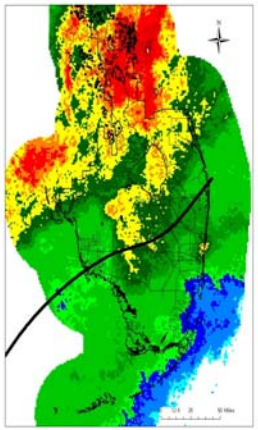
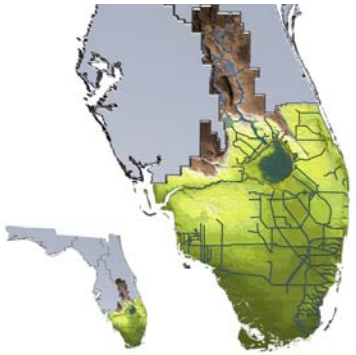
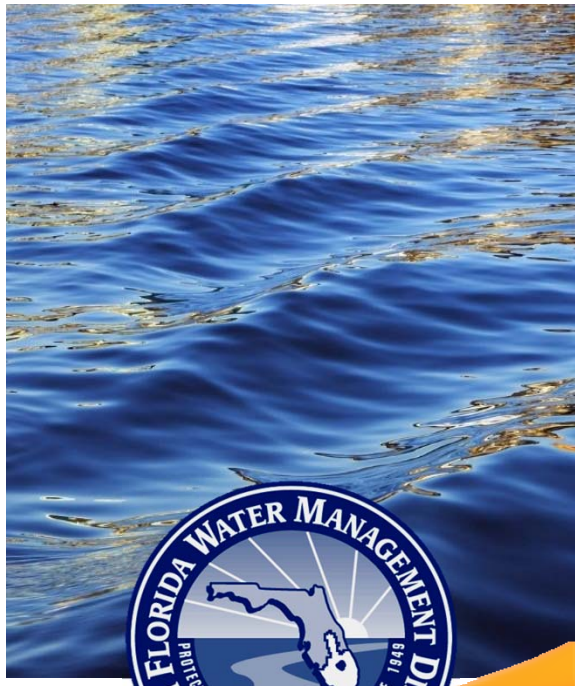


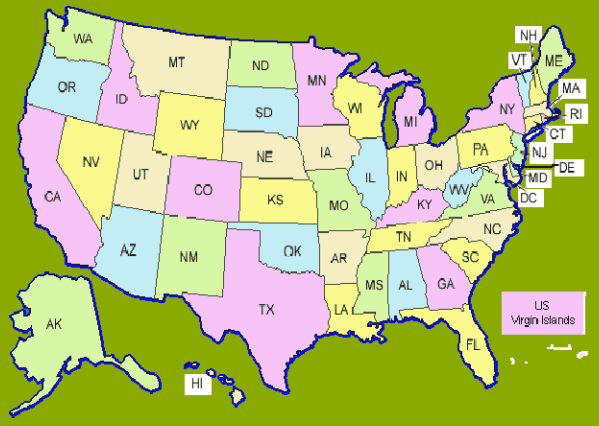
Big Water Data in Central and Southern Florida Water Management System

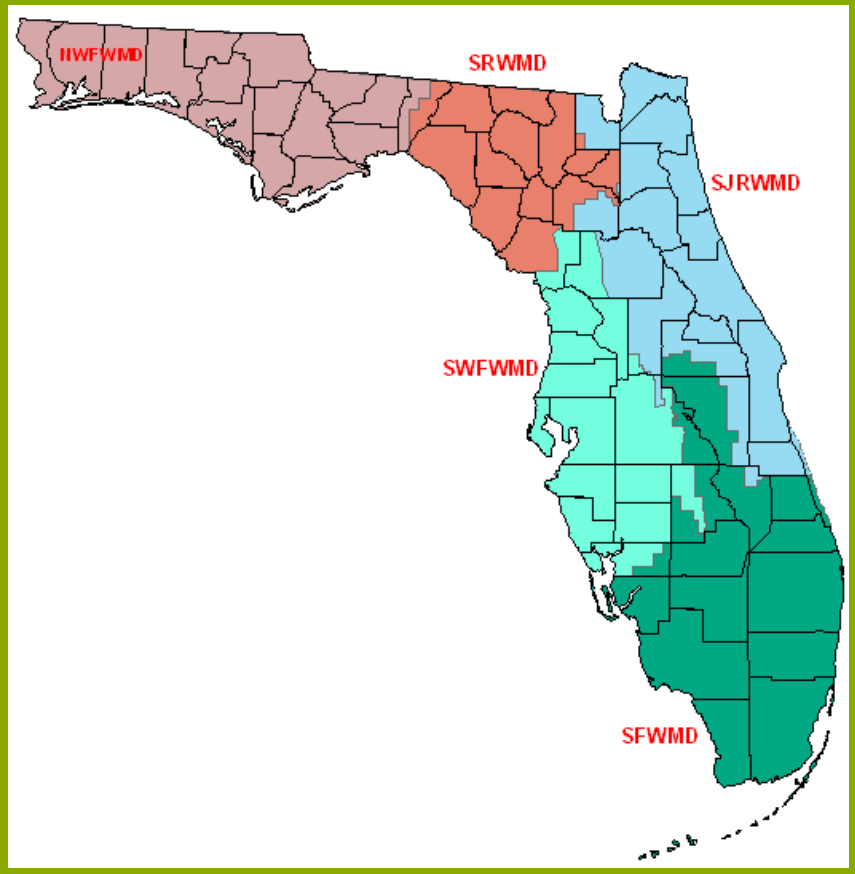
Matahel Ansar, Ph.D., P.E.
Applied Hydraulics Section
Hydrology and Hydraulics Bureau
South Florida Water Management District





South Florida Water Management District





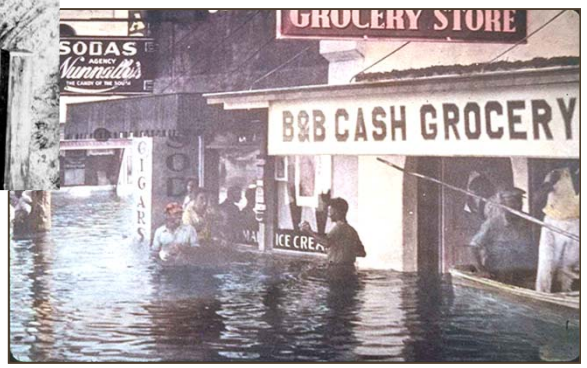
South Florida Water Management District

- The largest of five regional water management agencies in the State of Florida – 49,000 square km.
- Mission…

  "manage and protect water resources of the region by balancing and improving water quality, flood control, natural systems and water supply."
- These water resource objectives often conflict in the face of increasing development and public awareness of environmental value.

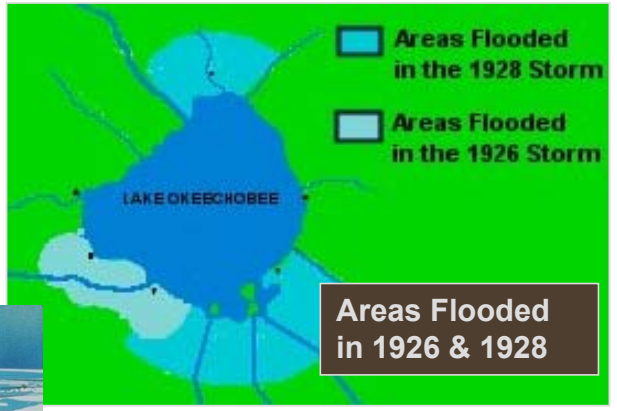
A Brief History of Water Management in South Florida

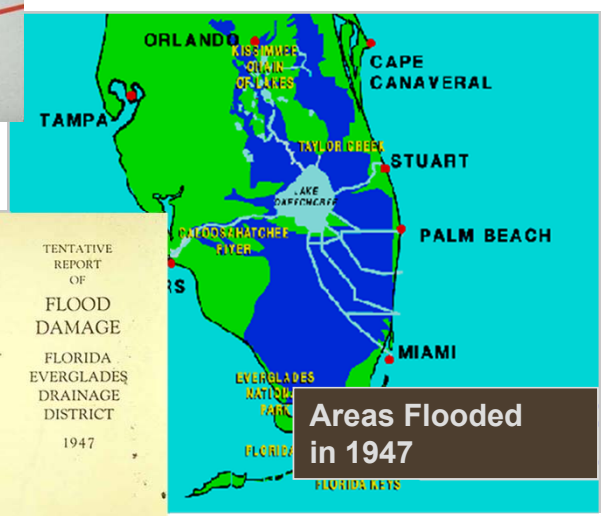
- Early explorers in south Florida recognized its value and challenges
  - Unique sub-tropical climate in North America offered a prime agricultural opportunity
  - Vast extent of flooded lands precluded settlement
- As development progressed in the early 20th century, pressure increased to drain the region
- The early efforts to reclaim these flooded areas were largely ineffective
  - Flooding and droughts persisted
  - Soil subsidence increased

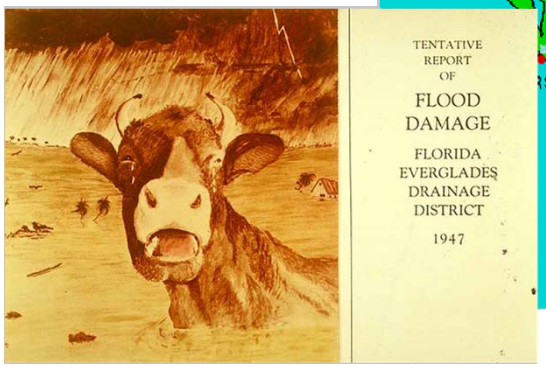


Historic Water Resource Problems

- Flood Control
  - 1926/1928: Lake Okeechobee Levee Failure
  - 1947: Hurricane Flooding
- Water Supply
  - 1931 - 1945: Lower East Coast saltwater intrusion threat identified
- State of Florida requested federal assistance



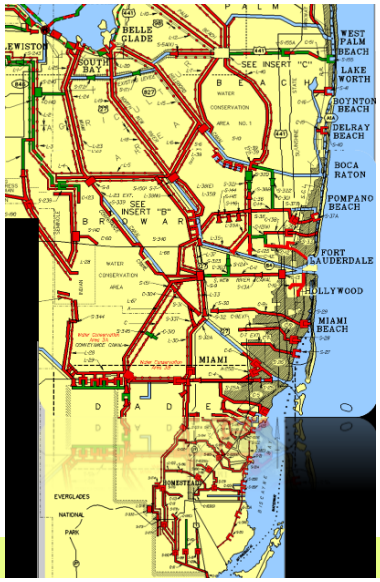


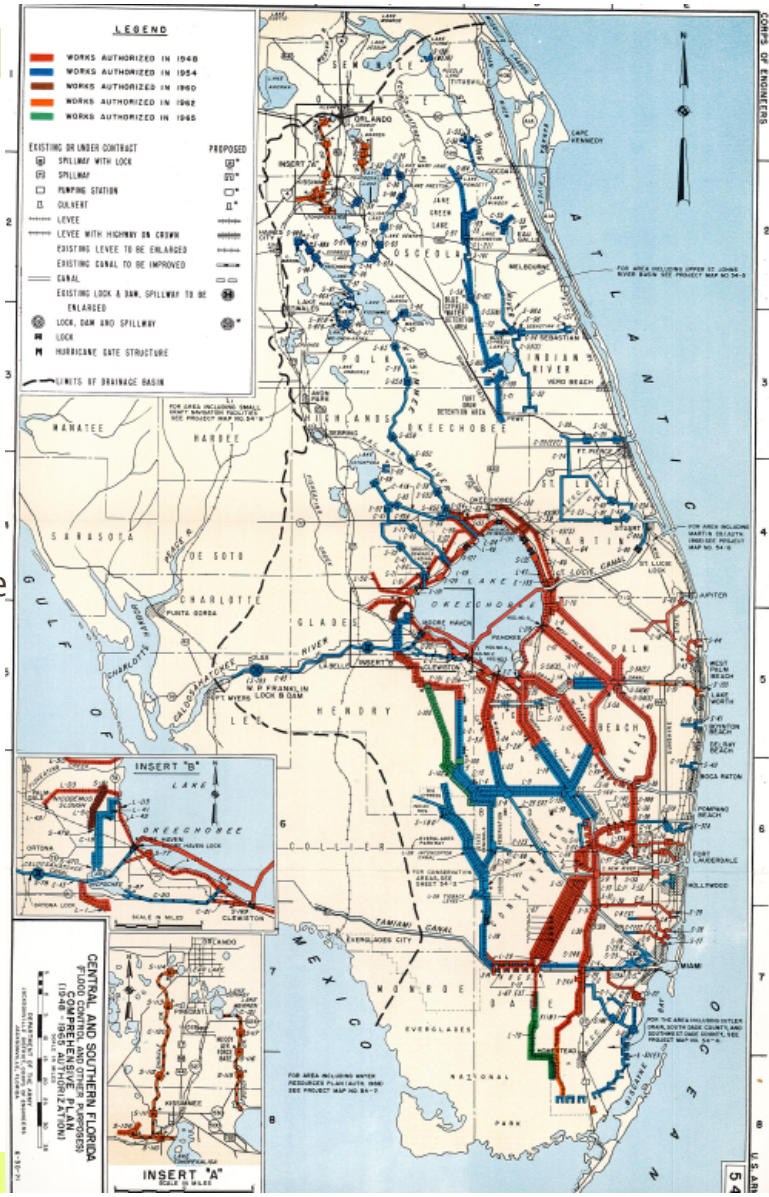


Central and Southern Florida Project for Flood Control and Other Purposes

- Through a series of Flood Control Acts (1948, 1954, 1960, 1962, and 1965) U.S. Congress authorized the U.S. Army Corps of Engineers to design and build a massive water management infrastructure known as the Central and Southern Florida (C&SF) Project

