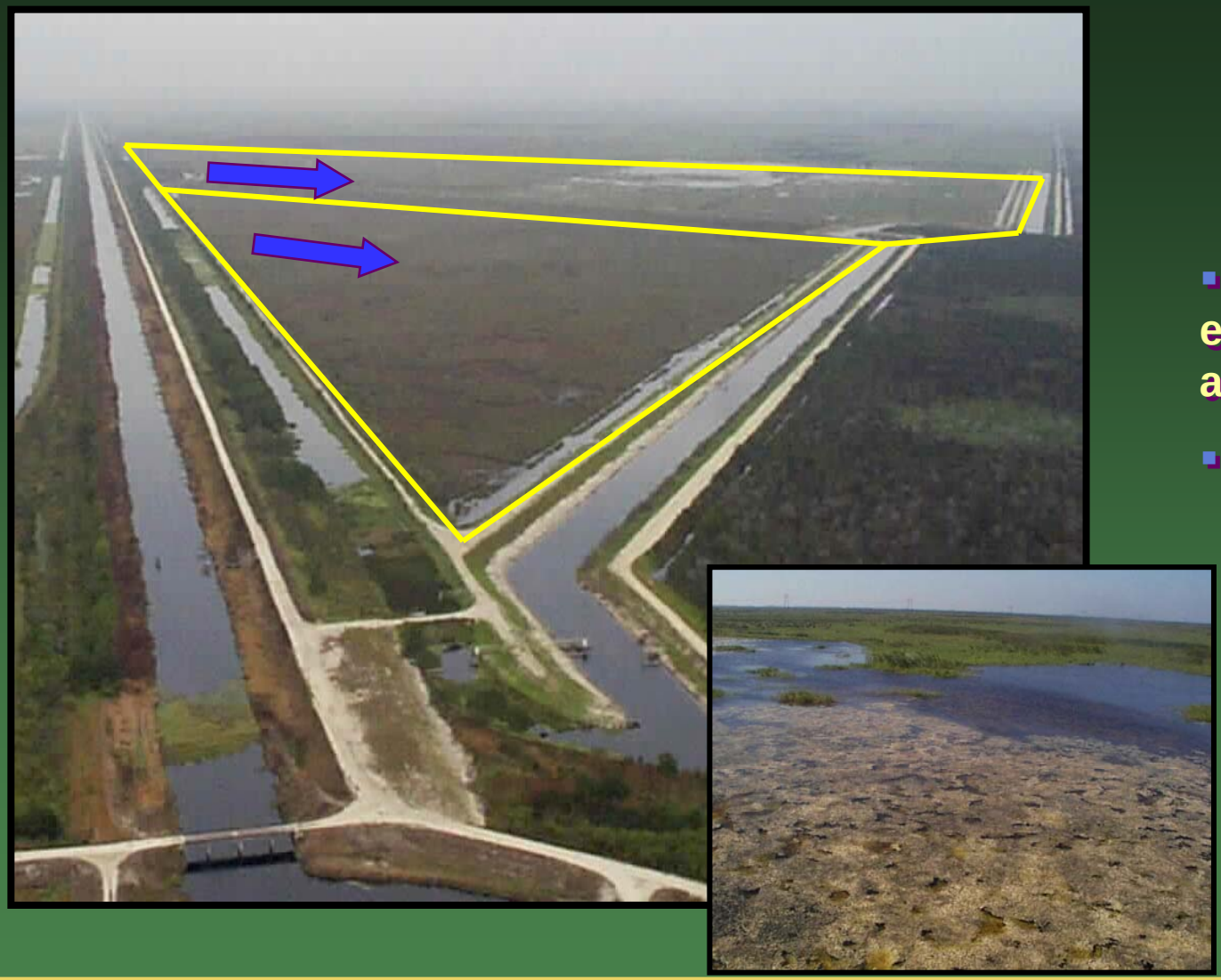
STA-5

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

Summary of 10 Years of STA Performance



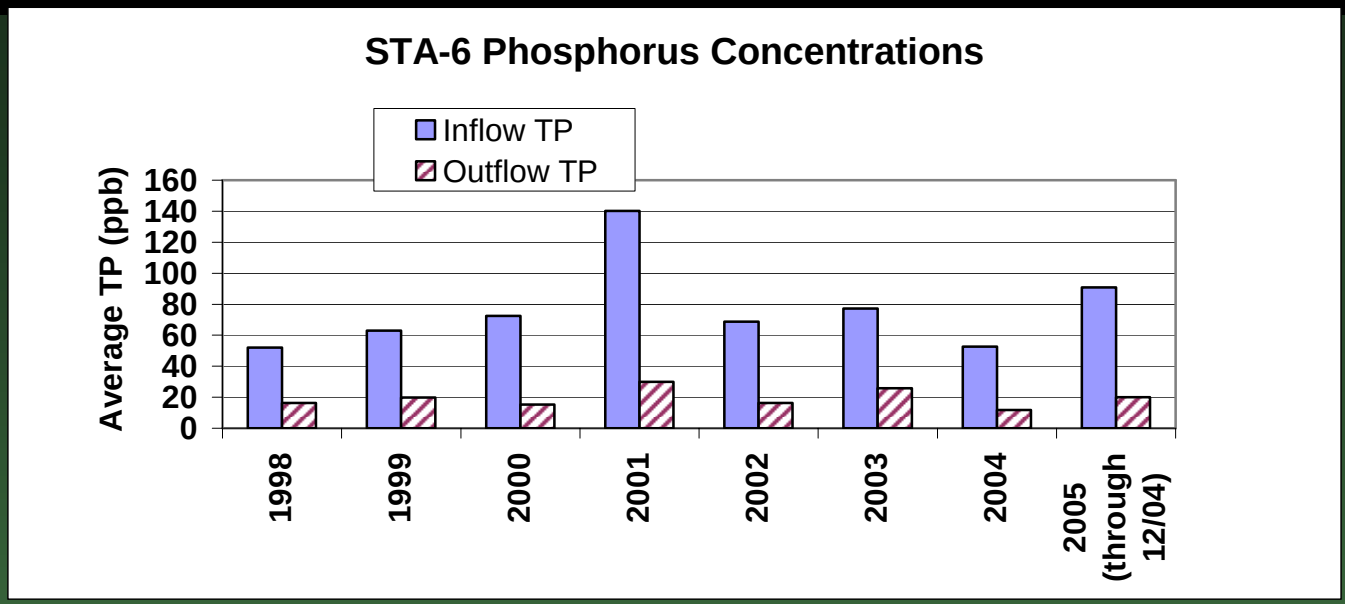


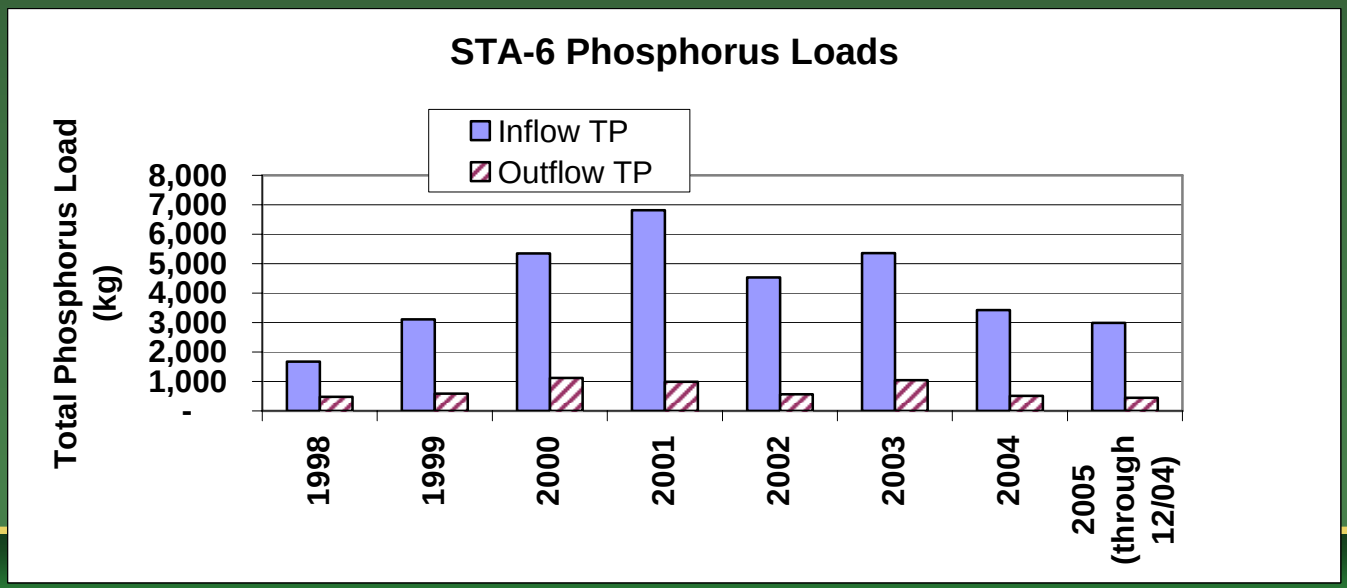


STA-6

- 870 acres of effective treatment area
- Parallel flow-ways: emergent and emergent with periphyton

