Phosphorus Balance Models for Everglades Applications

W. W. Walker & R.H. Kadlec

wwwalker@wwwalker.net & rhkadlec@chartermi.net

prepared for

U.S. Department of the Interior

CESI/CERP Modeling Workshop

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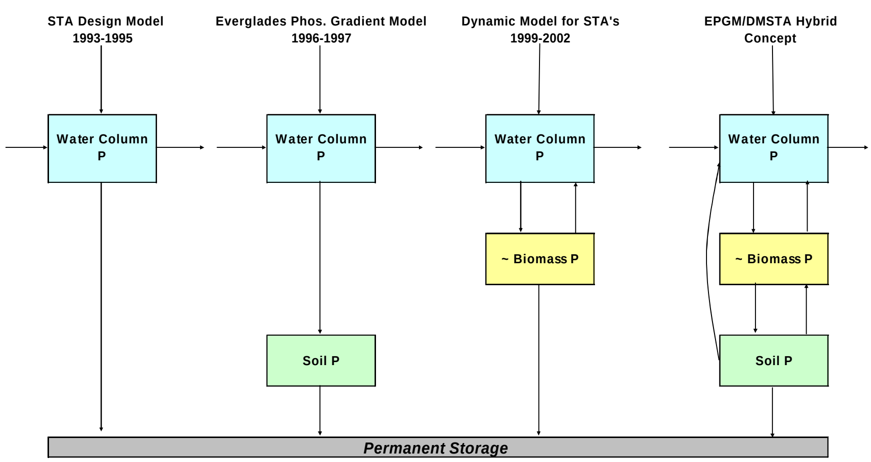

Phosphorus Mass Balance Models for Everglades Applications

Based upon Fundamental Mass Balance Concepts

Lumped State Variables & Processes

Low Input Data Requirements

Extensively Calibrated & Tested

Simple Spreadsheet Interface

Limited Range of Applicability

Can be Configured to Work With Existing Hydrologic Models

Phosphorus Mass Balance Models Developed for Everglades Applications

W. W. Walker & R.H. Kadlec for U.S. Department of the Interior

Model	STADM	EPGM	DMSTA	HYBRID
Description	STA Design Model	Everglades Phos. Gradient Model	Dynamic Model for STA's	EPGM/DMSTA Hybrid
Development Dates	1993-1995	1996-1997	1999-2002	Concept
Primary Purposes	Design of Phase I Stormwater Treatment Areas	Impacts of STA Discharges on WCA's	Design of Enhanced Stormwater Treatment Areas - All EPA Basins	Same as EPGM/DMSTA + WCA Recovery + CERP Applications
Applic. to Natural Wetlands	WCA-2A	WCA's	WCA-2A; C111	Everglades
Dynamic Time Scale	Steady State	Years	Days --> Years	Days--> Years
Computational Platform	Any Spreadsheet	Lotus or Excel	Excel / Visual Basic	Excel / Visual Basic
Wetland Trajectory	Steady State	Enrichment	Enrichment	Enrichment or Recovery
Spatial Configuration	Gradient (Plug Flow)	Gradient (Plug Flow)	1-Dim. Branched (Cells in Series, Parallel)	General 1-D Branched or Linked to Existing Hydro Models (NSM Output)
Model Coefficients	1	3	3	7
Calibration Basis	WCA-2A, Treatment Wetlands	WCA-2A	~70 Platforms: Tmt Wetlands, Test Cells, Mesocosms	EPGM/DMSTA; Updated to Include Threshold Research, EPA REMAP; ENP & USGS Research