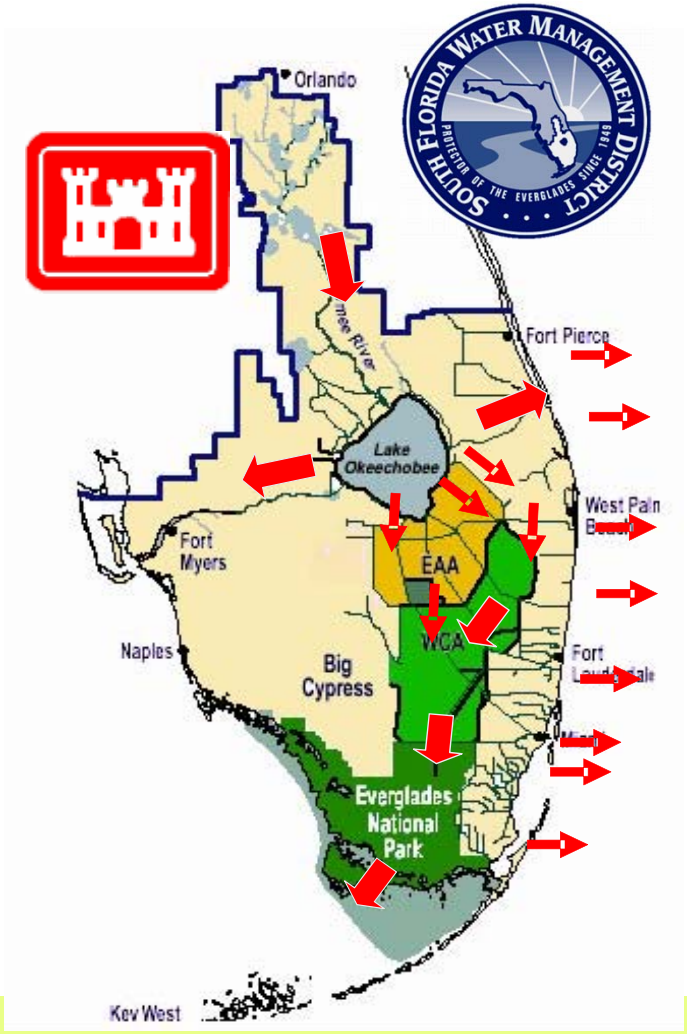
- The Central and Southern Florida Flood Control District (C&SFCD) was also created by the Legislature, to serve as a local sponsor, and to operate and maintain the C&SF System





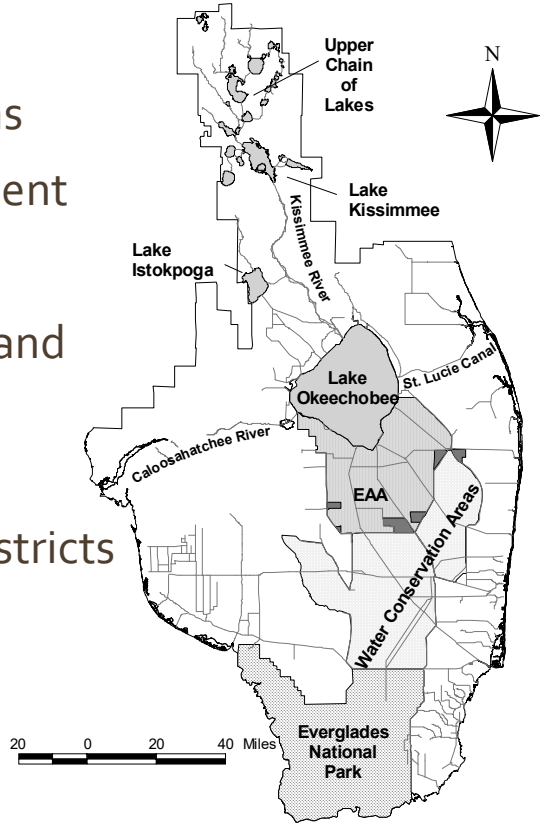
Central and Southern Florida Project for Flood Control and Other Purposes

- Designed for multiple purposes
  - Flood Control
  - Water Supply
  - Navigation
  - Prevention of Saltwater Intrusion
  - Protection of Fish & Wildlife
- Constructed by the U.S. Army Corps of Engineers between 1949 and 1970
- Operated and maintained by the South Florida Water Management District
- Recent improvements include regional stormwater treatment projects to improve water quality entering the Everglades



C&SF Water Management System

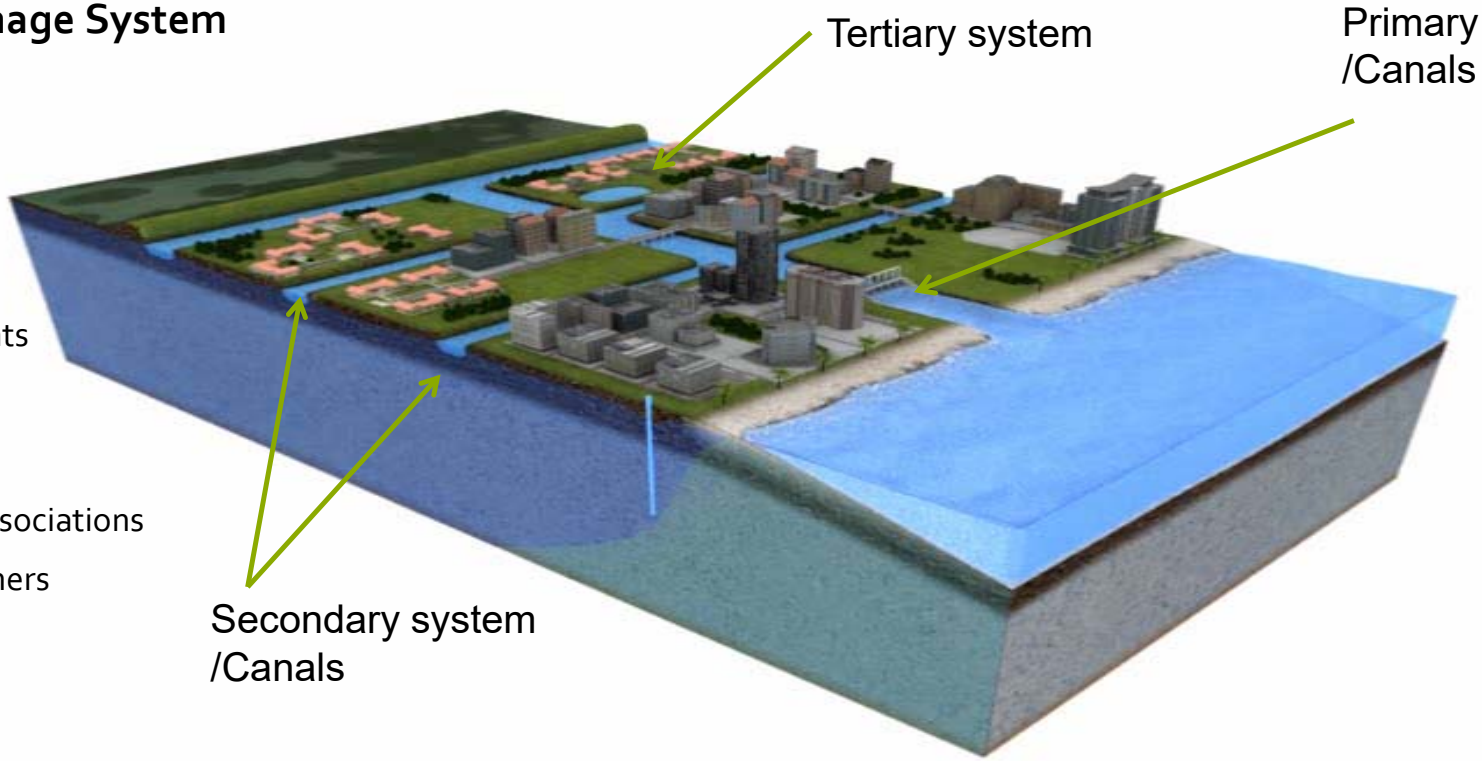
- 4,300 kilometers of canals and levees
- 160 major drainage basins
- 1,290 water control structures
- 70+ stormwater pumping stations
- 1,230 vehicles and heavy equipment
- Regional telemetry system
- 24,000 hectares of regional wetland Stormwater Treatment Areas
- 16 counties, over 7.5 M people
- Multiple Secondary Drainage Districts



Systems within a Regional Water Management System

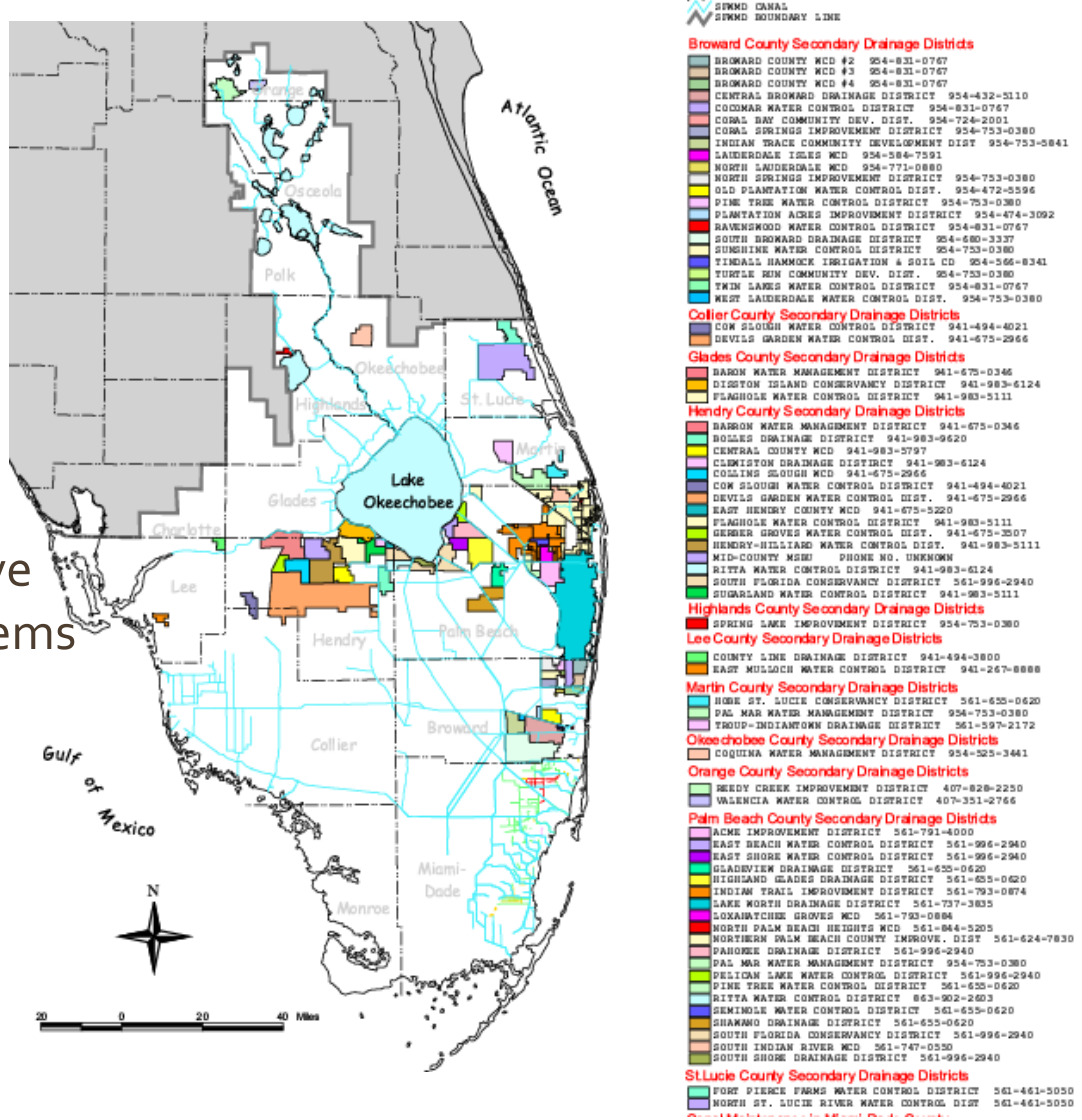
Three-Tiered Drainage System

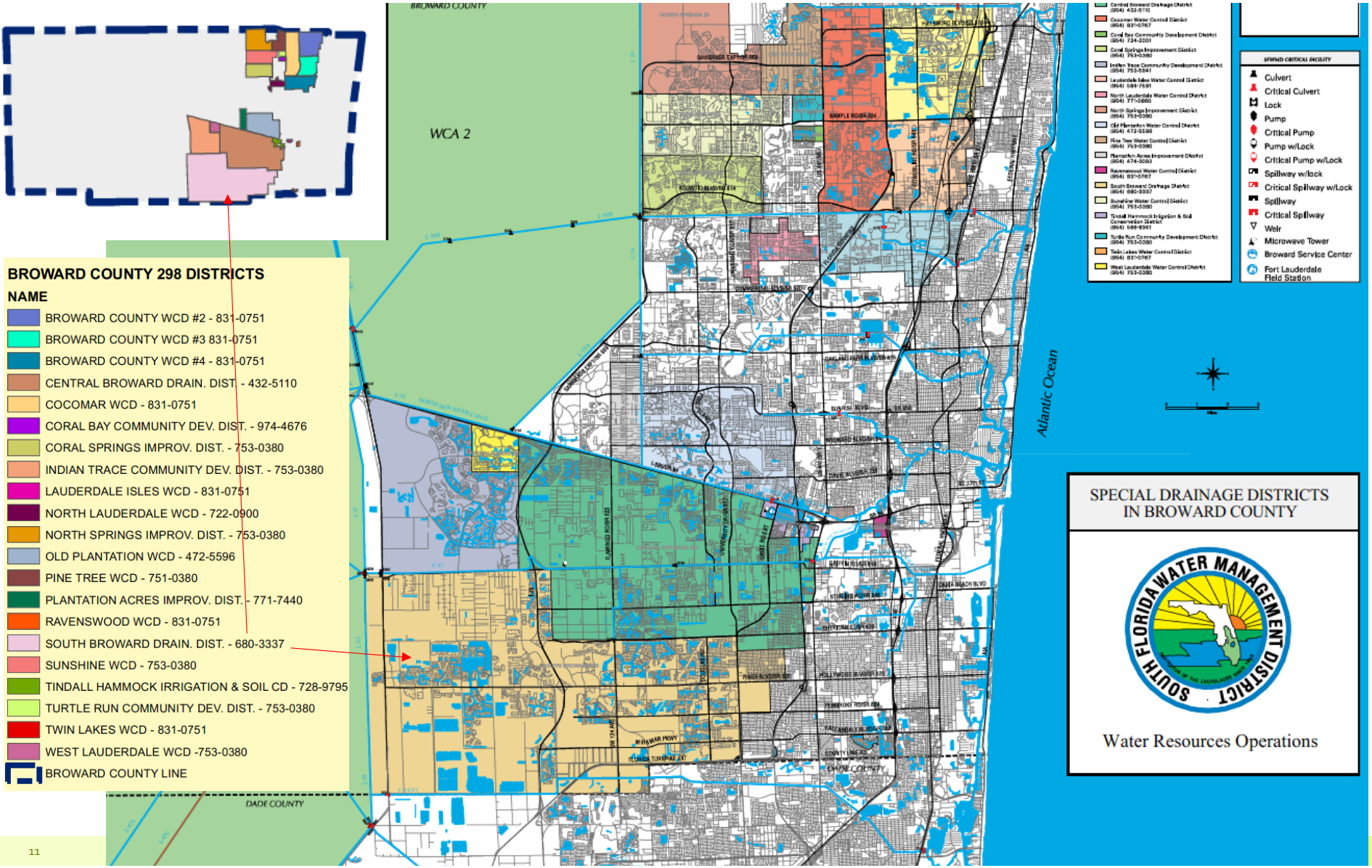
- Primary
  - USACE
  - SFWMD
- Secondary
  - Local Governments
  - Special Districts
- Tertiary
  - Home Owners Associations
  - Private Land Owners



