CENTRAL EVERGLADES PLANNING PROJECT

How Hydrologic Modeling and Ecological Criteria Inform Engineering Design of Restoration Project Features

GEER Conference 2015 Session 9

Linking Hydrology to Ecology in Restoration Planning, Design, and Implementation

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April 21, 2015

CEPP MODELING AND DESIGN

- Modeling -- what is it & what does it accomplish?
- Modeling approach
- Modeling & Engineering Design

WHAT IS A MODEL?

- A set of mathematical equations representing the physics of water movement within the ecosystem
- **STAGE= Y (rain, ET, Q_{in}, Q_{out})**
- Rain, ET, demands, and a bunch of rules → **stressors**
- STAGE → **responses**
- Equation solutions often need advanced numerical methods & computer programming
- SFWMM & RSM are examples of hydrologic models

CEPP MODELING STRATEGY

Table 2.1. Anticipated Modeling during the analysis phase of the Central Everglades Planning Project.

	Goals	Strategy	Model
Project Analysis Phase	**Updated Conceptual Framework** (~ 3 Months) • Restoration Flow Targets • Everglades Flow Scenarios	To provide modeling representations of the range of long-term restoration goals (of which CEPP will achieve an increment), the SFWMM will be used to represent the CERP configuration and the RSMGL will be used to represent updated concepts (e.g. River of Grass scenarios). RESOPS could be used to provide information of long-term northern storage and treatment needs.	RSMGL SFWMM RESOPS
	Plan Formulation (~6 Months) (Develop Next Increment) • EAA Storage and Treatment ○ Identify Formulation Scope/Constraints ○ Alternatives Screening ○ Alternatives Formulation/Evaluation ○ Identify Preferred Concept • DECOMP & Seepage Management ○ Identify Formulation Scope/Constraints ○ Alternatives Screening ○ Alternatives Formulation/Evaluation ○ Identify Preferred Concept	In plan formulation of the CEPP increment, up-front screening of alternatives above the red line will be performed primarily using the RESOPS, LOOPS and C-43 models. Additionally, use of batch processing and inverse modeling techniques will allow DMSTA to be applied during the screening phase of the effort to answer water quality questions north of the red line. Similar techniques will be applied to iModel and RSMGL to provide screening input south of the red line. Flow volumes will be translated across the models as boundary conditions and iteration between solutions north and south of the red line may be needed. Upon completion of the screening phase and identification of input assumptions for alternative assessment, final alternatives will be modeled using the RSMBN and RSMGL with detailed evaluation information being post-processed. Simulation of these alternatives will incorporate information gained from the screening, and DMSTA applications. HEC-RAS may also need to be applied in this final step to inform conveyance limitations or design requirements to the representation of alternatives.	RESOPS LOOPS C-43 RSMBN DMSTA HEC-RAS iModel RSMGL
	Project Assurances (~3 Months) ○ Finalize environmental assessments ○ Project Assurances ○ Water Made Available ○ Interim Operating Plan	Assurances assessment for saving clause, water made available and flood protection will primarily rely on post processing of the RSMBN and RSMGL representation of the CEPP Tentatively Selected Plan. Depending on public interest and management direction, other detailed models may also be needed for assessment of flood protection.	RSMBN RSMGL

RESOPS

SCREENING TOOLS AND TECHNIQUES

DMSTA

- Performing screening quickly tested the performance of management measures & potential components configurations
  - Allowed comparisons of the viability of management measures
  - Identified the feasible sizing ranges for further in-depth analysis
  - Not a replacement for the detailed regional models, but reduced the burden on the more detailed regional models (helped to expedite the schedule)

- Optimization & inverse modeling techniques were used to automatically evaluate thousands of operating rules & select the best performers.
  - Informed the discussion on what objectives are most critical to design

iModel

MODELING TOOLBOX

REGIONAL HYDROLOGIC MODELS

- Primary modeling tools used for Central Everglades assessment
- Provided daily, detailed estimates of hydrology across the planning domain

