Application of Groundwater Models for Groundwater Management at the South Florida Water Management District (SFWMD)

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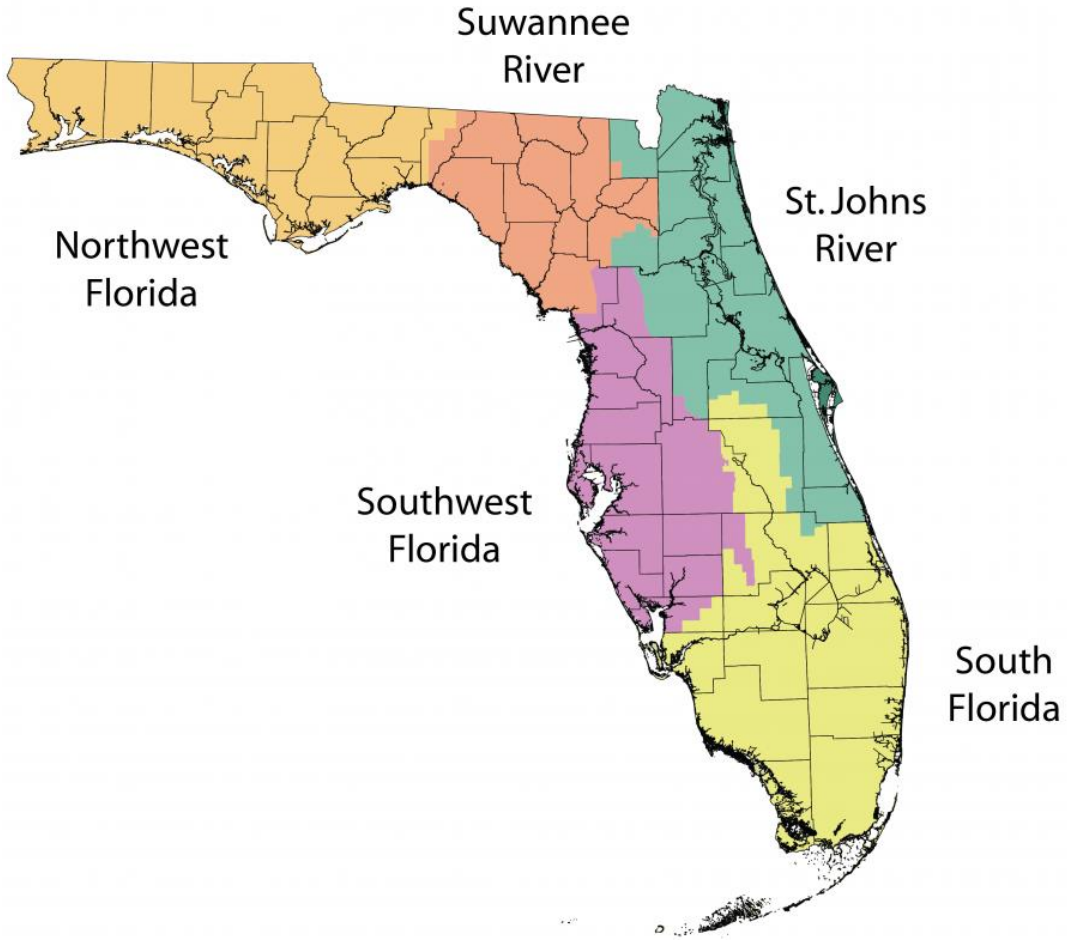
04/19/2023

Overview

- Water supply management and planning in South Florida
- Florida's major aquifer systems
- Groundwater use in South Florida
- Challenges of groundwater management
- Application of groundwater models for planning
  - Lower West Coast Surficial and Intermediate Aquifer System Model (LWCSIM)
  - East Coast Floridan Model (ECFM)

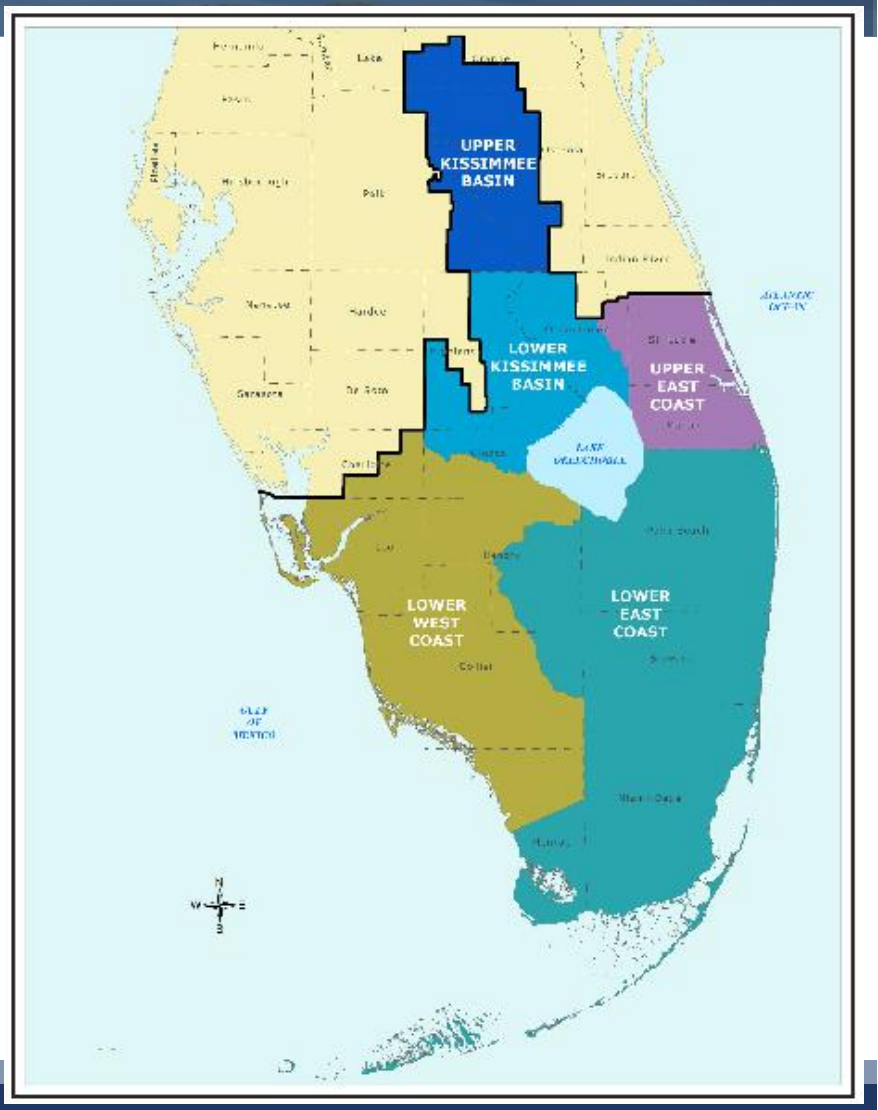
Florida State's Water Management Policy

- Managed at state and regional level
- State level-Department of Environmental Protection (FDEP)
- Regional level-5 Water Management Districts (WMD)
- Core missions of WMDs are
  - Water supply
  - Water quality
  - Flood protection & flood plain management
  - Natural systems

