Topics to Cover

- The path to Everglades Restoration
- Regional and Sub-regional modeling tools
- Standard model outputs
- Transformation to “Performance Measures”
- Project-specific examples
The “Original” Everglades Ecosystem

“River of Grass”

- Water connected the system, from top to bottom
- 9 million acres of wetlands providing a variety of habitat
- Diverse mosaic of landscapes and seascapes
PRE-DRAINAGE CHARACTERISTICS

- Large Spatial Extent
- Hydrologic Regime
  - Dynamic Storage
  - Sheetflow
- Diverse Habitats
1947 Flood

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THE C&SF PROJECT

- **Project Purposes**: Flood control, water conservation and control, regional water supply, prevention of salt water intrusion, fish and wildlife conservation, and water supply to Everglades National Park

- **Project includes**: 10 locks, 1,000 miles of canals, 720 miles of levees, over 150 water control structures, and 16 pump stations
Estimated Pre-drainage System Landscape (circa 1850)

Current System (1995) Landscape

* Area - 18,000 square miles
* Population today ~ 6 million
Today, water flows very differently
An Ecosystem in Trouble....

- Too much/too little water for the Everglades/south Florida ecosystem
- Massive reductions in wading bird populations
- Degradation of water quality
- Repetitive water shortages and salt water intrusion
- Declining estuary health
- 1.7 billion gallons of water a day wasted to tide

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Why are the Everglades Unique and Important?

- the Everglades is a National Park
- the Everglades is an International Biosphere Reserve
- the Everglades is a World Heritage Site
- the Everglades is a Wetland of International Significance
- The Everglades function as a filter to purify water flowing into Florida Bay and the Gulf of Mexico
- The Everglades is home to 68 threatened or endangered plant and animal species
- The Everglades is home to more than 900 types of plant species
- The Everglades is home to more than 600 types of animals
Q: How do we determine the best path to Restoration?

A: Hydrologic Models
South Florida Water Management Model (the “2x2”)

- Regional model to simulate hydrology and water management operations
- 2 mile x 2 mile grid
- Continuous daily simulation over 36 year record (1965 – 2000)
- Developed by SFWMD
- Domain from Lake Okeechobee to Florida Bay

www.sfwmd.gov/org/pld/hsm/models/sfwmm/index.html
Natural System Model (NSM)

- Simulates hydrology of pre-drainage Everglades
- Based on the South Florida Water Management Model

www.sfwmd.gov/org/pld/hsm/models/nsm/nsm45doc/nsm45.htm
MODBRANCH

- Simulates hydrology and water management of sub-regions
- Highly refined and variable grid spacing
- Simulates 3D groundwater
- Used for short term simulations (~1 year)
- 1-hour time steps
- Developed by USGS and USACE-Jacksonville
- Uses SFWMM2x2 results for boundary conditions
- Based on USGS MODFLOW and BRANCH models
Key Tenet of South Florida Ecosystem Restoration:

Hydrologic restoration is a “must” for ecological restoration
Q: What does the term “hydrologic restoration” mean?

A: It depends \textit{to whom} you are talking and what are their concerns and issues!
Agencies, Organizations, and other that have their own vision of restoration

- Agricultural Interests
- Miccosukee Indians
- Department of Interior (Everglades National Park)
- Department of Interior (US Fish and Wildlife Service)
- The State of Florida
- South Florida Water Management District
- Towns and Municipalities
- County Governments
- Audubon Society
- Sierra Club
- Friends of the Everglades
- Natural Resources Defense Council, ACLU, etc.
- Homeowners
- Rock Miners
- Others…
Generalized Hydrologic Numerical Models produce the following basic data:

• Stage for each time step
• Flow rates for each time step
S197 flows (Alt3 and Alt4)

Flow Rate, cfs

1995 Day
Stage-duration curves are derived directly from stage and time.
Stage Hydrograph at Everglades National Park
Gage NP_33, Cell R17 C20

Year

feet, NGVD

feet, NGVD

Run date: 01/14/08 09:23:47
For Planning Purposes Only
SFWQ 19.5
Temporal Variation in Mean Weekly Stage for NE Shark River Slough

Indictor Region 11 (R19C22-23 R20C22-26 R21C22-26)

Depth (feet)

Week

Std Deviation (feet)

WEEK 1 STARTS JAN 1
Depth and elev are weekly means for the Indicator region for a 31 year simulation
High/Low = 0 indicates criteria undefined for region
* Standard Deviations are calculated among-year values;
* they illustrate interannual variation in mean weekly depth over the 31 year simulation period.
So, what’s the big deal?

- Engineers speak in terms of stage, flow, and Reynold’s numbers.
- Biologists and Environmental Scientists speak in terms of breeding success and species diversity.
- Municipal and county governments talk about economic damages in dollars.
- Native Americans need to know how the plan will affect their way of life.
- Agricultural interests need to know if crops are likely to be damaged or if new crops need to be planted.
The stage-duration graphs are basically the same.