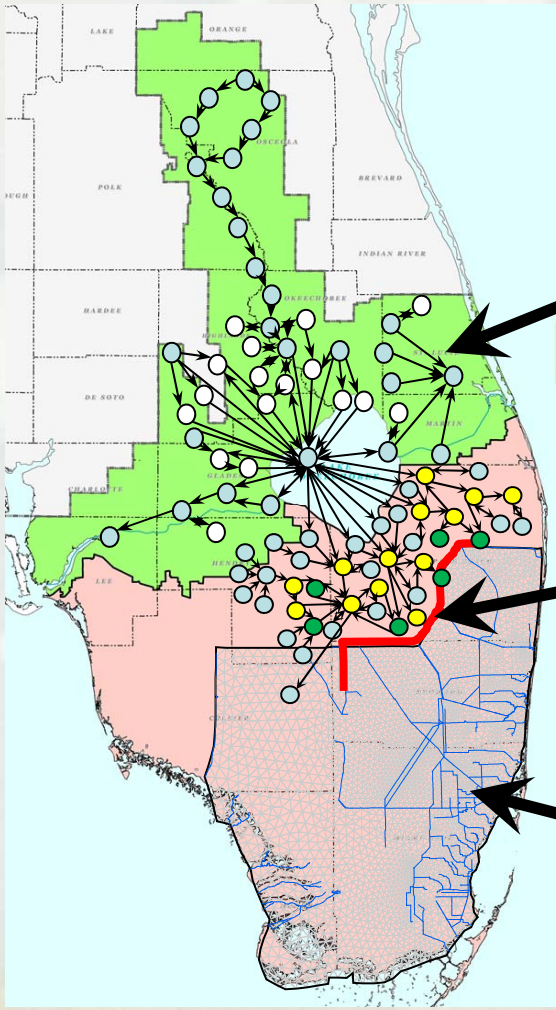
SUB-REGIONAL & DETAILED MODELS

- Smaller scale, more detailed models that helped analyze specific areas of interest (e.g., water quality, conveyance of water, etc.)

SCREENING TOOLS AND TECHNIQUES

- Simplified models & data processing techniques that analyzed a broad range of options & helped screen ideas for further in-depth analysis

DECOUPLED MODELING APPROACH



Northern Everglades

Southern Everglades

RSMBN:
EAA Storage & Treatment

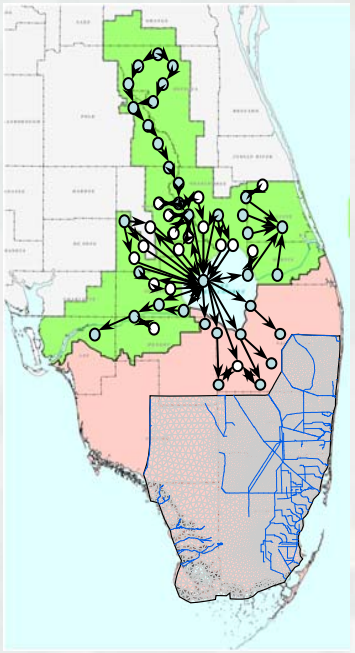
Interface ("Red Line"):
Flow Volumes

RSMGL:
Decompartmentalization & Seepage Management

REGIONAL MODELING APPROACH

SCENARIO

- Climatic Input
  - Rainfall
  - ET
- Boundary Conditions



Model Output
- Daily time series of water levels, flows
- Demands not met

PERIOD OF RECORD: 1965-2005

Evaluation (Environmental, Water Supply, etc.)