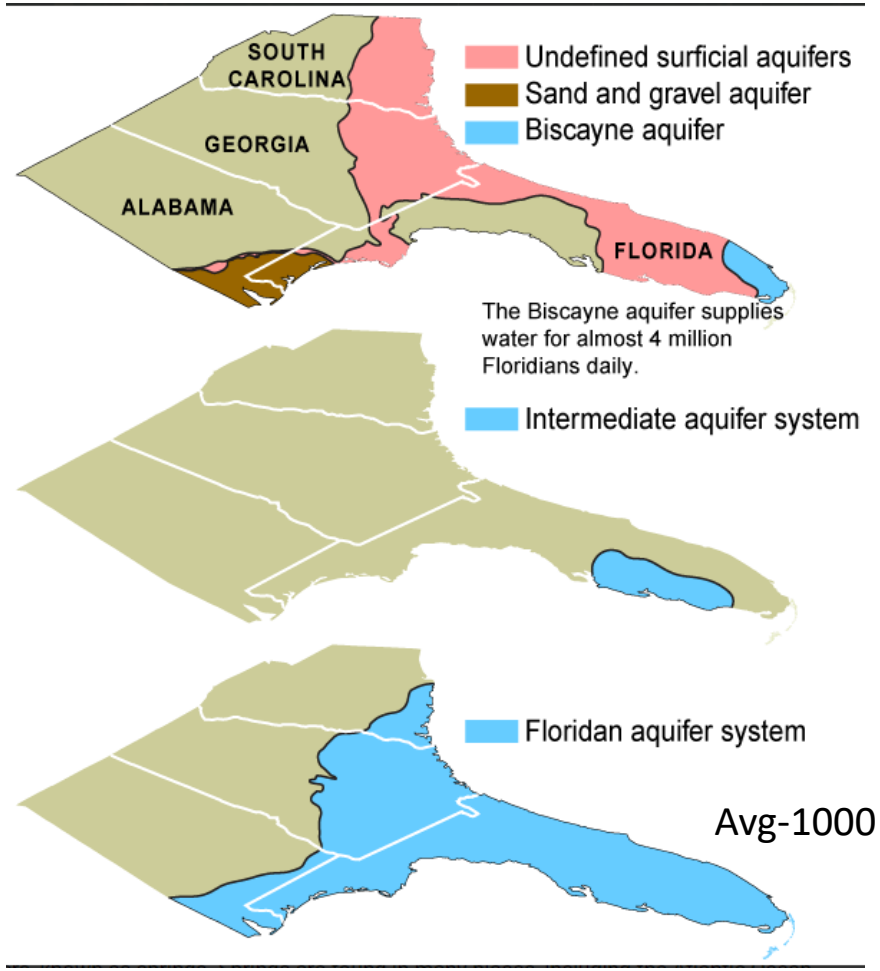


Water Supply Planning Requirements

- 5 planning regions
- 20-year planning horizon & updated every 5 years
- Demand estimates & projections
- Resource analyses & issues identification
  - If the current resources can meet the projected demands
- Evaluation of water resource options
  - Use of deeper brackish aquifers (Lower Floridan Aquifer)
  - Recycle water use
- Water resource development
  - Groundwater recharge, Aquifer Storage Recovery (ASR)
- Minimum Flows and Minimum Water Levels
  - Recovery & prevention strategies