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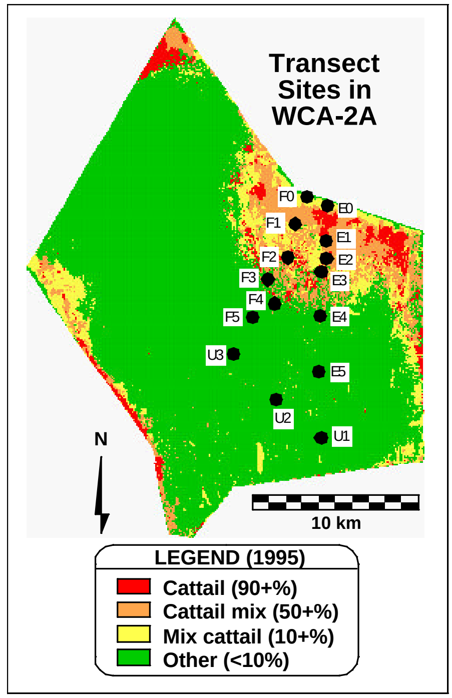
Model	STADM	EPGM	DMSTA	HYBRID
Soil Types	Peat	Peat	Peat or Marl	Peat or Marl
Vegetation Types	Emergent --> Slough	Emergent ---> Slough	Emergent, Submergent, Periphyton	Emergent, Submergent, Periphyton
State Variables	Flow Water Col P	Flow Water Col P Soil Accretion Soil P Cattail Density	Flow Water Col P Biomass P Any WQ Comp. with Simple Kinetic Rules	Flow Water Col P Biomass P Soil Accretion Soil P Cattail Density Any WQ Comp. with Simple Kinetic Rules
Potential CERP Applications	Design of External P Load Controls	---> Simulating P Impacts Downstream of Inflows	---> Simulating P Impacts Downstream of Inflows Optimization of CERP Reservoirs for WQ Benefits	---> ---> ---> Simulating Recovery of WCA/ENP Marshes
Relevant CERP Perfomance Measures		Vegetation, Periphyton, Soil Accretion	Vegetation, Periphyton	Vegetation, Periphyton, Soil Accretion
Reference: wwwalker.net	/stadesign.pdf	/epgm	/dmsta	

Research to Support the Derivation of the Numerical Criterion for P in the Everglades

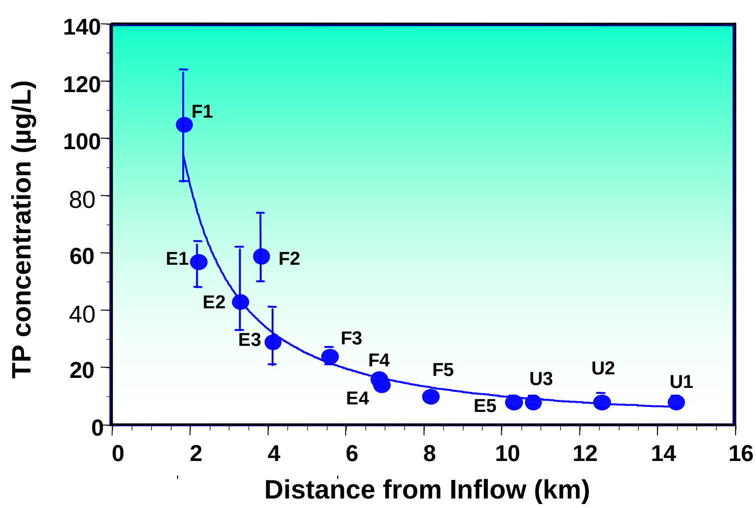
Everglades Division
South Florida Water Management District

