Everglades Rainfall Driven Operations

The Evolution of a New Paradigm for Operating the South Florida System

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Presentation Outline

- I've heard of Rainfall Driven Operations (RDO) before.
- RDO in "Model Land" – EAA Reservoir Case Study
  - Based on the output of the Natural System Model (NSM)
  - Used in simulations with the South Florida Water Management Model (SFWMM or 2x2)
  - Even in model land it's complicated
  - Policy objectives result in adjustments to RDO targets
- RDO in the "Real World" – Making Progress
  - Stage based RDO formula development
- Next Steps / Ongoing work – Stay tuned, more to come…

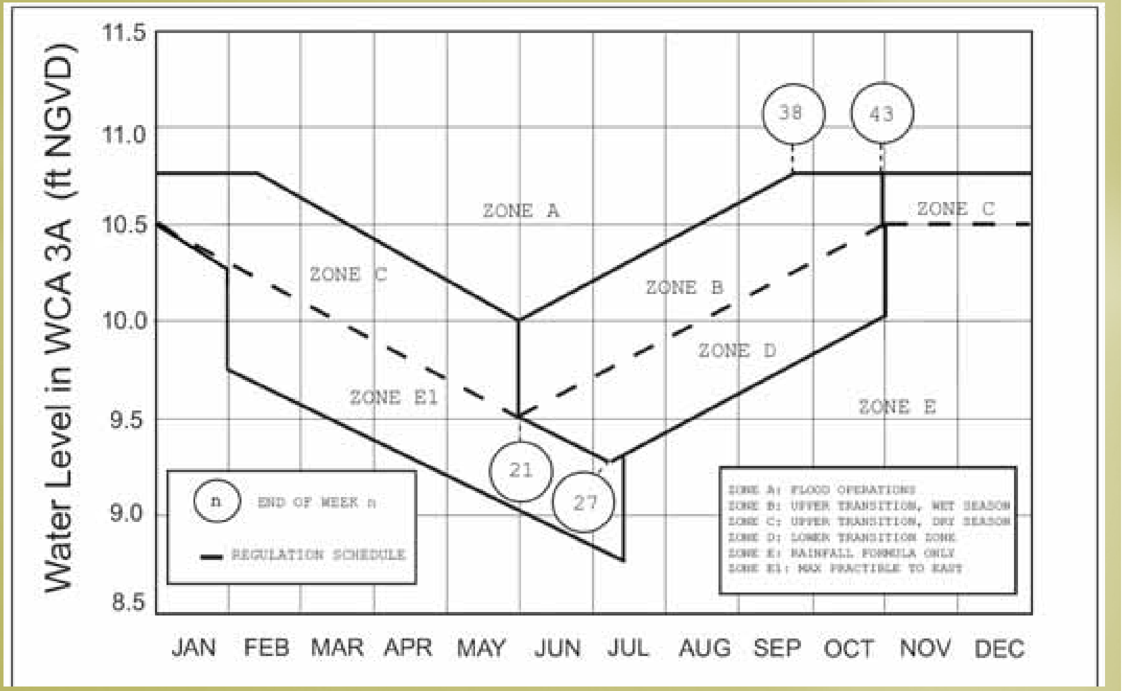
Background
Project Objective

The goal of the Everglades Rainfall Driven Operations (RDO) project is to provide a set of operational protocols for a current or projected future system infrastructure that are aimed at achieving pre-drainage conditions in a post-drainage, managed hydrologic system.

