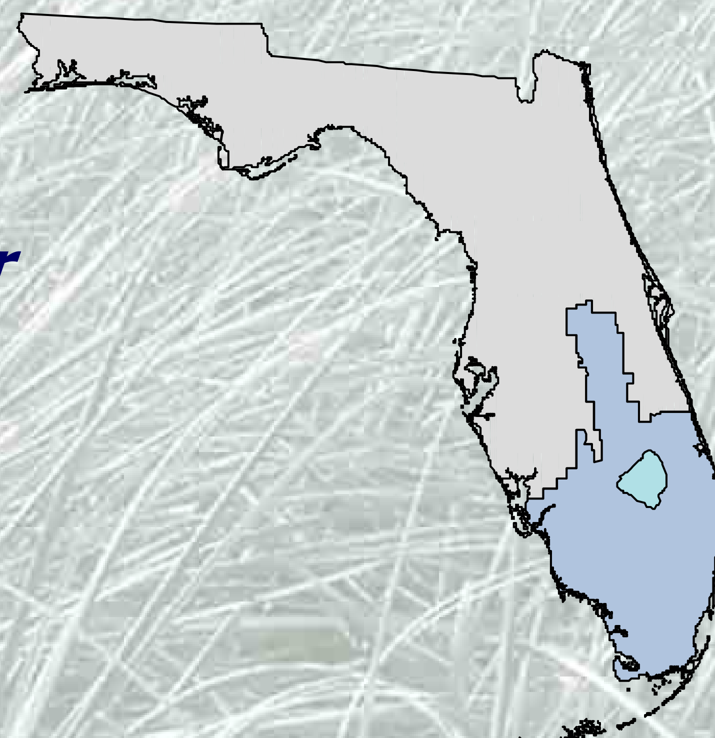
REGIONAL MODELING REQUIREMENTS

Presented By

Maged Hussein, Ph.D., P.E.
Interagency Modeling Center
US Army Corps of Engineers