- Project Features
- Land Use/Land Cover
- Water Demands
- Operating Criteria

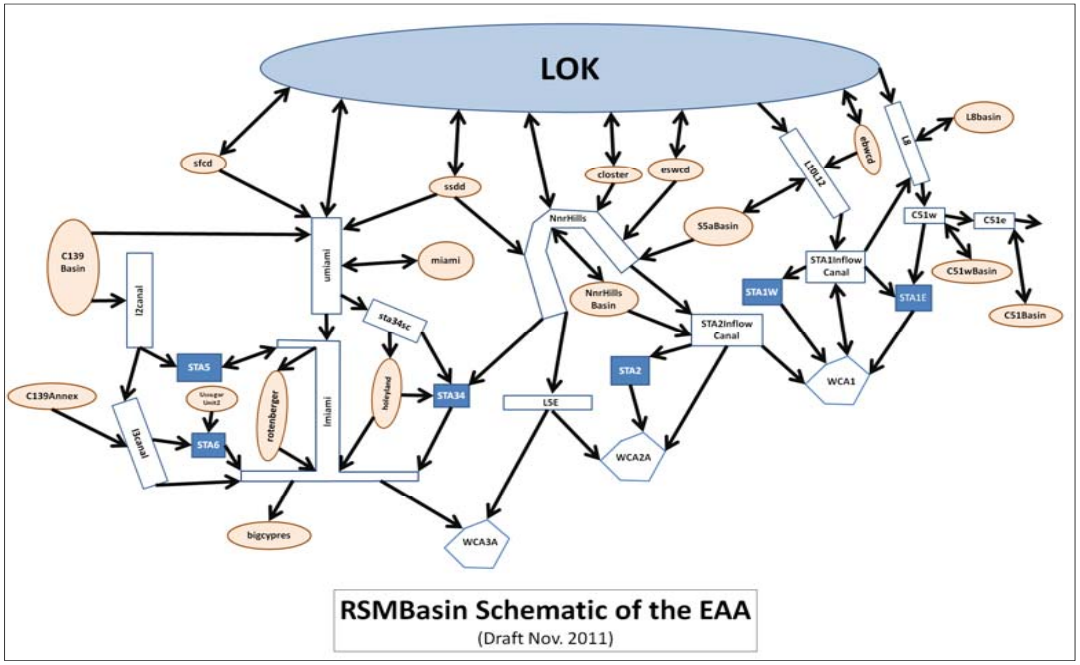
REGIONAL HYDROLOGIC MODELING

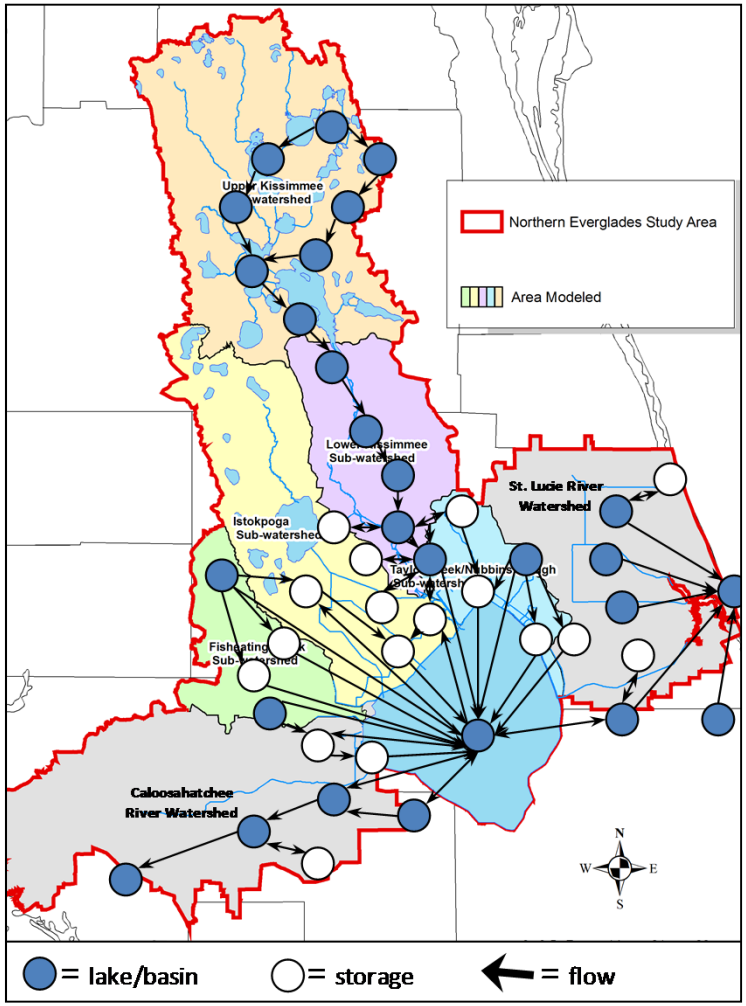
RSMBN (Basins)

Node Information:
total number of basins/lakes/canals represented: ~110

Link Information:
total number of connections represented: ~155

Run Time: ~ 10 minutes





Domain Information:
EAA area represented:
~690 sq. miles

REGIONAL HYDROLOGIC MODELING

RSMGL(Glades-LECSA)

Mesh Information:
Number of cells: 5,794
Average size: ~ 1 s. mile
Domain size: 5,825 sq. miles

Canal Information:
Number of segments: 979
Average length: ~ 1 mile
Total length: 1,043 miles