Background
RDO vs. Regulatory Releases

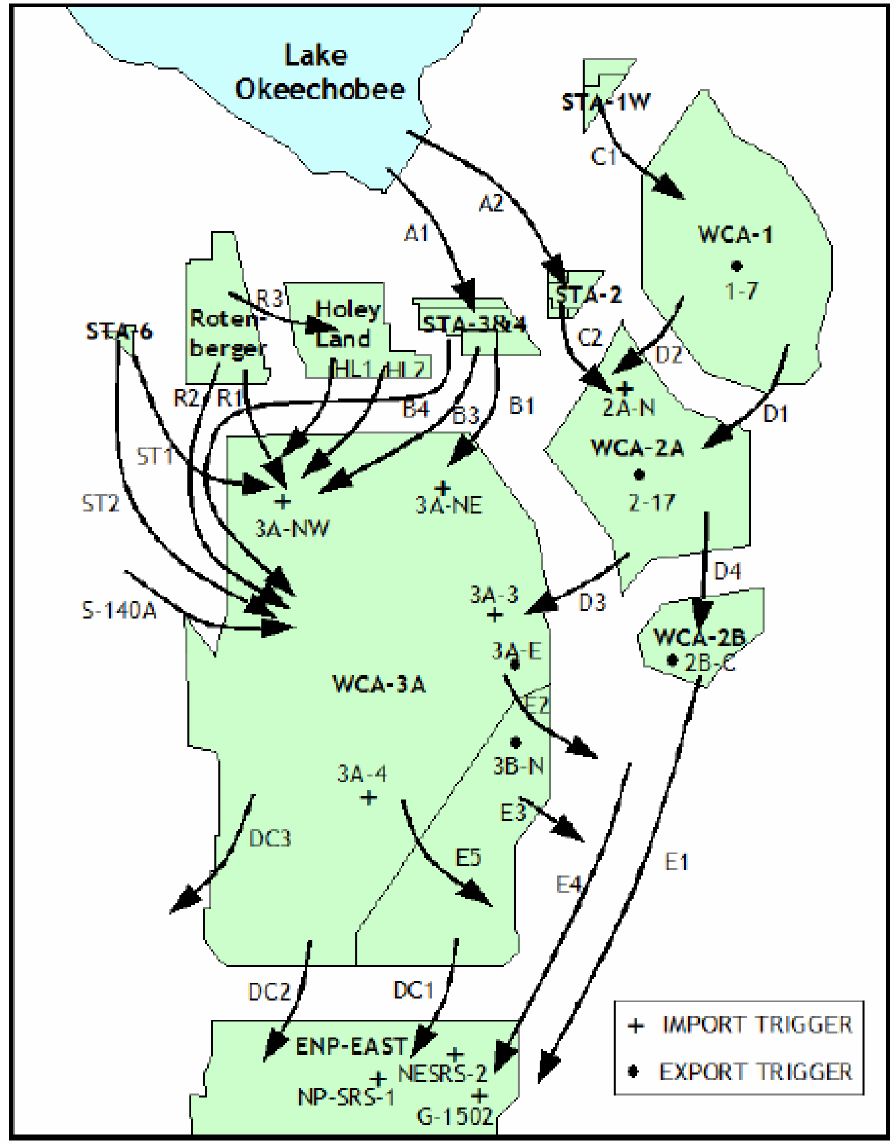
- **Regulation schedules tend to discharge water to downstream areas based on a primarily flood control paradigm. (PUSH)**
- **Typically, they are calendar-based so they capture seasonal variability, but not year to year variability.**