Summary of 10 Years of STA Performance





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Corps of Engineers constructed STA-1E

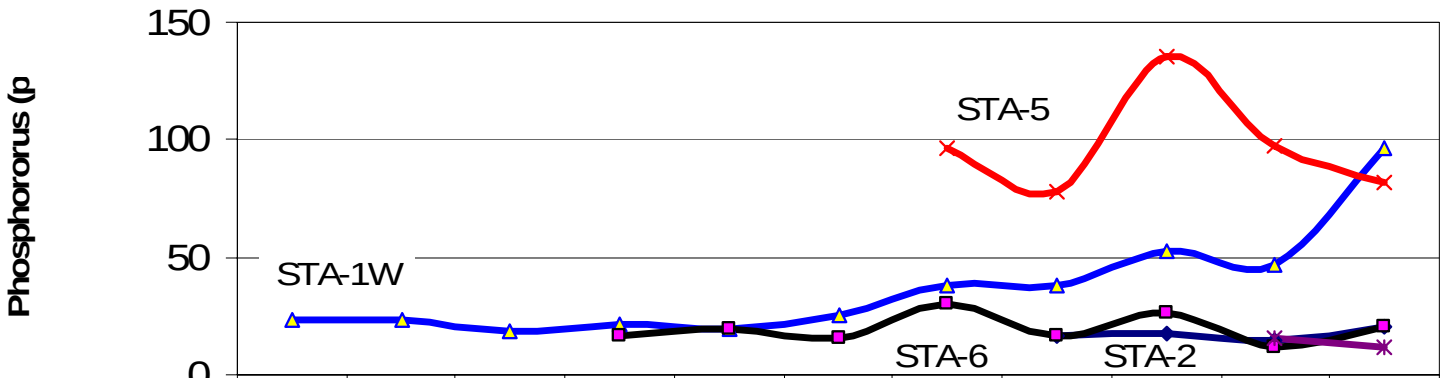
Performance

General operating principles

1. Try to ensure inflows (flows and TP loads) are within the design envelope
2. Avoid dry out – minimum of 15 cm depth
3. Avoid too deep for too long – maximum 137 cm depth for 10 days
4. Maintain target depths between storm events:
   - Emergent: 38 cm
   - SAV: 45 cm
5. Frequent field observations by site managers
6. Adaptive management for performance optimization