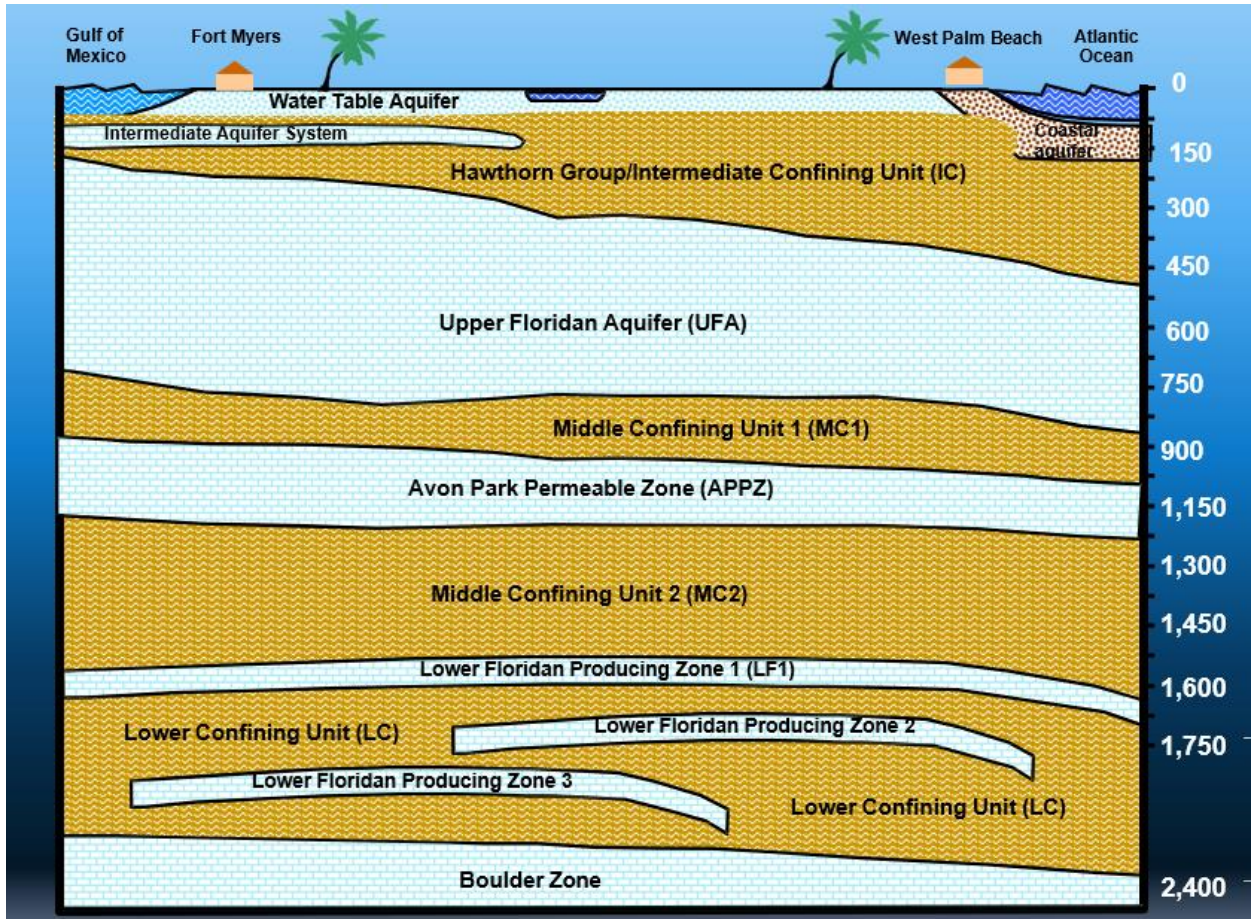


Florida's Major Aquifer Systems



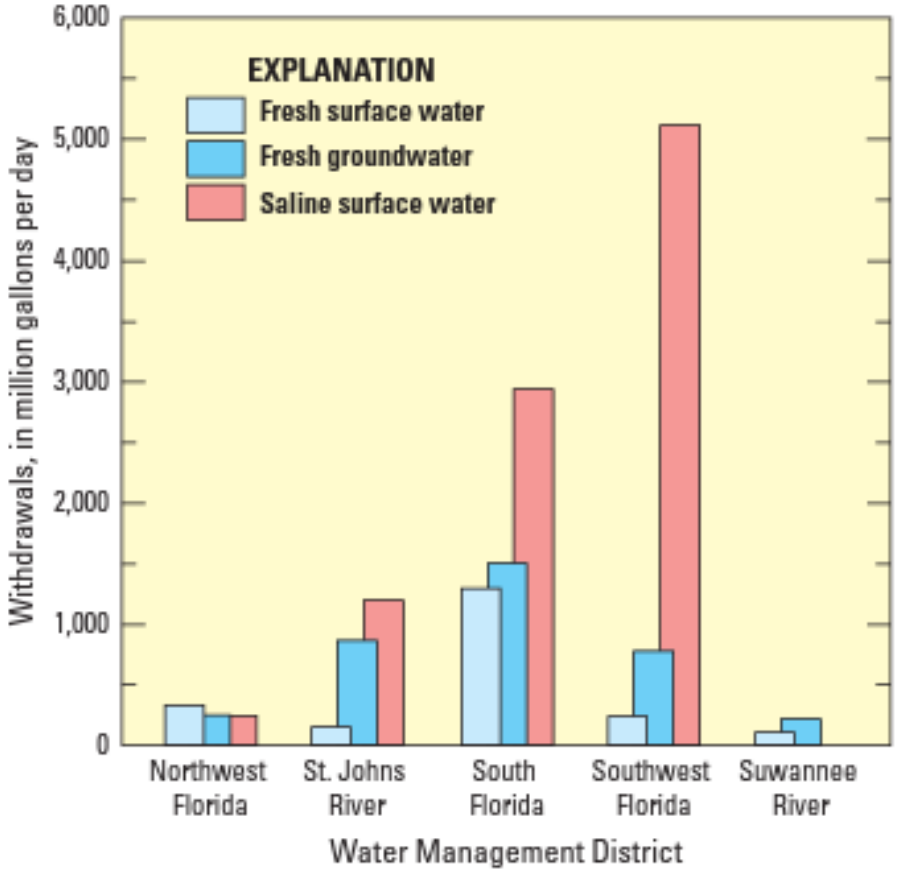
https://www.sjrwmd.com/water-supply/aquifer/#gsc.tab=0

Generalized Hydrogeologic Cross-section



Groundwater Use

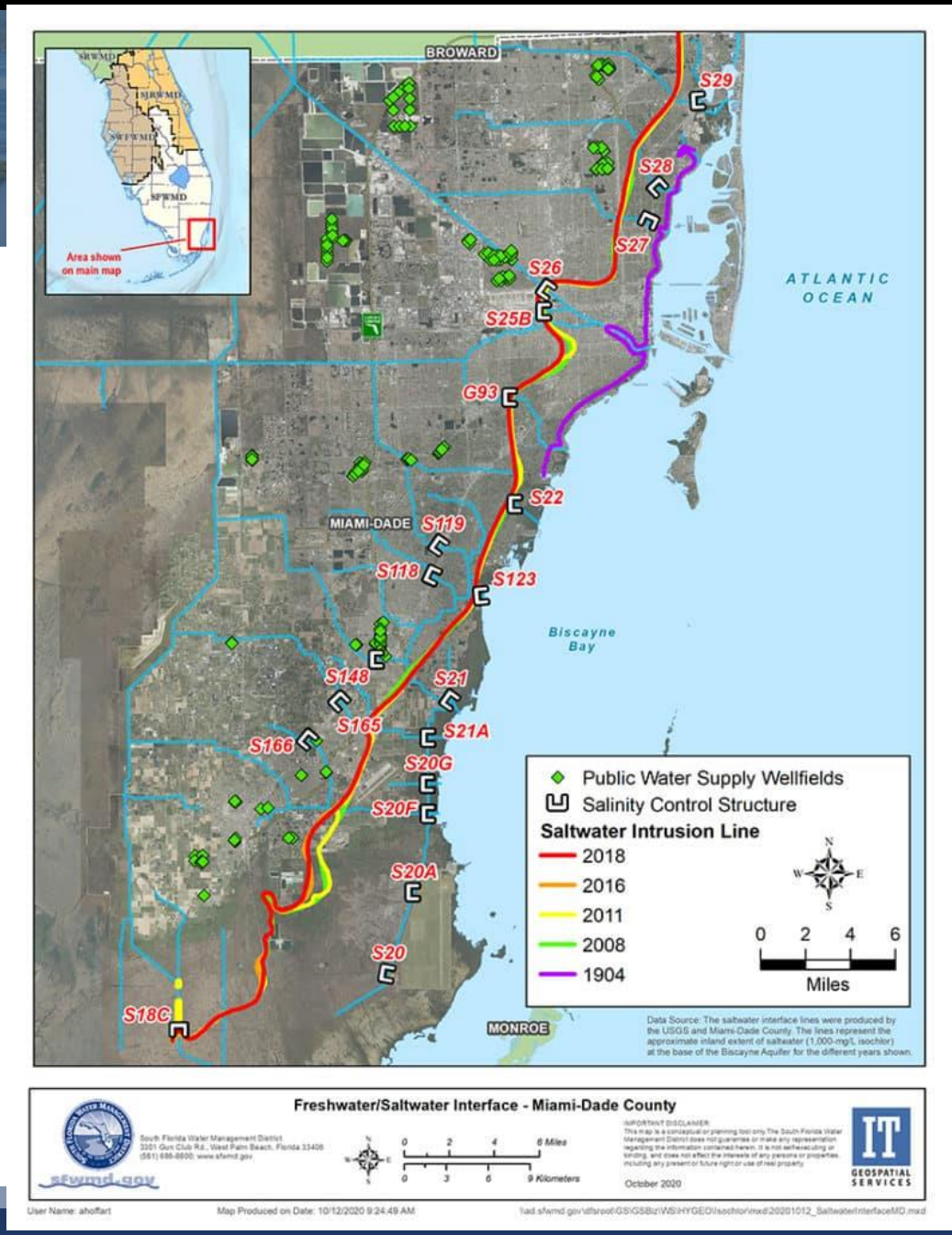
- South Florida heavily relies on groundwater for Public Supply, Agriculture, Landscape irrigation
- In 2021, SFWMD estimated **1.65 billion gallons per day** (60% of total water use) of groundwater use
- 70% of 1.65 billion gallons per day (1.15 bgd) used for Public Supply and the remainder (0.5 bgd) is used for Agriculture and Landscape Irrigation
- About 90 % of the Public Supply is from groundwater