Run Time: ~ 1 day

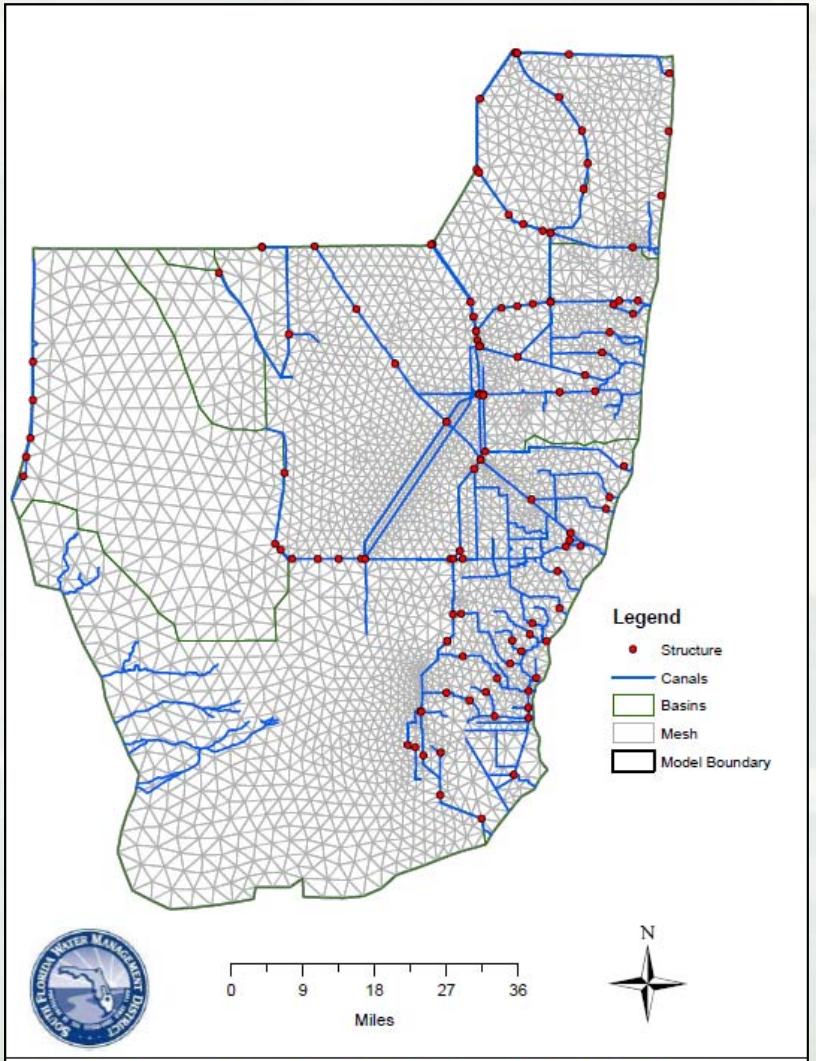
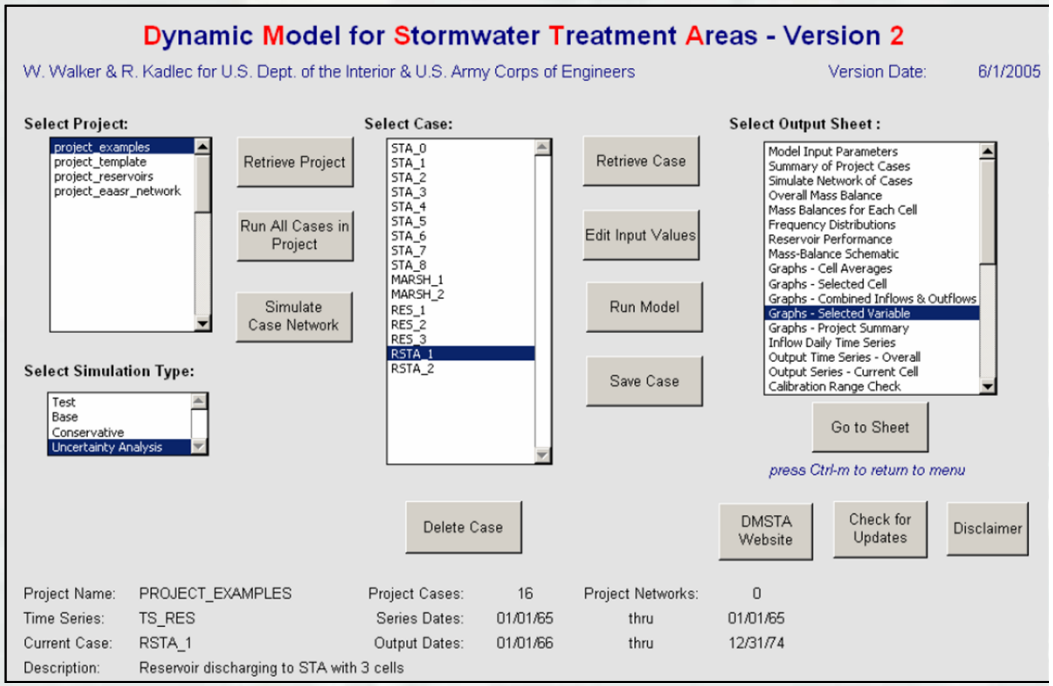


Figure 2.2: Glades-LECSA Model Domain with Canal, Mesh and Structure Locations

EXAMPLE: DYNAMIC MODEL FOR STORMWATER TREATMENT AREAS (DMSTA)

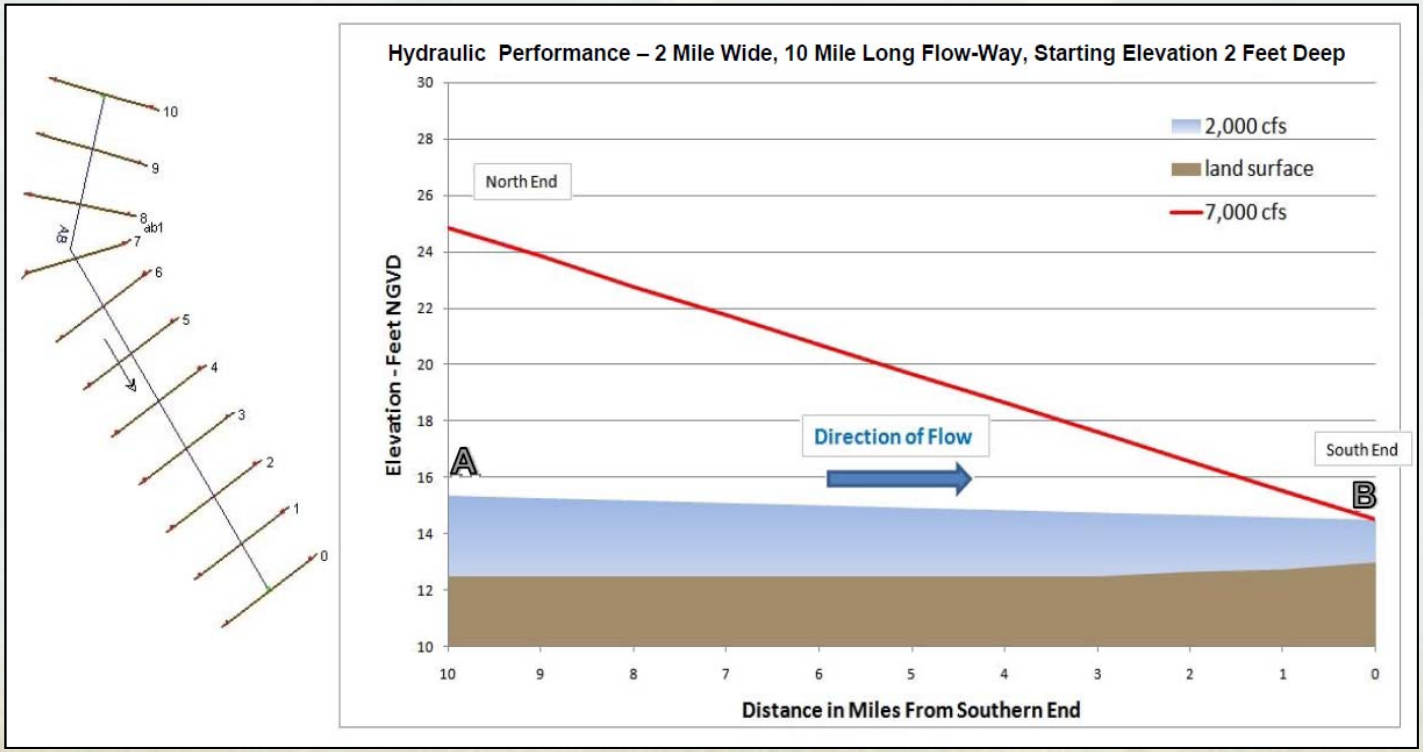
- Developed for the U.S. Department of the Interior (DOI) & the U.S. Army Corps of Engineers (USACE) (Walker and Kadlec 2005)
- Extensively used in south Florida to analyze Stormwater Treatment Area (STA) design, operation & management