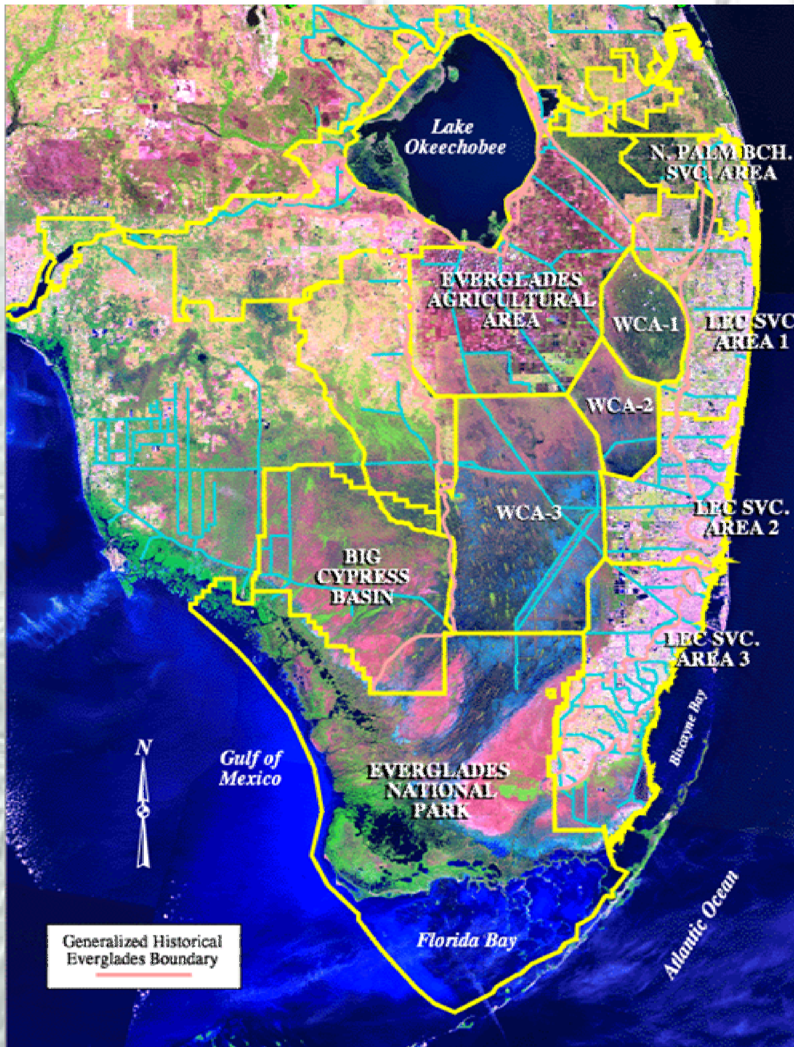
Some Definitions

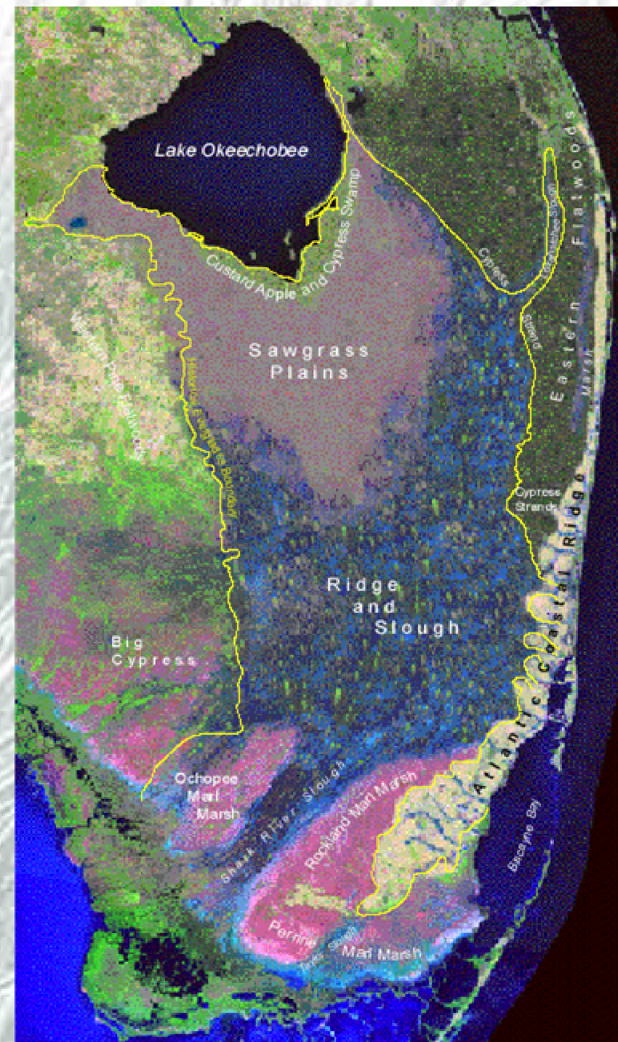
- **Model**
  - A mathematical representation of a device or process used for analysis and planning
- **Regional**
  - Cover the Everglades watershed
  - Include all of CERP components
- **Requirement**
  - Analyze the response of the natural and the managed systems to different components of CERP
  - Examine how the different 68 CERP projects will work together

Motives for Defining the Requirements

- **Modeling objectives:**
  - **Restoration of ecology to pre-drainage conditions (to the extent possible or to other healthy conditions) while maintaining water supply and flood protection**
- **Complex physics**
- **Very complex operation and management of water resources features**
- **The Gold Rush:**
  - **Proliferation modeling codes capable of a wide range of applications**
  - **The rush from CERCLA/RECRA to CERP**

CERP


Lake Okeechobee
N. PALM BCH. SVC. AREA
EVERGLADES AGRICULTURAL AREA
WCA-1
LEC SVC AREA 1
WCA-2
WCA-3
LEC SVC. AREA 2
BIG CYPRESS BASIN
LEC SVC. AREA 3
Gulf of Mexico
N
EVERGLADES NATIONAL PARK
Biscayne Bay
Florida Bay
Atlantic Ocean
Generalized Historical Everglades Boundary


Lake Okeechobee
Custard Apple and Cypress Swamp
Sawgrass Plains
Eastern Flatwoods
Cypress
Cypress Strand
Ridge and Slough
Big Cypress
Atlantic Coastal Ridge
Ochopee Marl Marsh
Shark River Slough
Rockland Marl Marsh
Perrine Marl Marsh
Biscayne Bay

Team Composition

- Walter Wilcox (South Florida Water Management District)
- Shawn Komlos (US Fish and Wildlife Service)
- Cary White (US Army Corps of Engineers)
- George Shih (South Florida Water Management District)
- Arturo Torres (US Geological Survey)
- Paul Trimble (South Florida Water Management District)
- Chuck Downer (Everglades National Park)
- Maged Hussein (US Army Corps of Engineers), Chair

