Dynamic STA Design Model

DESIGN MODEL STRUCTURE
FOR TREATMENT WETLAND SYSTEMS
AT
LOW PHOSPHORUS CONCENTRATIONS
FOR EVERGLADES PROTECTION

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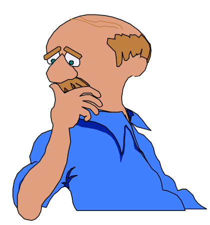
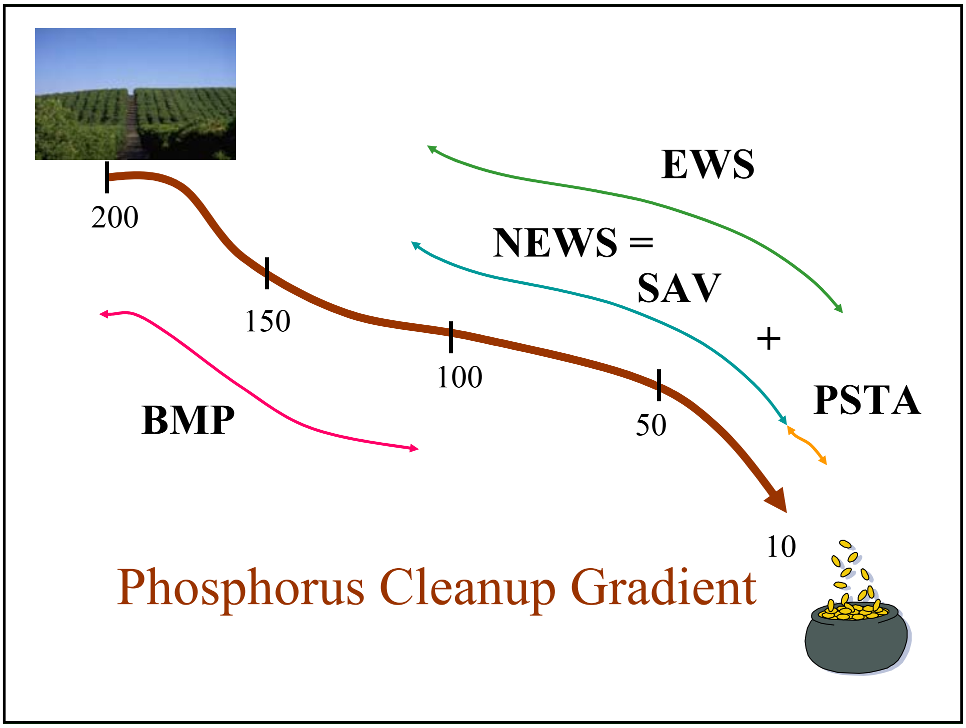
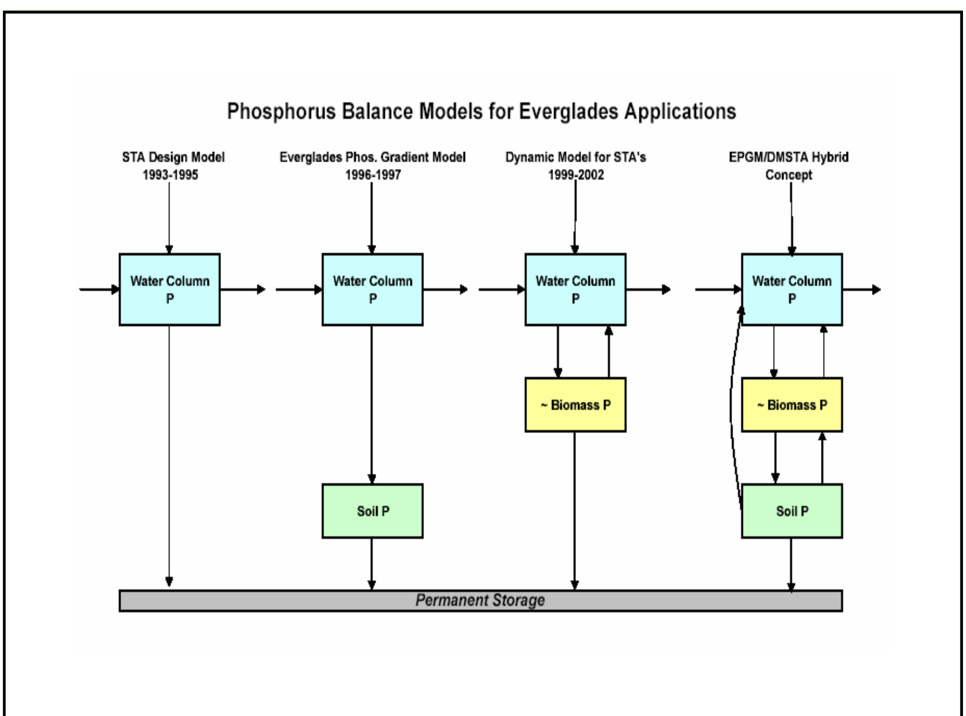
April 15, 2003