Example Regulatory Schedule



Background
RDO vs. Regulatory Releases

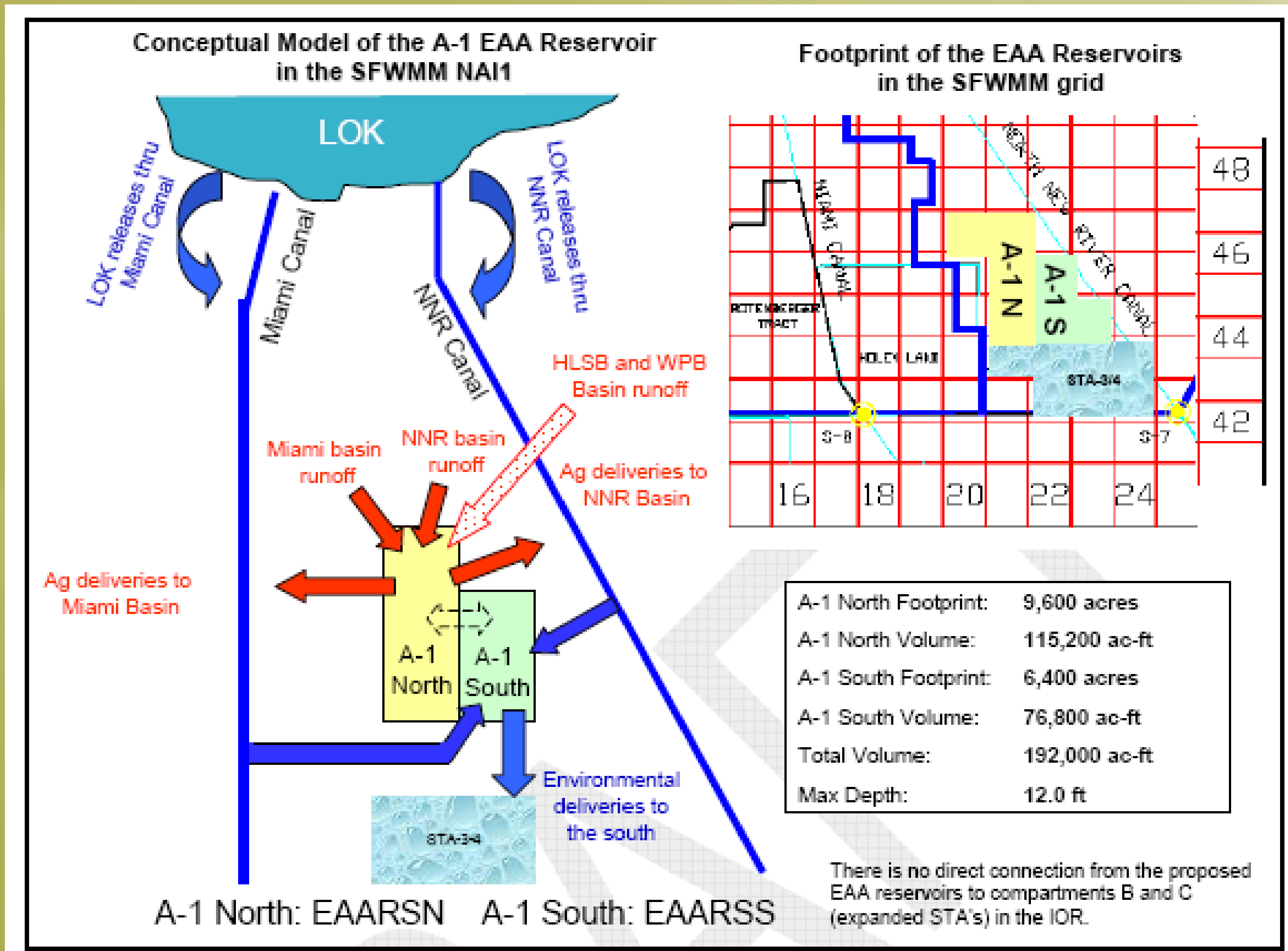
- RDO utilizes stage - based performance relative to desired targets at a series of selected gauges in the natural area to move water through the South Florida system. (PULL and PUSH)
- Stage targets are initially based on NSM depth added to current topography.
- Methodology responds to variability in climate, so both seasonal and year to year variability is observed.



Clarification: RDO "Lite" vs. RDO

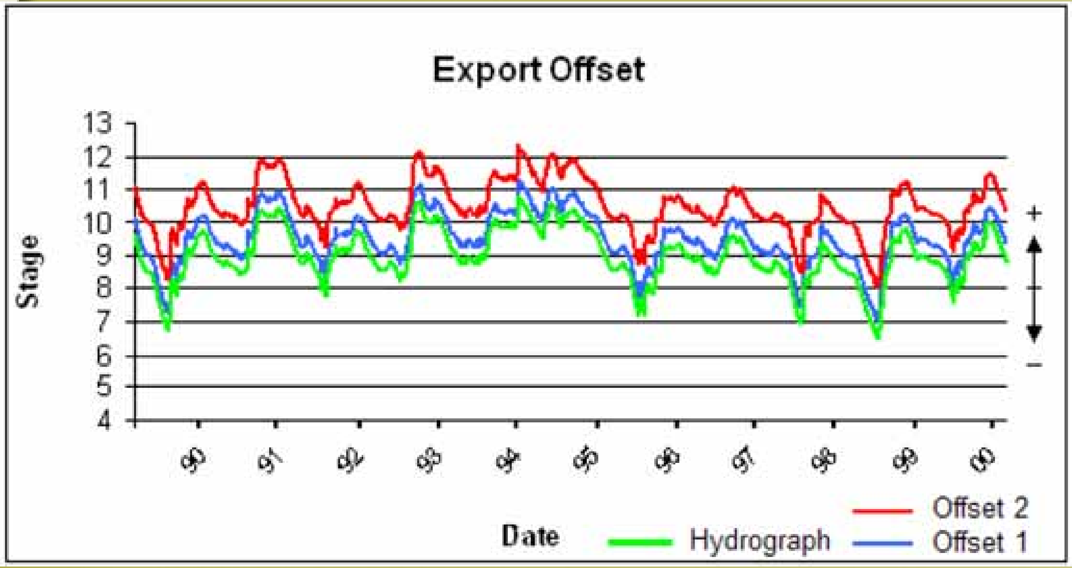
- Some planning efforts make use of an operation known as "RDO Lite".
- This refers to a flow-based formula (Ali 2004) that predicts NSM-like flow volumes across Tamiami Trail
- The flow-based formula is used to derive the environmental component of the WCA-3A regulation schedule, but does not change the schedule itself.
- Full RDO utilizes stage targets to dictate flows throughout the system and replaces regulation schedules.