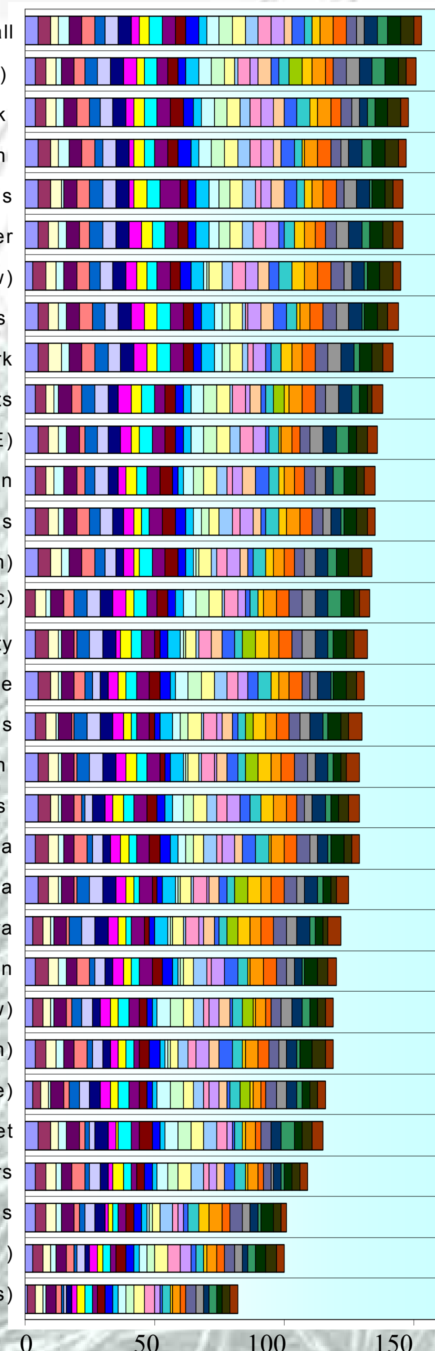
Model Customers

- Managers and decision makers at different agencies
- Ecologist studying the natural system
- REstoration COordination & VERification (RECOVER)
- Solicited Input from Potential Customers

Customer Input

- Use of the model in relation to resources of concern to customer: 4 questions
- Metrics and accuracy needed for evaluation of impact: 14 questions
- Processes of concerns: 3 questions