P Criterion Workshop
20-21 September 2001

Sites used in WCA-2A Gradient Studies

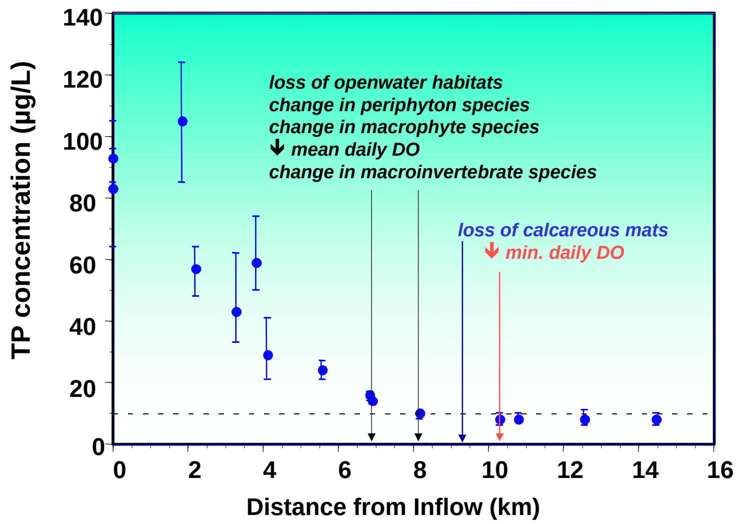


Regression

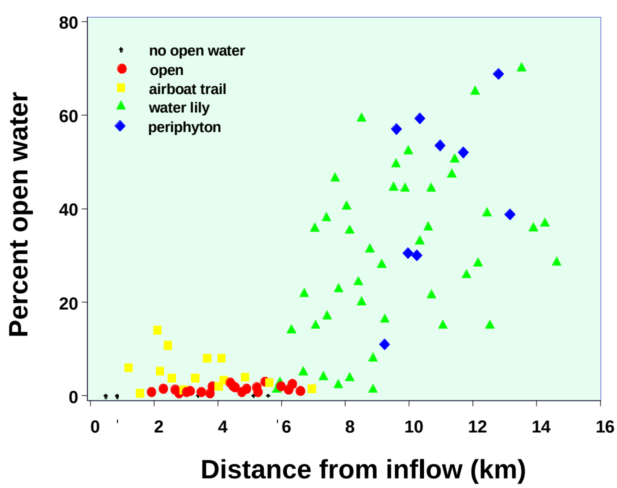


Geometric Mean (bars = annual range, 1994-1998)

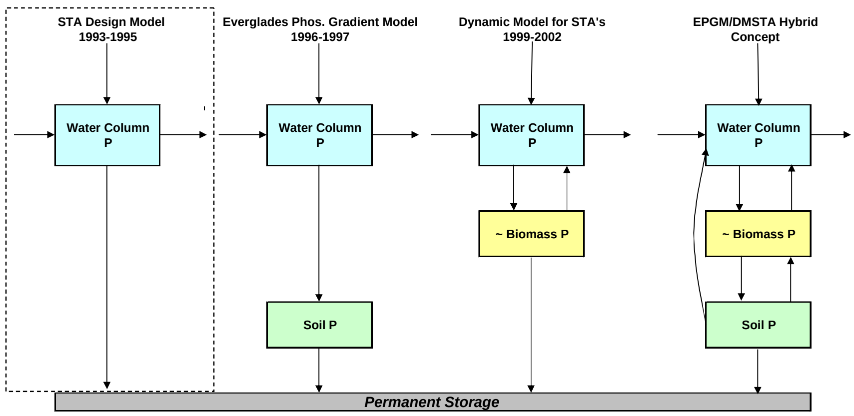
Ecological Changes along the WCA-2A Gradient



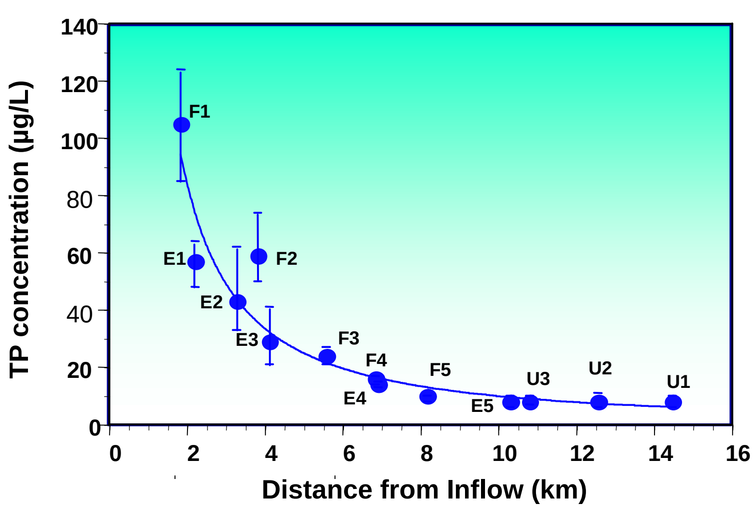
Changes in Open-water Habitat along the WCA-2A Nutrient Gradient



