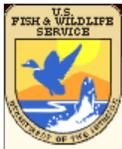# Refuge Modeling Update

Mike Waldon, PhD

Senior Hydrologist

A.R.M. Loxahatchee National Wildlife Refuge

337-852-3668, mike_waldon@fws.gov

Presented at TOC meeting, May 31, 2011

U.S. Fish & Wildlife Service
Arthur R. Marshall
Loxahatchee National Wildlife Refuge

Center for Louisiana Water Studies
Institute of Coastal Ecology and Engineering

Acknowledgements

- Dr. Ehab Meselhe (PI), and other UL-Lafayette faculty, staff, and students
- Model Technical Advisory Panel as well as internal and external reviewers, and others
- Data collection and archival primarily by state and federal staff
- Previous modeling efforts
- Findings and conclusions presented here are those of the author and do not necessarily represent the views of the USFWS or others

Model Study Approach

- Involve agencies, TOC, and interested parties
- Use off-the-shelf programs if possible
- Avoid computer program development
- Start simple, and add complexity as needed
- Objectives
  - Improve scientific understanding of mechanisms
  - Support management decisions

Modeling Suite

- Objective was to develop 2 types of models
  - Mass Balance Model
    - SRSM – 2/4 compartments
    - 9-Box
    - 39-Box
  - Spatially-explicit model
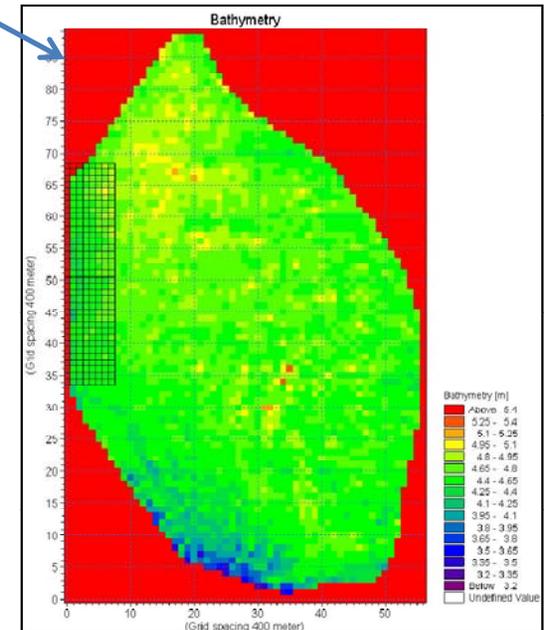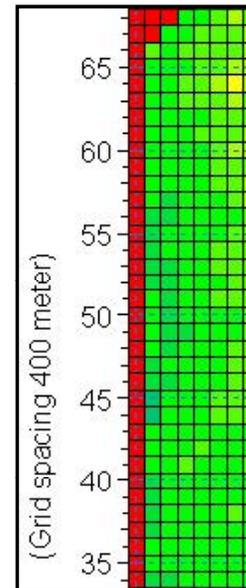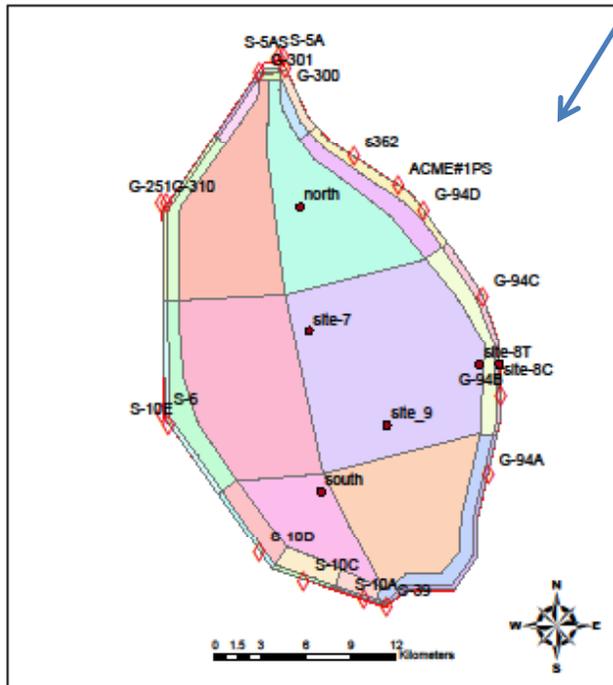   - MIKE-FLOOD (MF) - EcoLAB (by DHI)