Processes of Interest to Customers

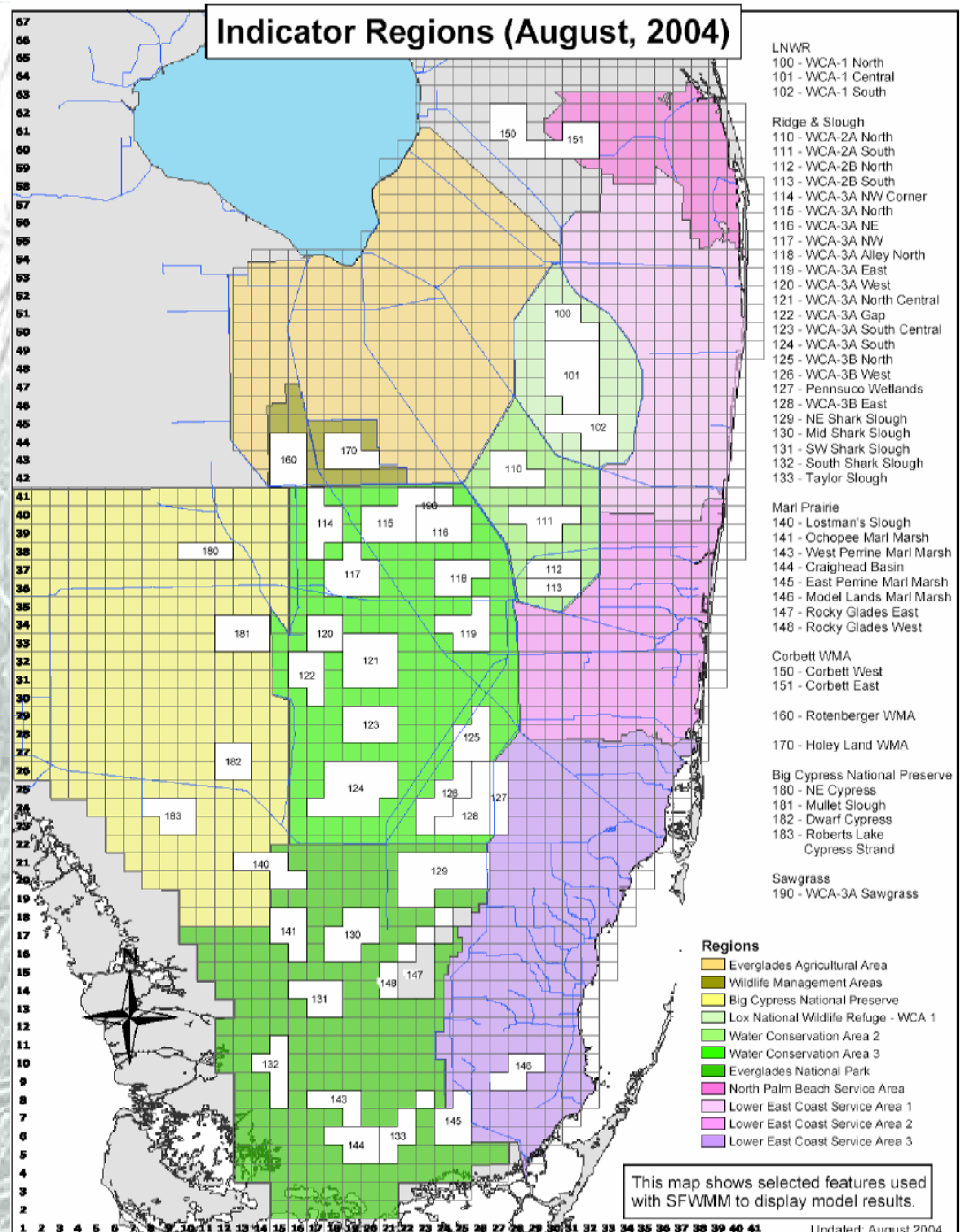


Process	Mean	Median
Rainfall	4.4	5
Fate and Transport of nutrients (total Phosphorus and total nitrogen)	4.2	5
Flow in canal network	4.2	4
Evapotranspiration	4.2	5
Water delivery to/from water conservation areas	4.3	4
Salinty of surface water	4.2	5
Flow in wetlands (Overland flow)	4.1	5
Water delivery to bays and estuaries	4.1	5
Water delivery to/from Everglades National Park	4.2	5
Fate and Transport of pollutants	3.8	4
Water delivery from Lake Okeechobee (SSM, WSE)	4.0	4
Canal-wetland interaction	3.9	4
Operation of individual primary structures	3.9	4
Reservoirs, STAs, ponds and lakes (flow and operation)	3.8	4
Nutrients cycles, please specify (e.g. N, T, O_2, Chlorophyll, light, ...etc)	4.0	5
Habitat suitability	3.8	4
Levee seepage	3.9	4
Succession of plant species	3.6	4
Aquifer-wetlands interaction	3.7	4
Accurate representation of physical features	3.8	4
Specific aquatic fauna	3.6	4
Specific terrestrial fauna	3.5	4
Specific flora	3.4	4
Aquifer-canal interaction	3.5	4
Flow in aquifers (saturated ground water flow)	3.4	4
Agriculture practices (retention/detention)	3.3	4
Agriculture Operation (irrigation/drainage)	3.2	3
Details accounting of Lake Okeechobee water budget	3.5	4
Salt water intrusion of aquifers	3.1	3
Unsaturated zone processes	3.0	3
Public Water Supply (individual permit)	3.0	3
Small water supply (general permits)	2.5	3

Performance Measures

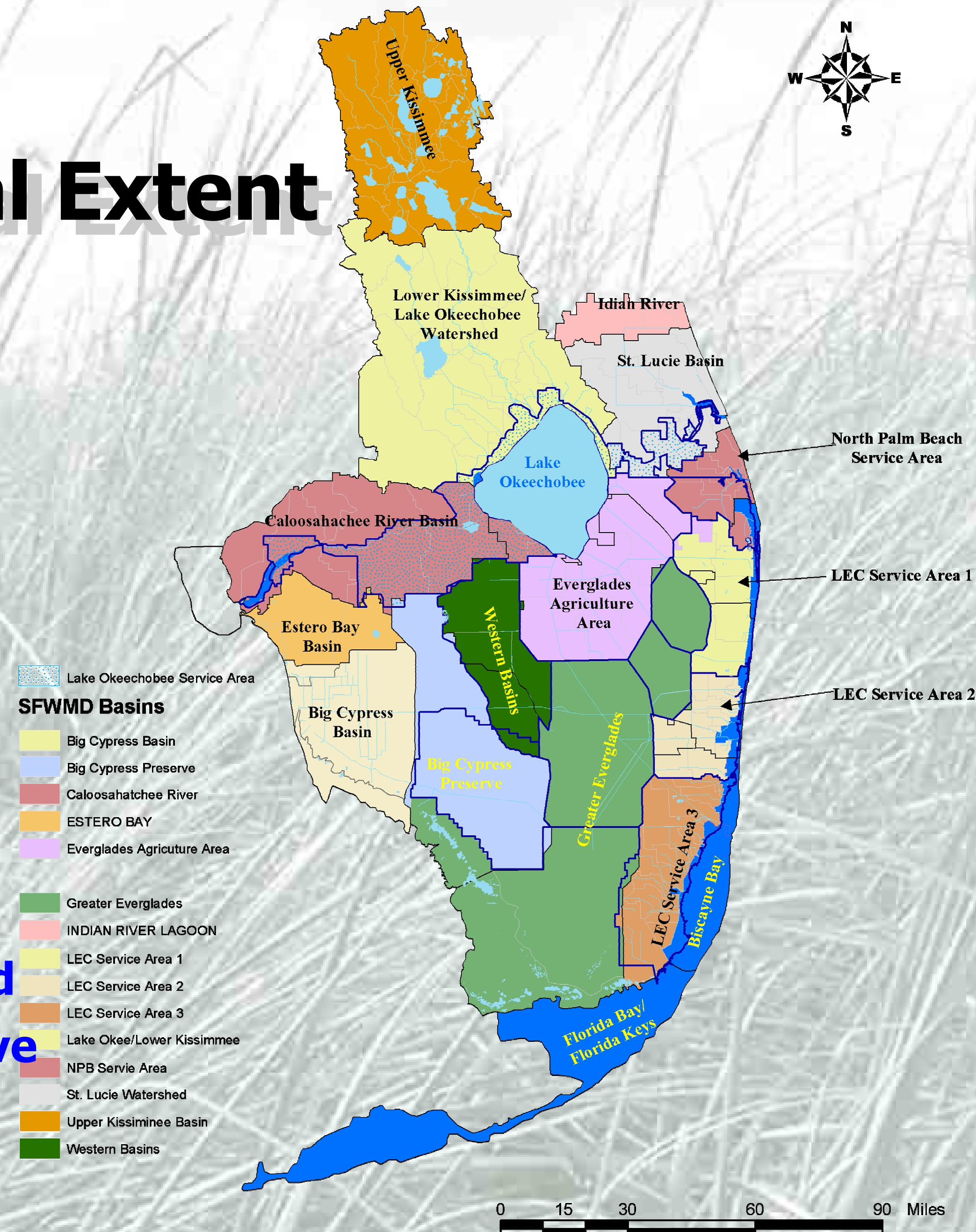
- RECOVER defined system-wide performance measures, 50+
- Model results of interest include; discharge in canals, overland flow depth and velocity, stage in surface and ground water, flow to tide, salinity, concentration of nutrients.
- Varying spatial and temporal scales