Phosphorus Balance Models for Everglades Applications

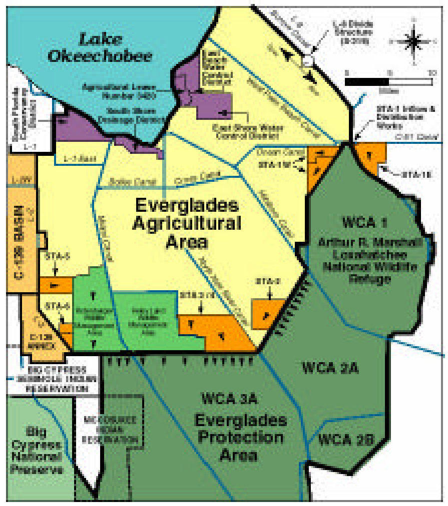


Regression



Geometric Mean (bars = annual range, 1994-1998)

EAA Stormwater Treatment Areas



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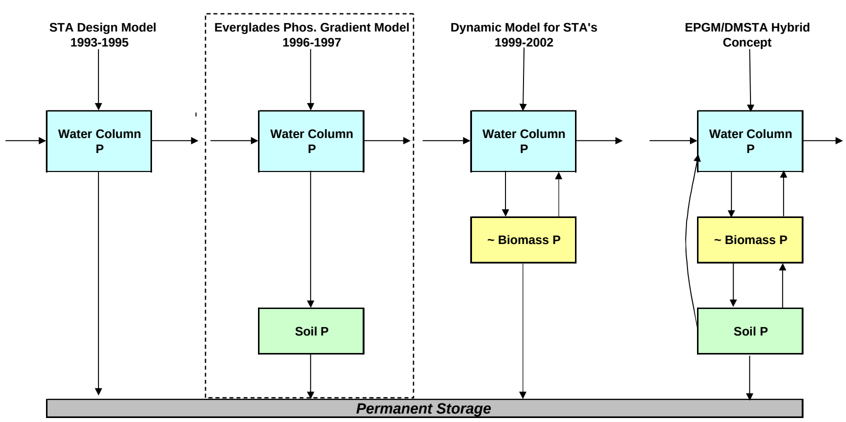


Everglades Phosphorus Gradient Model

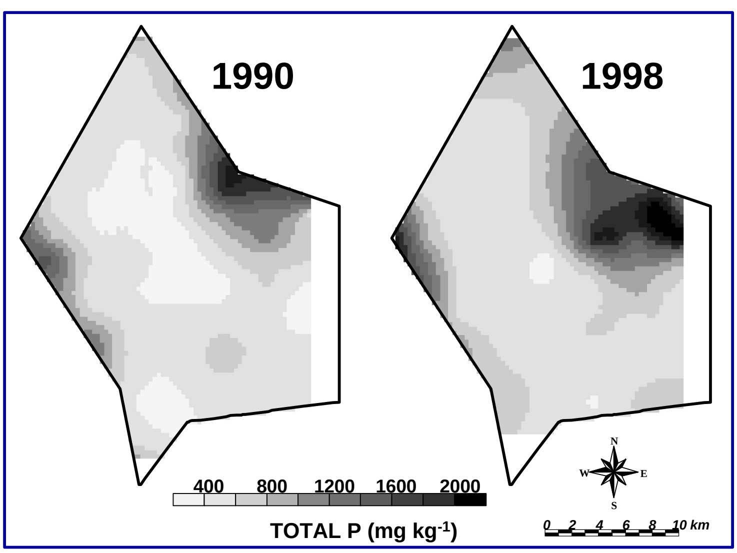
Primary Application:

Simulating Impacts of STA Discharges on Downstream WCA Marshes.