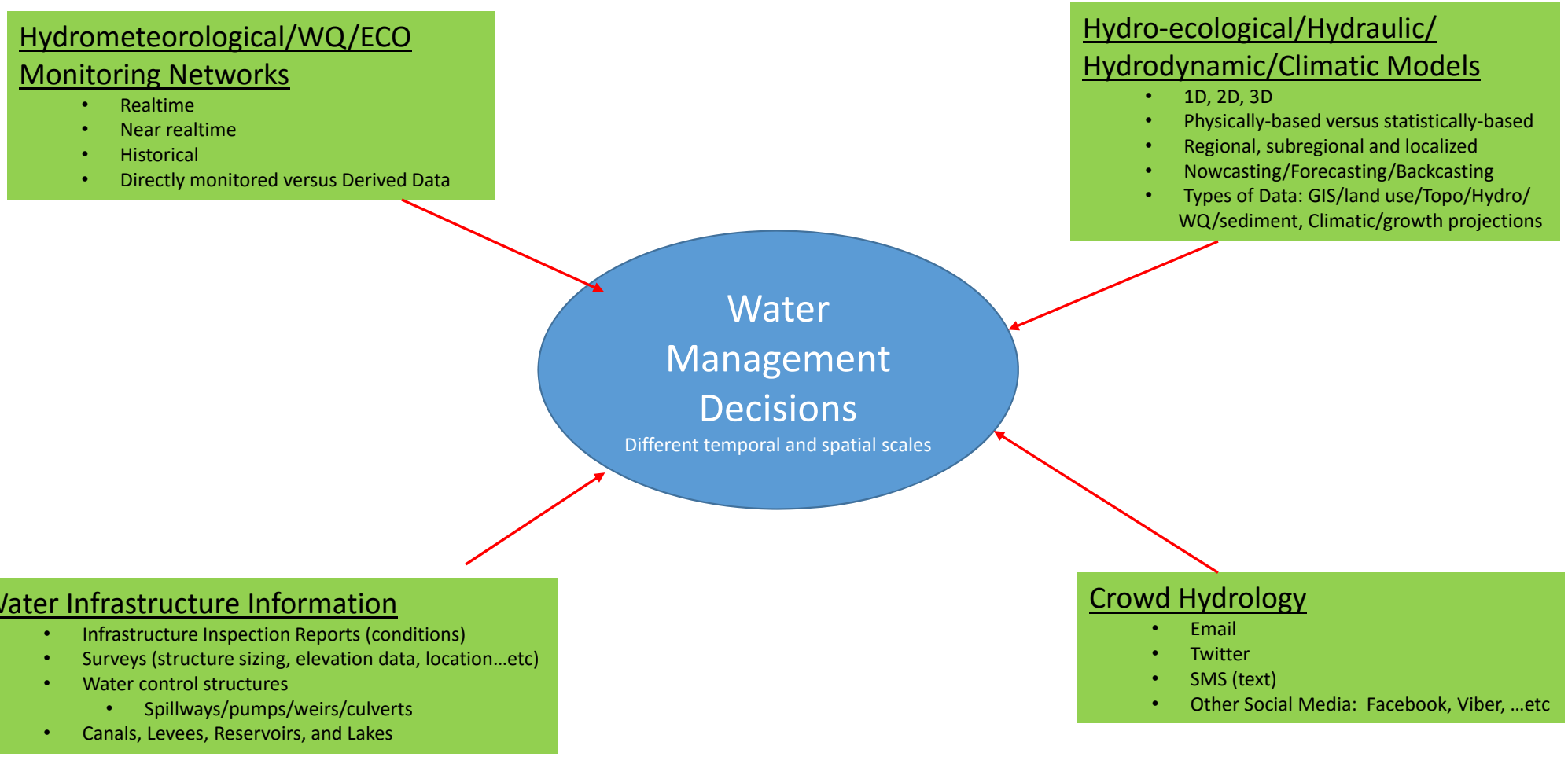
Secondary Drainage Districts

- 70+ Secondary systems District wide
- Created by FL legislature Chap. 298
- Broward and Palm Beach Counties have the largest numbers of secondary systems



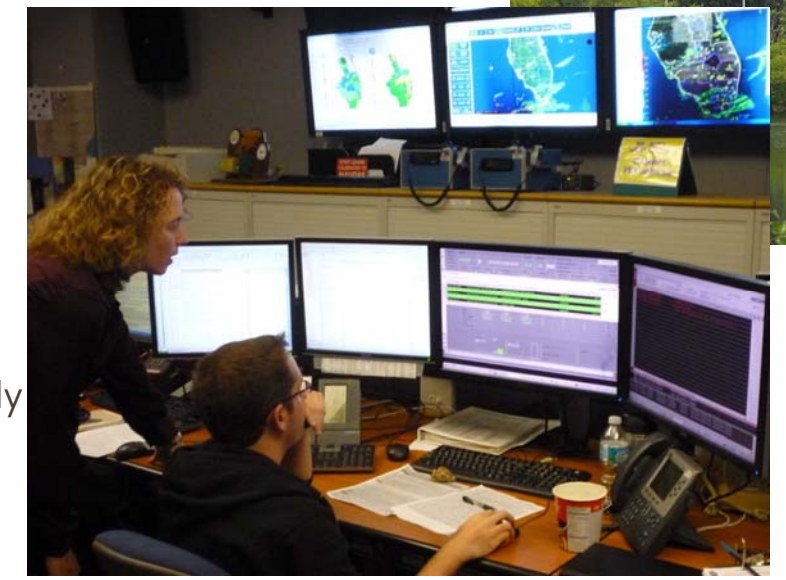

BROWARD COUNTY 298 DISTRICTS
NAME
BROWARD COUNTY WCD #2 - 831-0751
BROWARD COUNTY WCD #3 831-0751
BROWARD COUNTY WCD #4 - 831-0751
CENTRAL BROWARD DRAIN. DIST. - 432-5110
COCOMAR WCD - 831-0751
CORAL BAY COMMUNITY DEV. DIST. - 974-4676
CORAL SPRINGS IMPROV. DIST. - 753-0380
INDIAN TRACE COMMUNITY DEV. DIST. - 753-0380
LAUDERDALE ISLES WCD - 831-0751
NORTH LAUDERDALE WCD - 722-0900
NORTH SPRINGS IMPROV. DIST. - 753-0380
OLD PLANTATION WCD - 472-5596
PINE TREE WCD - 751-0380
PLANTATION ACRES IMPROV. DIST. - 771-7440
RAVENSWOOD WCD - 831-0751
SOUTH BROWARD DRAIN. DIST. - 680-3337
SUNSHINE WCD - 753-0380
TINDALL HAMMOCK IRRIGATION & SOIL CD - 728-9795
TURTLE RUN COMMUNITY DEV. DIST. - 753-0380
TWIN LAKES WCD - 831-0751
WEST LAUDERDALE WCD -753-0380
BROWARD COUNTY LINE
BROWARD COUNTY
WCA 2
DADE COUNTY
Atlantic Ocean
SFWMD CRITICAL FACILITY
Culvert
Critical Culvert
Lock
Pump
Critical Pump
Pump w/Lock
Critical Pump w/Lock
Spillway w/lock
Critical Spillway w/Lock
Spillway
Critical Spillway
Weir
Microwave Tower
Broward Service Center
Fort Lauderdale Field Station
SPECIAL DRAINAGE DISTRICTS IN BROWARD COUNTY
SOUTH FLORIDA WATER MANAGEMENT DISTRICT
Water Resources Operations

Sources of Water Data



Leveraging Technology in Water Resource Management

- Technology has been applied to increase the overall efficiency of the regional water resource management system
- A microwave telemetry system and an extensive hydro-meteorological monitoring network were developed to consolidate structure operations to a single location at the agency's Operations Control Center
- Automation of manual functions in the agency's growing number of stormwater pumping stations
  - Reducing staffing from 5 people per shift to 1 or 2
  - These functions were further consolidated to the point where multiple pump stations can be remotely operated by a single individual at a regional pump control center.



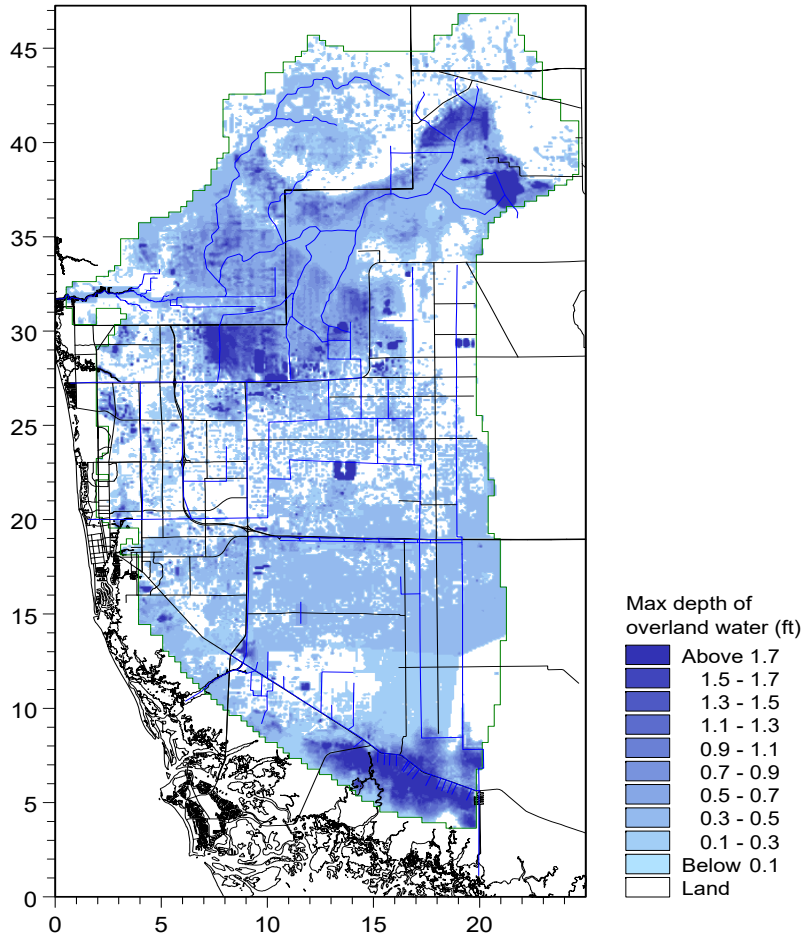
Data Analysis and Modeling

- Regional and Sub-regional Hydrology and Hydraulics Models: SFWMM, RSM, Mike-She/Mike 11, HEC-RAS, HEC-HMS…etc.
- Decision Support Tools integrated within the

SCADA system : Data Derived Set Point (DDSP), Maximum Allowable Gate Openings (MAGO), Operations Decisions Support System (ODSS), Best Available Point (BAP)

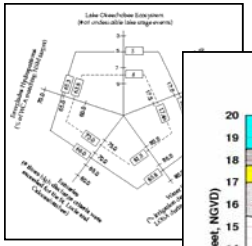
- Flood Forecasting Tool Development in select basins
- Re-assessment of the Water Management

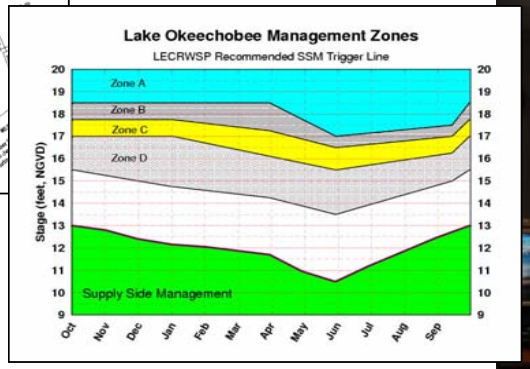
  System capacity and limitations

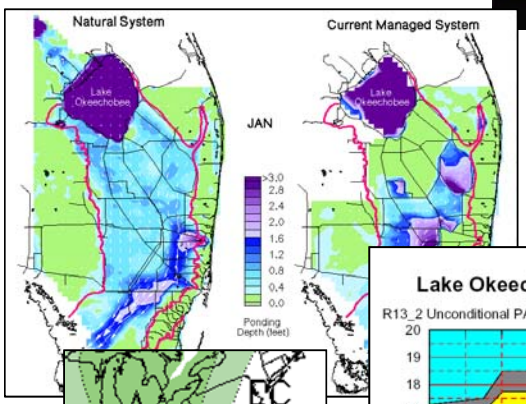


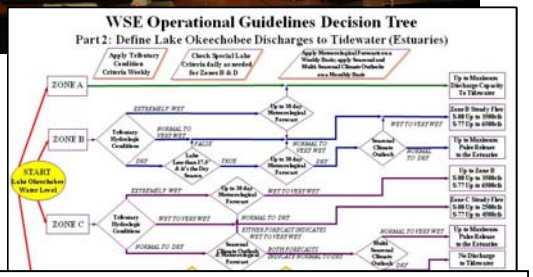
Decision Support

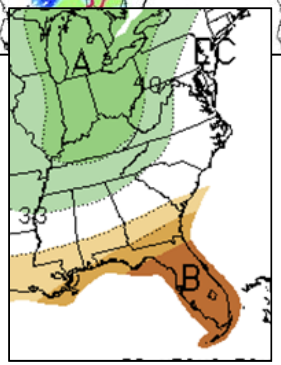
- Operations Control Center
  - Major water control structures are remotely controlled to optimize Flood Control and Water Supply operations
- Regional Operations
  - Utilize a multi-objective regulation schedule
    - Climate Outlooks
    - Computer based Position Analysis for projected Lake stages
    - Weekly coordination between agencies and the public