Indicator Regions



Spatial Extent

- **Highest priority**
  - Lower East Coast
  - Lake Okeechobee Service Area
  - Everglades Agriculture Area
  - Everglade Protection Area (the Park + Water Conservation Areas)
- **Important regions**
  - Upper East Coast
  - Lake Okeechobee Watershed
  - Big Cypress National Preserve
  - Lower West Coast



Temporal Extent

- Continuous or event simulations
- Period of record for continuous
  - 36 years of available data
  - Address water reserved for the natural system (reservations)
- Possibility of different models
  - Low fidelity models for multi-decadal simulations
  - High fidelity models for event simulations
  - Reconcile differences

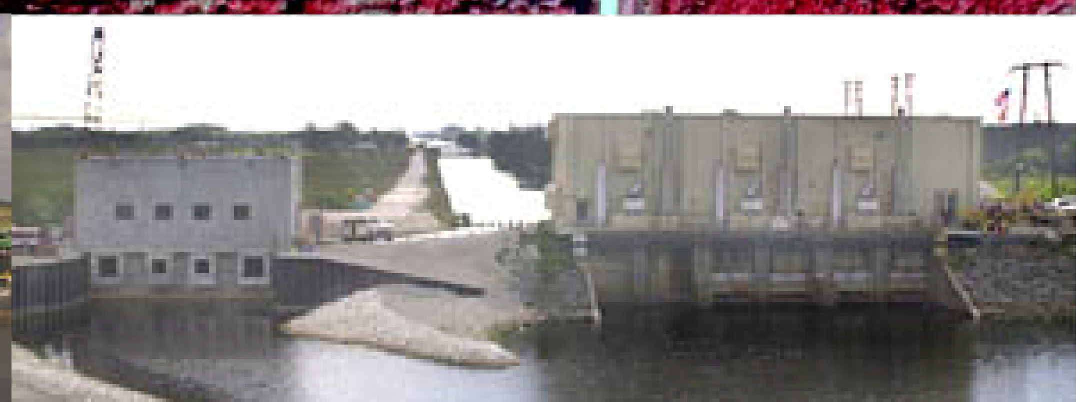
Water Management Consideration

- **The most complex part of the modeling**
  - **>160 major drainage basins and**
  - **~1800 miles of canals and levees.**
  - **> 2000 water control structures (spillways, pumps, gated culverts, adjustable weirs, … etc.)**
- **Operation decisions are based on local, sub-regional, and regional considerations and are very subjective**
- **Receives the least attention from developers of modeling code**
  - **Physics receives more attention**
  - **H&H models are not equipped with optimization modules**
  - **Model developers with local knowledge as well as understanding of numerical techniques are rare**
  - **R&D are focused on general purpose models.**

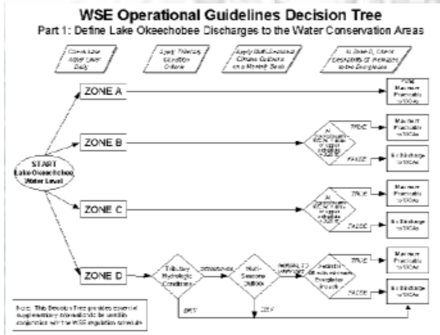
Water Management Consideration

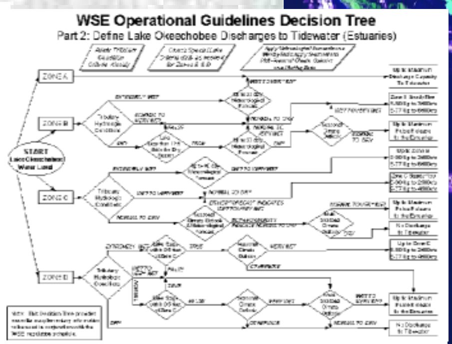
- Hydraulic Structures
  - Simple operation (head/tail control)
  - Complex operations (e.g. remote triggers, dual ops, storm drawdowns, etc.)
- Regulation Schedules
  - Lake Okeechobee
  - Water Conservation Areas
- Storage Facilities
- Local Management Practices
  - Golf Course
  - Urban detention or diversion components
  - Agriculture practices including detention and retention