USGS Report 2019–5147

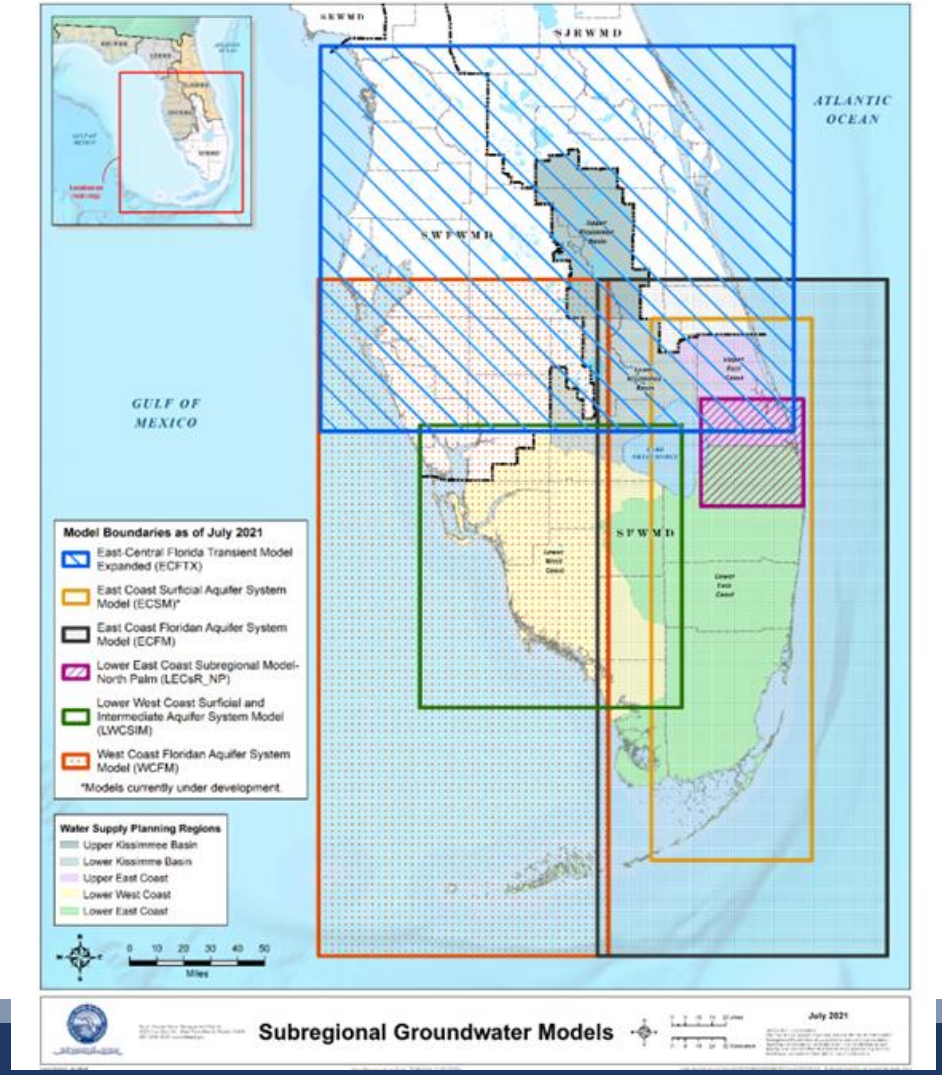
Challenges of Groundwater Management

- Depletion: Due to overdraft
- Saltwater Intrusion due to overdraft, sea level rise and climate change
  - Lateral intrusion
  - Up-coning
- Impact to natural systems-Groundwater is highly connected surface water in South Florida
  - Surface water (rivers, lakes and wetlands)
- Groundwater quality has degraded due to heavy use of agricultural fertilizers



SFWMD Groundwater Models

- Groundwater models are used to evaluate current and future pumping conditions, impact to natural systems such as lake wetlands, and impact to legal users
- For each planning region one or two groundwater models are available
- USGS's **MODFLOW** and **SEAWAT** code based
- Customized packages such as Wetland, SFR (surface water routing) used for wetland flow and complex surface water management system simulation
- Considers all the major component of the hydrologic cycle
  - Integrated with the surface runoff-recharge model
- Models can be downloaded
  - https://www.sfwmd.gov/science-data/gw-modeling

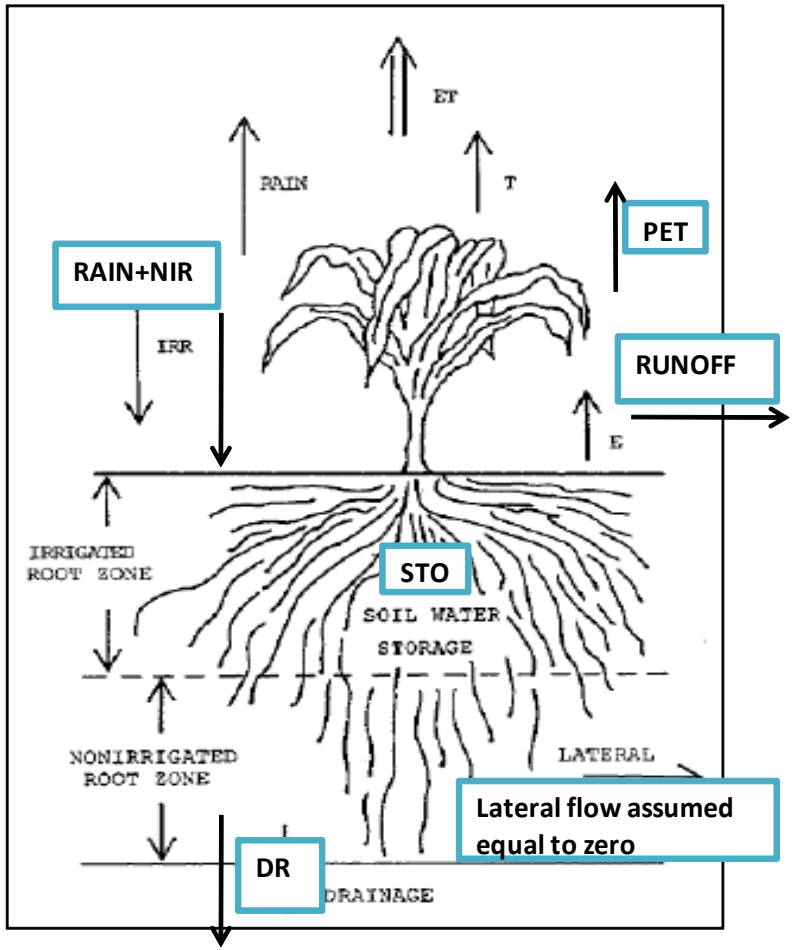


Agricultural Field scale Irrigation Requirement Simulation (AFSIRS) University of South Florida

- AFSIRS is a root-zone daily water balance model
- Simulates the dynamic processes of soil water infiltration, redistribution, and extraction by ET as steady-state processes
- Uses, daily rainfall, PET, soil data, crop data, and irrigation data
- Water balance in the crop root zone,

$$\Delta STO = Rain + IRR - RCH - Runoff - IA - ET_{PC}$$

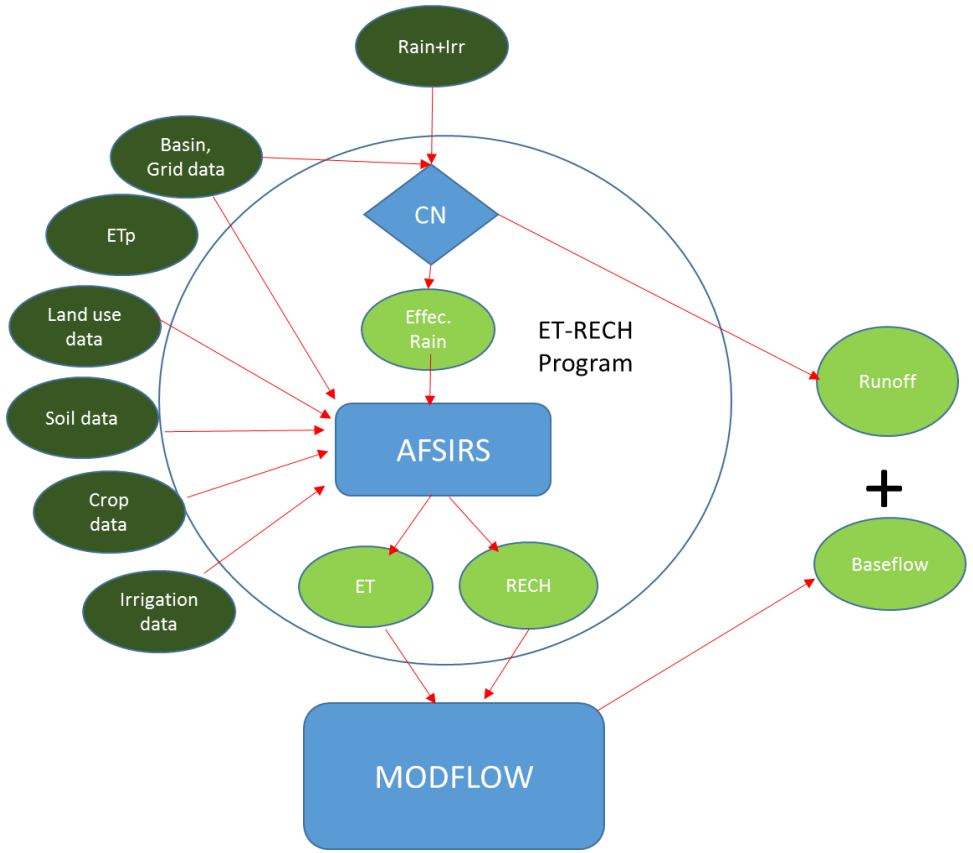
- Daily net irrigation demand is the ET deficit from root zone (NIR)
- Demands are adjusted to reflect metered water use