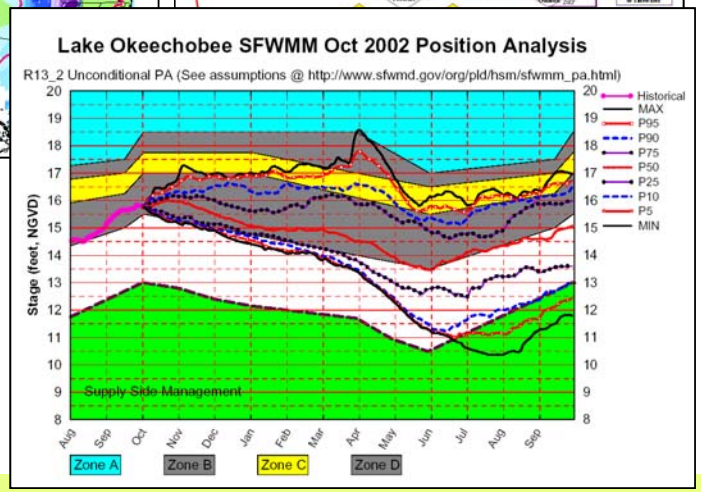




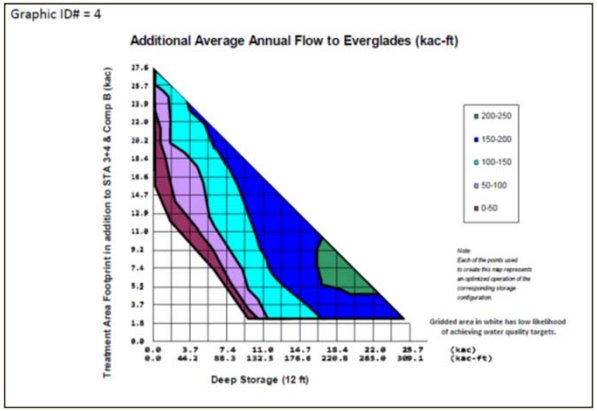


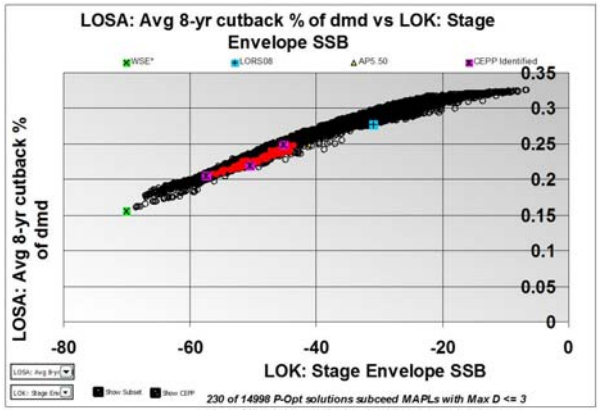


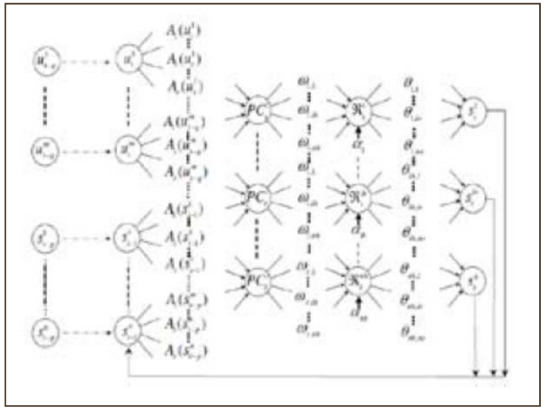


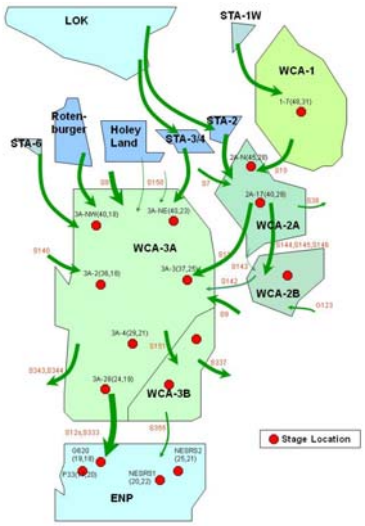


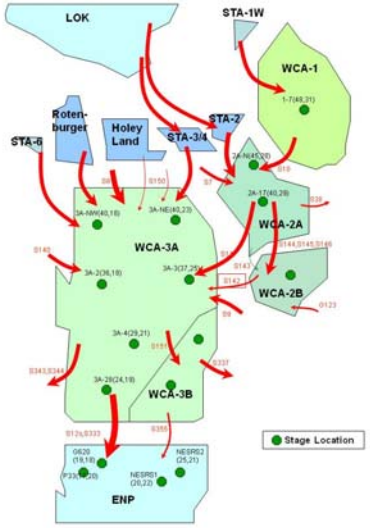
Use of Novel Inverse Modeling and Optimization Tools







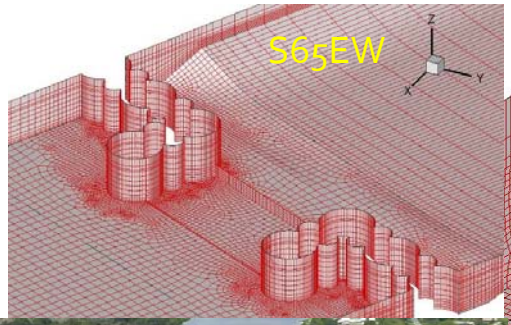


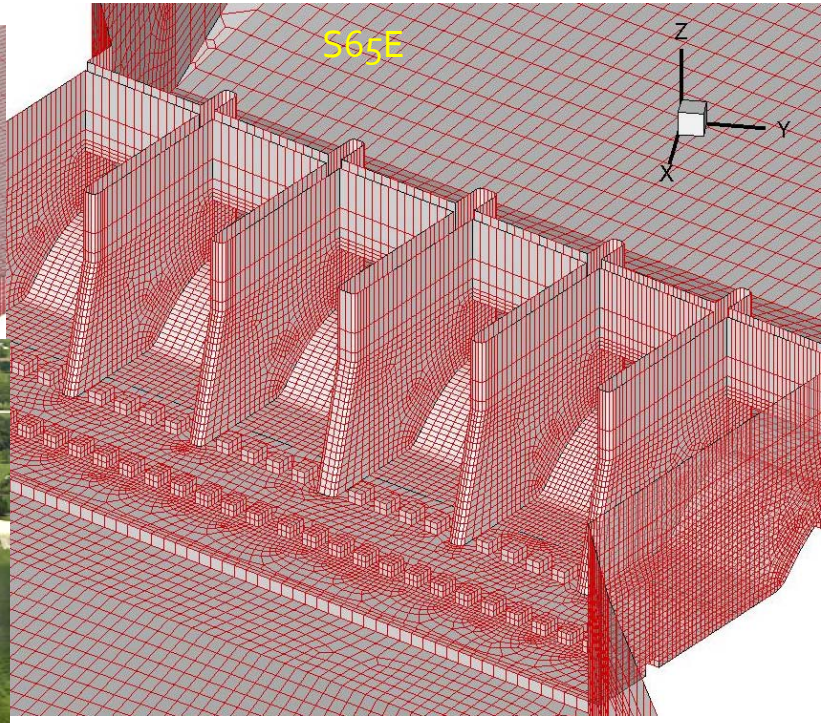


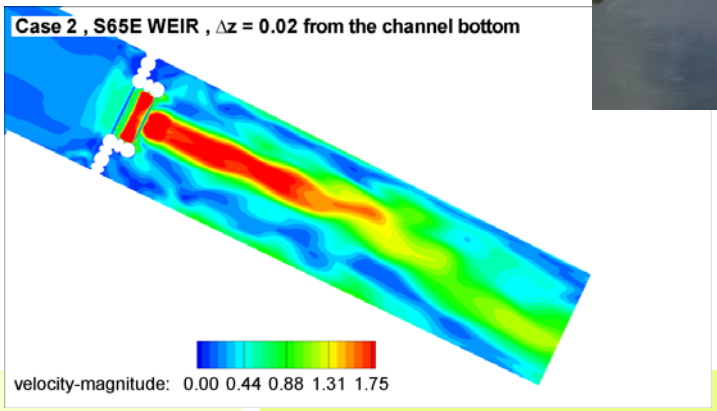
An example is the iModel© (Ali 2009, 2013), a modeling tool developed by the SFWMD that uses artificial neural network and optimization techniques to allow for rapid assessment of multiple project infrastructure and operations options.

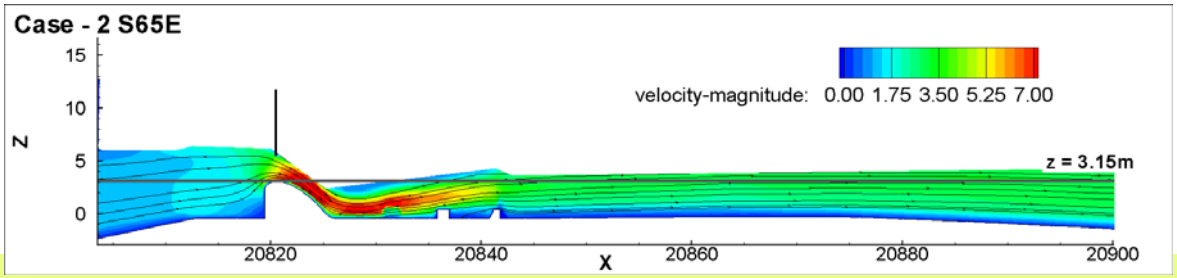
- iModel© has been taught as part of the Engineering curriculum at Columbia University.
- iModel© has been part of "HydroViz" project to support active learning in hydrology and water resources engineering through the US National Science Foundation.

Applications of Computational Fluid Dynamics to Hydraulic Design







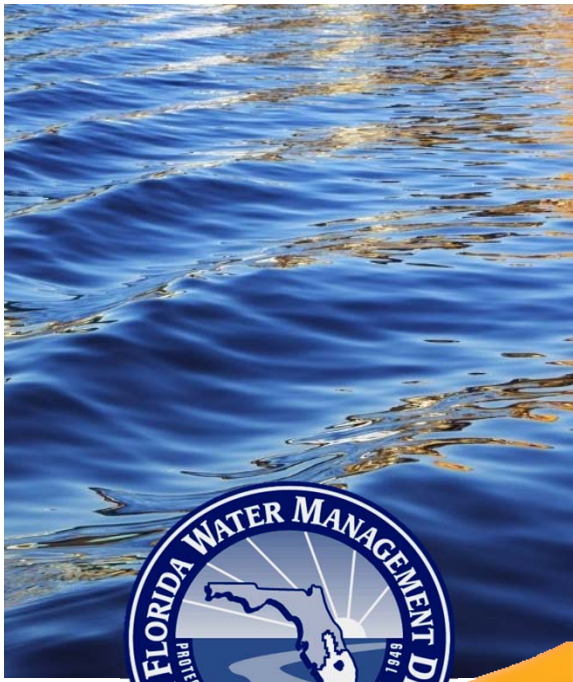


Public Communication

- During both floods & droughts, communication to the public is critical
- This involves extensive coordination with federal, state and local water management agencies to communicate…
  - The current and projected status of water control operations
  - Status of regional and local facilities
- Daily conference calls with all affected agencies
- Frequent media briefings & press releases
- Citizens Information Line

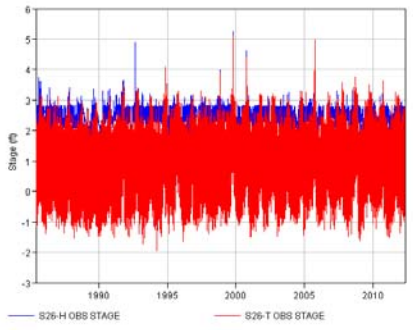
Managing the Balance

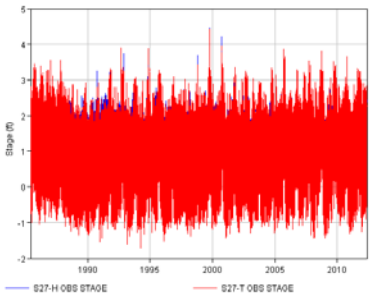
Evolving Challenges /Adaptation

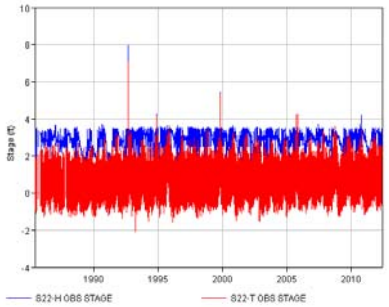


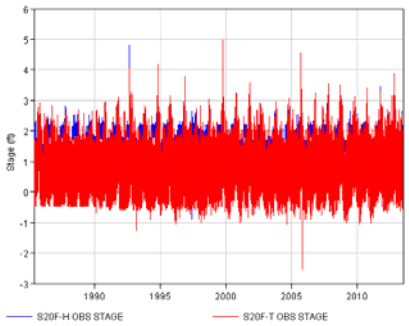
Considering Implications of Sea Level Rise

- Areas of south Florida lie mostly any where from 1 to 2 m above sea level
- Sea level has risen approximately 20 cm (8 in.) over the past 100 years
- The primary impact on District facilities will be the decrease in gravity head across the system
  - Reducing flood discharges
  - Increasing landward salinity encroachment
- Forward pumping systems may be a solution.
- But unprotected downstream areas will be more difficult to address