DMSTA



This is a work in progress. Calibrations are continuing as of April 15, 2003, and DMSTA is expected to undergo changes as the result of further review. The statements and results in the current website and documents and this presentation are those of the authors, and do not represent the position of any agency.


EWS
NEWS =
SAV
+
PSTA
200
150
100
50
10
BMP
Phosphorus Cleanup Gradient


Phosphorus Balance Models for Everglades Applications
STA Design Model
1993-1995
Everglades Phos. Gradient Model
1996-1997
Dynamic Model for STA's
1999-2002
EPGM/DMSTA Hybrid
Concept
Water Column
P
Water Column
P
Water Column
P
Water Column
P
~ Biomass P
~ Biomass P
Soil P
Soil P
Permanent Storage

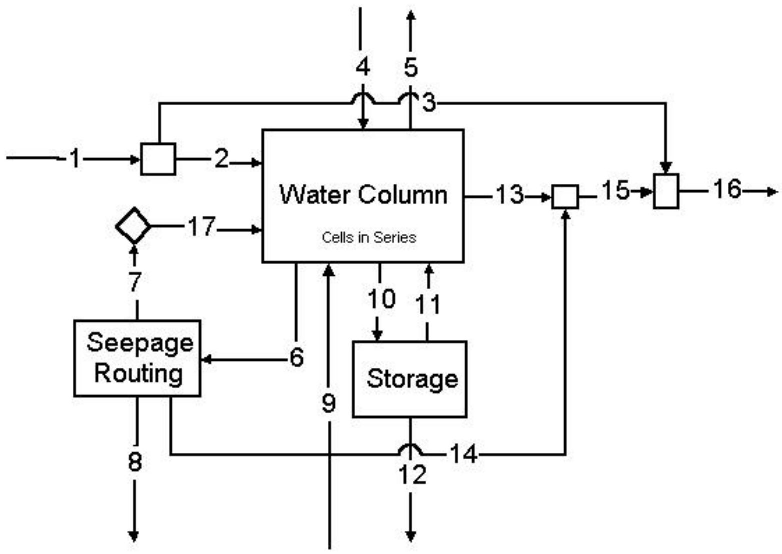
Applications

- Performance modeling and design of treatment wetlands for phosphorus in semi-tropical climates.
- DMSTA formed the basis for the Basin Specific Feasibility Studies.
- Forms a precursor for models of soil column phosphorus such as the Everglades Phosphorus Gradient Model (EPGM)

DMSTA Components

- Compartmentalized Layout
- Hydrology and Hydraulics
  - Water budget, stage-discharge,seepage
  - Tanks-in-series flow pattern
- Dynamic Phosphorus Cycling
  - Water column storage
  - Solid (biomass, sorption) storage
  - Uptake, recycle, permanent burial

DMSTA Flow Net



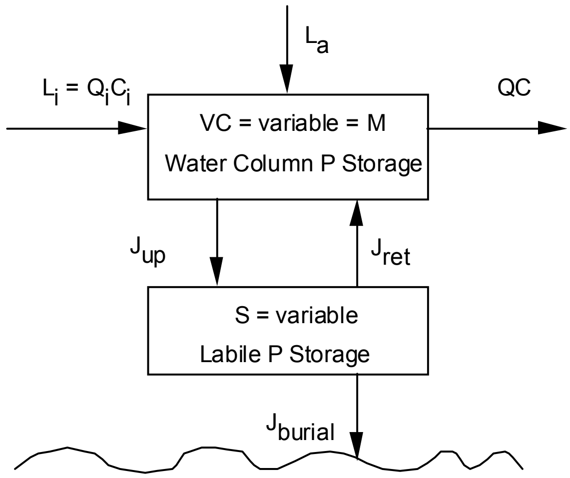
Depth & Flow

Water mass balance, level pool:

$$A\frac{dh}{dt} = Q_i + A \cdot (P - ET) - Q_o \pm I$$

Stage-discharge relation:

$$Q_o / W = ah^b$$



Phosphorus Cycling and Removal

Phosphorus Movement & Storage

$$J_{up} = F_z K_1 C S$$

$$J_{ret} = K_2 S^2$$

$$J_{burial} = K_3 S$$

$$\frac{\partial S}{\partial t} = F_z K_1 C S - K_2 S^2 - K_3 S$$

Parameter Redefinition

$$S^e = \frac{F_z K_1 C^e - K_3}{K_2} = \frac{F_z K_1}{K_2}(C^e - \frac{K_3}{F_z K_1})$$

$$C_0 = K_3 / F_z K_1 \quad (= C^*)$$

$$\frac{S^e}{1000} = \frac{(C^e - C_0)}{(C_1 - C_0)}$$

$$J_b^e = K(C^e - C^*)$$

$$K = K_1 K_3 / K_2$$

Wetland Design Information

A. Surface area (A). (Wetted area at normal operating depth)
B. Mean wetland width (W). Allows different L:W ratios and affects stage- discharge relation.
C. Outflow control depth (Z_c). (Weir setting for example)
D. Community type. (Triggers selection of P- removal parameters)
E. Hydraulic efficiency. (Number of TIS, N)
F. Bypassing depth (Z_{max}).
G. Bypassing inflow maximum (QIN_{max}).
H. Outflow pump ca[pacity ($QOUT_{max}$).
I. Out-seepage return fraction.
J. Out-seepage feed-forward fraction.
K. Out-seepage concentration.

Hydrologic Parameters

- Conveyance coefficient, a.
- Depth exponent, b.

Phosphorus Removal Parameters

Three primary parameters:

1. Community turnover rate, or biogeochemical cycling rate, K_s.
2. Lowest attainable P concentration, C_o .
3. Community P storage potential, measured as the water concentration C_1 at which the community stores 1000 mgP/m^2.

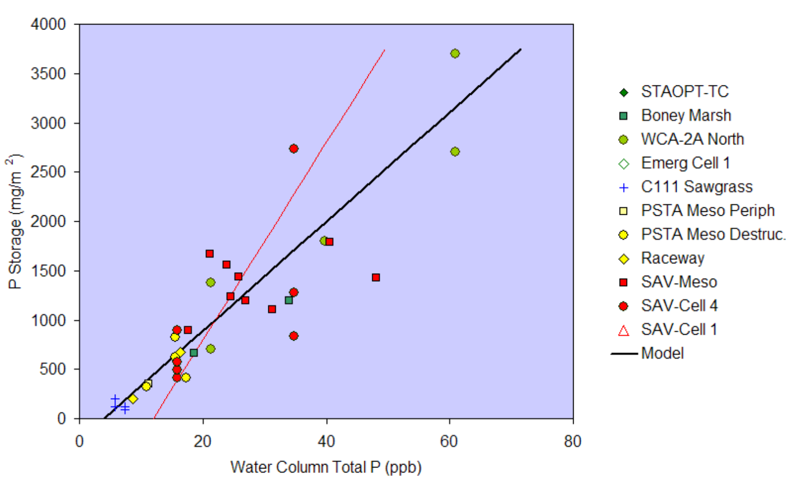
Three secondary parameters:

4. The depth dependence maximum, Z_{max}.
5. The community transition midpoint, S_M.
6. The community transition bandwidth, S_B.