ET=Evapotranspiration; PET= Potential Evapotranspiration; DR=Deep percolation; IA=Initial Abstraction; STO=Storage

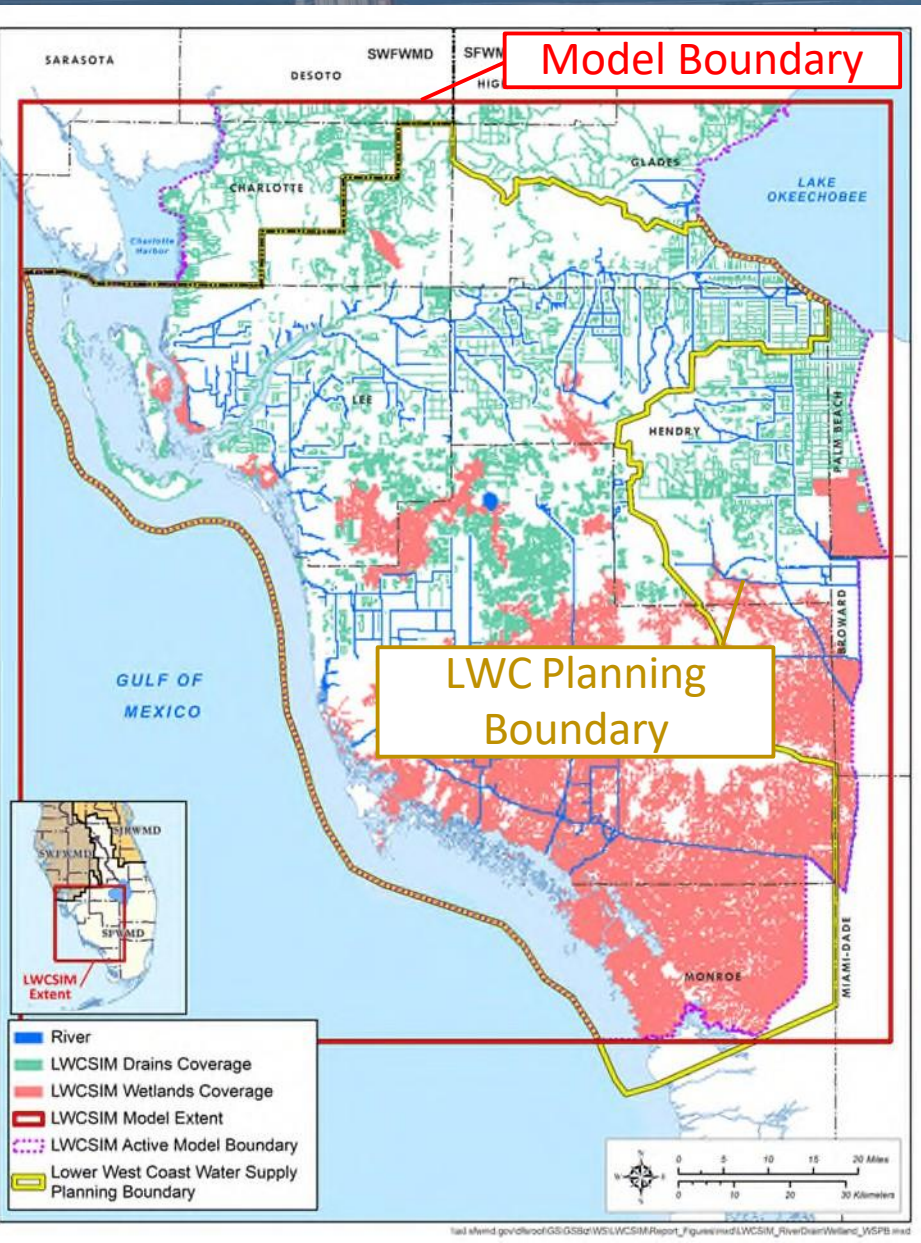
ET-Runoff-Recharge Model

- AFSIRS: Agricultural Field scale Irrigation Requirement Simulation Model (**AFSIRS**)
  - Drainage (DR) term is assumed to be groundwater recharge (RCH)-smaller unsaturated zone in South Florida
  - ET deficit is assumed to be the max groundwater ET in non-irrigated areas (irrigated areas groundwater ET=0)
- Surface runoff routing
  - Muskingum method
  - Basin level routing
- Rectangular grids based on the groundwater model grid
  - Further sub divided into to different land use polygons depending GIS coverages
- Use daily time steps
- GIS based inputs-Land use, soil, watershed
- Output from the model are ET and Recharge inputs to MODFLOW model
- Runs iteratively between MODFLOW and ET-Recharge-Runoff model