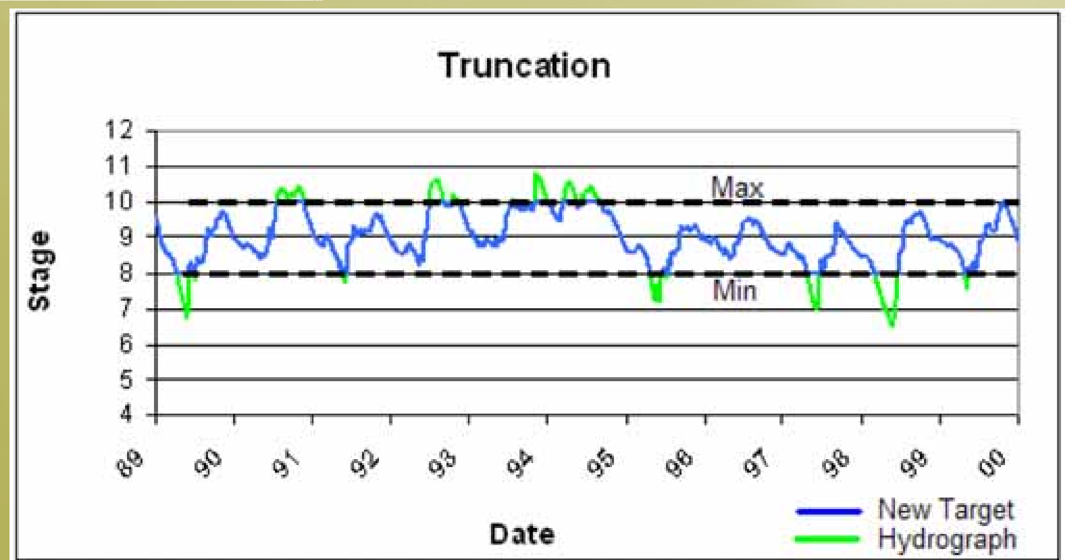
EAA Reservoir Case Study



A-1 North Footprint:	9,600 acres
A-1 North Volume:	115,200 ac-ft
A-1 South Footprint:	6,400 acres
A-1 South Volume:	76,800 ac-ft
Total Volume:	192,000 ac-ft
Max Depth:	12.0 ft