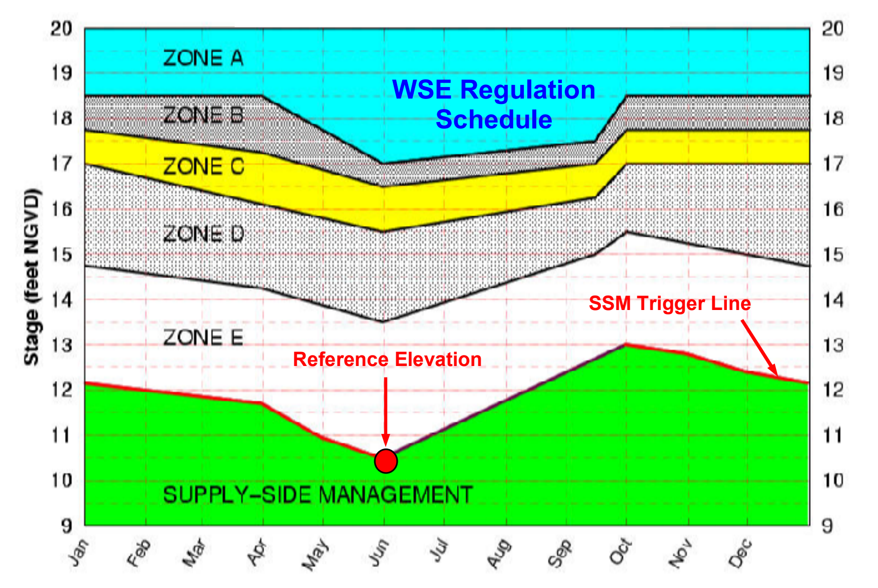
Confusion corner and S-9 Pump Station

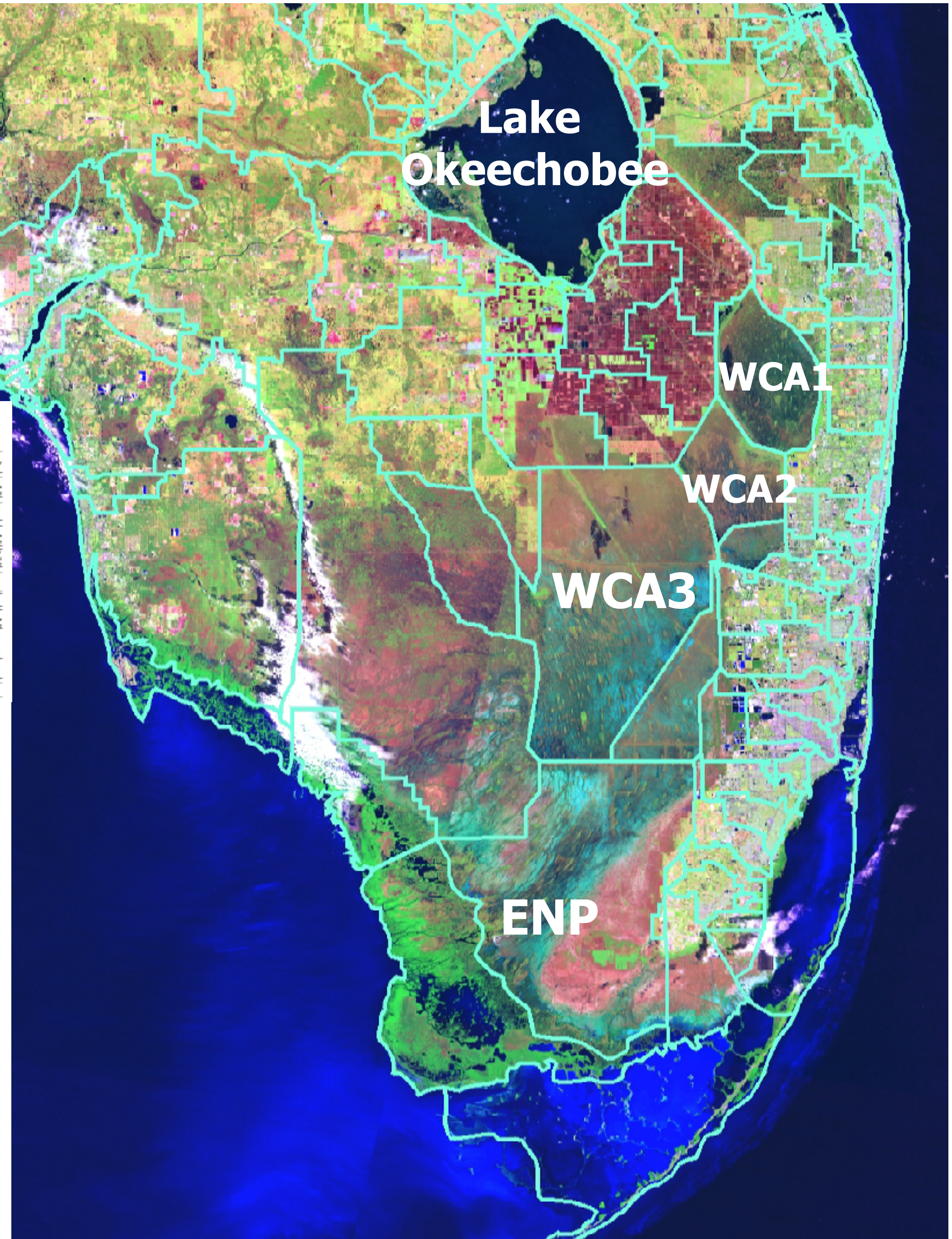


Regional Storage









Other Consideration

- Distributed parameters models
- Rainfall and Evapotranspiration
- Coupled ground water/surface water models
  - Ground water flow
  - Overland flow in wetlands
  - Canal flow
  - Hydraulic structures
- Local scale processes
  - Agriculture and urban
- Coupling with water quality, salinity, and ecological models

Policy Considerations

- Distinguish between types of releases:
  - water supply releases,
  - releases to satisfy environmental restoration
  - releases to achieve flood protection
- Existing legal sources of water
- Natural system model:
  - establish interim goals
  - implementation of rainfall driven operations (
  - establishing targets for comparing alternatives based on performance measures.
- Level of service for flood protection (local or sub-regional models)

Recommended Approach for Model Selection

- **Two issues in model selection:**
  - **Selecting of the modeling code**
  - **Definition of the conceptual site model (conceptual representation and modeling assumption)**
- **Two phase approach:**
  - **Screening of modeling codes based on general capabilities**
  - **Detailed examination of modeling assumptions, capabilities and ability to satisfy most of stakeholders expectations**

Critical Capability

	Critical Capability
A	Adaptability to recognize spatial and temporal variability of sound meteorological data
B	Ability to simulate overland flow, canal flow, hydraulic structure flow, and ground water flow
C	Ability to simulate interaction between hydrologic components in criteria B
D	Capability to simulate operational decision logic of hydraulic structures and storage areas (sluice gates, pumps, gated culverts, above-ground and in-ground reservoirs, ASRs, lakes, seepage management features, …etc.) based on one or more nearby and/or regional triggers' conditions and/or trends
E	Capacity to simulate management of a system of hydraulic structures, system of interconnected basins, and system of water control units such as regulation schedules, regional water shortage policies, regional water rationing policies, … etc. based on one or more nearby and/or regional triggers' conditions and/or trends
F	Potential to address operation and management related to drainage districts (298 districts), agriculture practices, demand of the natural system and urban regions and the cumulative impact of operations associated with each on the regional system