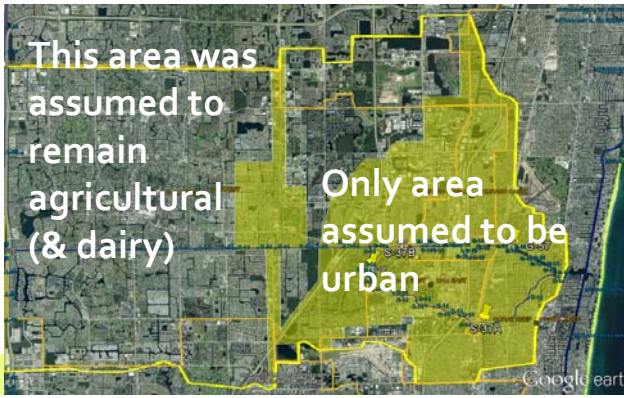






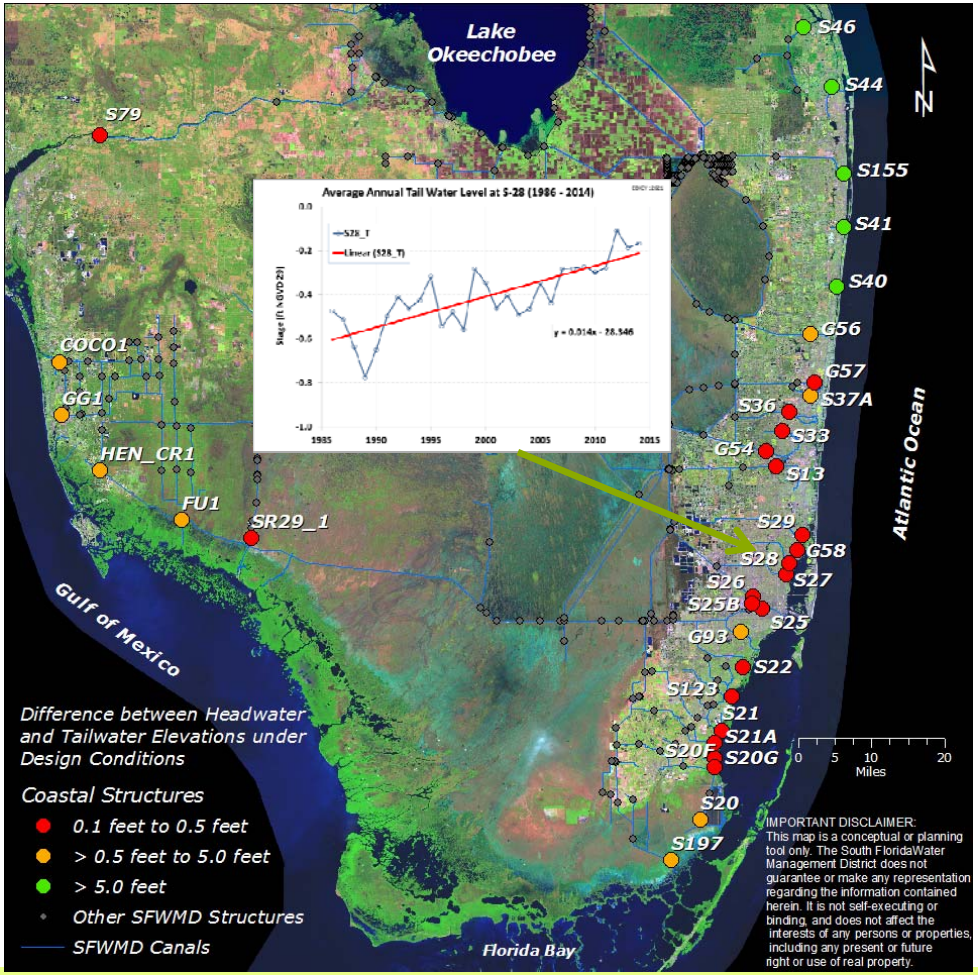
Flood Control

- Gravity Driven Flow with decreasing gradient
- System that is significantly more urbanized than what was originally anticipated during design
- Potential changes in rainfall extremes
- Other areas of concern: areas downstream of SFWMD coastal structures, Island communities outside SFWMD



Flood Control: Level of Service (LOS) Assessment

- Screening and prioritization of coastal salinity control structures (completed)
  - Aging infrastructure with reduced capacity to remove flood waters under SLR scenario
- Assessment Procedure
- Sea Level Rise
- Rainfall Change – literature review and Updated Rainfall Frequency Analyses
- Basin-Scale Assessment Projects:
  - LOS modeling for Basin
  - Basin Atlas (update) : operational intent, Original design criteria, structure info., known operational issues



BIG WATER DATA CHALLENGES

- Common Platform and integrating multiple legacy databases and applications
  - Webmethods, Hydro Data Roadmap

- Data Quality Assurance/ Quality Control
  - Data collected with different instruments and/or following different data collection standards/techniques
  - Automated Data Processing Tools

- Development of Data Integration and Analysis Tools to extract useful, timely, and actionable information
  - So many data, so little Information
  - Data Fusion/Data Mining

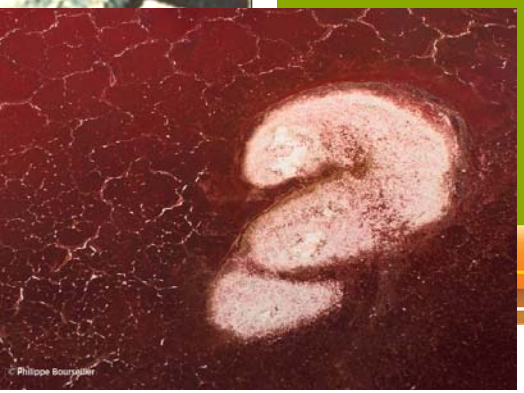
- Integrating data from various temporal and spatial scales using physically-based models

  - Sub-hourly to multi-decadal; localized to regional issues

- Common Vertical Datum

Thank You…

Questions



Water is a very good servant, but it is a cruel master.
C.G.D. Roberts, "Adrift in America", 1891

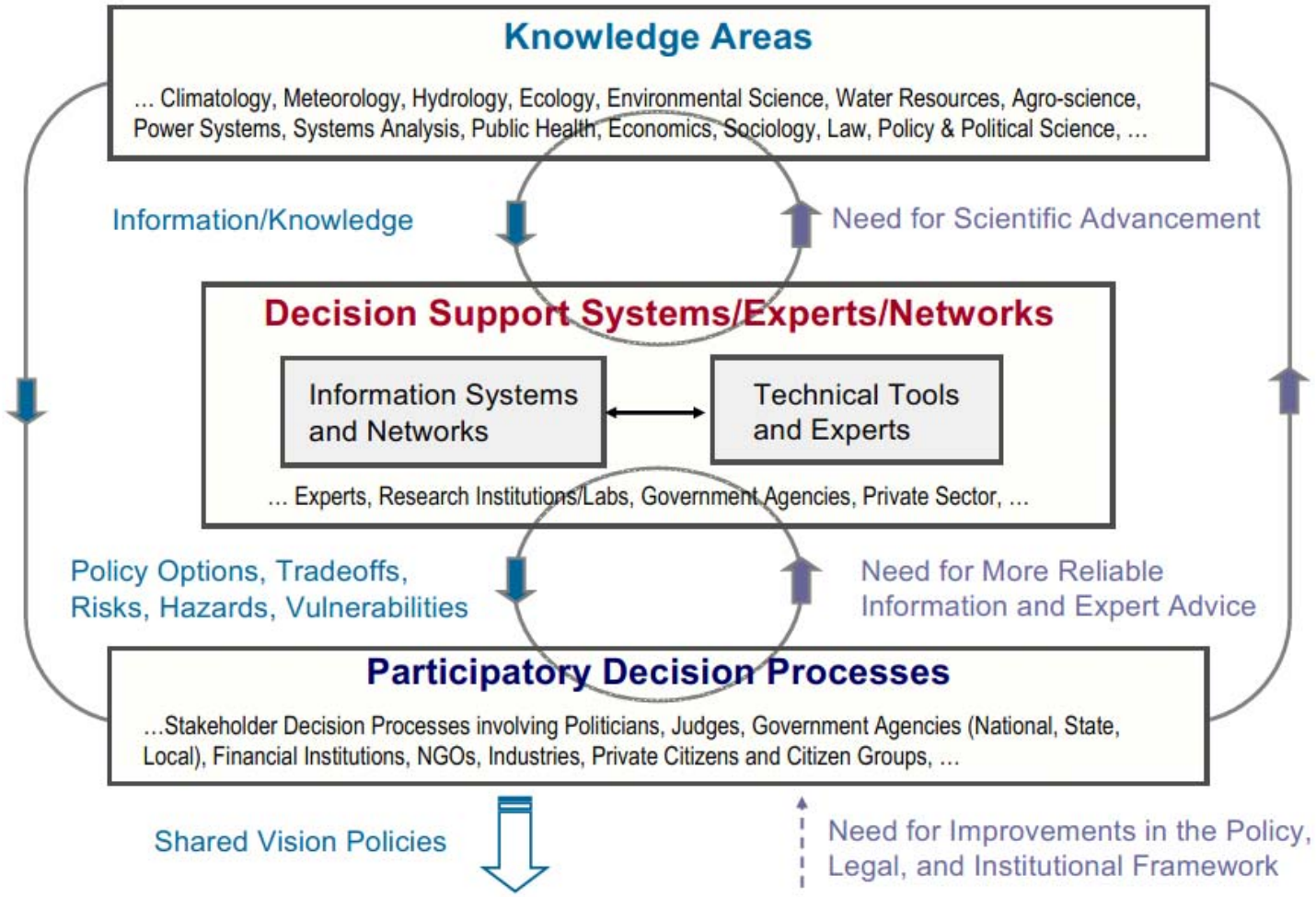
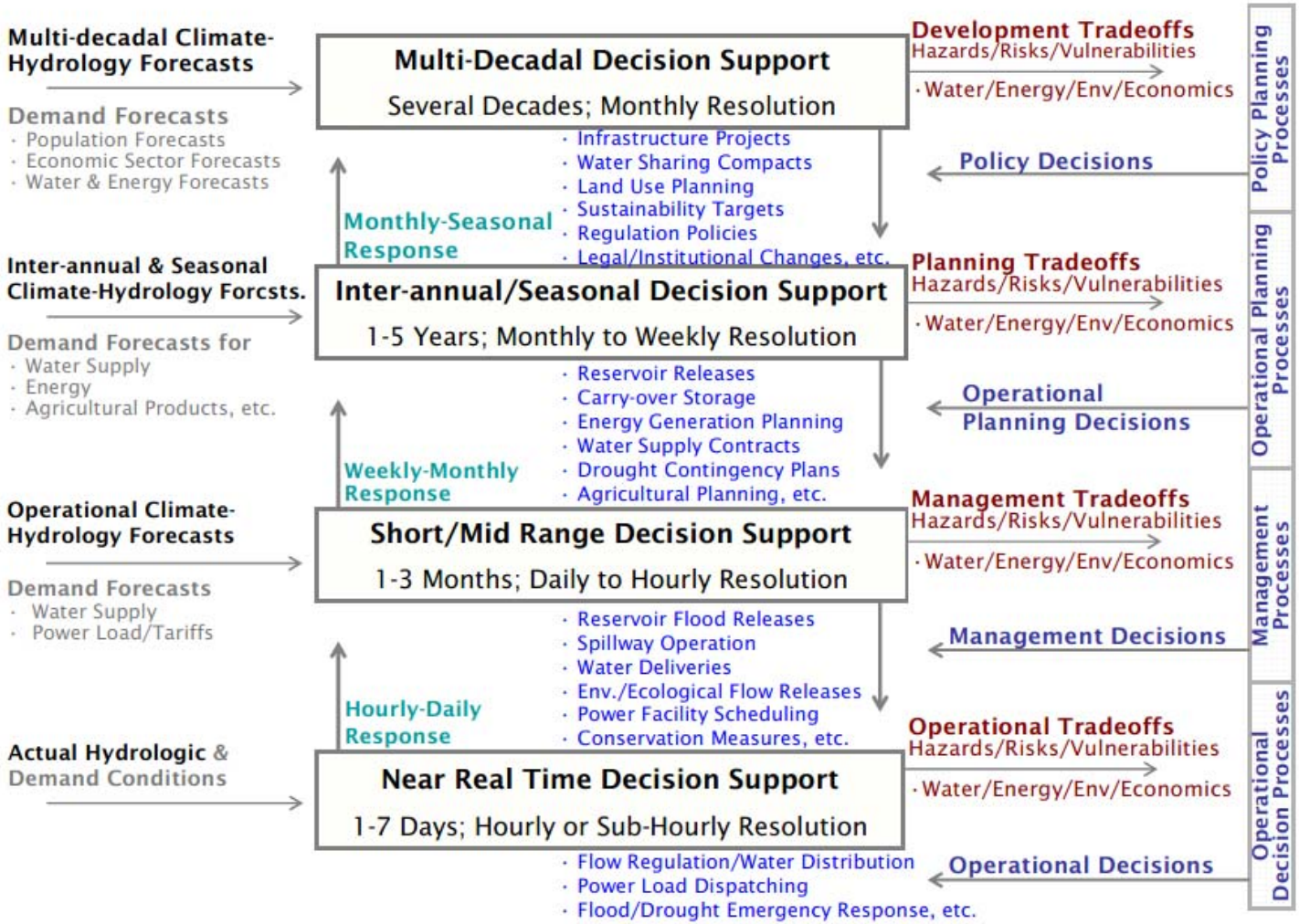