EXAMPLE: HEC-RAS HYDRAULIC TOOL

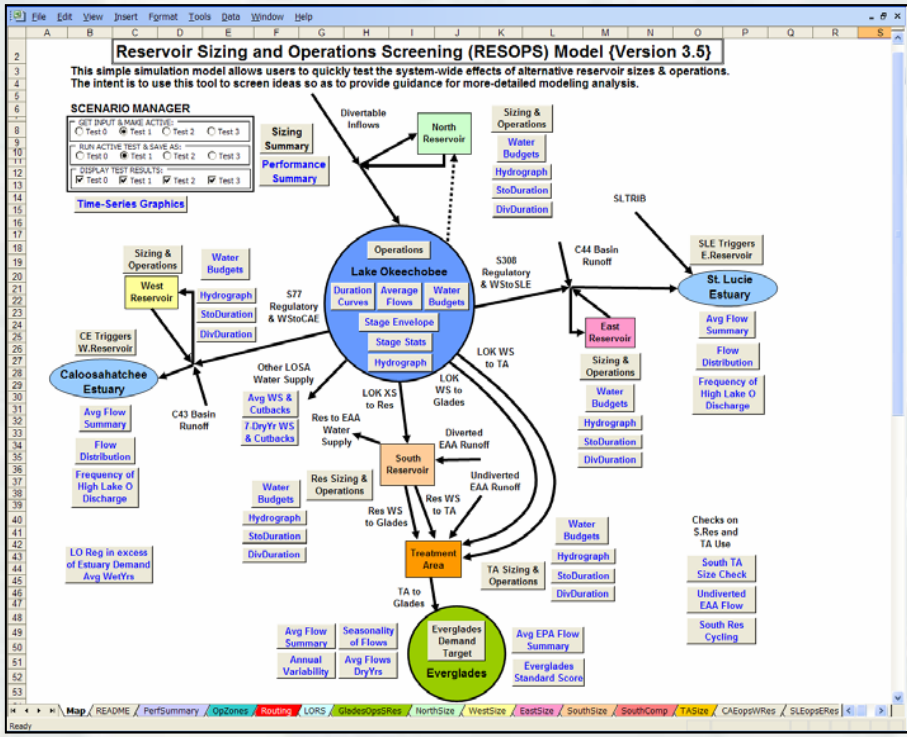
Hydrologic Engineering Center River Analysis System (HEC-RAS)

- Developed by USACE
- Used nation-wide for design & analysis of conveyance systems



EXAMPLE: REservoir Sizing & OPerations Screening (RESOPS) Model

- Coarse-scale Water Management Simulation Model
- Provides rapid screening-level testing of the integrated effects of alternative reservoir sizes & proposed operating rules:
  - Lake Okeechobee
  - EAA Storage
  - Other Northern Everglades Storage
  - Flows to the Everglades
- Performs 41-year continuous simulations (monthly time-step) of the hydrology & operations of the water management system
- Runtime = ~ 1 second