G	Ability to forecast and to extend expected trends, spatially and temporally, caused by CERP implemented structures and their operation rules for discrimination of alternatives according performance measures
H	Ability to provide detailed water budget accounting on basin and structure scale.
I	Functionality of an implementation using a verified, documented and peer reviewed code to provide boundary conditions to sub-regional models and generate output with reasonable runtime

No	Criterion Definition	Type	W
First Priority			
1	Accurate representation of rainfall and evapotranspiration	Hydrologic	16
2	Accurate simulation of flow/stage in wetlands, canals, and ground water	Hydrologic	16
3	Operations and Management of the Everglades Protection Area (ENP and WCAs), Lake Okeechobee, and Kissimmee River	Operation and Management	16
4	Accurate simulation of surface water – ground water interaction	Hydrologic	14
5	Accurate representation of hydraulic structures and their operation	Operation and Management	14
6	Ability to extract boundary conditions for subregional models	Functionality	12
7	Freshwater delivery to bays, estuaries, and other near shore regions	Hydrologic	12
8	Detailed accounting of regional and basins water budget including type of releases (environmental, water supply, flood protection, … etc.)	Hydrologic	11
9	Based on verified, documented, and peer reviewed modeling code	Functionality	10
10	Reasonable runtime (allows multiple years to be simulated)	Functionality	10
11	Ability to account for seepage below, around, and through levees and associated borrow canals	Hydrologic	10
12	Accurate representation reservoirs, STAs, ponds, lakes, and other storage facilities and their operations	Operation and Management	9

No	Criterion Definition	Type	W
Second Priority			
13	Account for salinity effects on flow (density effects on head)	Hydrologic	8
14	Accurate simulation of velocity field necessary for use in simulating transport of water quality and ecological constituents	Water Quality /Ecological	8
15	Simulation of agriculture operations and practices	Operation and Management	6
16	Simulation of urban regions water supply and flood protection needs	Operation and Management	6
Third Priority			
17	Accurate simulation of the unsaturated zone process	Hydrologic	4
18	Consistent with existing natural system model for target evaluation	Functionality	3
19	Cost of deployment for model users, customers, and stakeholders	Functionality	3
20	Ability to perform water quality simulations (fate and transport of nutrients and other constituents)	Water Quality /Ecological	2