EAA Reservoir Case Study
Example RDO Transformations

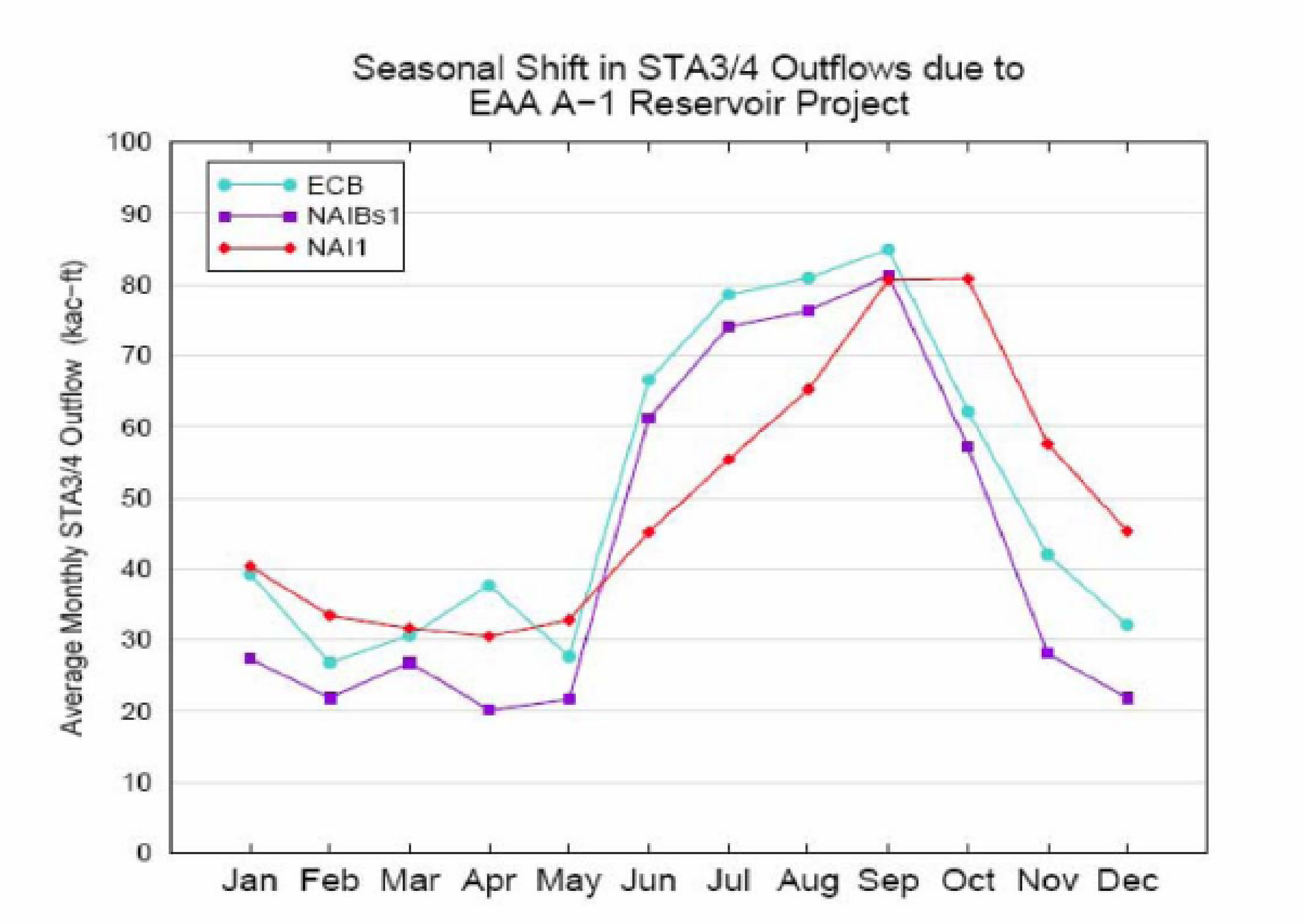




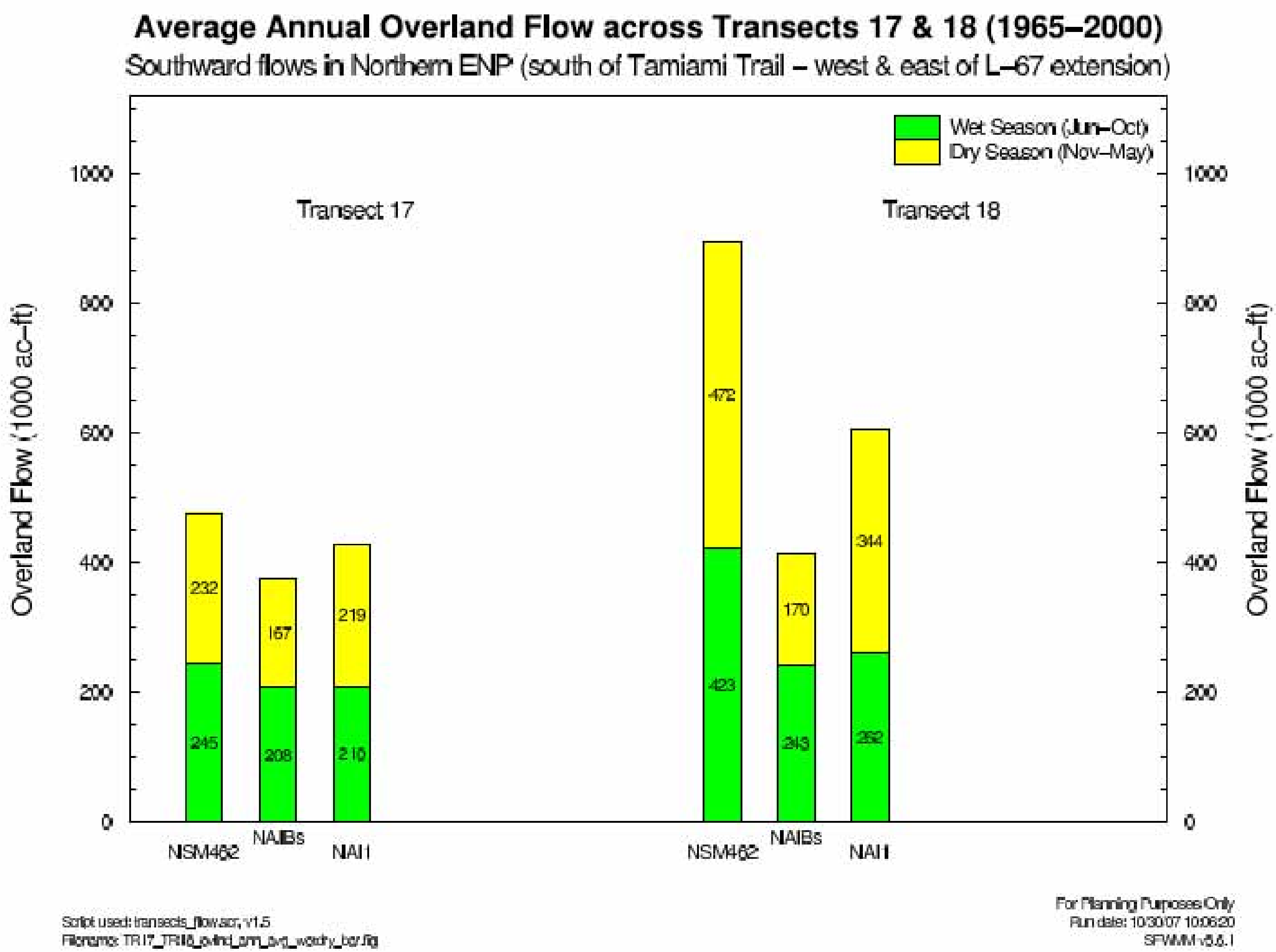
EAA Reservoir Case Study Meeting Project Objectives

- Typically, a series of modifications to RDO targets (initially NSM depth) are required in order to achieve desired outcomes.
- This is due to a number of considerations including:
  - Balancing the competing objectives of the natural system
  - Limitations of downstream infrastructure
  - Performance constraints related to water quality or endangered species.
- As part of the CERP planning process, RDO schemes are utilized in both current and future modeling scenarios, further complicating matters.