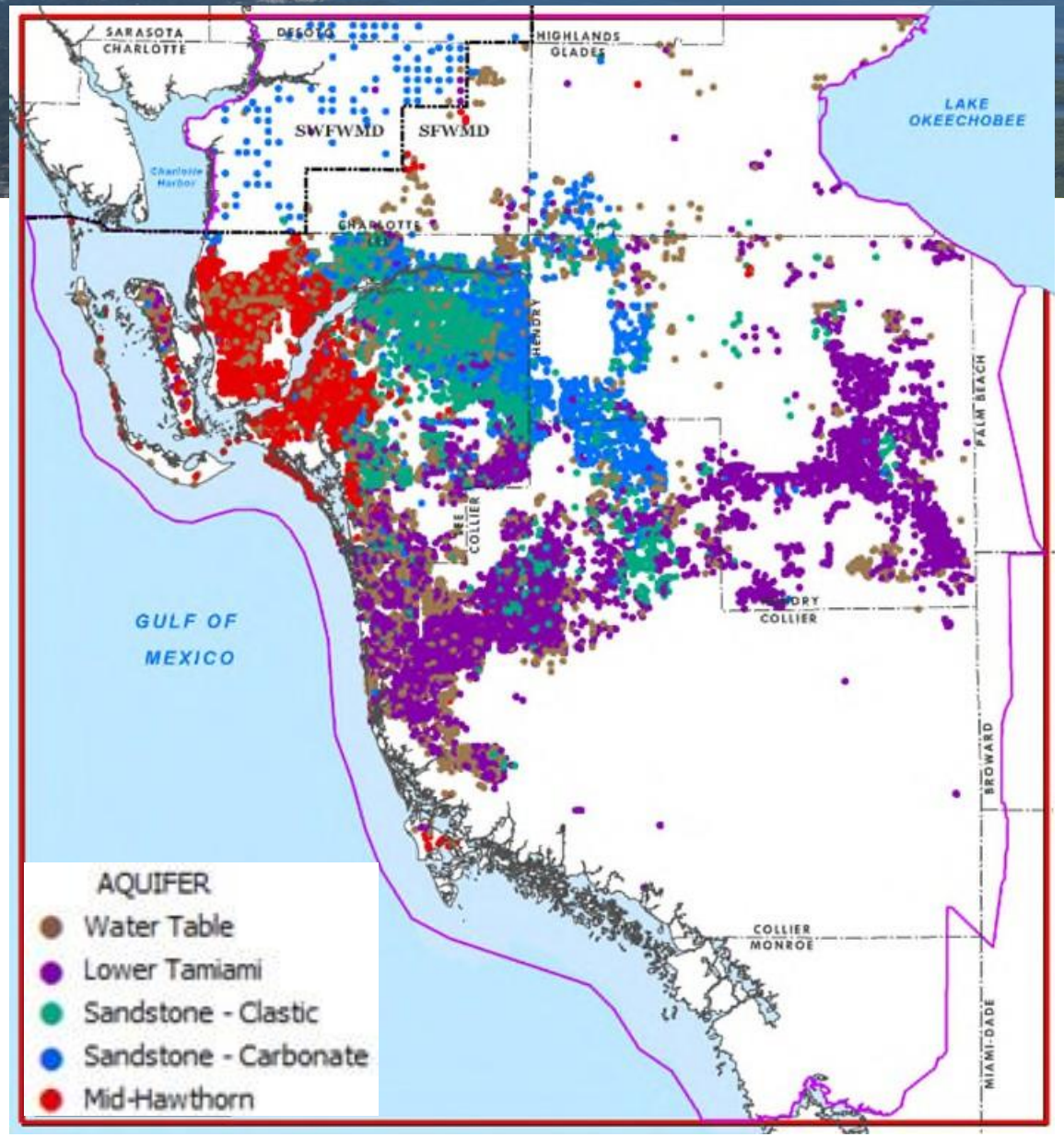
AFSIRS = Agricultural Field Scale Irrigation Requirement Simulation-University of South Florida

Lower West Coast Surficial and Intermediate Aquifer System Model (LWCSIM)

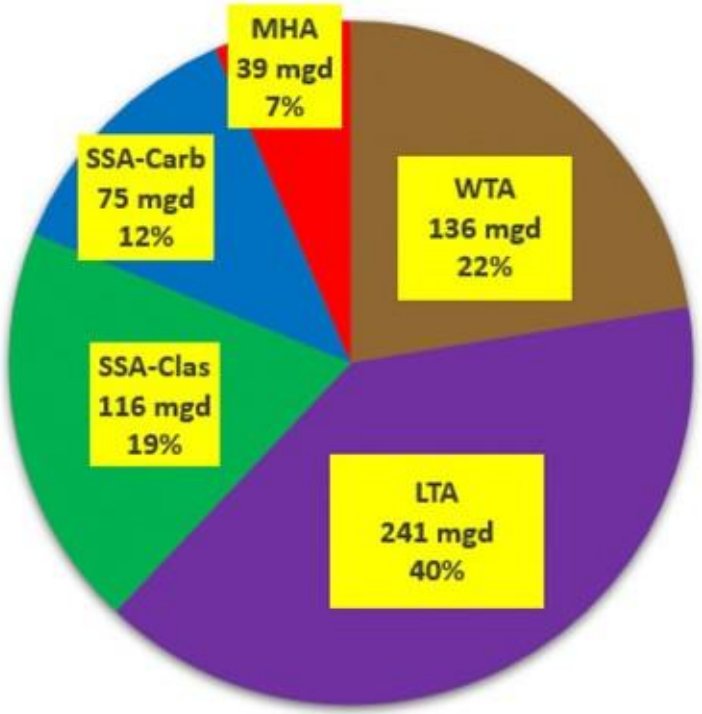


- MODFLOW based, uniform grid size of 1,000 ft × 1,000 ft, 9 layers, monthly stress periods
- Calibrated and Peer reviewed
- Calibration period: 1999-2012, verification period 2013-2014
- Calibrated for surface water levels and flows and groundwater levels
- 2014 base and 2040 projected condition runs
- Results
  - Drawdown analysis
  - Maximum Developable Limit analysis
  - Velocity vectors analysis

Pumping Wells in Model



Pumped Volumes by Aquifer (2014)