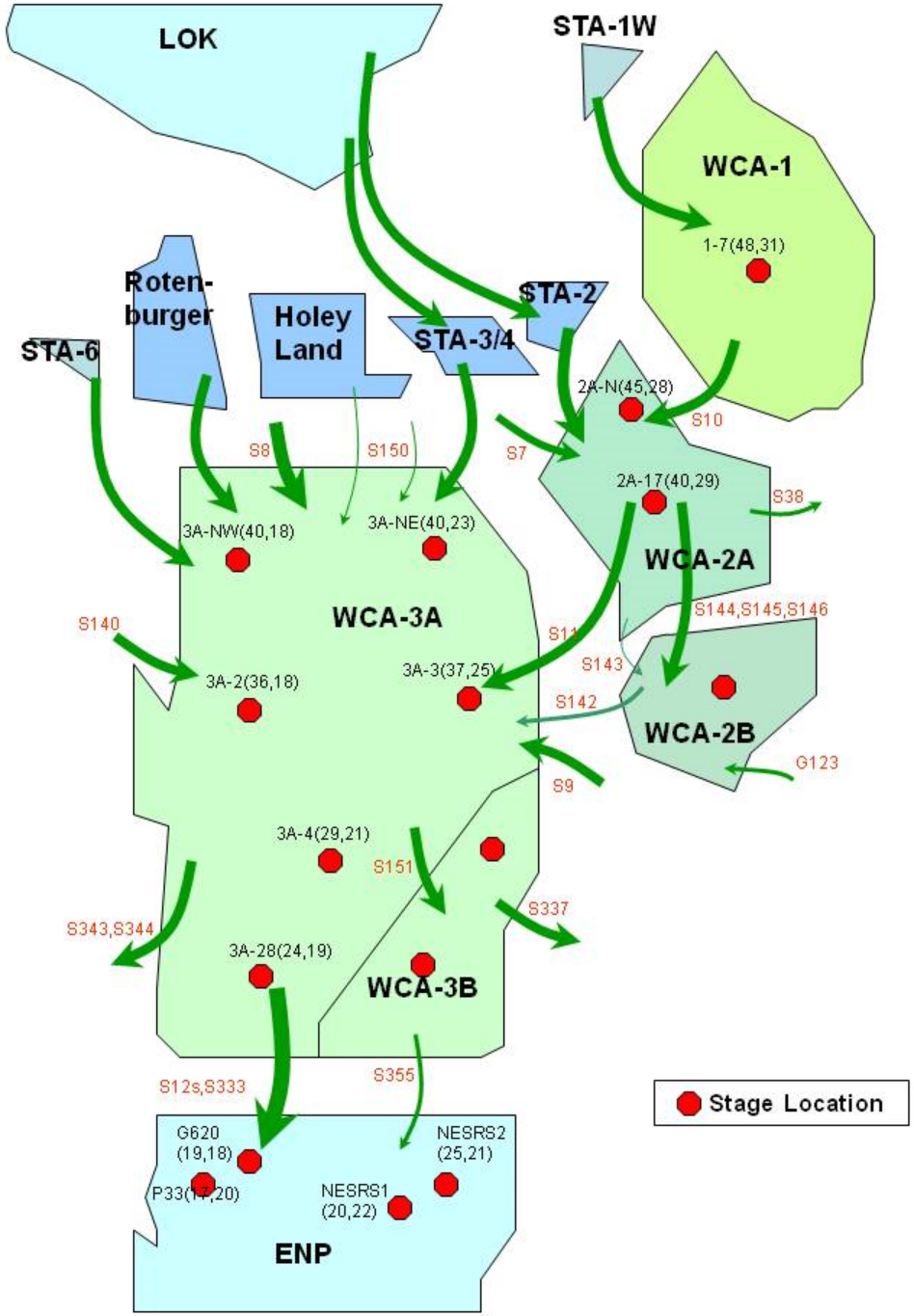


SAME THING DIFFERENT NAMES

	DIRECT MODELS	INVERSE MODELS
FLOW DELIVERIES	STRESSORS	DECISION VARIABLES
HYDRO-PATTERNS (STAGE)	RESPONSES	TARGETS
SYSTEM FEATURES	▪DEMANDS ▪STRUCTURES ▪RULES	CONSTRAINTS