Summary of 10 Years of STA Performance

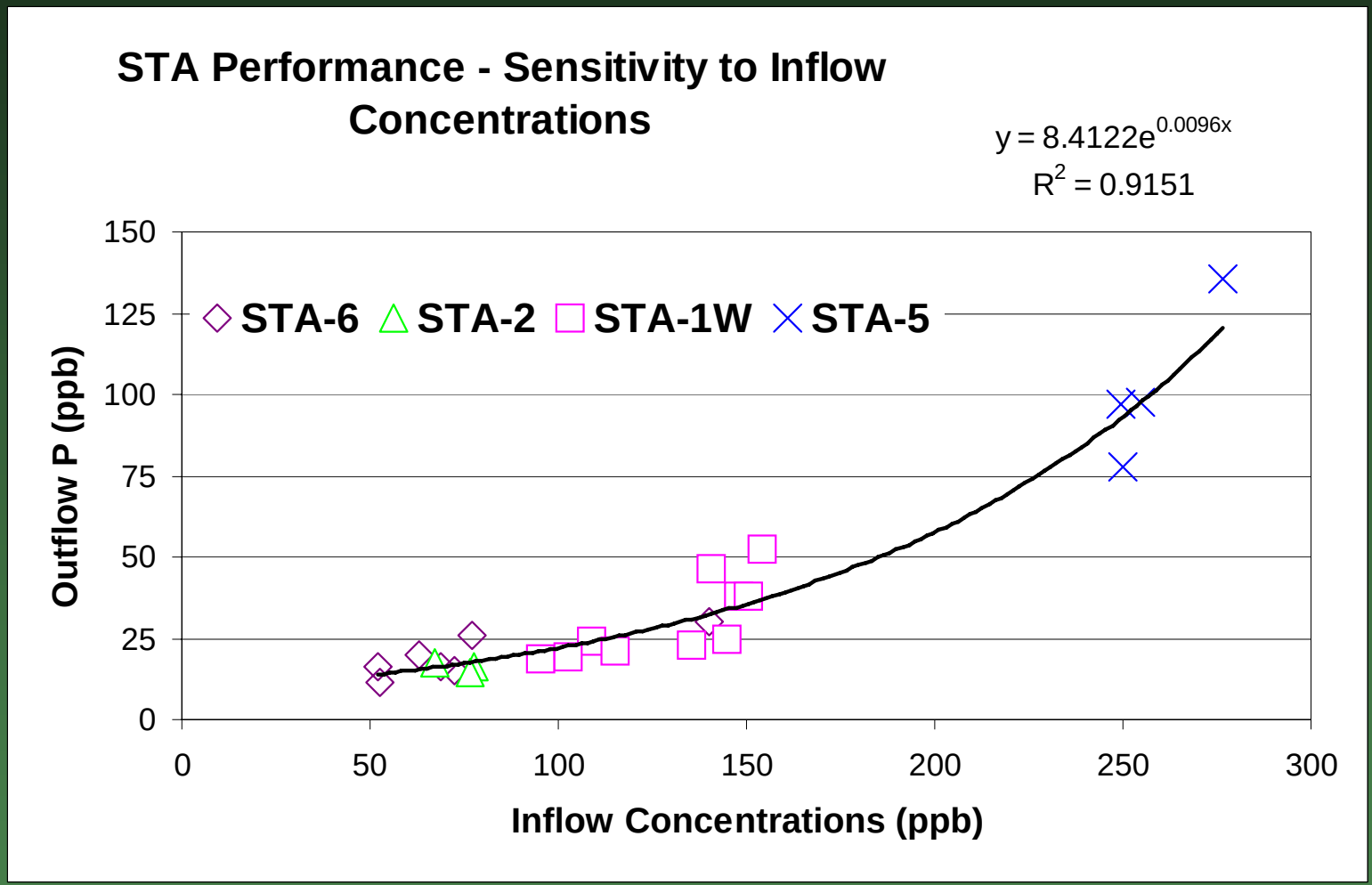
STA Outflow Concentrations



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005 (through 12/04)
STA-1W	23	24	19	21	19	25	38	38	53	47	97
STA-2								16	17	14	20
STA-5							97	78	136	97	82
STA-6				16	20	15	30	16	26	12	20
STA-3/4										16	12