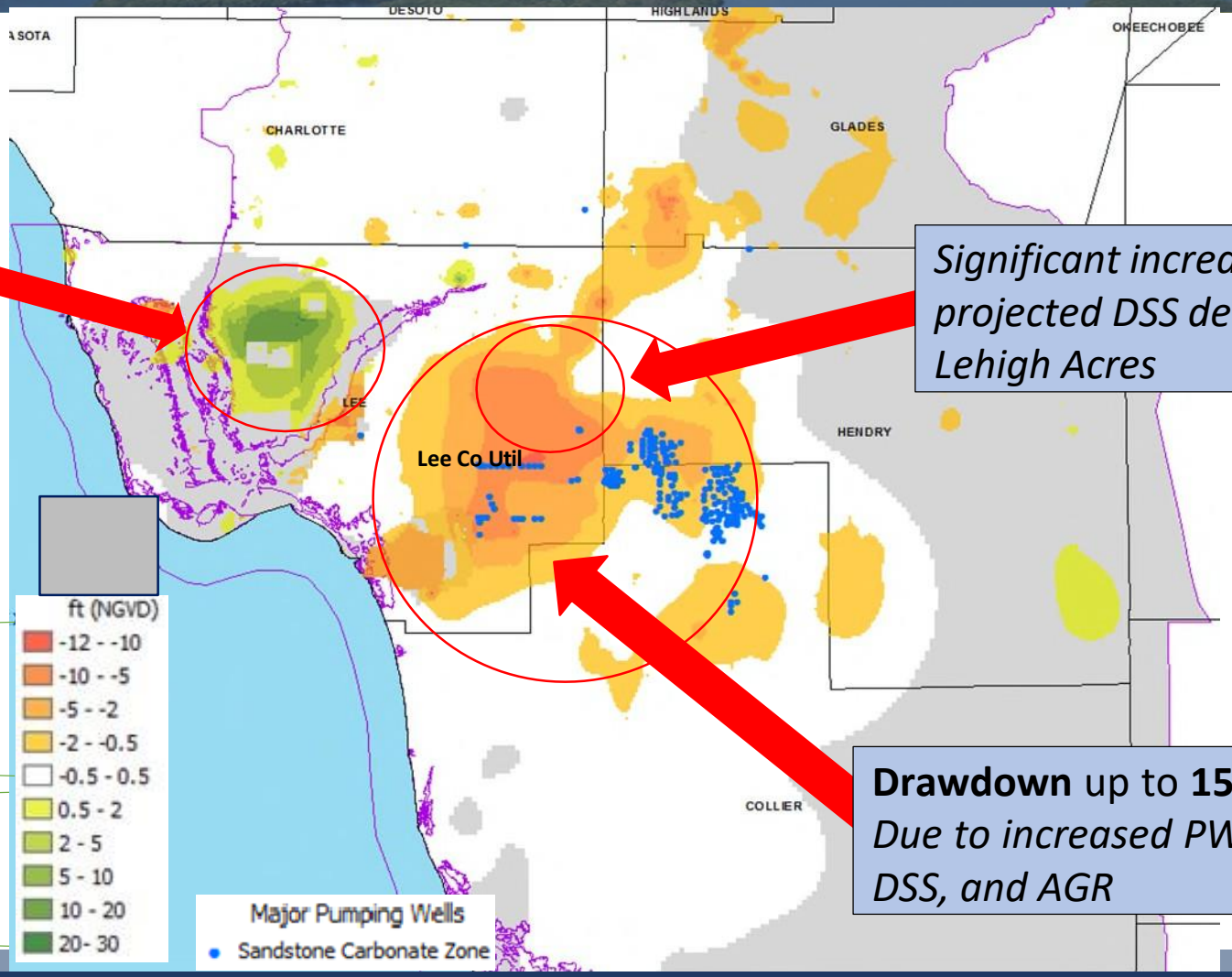
Total Pumped = 606 mgd

WTA: Water Table aquifer
LTA: Lower Tamiami aquifer
SSA: Sandstone aquifer
MHA: Mid-Hawthorn aquifer

Drawdown Analysis: Sandstone-Carbonate Aquifer

2040 Future Average Heads minus– 2014 Reference Condition Average Heads

Rebound up to 20 ft due to users switching to recycled water and Floridan aquifer



Significant increase in projected DSS demand in Lehigh Acres

Aquifer absent

Drawdown

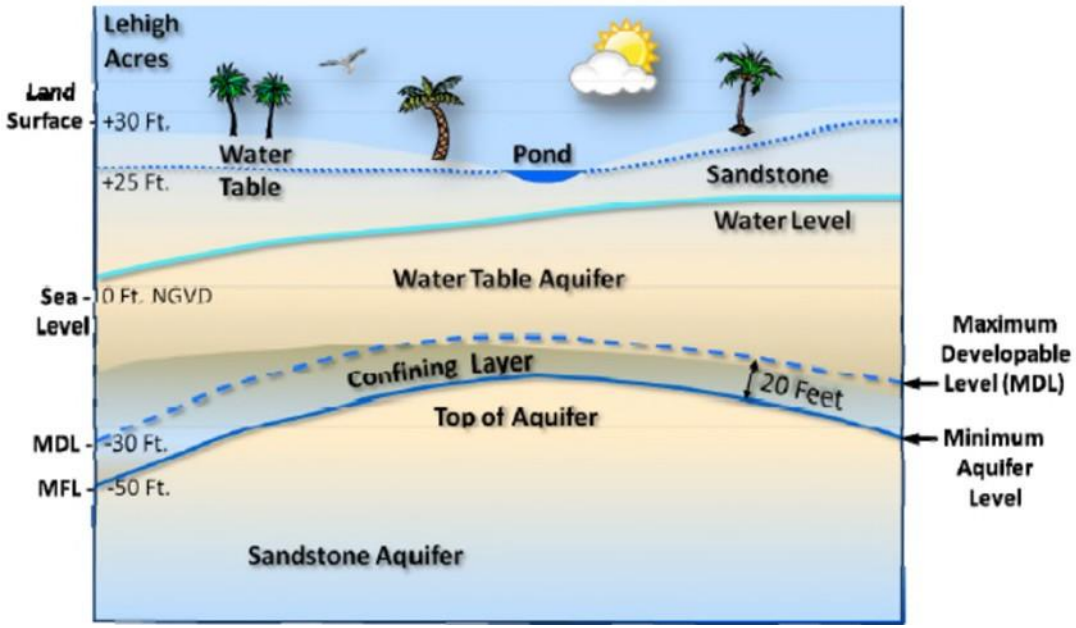
Rebound

Drawdown up to **15 ft**
Due to increased PWS, DSS, and AGR

Maximum Developable Limit (MDL) Analysis

- MDLs are part of Minimum Flow Level (MFL) prevention strategy that prevent harmful withdrawals from the following aquifers:
  - Lower Tamiami
  - Sandstone
  - Mid-Hawthorn
- MDLs prohibit water withdrawals that lower the water levels less than 20 ft above the top of the uppermost geologic strata of the aquifer at any point during a 1-in-10 year* drought condition

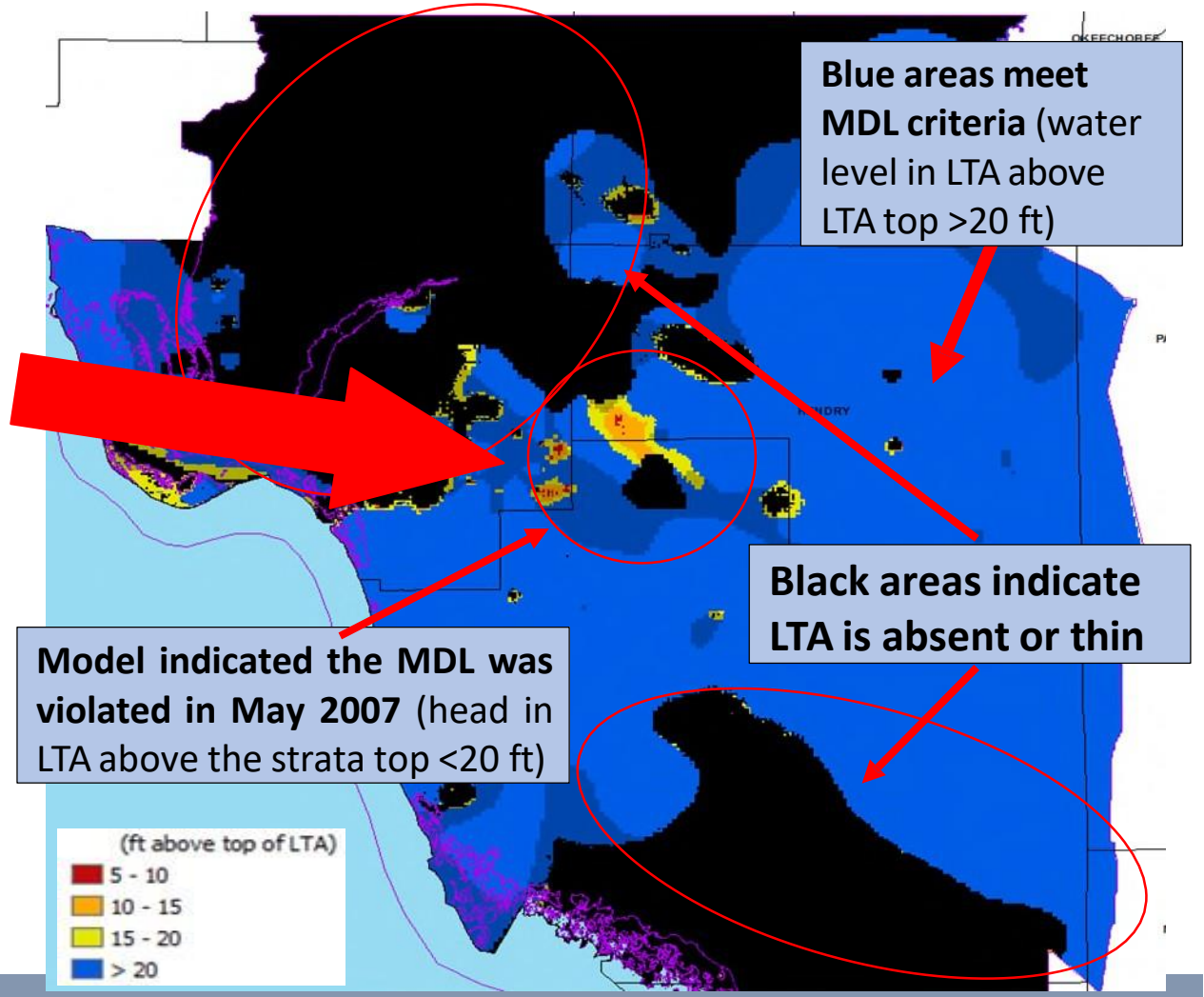
Sandstone Aquifer MDL Example



*1-in-10 drought year for LWC Planning Area for the period 1999-2012: 2007

MDL Analysis: 2014 Lower Tamiami Aquifer (LTA)