Reference:

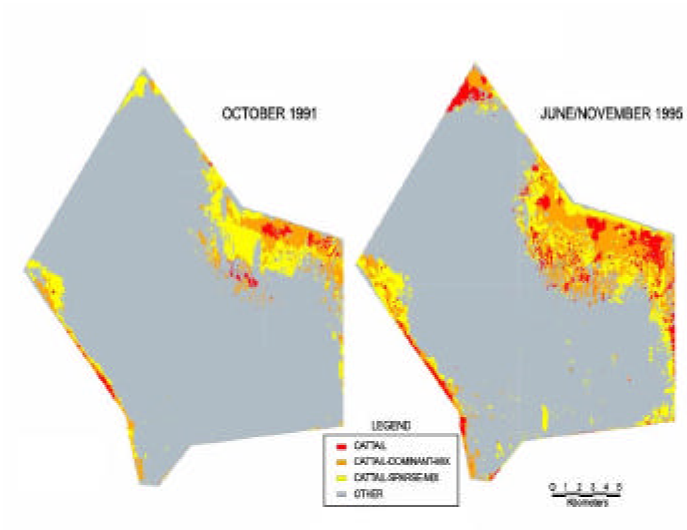
W.W. Walker & R.H. Kadlec, "A Model for Simulating Phosphorus Concentrations in Waters & Soils Downstream of Everglades Stormwater Treatment Areas", prepared for U.S. Department of the Interior, August 1996. http://www.wwwalker.net/epgm

Soil P change over Time (0-10 cm)