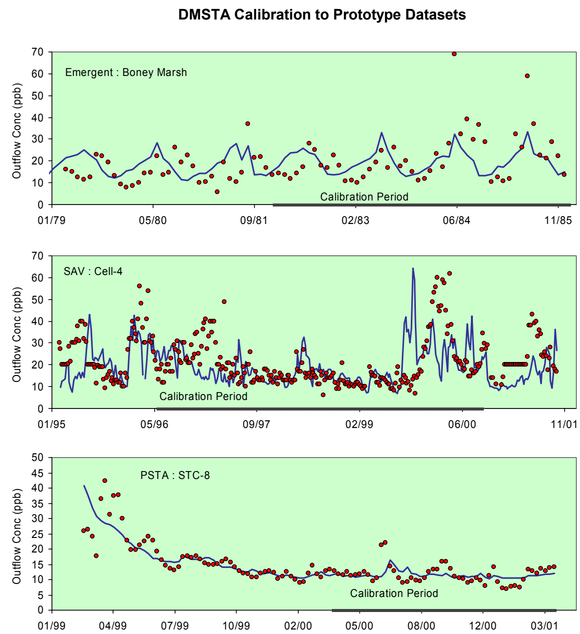
Driving Forces

a. Daily time series of water inflows.
b. Daily time series of inflow concentrations.
c. Daily time series of rainfall.
d. Daily time series of rainfall concentratons.
e. Atmospheric dry deposition.
f. Daily times series of evapotranspiration.
g. In-seep supply elevation, Z_i.
h. In-seep rate coefficient, E_i.
i. Seepage water inflow concentration.
j. Out-seep receiving elevation, Z_o.
k. Out-seep rate coefficient, E_o.