DIRECT MODEL, → RSM

$$y = f(x)$$

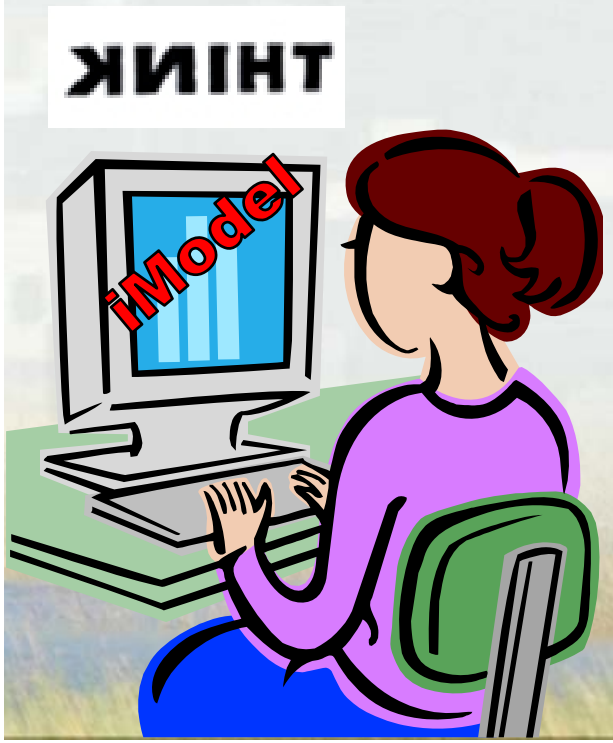


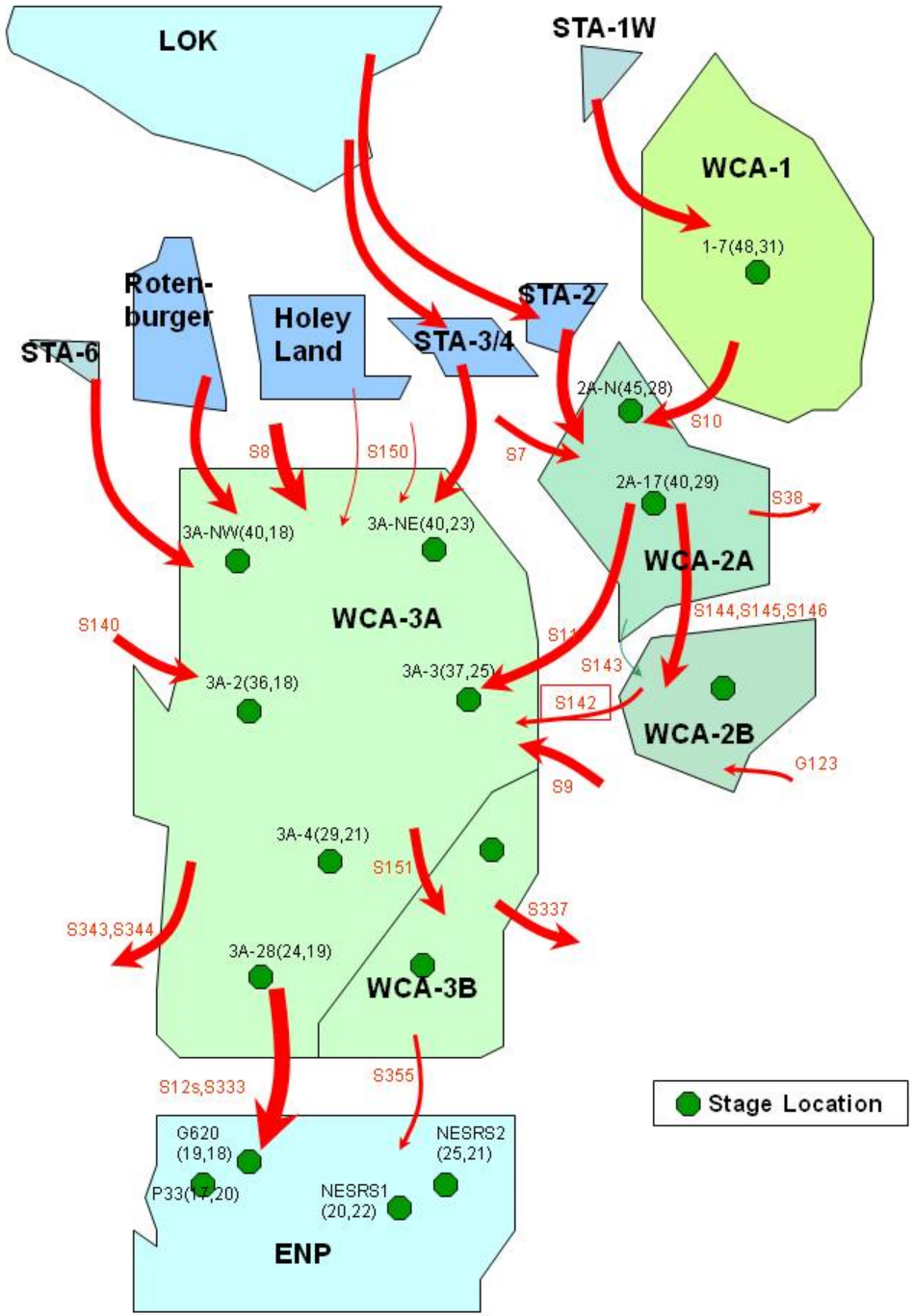
GSE8

iNVERSE MODEL, → iMODEL

developed by Alaa Ali

$$x = g(y)$$





Slide 16

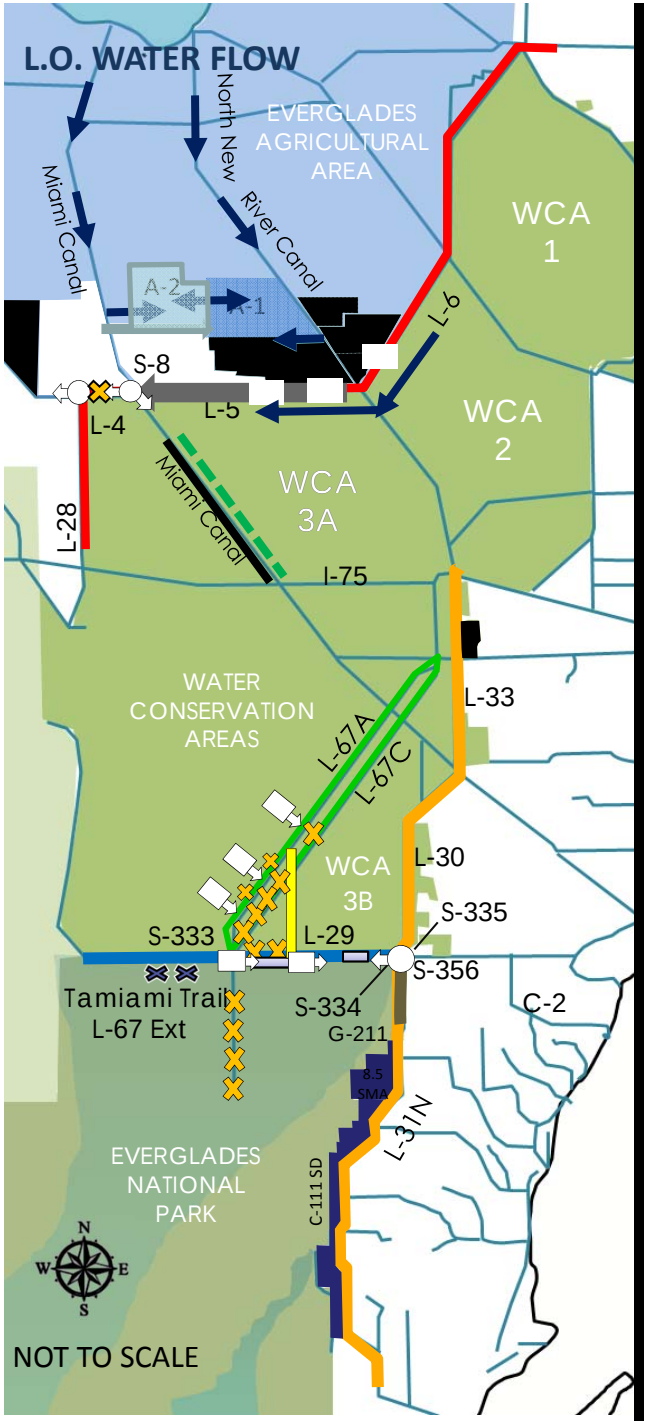
GSE8 Give the definition of an indirect model here from slide 26 and delete slide 26.
Gretchen Ehlinger, 4/17/2015

iMODEL: DIFFERENT FROM TRADITIONAL HYDROLOGIC MODELS

- iModel is an inverse modeling tool that reverses the process of a traditional model
- A traditional model **predicts** a system's **response** (e.g., stage) to the system's **input** (e.g., inflows, outflows)
- iModel **computes** a system's **required input** (e.g., inflows, outflows) to achieve a system's **desired response** (e.g., stage)
- One iModel run is equivalent to numerous traditional model runs & extensive output analyses

MODELING TO ENGINEERING DESIGN

- Based on criteria from regional & sub-regional models, ecological targets & constraints, limits were established controlling the function of project features
- Project features are designed for function & form
  - The features control flow by constraining or releasing at desired times or it is passive meaning it provides no control of flow (flow is unconstrained)
- Engineering design incrementally progressed with screening & plan formulation (design and costs considered)



RECOMMENDED PLAN (Alt 4R2)

STORAGE AND TREATMENT

- A flow equalization basin, or shallow reservoir, that will be integrated with the state's water quality treatment facilities to increase the amount of clean water flow to the Everglades from Lake Okeechobee

DISTRIBUTION/CONVEYANCE

- Increasing the L-5 canal capacity and modification to the S-8 pump station to convey water west