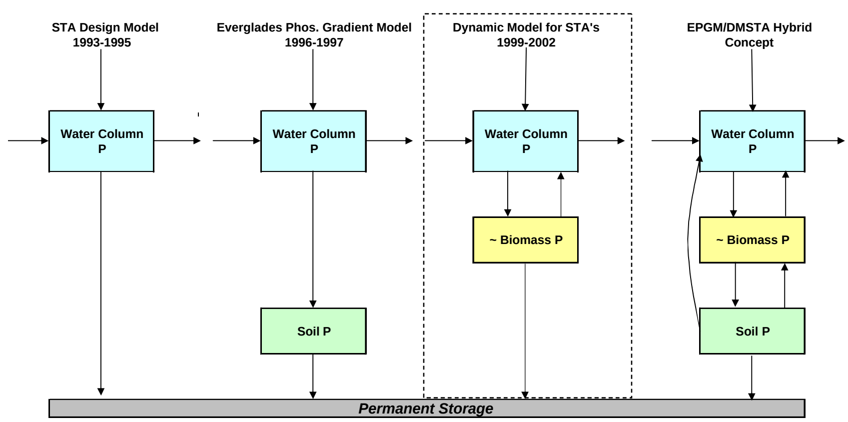


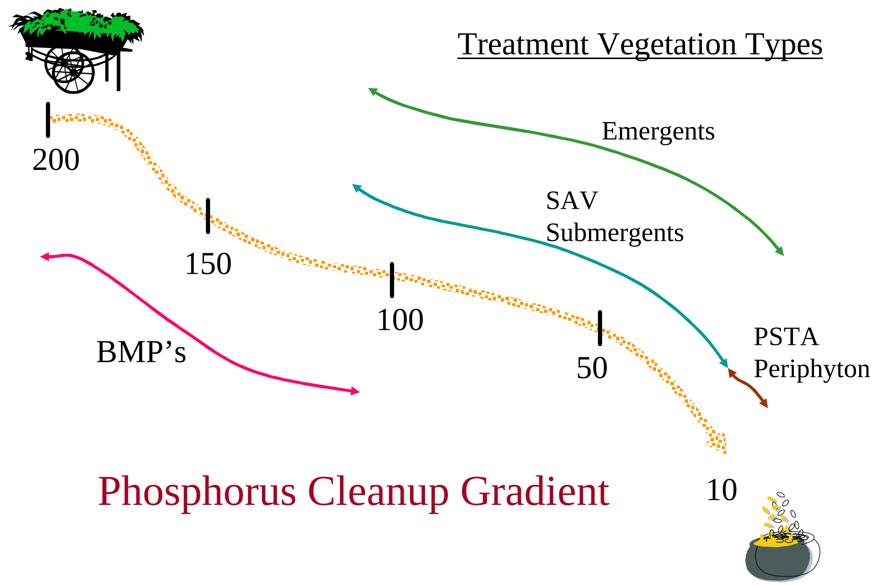
University of Florida

Vegetation change over Time



Phosphorus Balance Models for Everglades Applications





DMSTA Vegetation Types: Emergent Macrophytes

DMSTA Vegetation Types: Submersed Macrophytes

DMSTA Vegetation Types: Periphyton

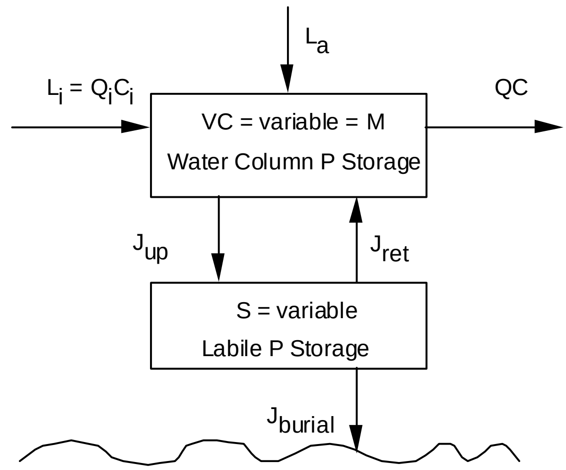


Figure 1. Concepts of the DMSTA structure.

Phosphorus Removal Parameters

Three primary parameters:

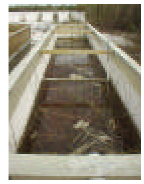
1. The community turnover rate, or biogeochemical cycling rate, K_s.
2. The lowest attainable P concentration, C_0.
3. The community storage potential, measured as water concentration C_1 at which the community stores 1000 mgP/m^2.

Three secondary parameters:

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

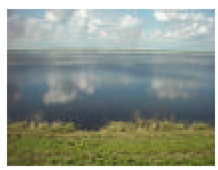
Platforms Used for DMSTA Calibration & Testing