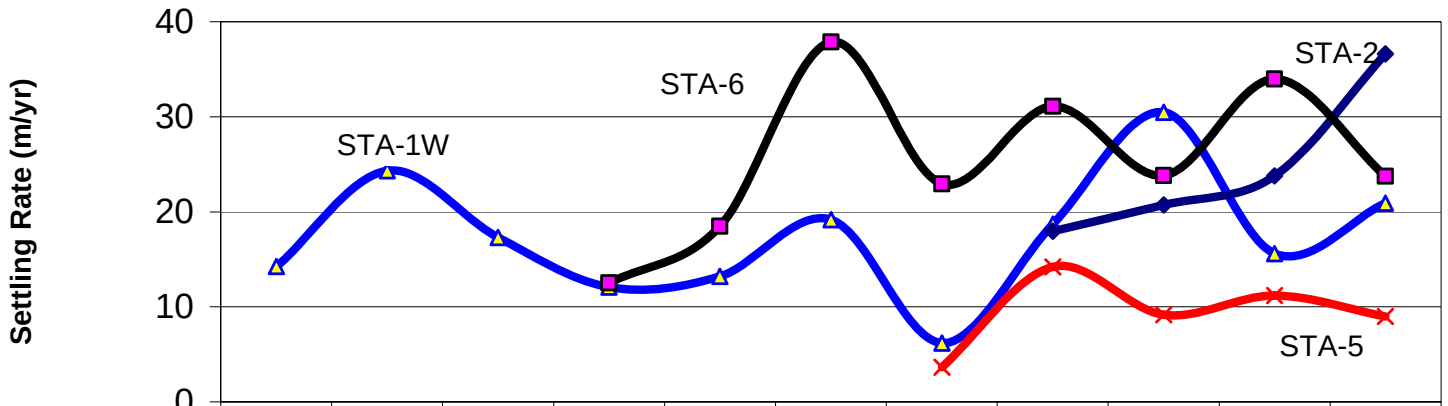
Water Year

Summary of 10 Years of STA Performance



Summary of 10 Years of STA Performance

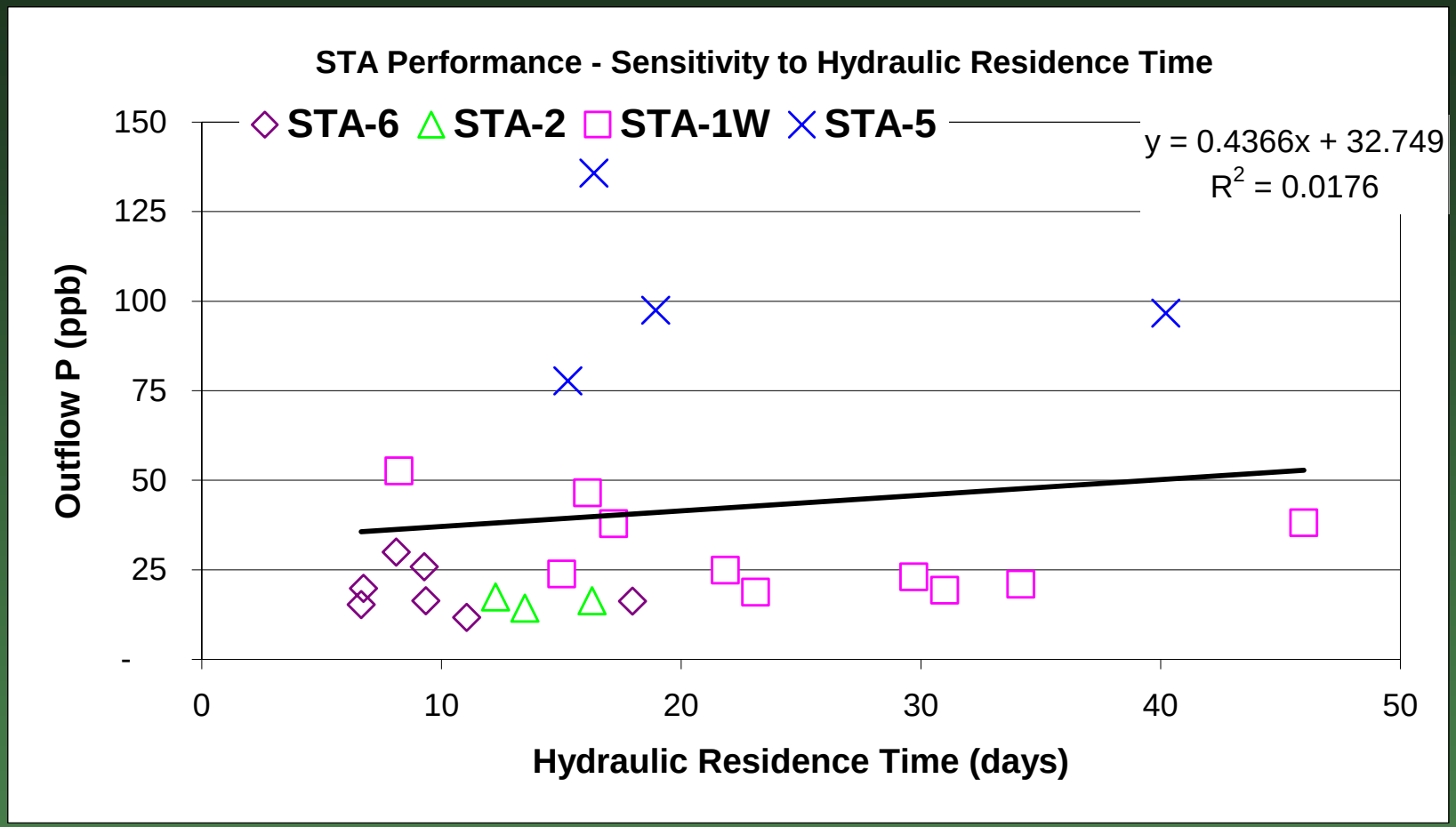
Effective Settling Rate (K)



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005 (through 12/04)
STA-1W	14.3	24.3	17.3	12.1	13.2	19.2	6.2	18.7	30.5	15.6	20.9
STA-2								18.0	20.7	23.8	36.6
STA-5							3.6	14.2	9.2	11.2	9.0
STA-6				12.5	18.5	37.9	22.9	31.1	23.8	34.0	23.7

Water Year

Summary of 10 Years of STA Performance



STA Performance Synopsis – 9/04

- 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
    - Restricting inflow to 5% of maximum – diversion to Refuge
    - Additional monitoring and assessment
    - Additional vegetation and wq monitoring