Modeling Suite
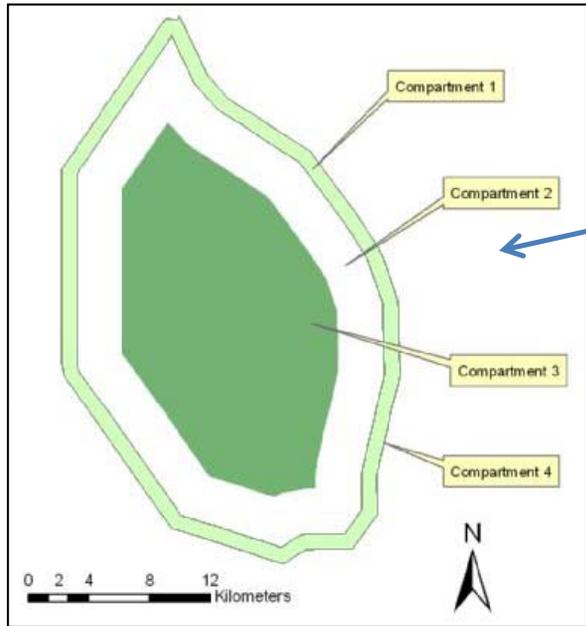
SRSM

9-Box

39-Box

MF
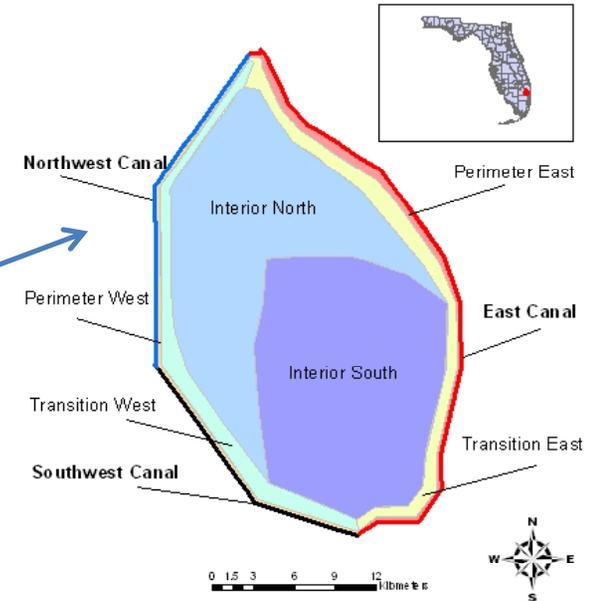
Modeling Suite – Findings

- Berkeley-Madonna
  - Has significant advantages over STELLA
  - Provides flexibility for testing and prototyping
  - Cluster analysis provides basis for compartments
- MIKE-FLOOD
  - Integrated efficient GUI reduces level-of-effort
  - Has significant bugs that require user competency and diligence

Stage – Approach

- Inputs include daily inflows, precipitation, ET, water supply withdrawals, and storm event releases
- Calculate regulatory releases based on regulation schedule

Stage – Findings

- Calculated regulatory releases are adequate for modeling historic management since initiation of 1995 regulation schedule
- Even the most highly spatially aggregated model, SRSM, is reliable in predicting stage and annual outflow
- Stage is insensitive to vegetation pattern and vegetative resistance to flow
- Stage is sensitive to overall seepage (recharge) rate, but insensitive to spatial pattern
- Some inconsistency exists among gage datums
- Conjecture – natural levee formation along marsh-canal interface

Chloride – Approach

- Modeled as a conservative
  - i.e. only physical processes, no chemical or biological kinetics