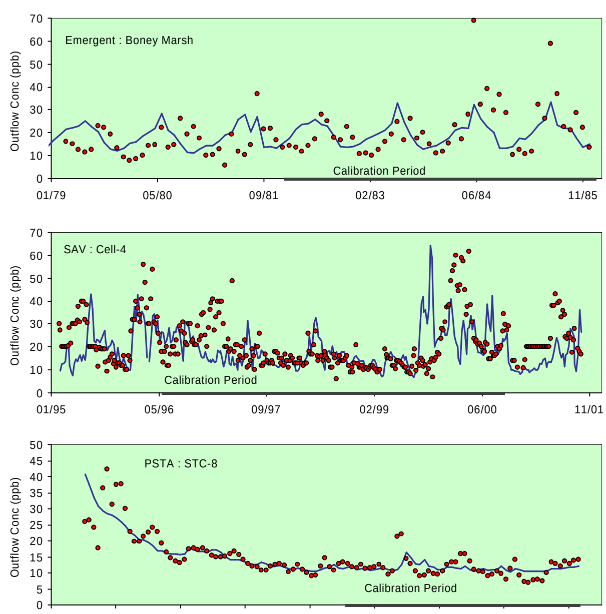




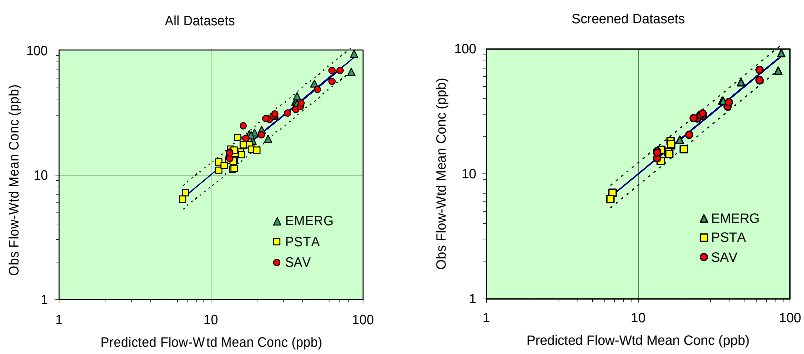




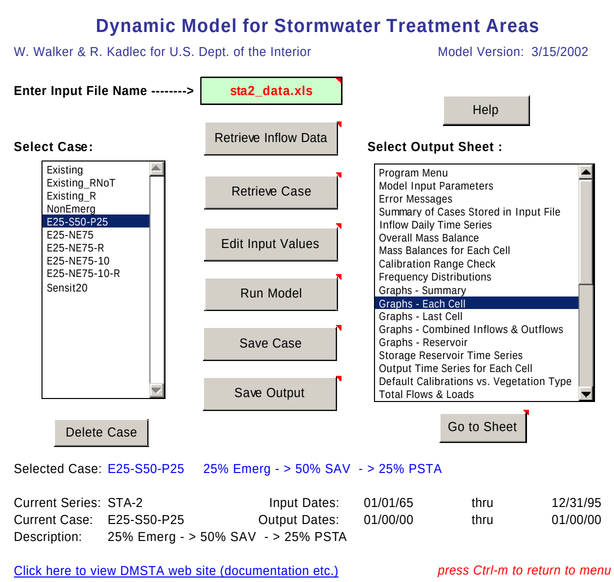

DMSTA Calibration to Prototype Datasets



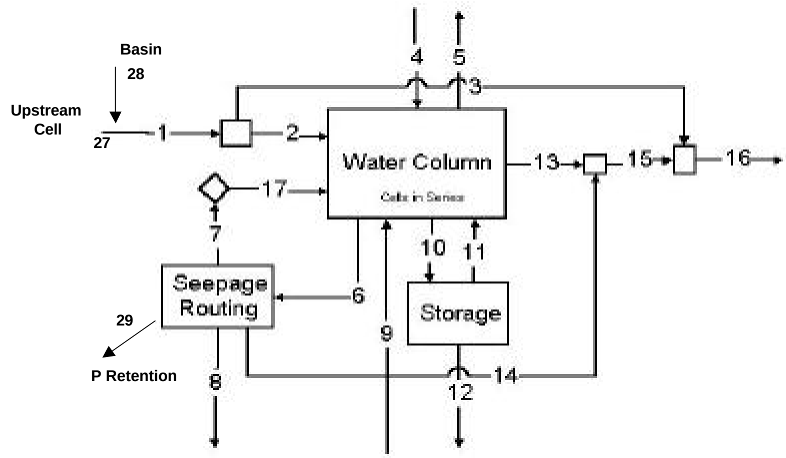
DMSTA Testing Using Independent Datasets



Datasets represent experimental mesocosms, test cell, full-scale treatment cells, & natural wetlands.
Screen datasets have at least 1 full year of data.



DMSTA Flow Net



Driving Forces

a. Daily time series of runoff water inflows.
b. Daily time series of runoff water concentrations.
c. Daily time series of rainfall.
d. Rainfall P concentration.
e. Atmospheric dry deposition.
f. Daily time 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.