Evaluation Criteria Definitions and Priority

Evaluation Criteria		*W*	*Definition of Rankings*				
N	***Description***		**0**	**1**	**1.1**	**1.2**	**1.3**
First Priority							
1	Rainfall/ET	16	Uniform rain and PET. Actual ET calibrated	Temporally varied rainfall and ET AET calibrated.	Spatially and temporally varied rainfall and PET utilizing multiple gauges, and a consistent methodology for actual ET based on land use, crop type, … etc.	INTENTIONALLY BLANK	Spatially and temporally varied rainfall. AET computed as part of integrated unsaturated zone solution.
2	Flow Simulation	16	Lumped parameter model (link-node)	Distributed but simplified (e.g. Horton's or Kadlec equation for overland, kinematic equation for canal or 2-D for ground water)	Diffusive flow in surface water and 2D flow in ground water	Dynamic wave in canals, diffusive wave in overland and quasi 3D in ground water	Dynamic wave is surface water, full 3D variably saturated flow in ground water
3	Operation & Management	16	Internal boundary with prescribed flows or simple if/then rules based on the structure book for each structure or other simple approach	INTENTIONALLY BLANK	INTENTIONALLY BLANK	Complex operation of multiple structures based on multiple criteria + Regulation Schedule + Rainfall Driven Operation + water shortage/rationing logic	As in 4 + optimization routine
4	Surface/Ground water interaction	14	No interaction	Loosely coupled (one system as a sink/source for the next)	Coupled through a simple time lag approach	2 out of 3 fully coupled (overland, canal, and ground water)	All 3 systems fully coupled
5	Hydraulic Structures	14	Not simulated	Simplified/passive hydraulic structure simulation capabilities, rating curves and/or no operation (Steady state or Quasi-dynamic routing)	Accurate simulation of hydraulic structures + simple/active operations (Quasi-dynamic routing)	Accurate simulation of hydraulic structures + multi-criteria decision logic based on combination of local and regional triggers	Accurate simulation of hydraulic structures + optimization of their operation (Dynamic routing through structures)
6	Subregional Models	12	Not possible to extract boundary conditions for subregional model	Possible to extract flow and stage/head boundary conditions for subregional models with some interpolation scheme (e.g. Telescopic Mesh Refinement)	INTENTIONALLY BLANK	INTENTIONALLY BLANK	Fully scalable and capable of being utilized in regional, subregional modeling, and site specific modeling
7	Water delivery to near shore regions	12	None	Near shore regions treated as boundary conditions. Tidal effects not taken into consideration	Near shore regions as boundary conditions. Tidal effect taken into consideration.	Density corrected heads in near shore and estuarine environment, which are included in the regional model.	Full density dependent flow in estuaries and near shore regions which are encompassed in the regional model
8	Water Budget	11	Overall water budget computed and balanced	As 1 + basin-wide water budget	As 2 + detailed water budget by layer and basin including service area-specific sinks/sources	As 3 + detailed water budget for each structure by the type of release (environmental, flood control, and water supply)	As 4 + flexibility to easily define/modify water budget zone boundaries
9	Code Maturity	10	New untested code.	Methodology peer reviewed and code verified against analytical solution by developer	Code verified against analytical and other numerical models by independent reviewers	Code extensively used throughout the modeling industry with documented applications	Code extensively used throughout the modeling industry with documented applications + extensive code verification by independent reviewers
10	Reasonable runtime	10	Prohibiting runtime. Model cannot be used for alternative evaluation (multi-decadal runs cannot be performed within a reasonable period of time).	Excessive runtime. Model can be used for alternative evaluation but with extensive resource allocation (only one multi-decadal runs can be performed within a reasonable period of time).	High runtime. Model can be used for alternative evaluation (at least two multi-decadal runs can be performed concurrently within a reasonable period of time).	Low runtime. Model can be used for alternative evaluation (more than three multi-decadal runs can be performed concurrently within a reasonable period of time).	Optimal runtime. Model can be used effectively for alternative comparison (up to 5 concurrent multi-decadal runs can be compared within a "very" reasonable period of time)
11	Levee Seepage	10	Not simulated	2-D groundwater flow equation on single ground water layer below levees. No seepage through levees	Quasi 3-D ground water flow below levees, seepage through levees	Full 3-D flow below and through levees	Full 3-D flow below and through levees with detailed discretization of the levee material and ability to represent seepage control measures

Conclusion

- Regional models are good decision support tool but should not be a substitute for engineering judgment
- Regional models requirements are considerably different from models utilized for H&H, RECRA/CERCLA, TMDL, or other local or sub-regional models
- At the regional scale water management plays a profound role
- Model developer should consider incorporating Operation Research components in their modeling codes
- Local scale processes should not be represented explicitly in regional models. Lumped representation is sufficient. Otherwise run time will be prohibitive