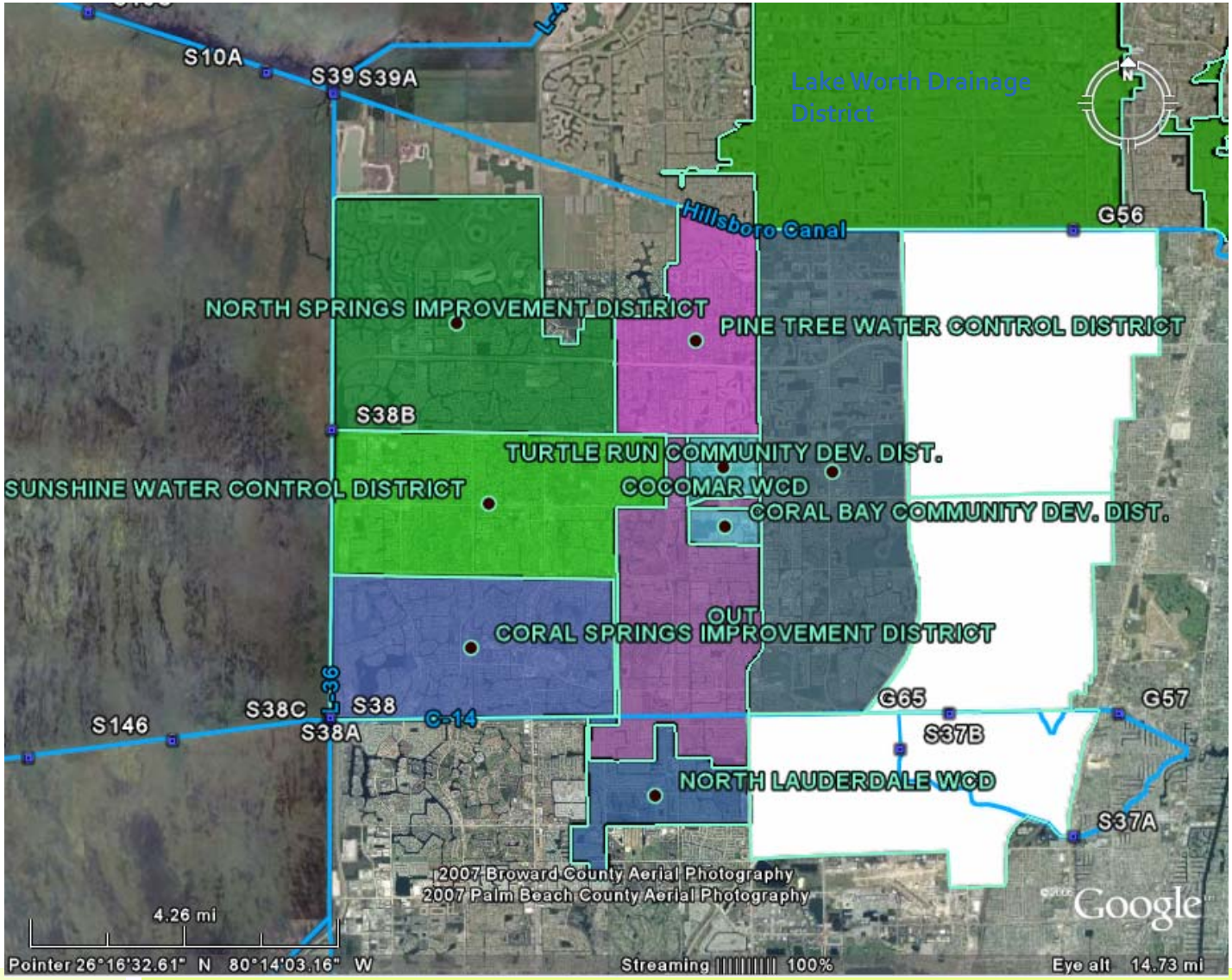
Figure 1: Water Resources Decision Processes

Aris Georgakakos
Georgia Water Resources Institute, Atlanta, Georgia 30332, USA



Aris Georgakakos
Georgia Water Resources Institute, Atlanta, Georgia 30332, USA

Figure 2: Water Resources Decisions: Range and Attributes

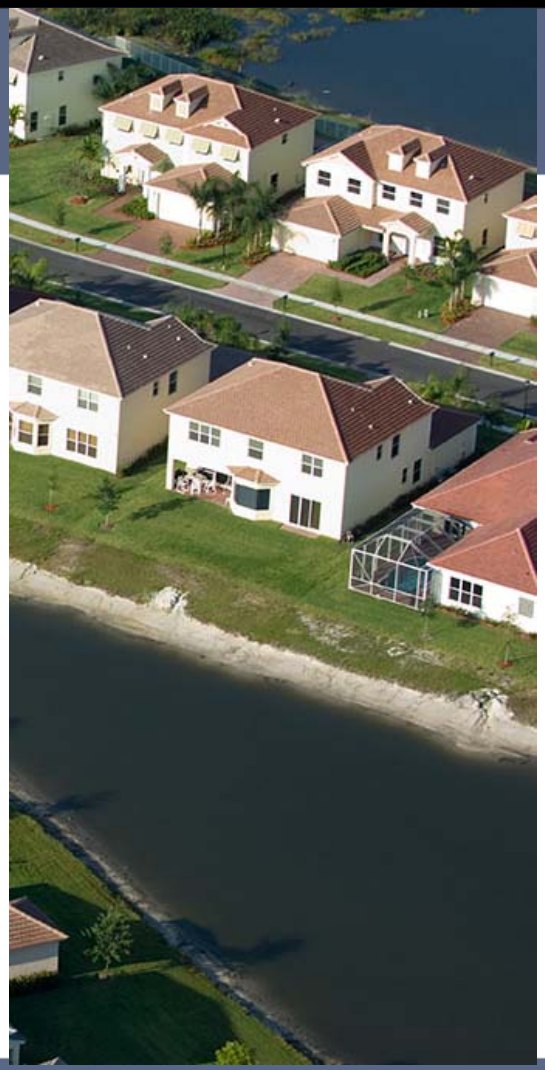


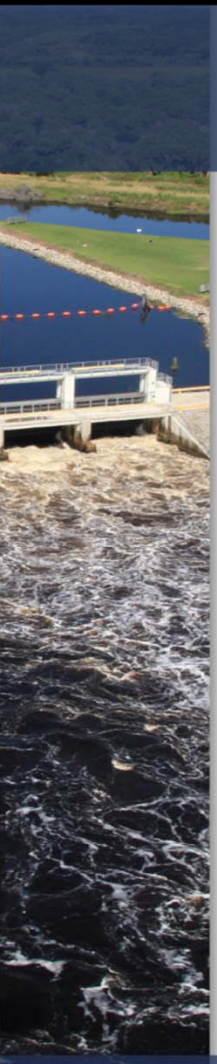
298 Districts between Hillsborro and C14.

Of course LWDD is not in Broward but it does share some of Hillsboro's capacity.

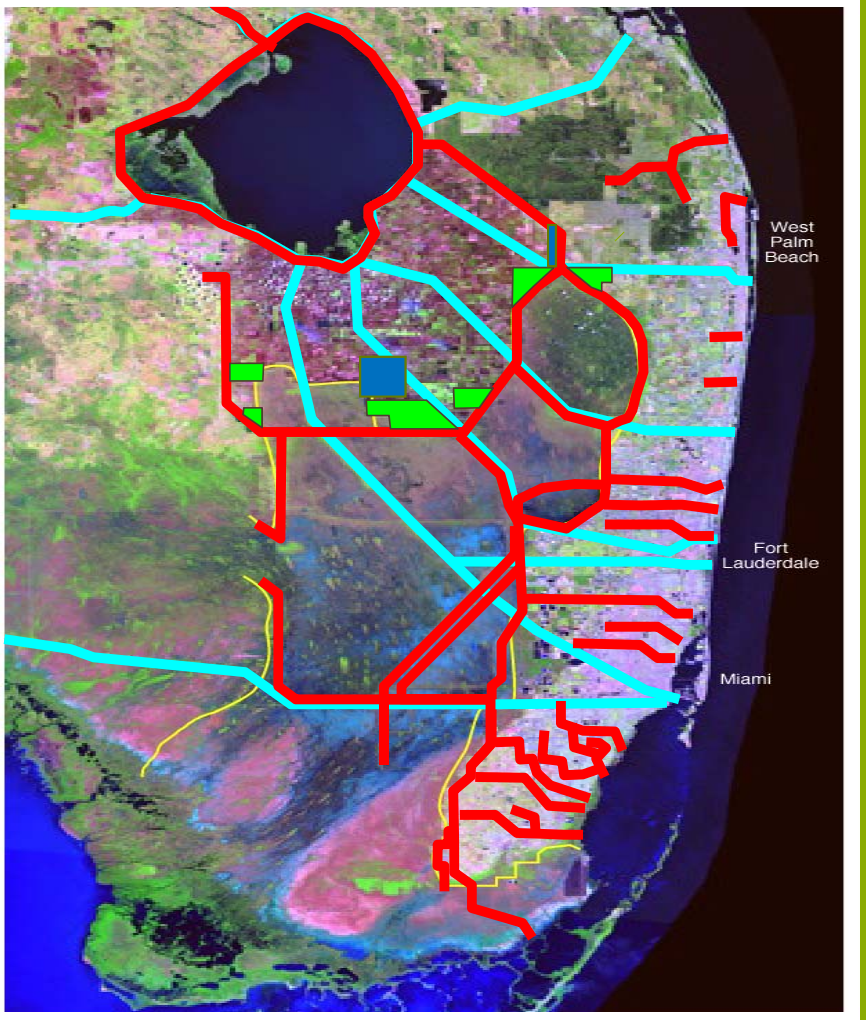
Surface Water Regulation

- Enhanced benefit of the C&SF system by limiting inflows to avoid overwhelming the system
- Requires water storage systems for new development to limit storm flows into the primary canal system
- This insures that no increase in the peak rate of flow is discharged to the canals after development occurs
  - Has been a key in avoiding having to increase canal capacity over time (unlike the highway system)





Chronology of Water Management Changes



Managed System (2015)

Pre-Central & South Florida Projects

- Caloosahatchee/Kissimmee Rivers 1881-93
- East Coast Canals/St. Lucie Canal 1905-24
- Tamiami Trail – 1915-28
- Lake Okeechobee HH Dike – 1932-38

Central & Southern Florida Project

- Eastern Protective Levee System – 1952-54
- Everglades Agricultural Area – 1954-59
- Water Conservation Area Levees – 1960-63
- Lower East Coast Canals – 1954-65
- Lake Okeechobee Levees – 1960-64
- Kissimmee River Channelization – 1962-71
- South Dade System – 1965-83

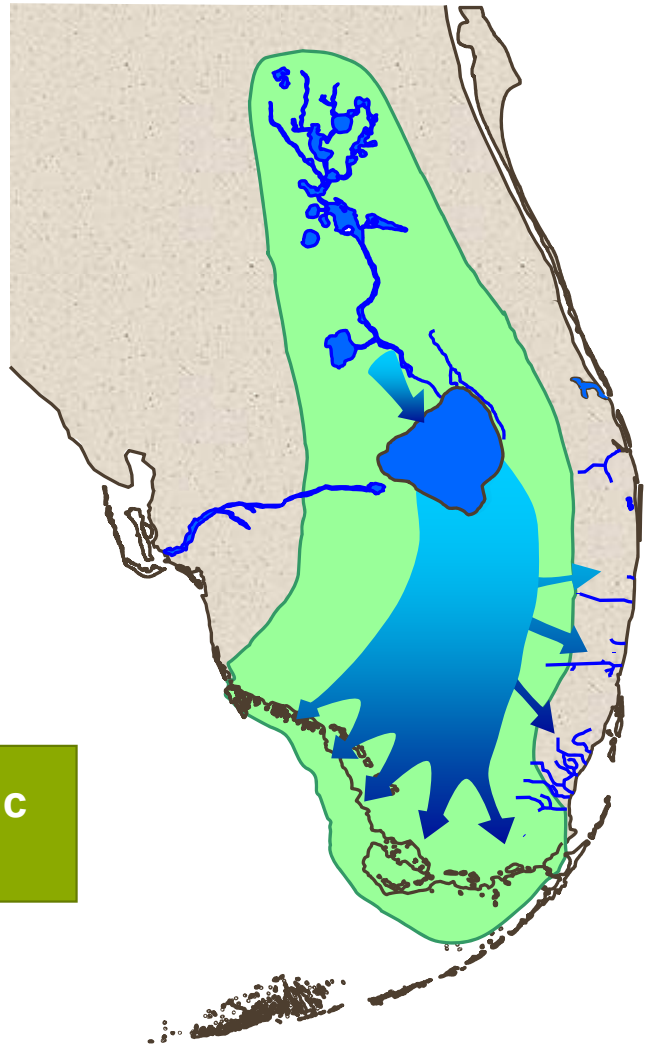
Everglades Construction Project

- Stormwater Treatment Areas & FEBs – 1994-2015

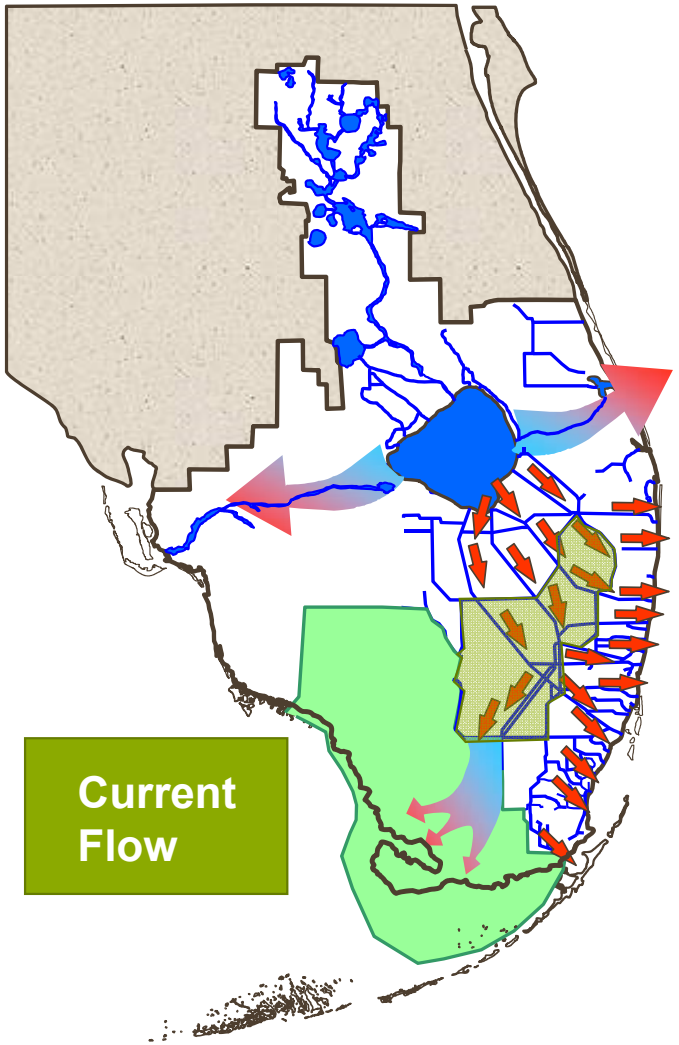
Source: Light and Dineen, 1994; SFWMD & USACE, 2008

Kissimmee River Restoration

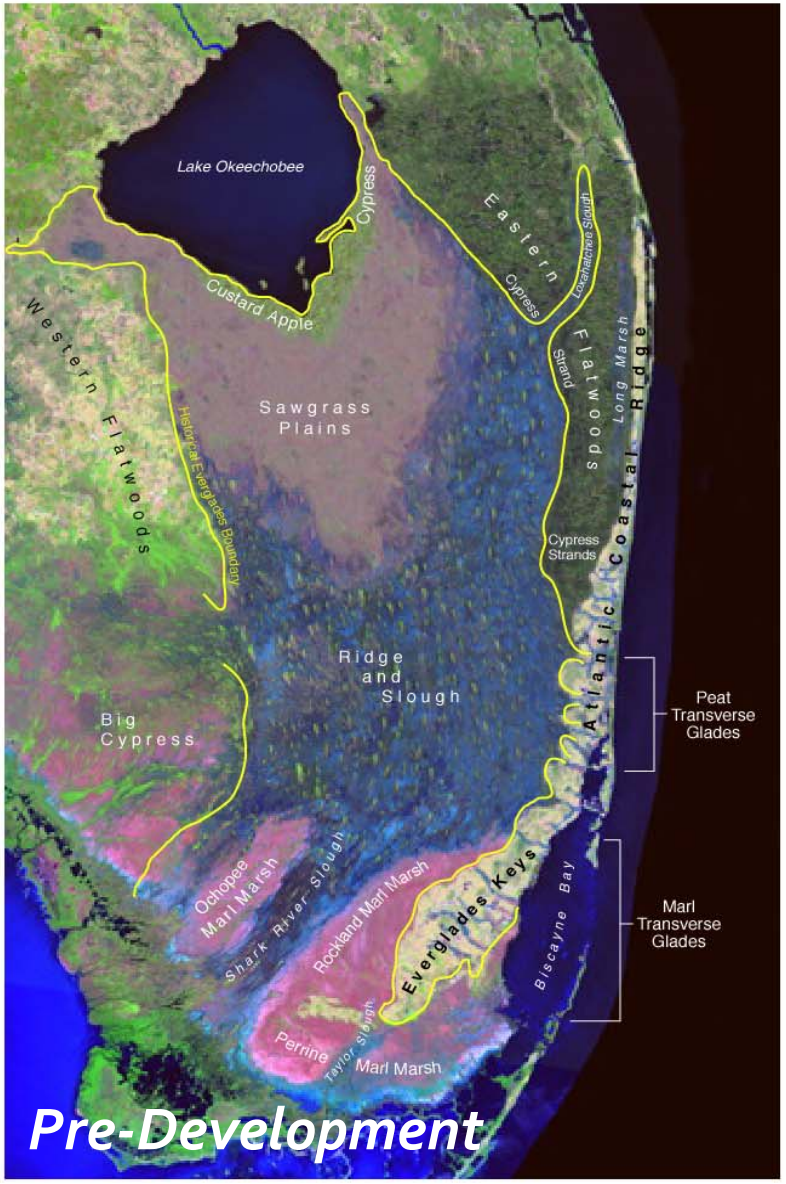
Looking north from the south end of the Phase IVB backfill which was completed in December 2009.