Wetland Design Information

A. Surface area (A). (wetted area at normal operating level)
B. Mean wetland width (W). (This allows different length to width ratios and, in turn, affects the discharge vs. stage relationship)
C. Outflow control depth (Z_c). (A weir setting for instance)
D. Community type. (This triggers the selection of P removal parameters)
E. The hydraulic efficiency, determined by the number of tanks in series, N.
F. Bypassing depth maximum (Z_{max}).
G. Bypassing inflow maximum (QIN_{max}).
H. Outflow pump capacity ($QOUT_{max}$).
I. Out-seepage return fraction.
J. Out-seepage feed-forward fraction.
K. Out-seepage concentration (if not wetland water concentration).

Intangibles

Phosphorus Speciation

Calcium availability

Hydrilla

Dryout

Fire

Herbiciding and Other Vegetation Management

Phosphorus Mass Balance Models for Everglades Applications
Potential CERP Applications

Designing Treatment Areas to Achieve CERP "Assumption":
Inflow P < 10 ppb

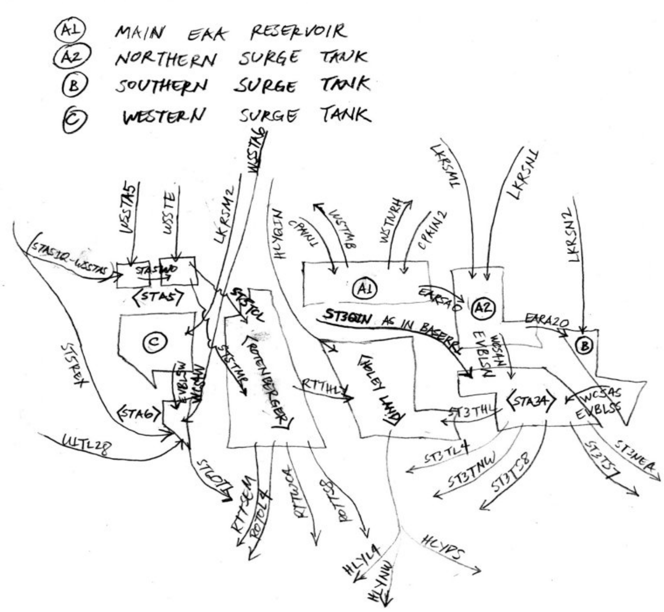
Evaluating Impacts Downstream of Inflow Points
If CERP Inflow P Assumption not Achieved

Optimizing CERP Reservoirs for Water Quality Benefits:
Control Peak Inflows to STA's
Phosphorus Removal

Simulating Recovery of Previously Impacted Areas

Relevant CERP/ENP Performance Measures:
Periphyton
Vegetation
Peat Accretion

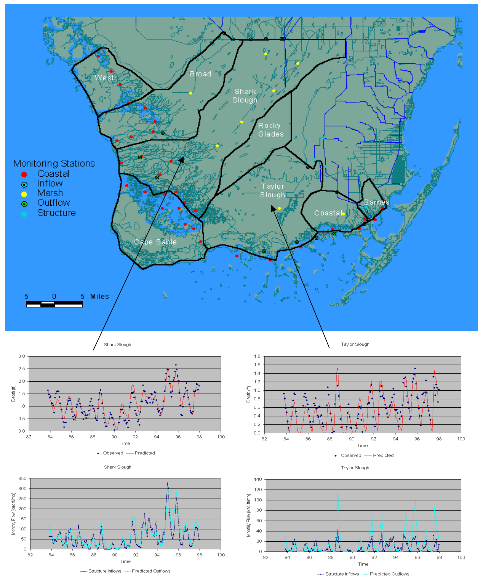
Plumbing of CERP EAA Reservoirs



Monthly Water-Budget Models for ENP Basins

Developed to Support Estimation of Flow & Nutrient Inputs to Florida Bay

Model: Outflow = Inflow + Rainfall - ET - Increase in Storage



http://www.wwwalker.net/flabay