EAA Reservoir Case Study - Results



EAA Reservoir Case Study – Results
Inflows to Everglades National Park



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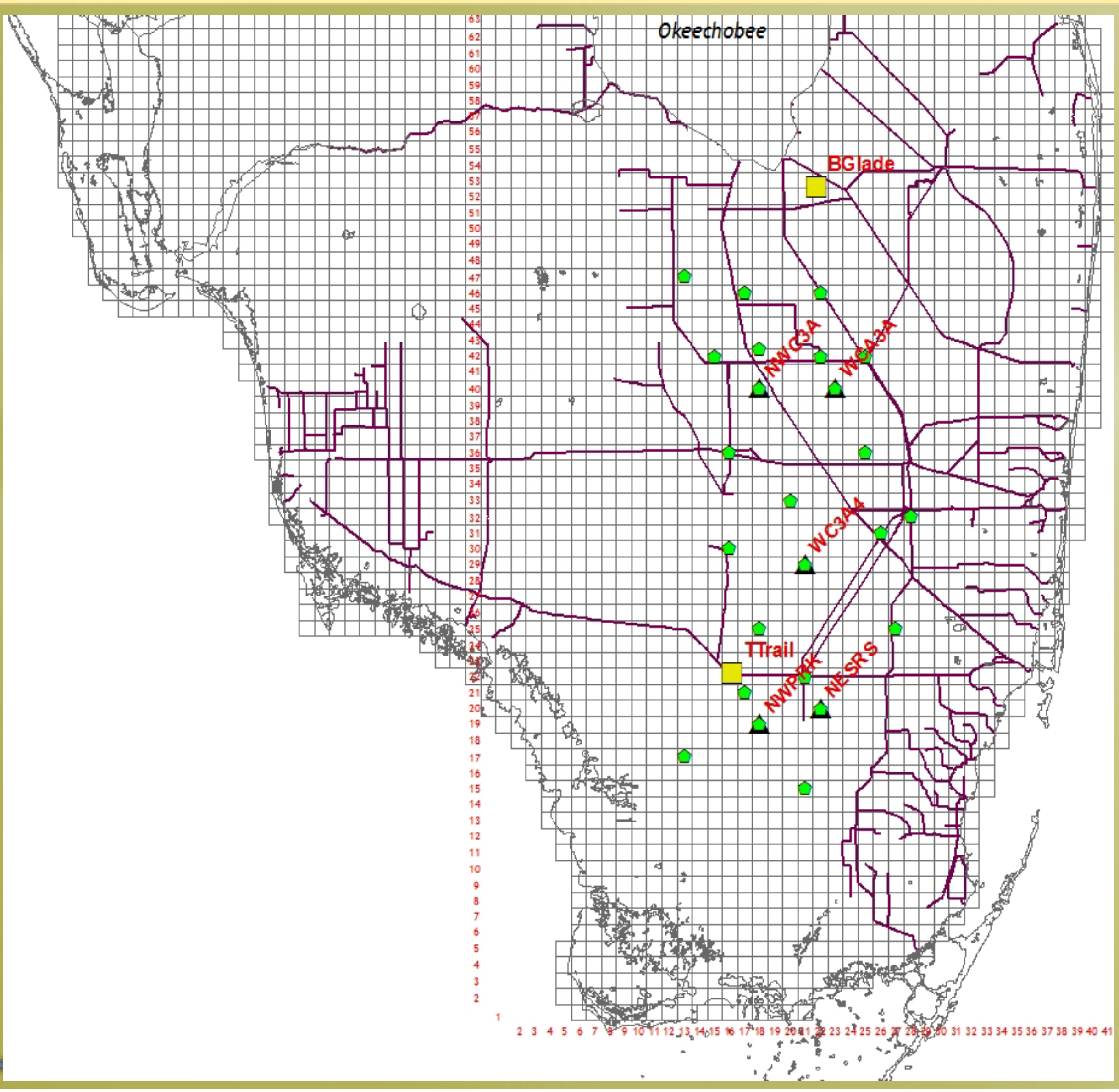
Real World RDO - Challenges

- Exploratory data analysis
  - What data is needed to do real time RDO?
- Determining the target to attempt to reach
  - NSM depths are not available real-time.
  - How do policy objectives and “model land” translate into operational protocols?
- Identifying the flow regime that will produce desired targets
  - Inverse modeling techniques
  - Field validation