Chloride – Findings

- Calibrated marsh dispersion in MF is high
- Chloride is valuable as tracer of flow and intrusion in the peripheral marsh
- Chloride is less useful as a tracer in the most interior marsh because of long residence time relative to events
- Chloride is sensitive to vegetation pattern and vegetative resistance
- Chloride calibration constrains calibration of other constituents

Sulfate – Approach

- Modeled as a single non-conservative state-variable with disappearance and no internal source

Sulfate – Findings

- Single state-variable model of only sulfate gives reliable model predictions
- Sulfate traces intrusion into interior and tests mechanisms not tested with chloride
- First-order kinetics (disappearance proportional to concentration) required large spatial adjustment of rate "constant"
- Zero-order kinetics (constant mass loss per unit area) describe disappearance well
- Sulfate disappearance not sulfate limited until very small concentration is reached
- Sulfate events at less-impacted sites are consistent with modeling that has canal intrusion as the sole source

Total Phosphorus – Approach

- Model TP, does not separate P into inorganic/organic or particulate/disolved
- Model now uses DMSTA reaction kinetics
- 2 non-conservative state-variables
  - Water column TP
  - Storage (stationary)

Total Phosphorus – Findings

- Models operate well with TP as state-variables
- More complicated speciation of P forms was not required
- First-order and k-c* formulations inadequate and unreliable in less-impacted interior marsh
- DMSTA kinetics follow dynamics in marsh
- Published DMSTA parameter sets work well
- Re-calibration to Refuge data does improve performance

Applications – Water Needs

- Performance Measures (PMs) use stage to evaluate alternatives
- SRSM is adequate for alternative evaluation
- Evaluation supports the water needs working group consensus that average annual inflow volume is not a suitable PM for the Refuge
- High stage PM has been used to evaluate alternatives, and is available for use

Applications – Rainfall-Driven?

- Models reject the characterization of Refuge interior as *ombrotrophic*

- Cl at the least-impacted marsh sites is about 4x higher than anticipated when inflow equals rainfall Cl concentration

- Modeled events of short-duration elevated concentration (spikes) of sulfate at interior sites also indicate that canal water penetrates and impacts the interior

Applications – TP Inflow

- Model runs compare historic inflow concentration time-series with constant 10 ppb inflow

- Modeled water column TP concentration at the least-impacted interior sites is insensitive to inflow TP concentration

- However, modeled TP storage at these sites is somewhat sensitive to inflow TP concentration

- Modeled short-duration events of high water column TP (spikes) at more peripheral sites (e.g. LOX-10) are eliminated when inflow is set at 10 ppb

Applications – Eastern Flow Barrier

- Model blocked all flow between the L-40 Canal and the marsh

- Modeling is preliminary and does not substitute for complete EA of impacts

- Only small change in canal and marsh stage and outflow volumes were predicted with barrier

- Large water quality improvements in the eastern marsh

- At western marsh sites, little/no degradation of water quality and some improvement

Applications – Hourly vs. Daily Inflows

- We have assumed that daily average inflow is appropriate level of temporal aggregation
- Tested assumption by using hourly rather than daily flows for SRSM
- Average Cl concentration increased in all marsh cells by ~0.5 mg/L
- Maximum concentration in all marsh cells increased ~5 mg/L
- Result have implications for pump operations as well as future modeling

Current Projects

- Slough/airboat trail/fire break impact on dispersion in the Refuge marsh
- Comparison of MF and 39-Box models
  - Determine when compartmental model (39-Box) can substitute for spatially-explicit (MF) model
  - Identify needed 39-Box compartmental design improvements
- Extend period of simulation
- Documentation
- Maintenance

Documentation

- Throughout the monitoring and modeling project documentation has been a priority
- Over 60 presentations, reports and papers to-date
- Model web pages for the project, SRSM, and MF models
- Additional documentation is under development

Further Information

Model Project Home

http://loxmodel.mwaldon.com/

There you will find links to:

- Past workshop agendas and presentations,
- Bibliography
- SOFIA Refuge modeling and monitoring site
- SRSM and MF model home pages