- Construction of a 360 cfs pump station to maintain water supply to the Seminole Tribe and western basin
- Removal of 2.9 miles of the L-4 levee to distribute inflow to WCA-3A and backfilling 13.5 miles of the Miami Canal

DISTRIBUTION/CONVEYANCE

- Construction of 8 miles of new levee and removal of 12 miles of existing levees to create a flowway through WCA-3B;
- Two 500 cfs gated culvert structures will provide inflow to the flowway and an 1150 cfs spillway will provide deliveries directly to eastern Shark River Slough;
- A 1,230 cfs spillway will maintain flow to the east of the flowway
- Additional 500 cfs gated culvert structure outside of the flowway to rehydrate the eastern portions of WCA-3B
- Removal of 5.5 miles of the L-67 extension levee and canal; and 6 miles of the Old Tamiami Trail within ENP

SEEPAGE MANAGEMENT

- A 1,000 cfs pump station and 4.2 miles of seepage barrier wall along the protective levee south of Tamiami Trail

Note: System wide operational changes and adaptive management considerations will be included in project

FEB | STA | Pump | Old Tamiami Trail Removal
Backfill | Levee Removal | Gated Structure
Seepage Barrier | Canal Improvement | Levee

ENGINEERING DESIGN & BEYOND

- Models (predictive simulations of capacity and operations) contribute greatly to the detailed design of restoration project features (i.e., levees, berms, control structures, canals & non-structural features)

- Projects features are further analyzed during Pre Construction Engineering and Design (PED) for design refinements & efficiencies.

ACKNOWLEDGMENTS

USACE and South Florida Water Management District
CEPP Project Delivery Team Members

USACE/SFWMD Hydrologic Modelers

USACE/SFWMD Water Managers

QUESTIONS?