Selecting Rainfall and ET stations



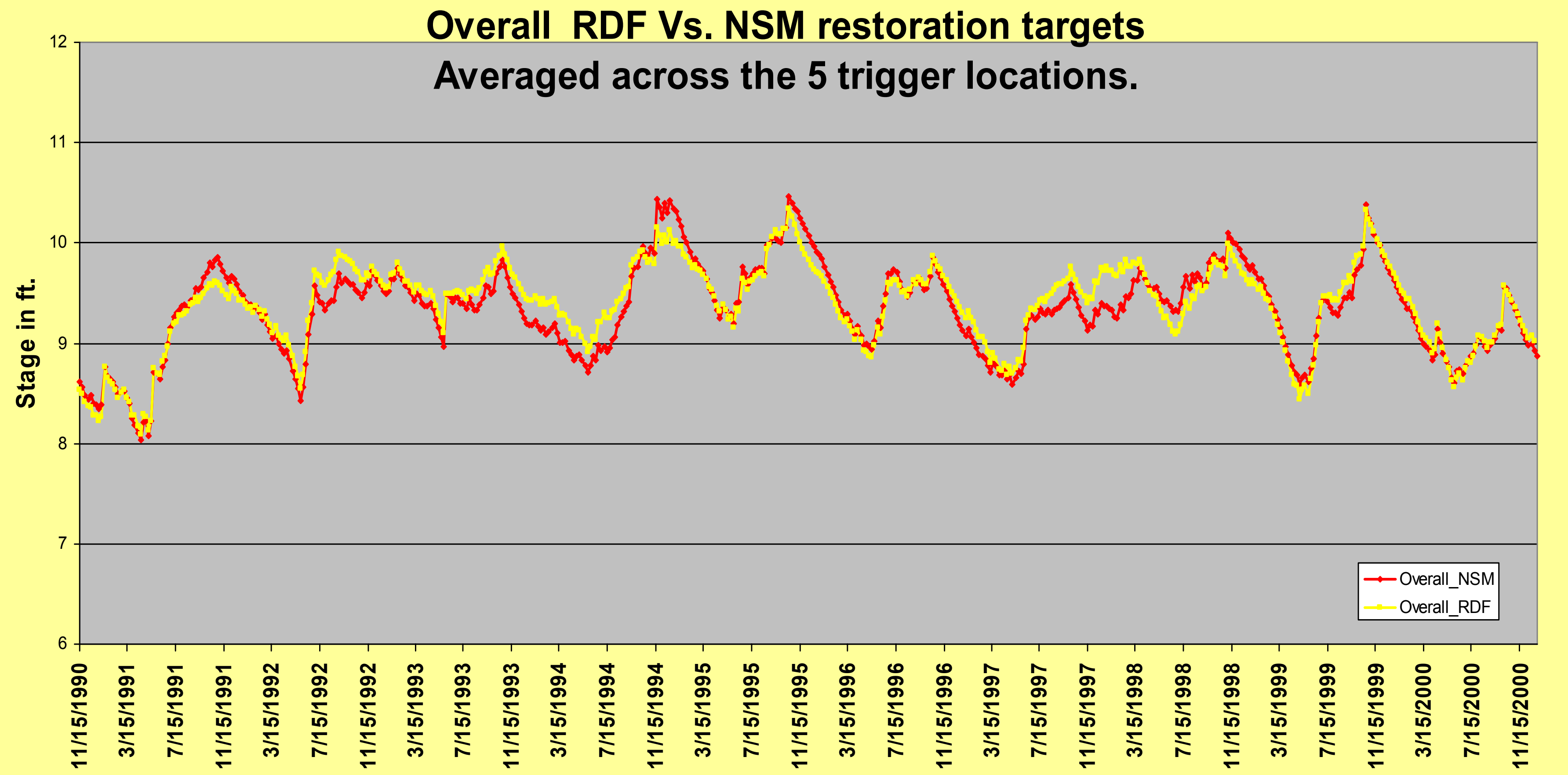
Real World RDO – New Rainfall Driven Formula

$$\hat{S}tg_t = \left(\sum_{i=1}^{n} Tansig\left(\sum_{k=1}^{19} \omega_{k,i} * \sum_{j=1}^{114} \left(x_{t,j} * p_{j,k} \right) + \alpha_i \right) * \theta_i + \beta \right) * \sigma_q + \mu_q$$

- $\omega_{k,i}$ is the (k,i) element of hidden layer weight matrix Ω
- α_i is i^{th} element of the hidden layer bias vector A
- θ_i is the i^{th} entry of output layer weight vector Θ
- β: The output layer bias vector term
- *Tansig*: Hyperbolic tangent sigmoid transfer function
- n: Number of hidden layer nodes (14 in this case)
- μ_q: Historical global mean vector of stage target time series of the modeling data set.
- σ_q: Historical global standard deviation vector of stage target time series of the modeling data set.

Structured as a Nonlinear autoregressive network with exogenous inputs (utilizes a *Feedforward Levenberg-Marquardt backpropagation*)

New Rainfall Driven Formula - Results



New Rainfall Driven Formula - Results

Overall Statistics for Global Prediction (ft.)

	NWC3A	WCA3A	WC3A4	NESRS	NWPRK	OVERALL
MSE	0.049	0.051	0.025	0.027	0.030	0.037
Std Err	0.208	0.216	0.158	0.164	0.172	0.188
Bias	0.078	0.067	-0.011	0.028	0.024	0.037

Real World RDO – Next Steps

- Exploratory data analysis
  - What data is needed to do real time RDO?

- Determining the target to attempt to reach

  - NSM depths are not available real-time.
  - How do policy objectives and model land translate into operational protocols?

- Identifying the flow regime that will produce desired targets
  - Inverse modeling techniques

  - Field validation