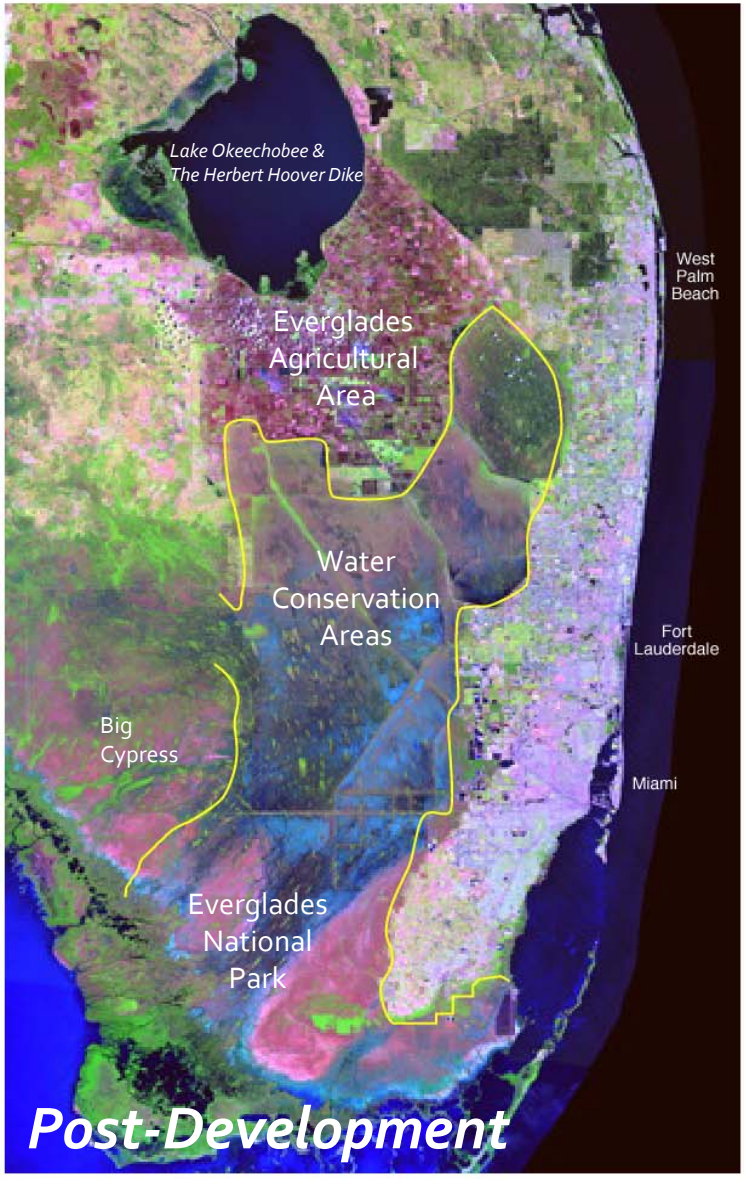


Historic Flow



Current Flow

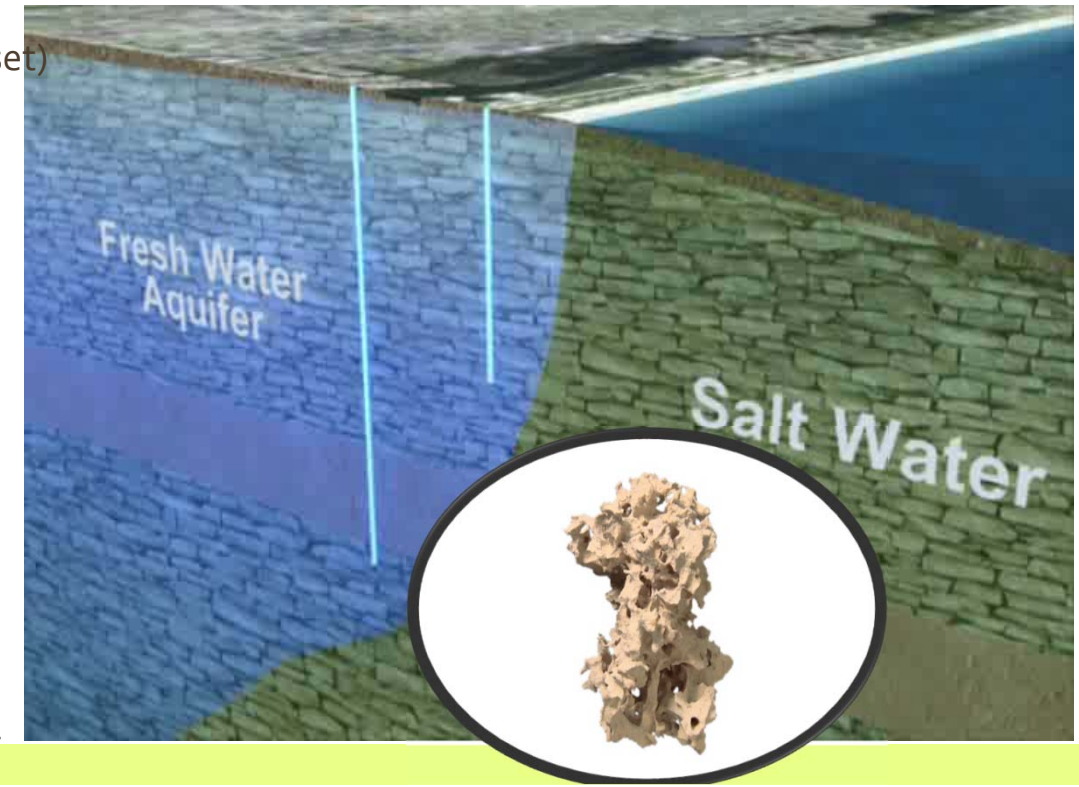

Lake Okeechobee
Cypress
Eastern
Cypress
Loxahatchee Slough
Custard Apple
Western Flatwoods
Historical Everglades Boundary
Sawgrass Plains
Flatwoods
Strand
Long Marsh
Ridge
Cypress Strands
Atlantic Coastal Ridge
Ridge and Slough
Peat Transverse Glades
Big Cypress
Ochopee Marl Marsh
Shark River Slough
Rockland Marl Marsh
Everglades Keys
Biscayne Bay
Marl Transverse Glades
Perrine Marl Marsh
Taylor Slough
Pre-Development


Lake Okeechobee & The Herbert Hoover Dike
West Palm Beach
Everglades Agricultural Area
Water Conservation Areas
Fort Lauderdale
Big Cypress
Miami
Everglades National Park
Post-Development

Water Supply: Saltwater Intrusion

Several municipal well fields close to the coast .
Some have potential risk of saline water entrainment with rising sea level (both coasts)

Risk higher especially where aquifer is very permeable (see inset)



Update saltwater/ freshwater interface

Identify utilities at risk

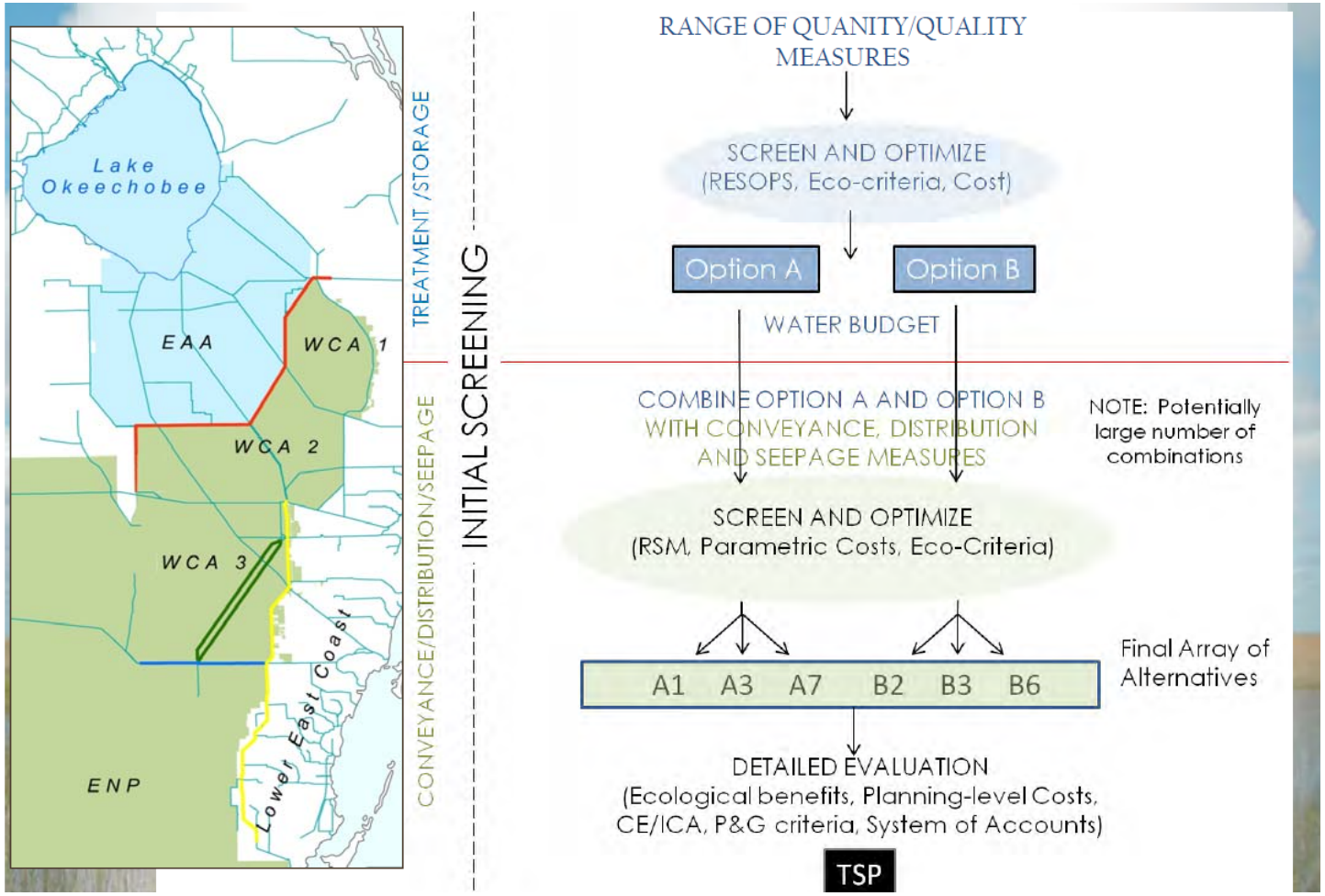
Emphasize water conservation

Alternatives sources of water

Increasingly incorporate SLR into water supply planning

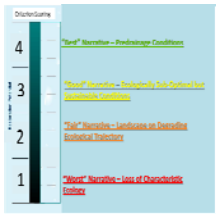
Main sources of water are: Lake O, WCAs and Floridan Aquifer

Everglades Restoration Planning – Expedited Schedule, but Robust Analysis

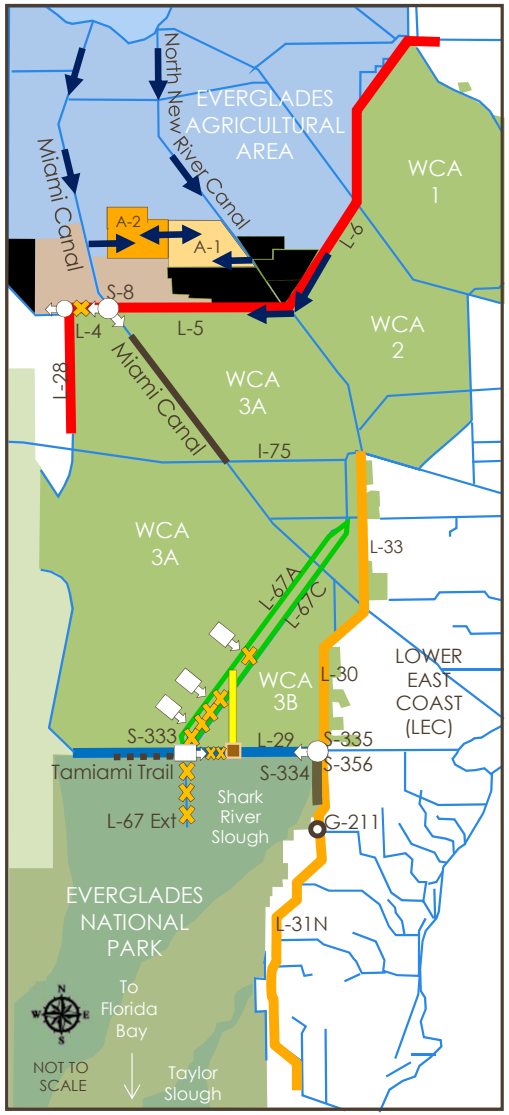


Multi-Criteria Decision Analysis (in each step)