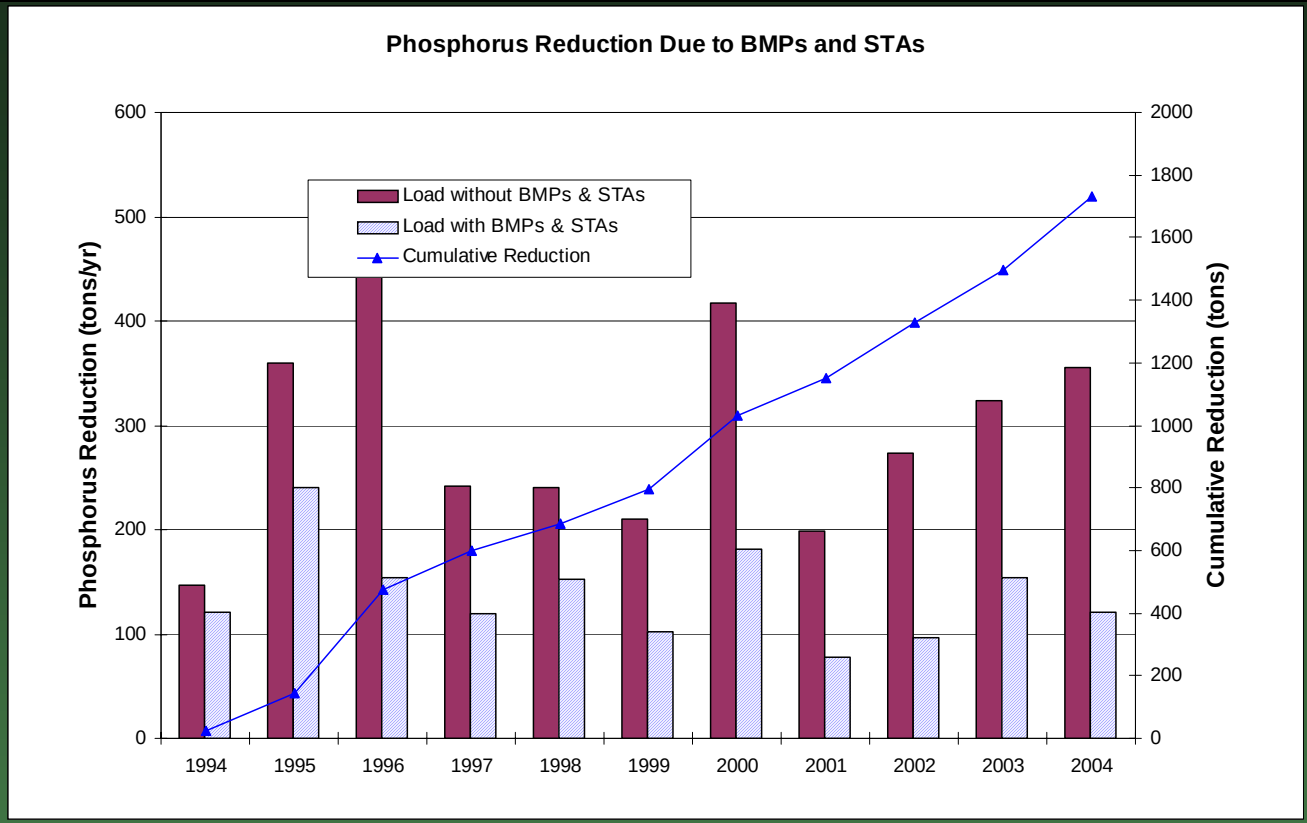
Summary of Performance

- STA-1W (8/1994 – 12/2004)
  - 296 m tons removed; average outflow = 47 ppb
- STA-2 (6/1999 – 12/2004)
  - 84 m tons removed; average outflow = 17 ppb
- STA-3/4 (10/2003 – 12/2004)
  - 51 tons removed; average outflow = 12 ppb
- STA-5 (1/1999 – 12/2004)
  - 122 m tons removed; average outflow = 101 ppb
- STA-6 (12/97– 12/2004)
  - 28 m tons removed; average outflow = 19 ppb

Summary

- Performance has exceeded expectations
  - More than 580 metric tons of phosphorus removed
  - Discharges have averaged 41 ppb
  - Continuing a strong science-based program of research to optimize performance
- Removal influenced by nutrient loading rate, inflow concentrations, soils, vegetation and hydraulic loading rate, depth
- STA enhancements underway to achieve new phosphorus criterion of 10 ppb in the Everglades

Summary of 10 Years of STA Performance



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

Long-Term Water Quality Solutions

- Expansion of BMPs (esp. urban basins)
- Expansion of STAs
- Enhancement of STAs
  - Continue strong science-based program to optimize performance
- Synchronization with CERP projects
- *ADAPTIVE MANAGEMENT*

For More Information:

- www.sfwmd.gov
  - Everglades Restoration
  - Everglades Construction Project
  - Long-Term Water Plan
  - Everglades Consolidated Report
    - Summary of all available data
    - http://www.sfwmd.gov/org/ema/everglades/index.html
- Gary Goforth (772) 223-8593
  - gary@garygoforth.net
  - www.garygoforth.net