Storage Relationship



Time Series Predictions

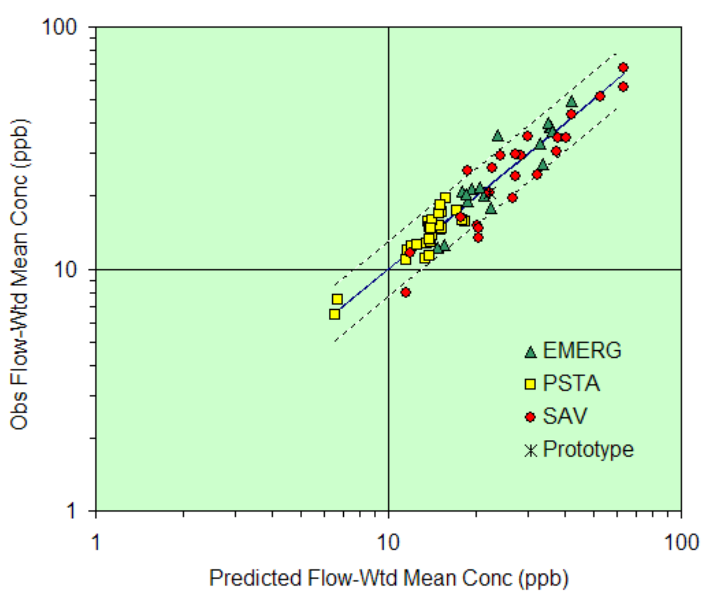


Boney

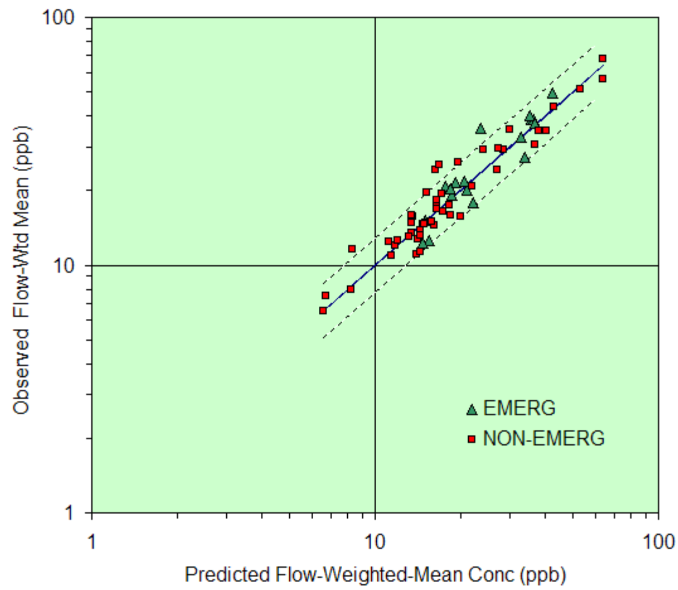
SAV
Cell 4

PSTA
STC 8

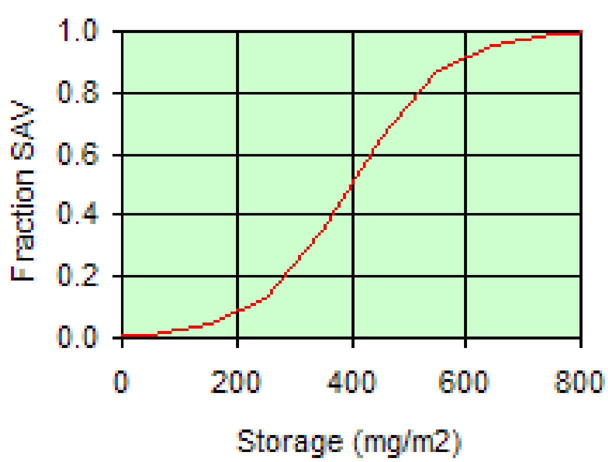
Community Validations



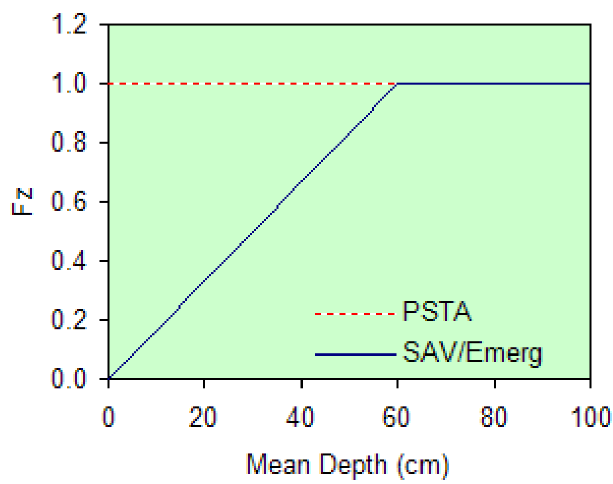
NEWS Validation



SAV to PSTA Switch



Depth Rate Modifier



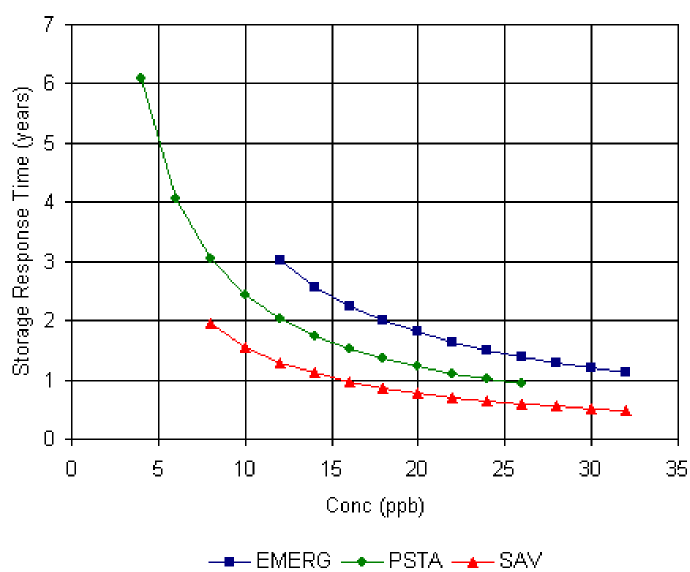
Calibration Results

	Boney Marsh	STA1W Cell 4	STC 8	Cell 4 + STC 8	STA1W Cell 4 98-99
	Emergent	SAV	PSTA	NEWS SAV/PSTA	SAV
K, m/yr	16	129	24	24/129	90
Co, ppb	4	12	4	4/12	4
C1, ppb	22	22	22	22	22

Current Calibration Limits

	Depth Range cm	Hydraulic Loading cm/d	P Concentration µg/L
Emergent	10 - 60	2 - 20	20 - 135
SAV	20 - 90	6 - 40	15 - 135
PSTA	10 - 60	6 - 12	7 - 30

Turnover Times



Intangibles

- Phosphorus Speciation
- Calcium Availability
- Hydrilla & Other Invasions
- Hydraulic Robustness
- Phosphorus Robustness
- Herbiciding & Other Vegetation Management

Summary & Conclusions

- DMSTA is a highly aggregated dynamic model for P cycling and removal.
- DMSTA has been calibrated to data from 68 operating systems of varying sizes.
- DMSTA is designed to interface with reservoir and soil models.
- DMSTA runs rapidly and easily, allowing investigation of multiple scenarios with immediate turn-around.