The Tree Islands are being harmed! (I think)

You have reduced the number of habitat units! (based on my best guess)

The Corps is going to hear from my lawyer!

We are going to lose $100,000,000 in Papayas!

Engineer/Hydrologist

Environmentalists

Farmer

Biologist, farmers, and others need more than the hydrological output of the models. They need to have information that is important to them!
Q: How do we translate the hydrologic “babble” of stage and flow into information that is useful to people who speak and think in different ways?

A: Performance Measures!
Whether or not a plan is “good” for a specific purpose is determined by the use of “performance measures.”

Performance Measures are functions of stage, flow, and other variables.

\[ PM = f(\text{stage, flow, ground elevation, season, etc.}) \]

A Performance Measure’s functional definition is determined by the biologist, ecologist, economist, or other specialist.

The definition is provided to the hydrologist/engineer. The hydrologist/engineer and programmers use it to produce the performance measure from the standard numerical model outputs of stage and flow.
Performance Measures

A “performance measure” is a data value or a data set that will give an indication of how close an alternative will come to attaining a specific goal.

There can be as many different Performance Measures as there are interested parties!
Examples of Select CSOP Performance Measures

- Peat Forming Wetlands
- Marl Forming Wetlands
- Cape Sable Seaside Sparrow (CSSS) habitat
- Average Hydroperiod
- Jurisdictional Wetlands
- Recession Rates in Marl Wetlands
- Stage-Duration Curves
- Slough “wet days” for selected periods
- Slough Tabular data
Example: Spatial Distribution of Marl Prairie Habitat

Delineation of habitat according to hydroperiod:

Required:
- Wet year: 120 – 364 days
- Average Year: 60 – 364 days
- Dry Year: 0 – 270 days

60 days minimum during an average year to discourage woody plant incursion in the dry end of marl prairie.
The maximum of 270 days during the dry year reflects conditions observed during the dry year.
Spatial Distribution of Marl Prairie Habitat

C111 GRR 156,188 acres
West bookend 144,922 acres
Example: Alligator Courtship

The number of adult female alligators that initiate nesting during June each year is proportional to the area of surface flooding in the sloughs during the courtship period in April and May.

Metric: Surface flooding in sloughs in April and May

Target: Maximize the area of surface flooding in the sloughs during the alligator courtship period in April and May
Alligator Courtship

C111 GRR

Number of Days Flooded April – May, 1989

20 25 30 35 40 45 50 55 60

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Example: Habitat suitability for alligators

What happens if we lump several performance measures together?
Example: crocodile habitat suitability

Salinity conditions in Florida Bay (a function of flows received from the Everglades system) directly impact species habitat range.
Example: Cape Sable Seaside Sparrow Breeding Success

The Cape Sable Seaside Sparrow nests between March 1 to July 15.

It requires a minimum of 45 days of dry conditions to successfully rear one clutch.
Example: Cape Sable Seaside Sparrow Breeding Success

C111 GRR

West Bookend

Possible Number of Successful CSSS clutches, 1995

Number reduced

Number decimated

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Example: regional agricultural impacts to fruit crops

Damage to tree crops occurs whenever water is within 1.5 feet of the ground surface for a specified amount of time.
Example: Potential % Lychee Fruit Lost

Potential damage to tree crops occurs whenever water is within 1.5 feet of the ground surface for a specified amount of time.

For Lychee trees the damage begins at 10 days with 100% loss at 42 days (reality vs. model)

For Lychee fruit the damage begins at 0 days an 100% crop loss at 10 days.
Example: Potential % Lychee Fruit Lost

27,620 acres of damage

30,119 acres of damage

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Generalized performance measures for flooding potential

Average Annual Ground Water & Levee Seepage Flows
from WCA’s & ENP to LEC & ENP for 1986 - 2000 Simulation Period

- Ground Water
- Levee Seepage

Flow (1000 ac-ft)

Stage (feet, NGVD)

Percent Time Equalled or Exceeded

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Example: average stage difference at the end of the wet season

Direct comparison of model output stages to an observed “target” period of record
Example: Estimating the potential number of homes flooded

The potential number of homes that could be flooded under specified conditions is estimated based on peak stage, computational cell elevation, and a % Residence Flooded curve.

The probability curve is derived from 3,567 points consisting of surveyed 1st floor elevations and corresponding ground elevation.
Example: Estimating the potential number of homes flooded

Percent Potentially Impacted

0%  5%  10%  15%  20%  25%
What happens next?

- The suite of performance measures (several sessions would be needed to cover them all) are reviewed by interagency “experts”
- The results are tabulated, weighted, and compared to arrive at a recommended plan by the Project Delivery Team
  - Additional constraints are considered
- “Experts” can agree to disagree
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Questions?

Solutions?
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