- Purpose:
  - Helps to identify and understand conflicts and trade-offs
  - Decisions supported by transparent and replicable analysis
  - Identify performance trends for multiple options across numerous criteria
- Hieratical approach to evaluation
  - Level 1 : Primary ecological objectives
  - Level 2: Other important considerations
- Ordinal quartile rating
  - 1 -4 rating system used for each criterion.
  - Scores are ordinal in nature.
  - There is NO inherent magnitude in the scores (i.e. a score 4 is not necessarily twice as good as a 2)



CENTRAL EVERGLADES PLAN (Alt 4R2)



STORAGE AND TREATMENT

- Construct A-2 FEB and integrate with A-1 FEB operations
- Lake Okeechobee operational refinements

DISTRIBUTION/CONVEYANCE

- Diversion of L-6 flows, infrastructure, and L-5 canal improvements
- Remove western ~2.9 miles of L-4 levee west of S-8 (3,000 cfs capacity)
- Construct 360 cfs pump station at western terminus of L-4 levee removal
- Backfill Miami Canal and Spoil Mound Removal from ~1.5 miles south of S-8 to I-75

DISTRIBUTION/CONVEYANCE

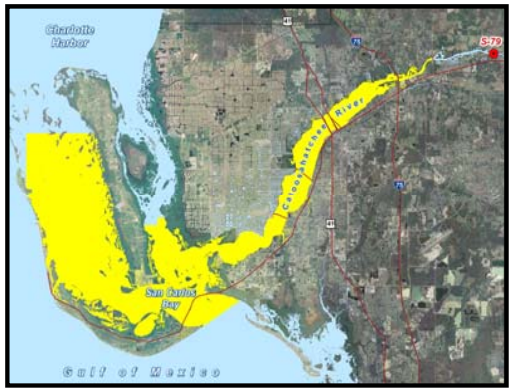
- Increase S-333 capacity to 2,500 cfs
- One 500 cfs gated structure north of Blue Shanty levee and 6,000-ft gap in L-67C levee
- Two 500 cfs gated structures in L-67A; 0.5 mile spoil removal west of L-67A canal north and south of structures
- Remove ~8 miles of L-67C levee in Blue Shanty flowway (no canal back fill)
- Construct ~8.5 mile levee (Blue Shanty levee) in WCA 3B, connecting L-67A to L-29
- Remove ~4.3 miles of L-29 levee in Blue Shanty flowway; divide structure east of Blue Shanty levee at terminus of Tamiami Trail Next Steps western bridge
- Remove entire 5.5 miles L-67 Extension levee; backfill L-67 Extension canal
- Remove ~6 miles of Old Tamiami Trail road (south of L-29 western levee, fromL-67 Ext to ENP Tram Rd)

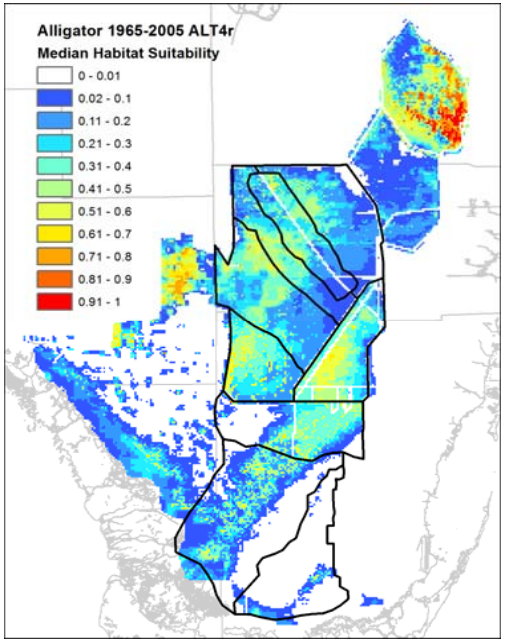
SEEPAGE MANAGEMENT

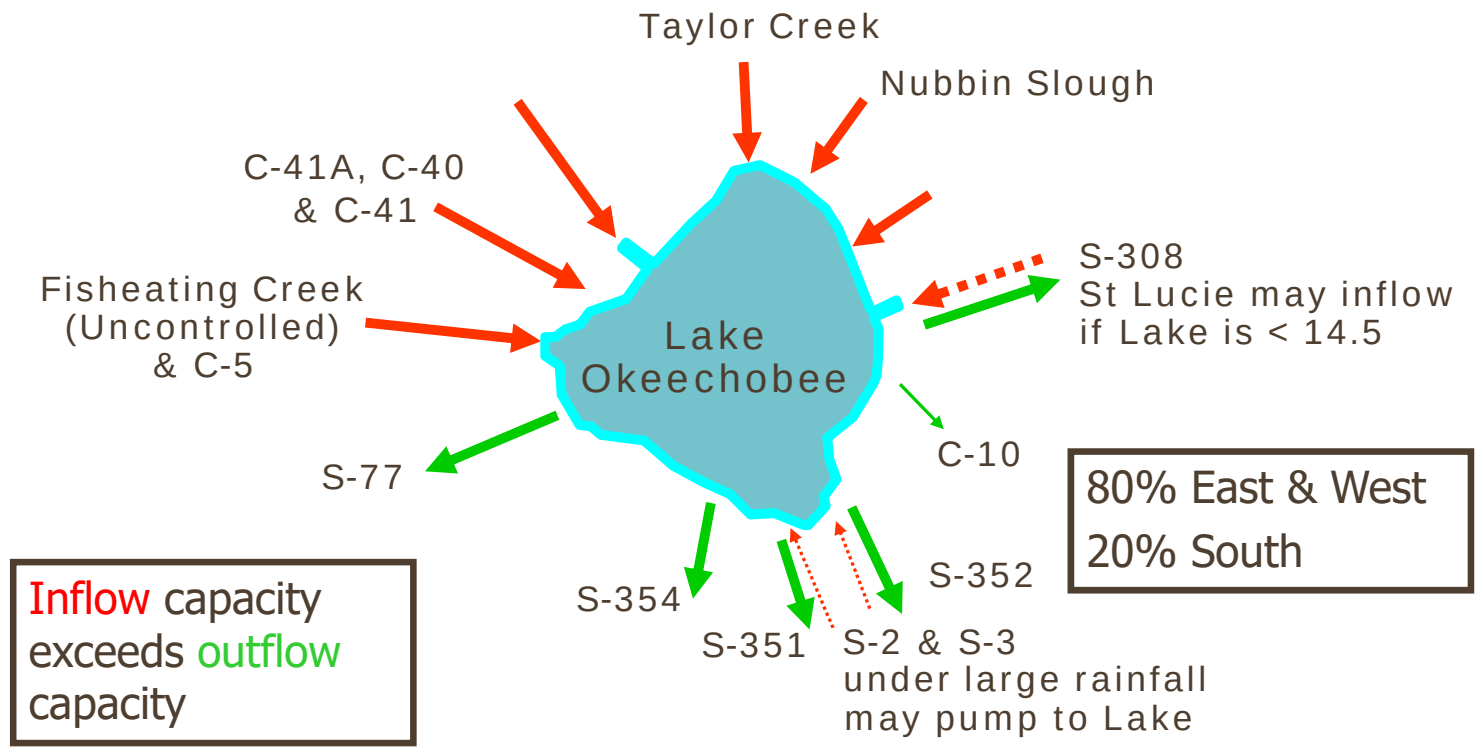
- Increase S-356 pump station to ~1,000 cfs
- Construct 4.2 mile partial depth seepage barrier south of Tamiami Trail (along L-31N)
- G-211 operational refinements; use coastal canals to convey seepage

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 · Divide · Levee






Taylor Creek
Nubbin Slough
C-41A, C-40
& C-41
Fisheating Creek
(Uncontrolled)
& C-5
Lake
Okeechobee
S-308
St Lucie may inflow
if Lake is < 14.5
C-10
S-77
S-354
S-351
S-352
S-2 & S-3
under large rainfall
may pump to Lake
80% East & West
20% South
Inflow capacity
exceeds outflow
capacity
Lake Okeechobee's drainage basin covers more than 4,600 square miles

For Ecological Sustainability: 12.5 to 15.5 ft-NGVD

For Dike Stability: < 18.0* ft-NGVD

Top of Dike (Elevation 32.3 – 45.6')

Littoral Wetland (Elevation 11-15')

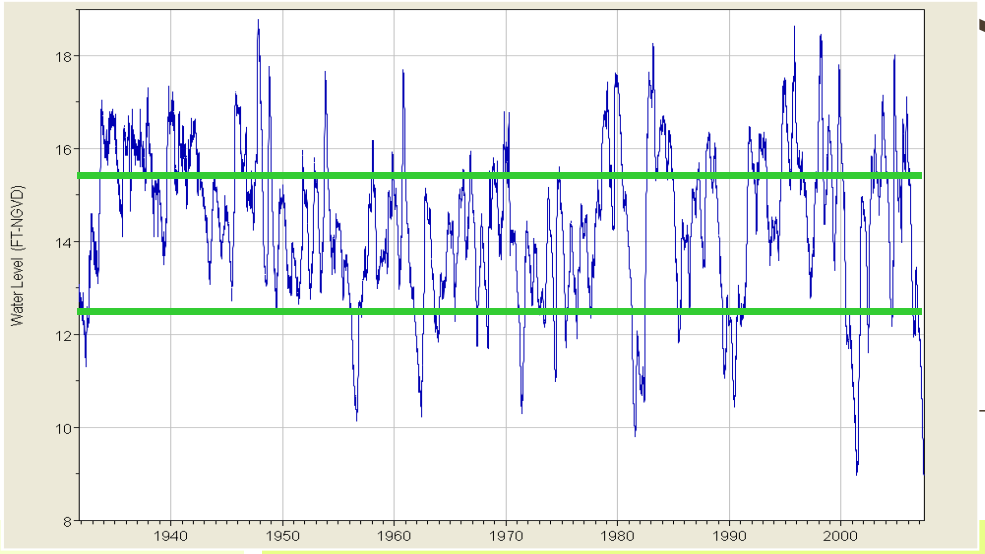
12.5-15.5' variation = healthy littoral and submerged grass beds

Deep Pelagic Zone (Elevation < 10')

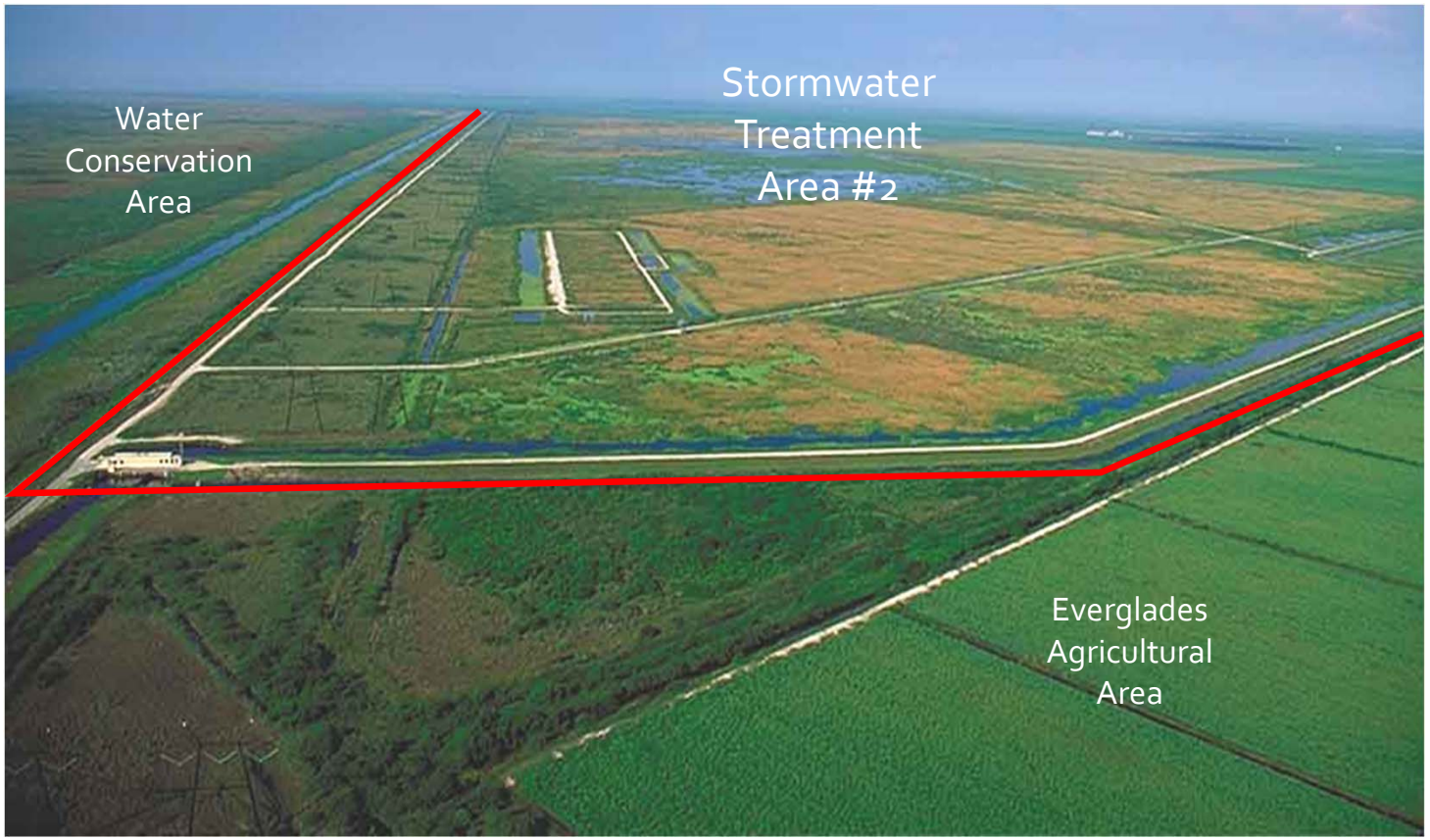
Submerged Grass Beds (Elevation 10-12')

Not to Scale

*Less than 17.33 ft-NGVD according to the USACE



Stormwater Treatment Areas



Data Acquisition & Automation