- Impacted areas are determined by subtracting the LTA top by the LTA simulated head for 1-in-10 drought condition (May 2007)
- Simulated impacted areas are associated with agricultural withdrawals
- Agricultural demands simulated with AFSIRS estimated due to absence of metered data
- What was actually pumped may differ from AFSIRS
- Ag users are cautioned for potential future violations and increased monitoring is recommended



AFSIRS = Agricultural Field Scale Irrigation Requirement Simulation

Velocity Vector Analysis-Potential for Saltwater Intrusion : Bonita Springs – Lower Tamiami Aquifer

Permittee	Aquifer	2014 (MGD)	2040 (MGD)	Increase
Bonita Springs	Lower Tamiami Aquifer	3.53	5.48	1.95

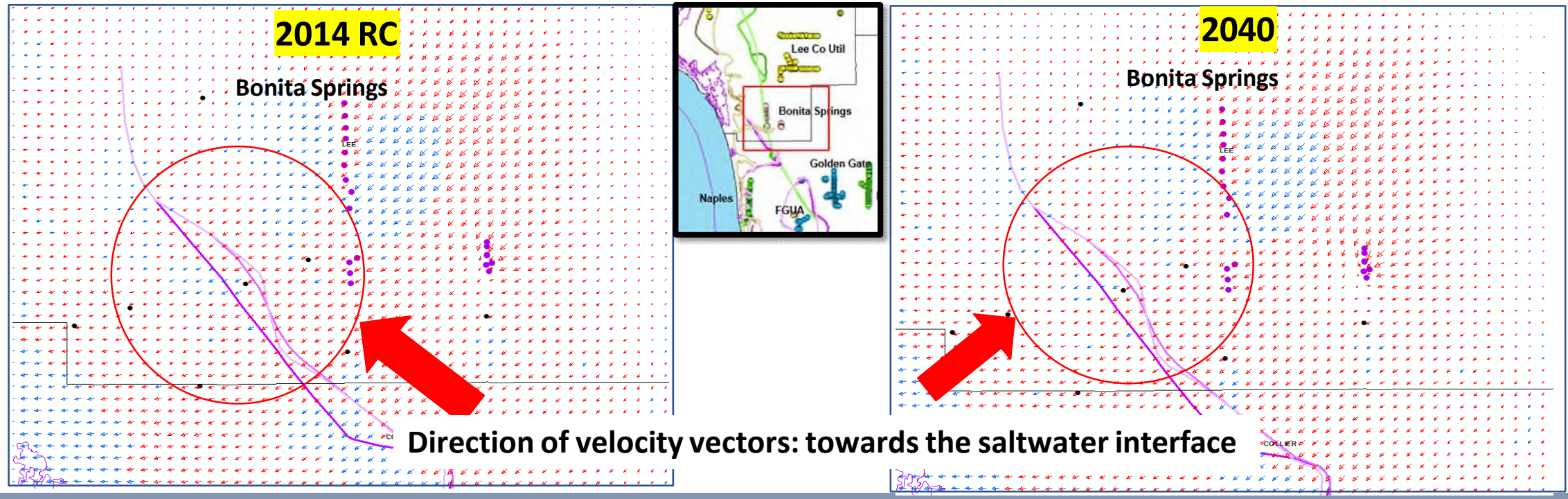
- 2014: Direction of velocity vectors: towards the saltwater interface
- 2040: Conditions are almost the same

Saltwater Interface (LTA)

2009
2014
2019

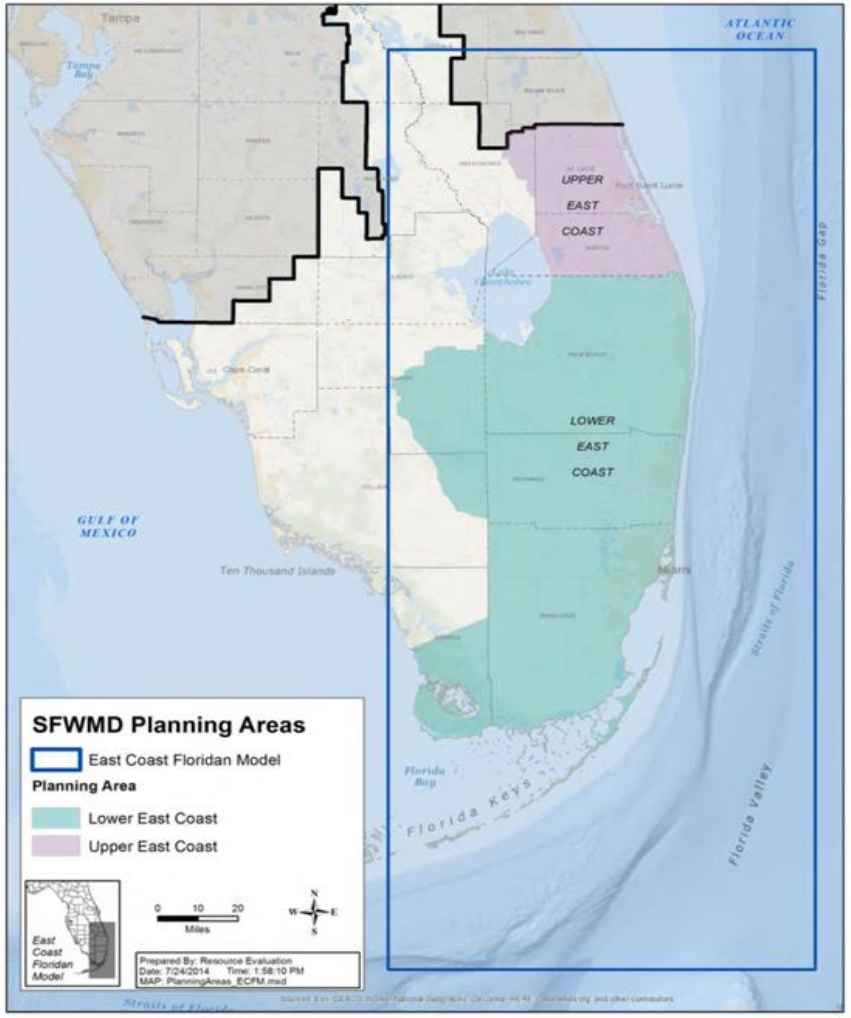
Upward
Downward

Velocity vectors in every model cell
Vector size proportional to velocity



East Coast Floridan Model (ECFM)

- SEAWAT based model (density dependent)
- 7 Layers, 552 rows and 236 columns
- Monthly stress periods
- Grid size 2400 ft x 2400 ft
- Calibration period 1985-2016
- Both PEST and manual calibration
- Calibrated to groundwater levels and water quality
- Scenarios
  - 2016 base condition
  - 2040 projected condition



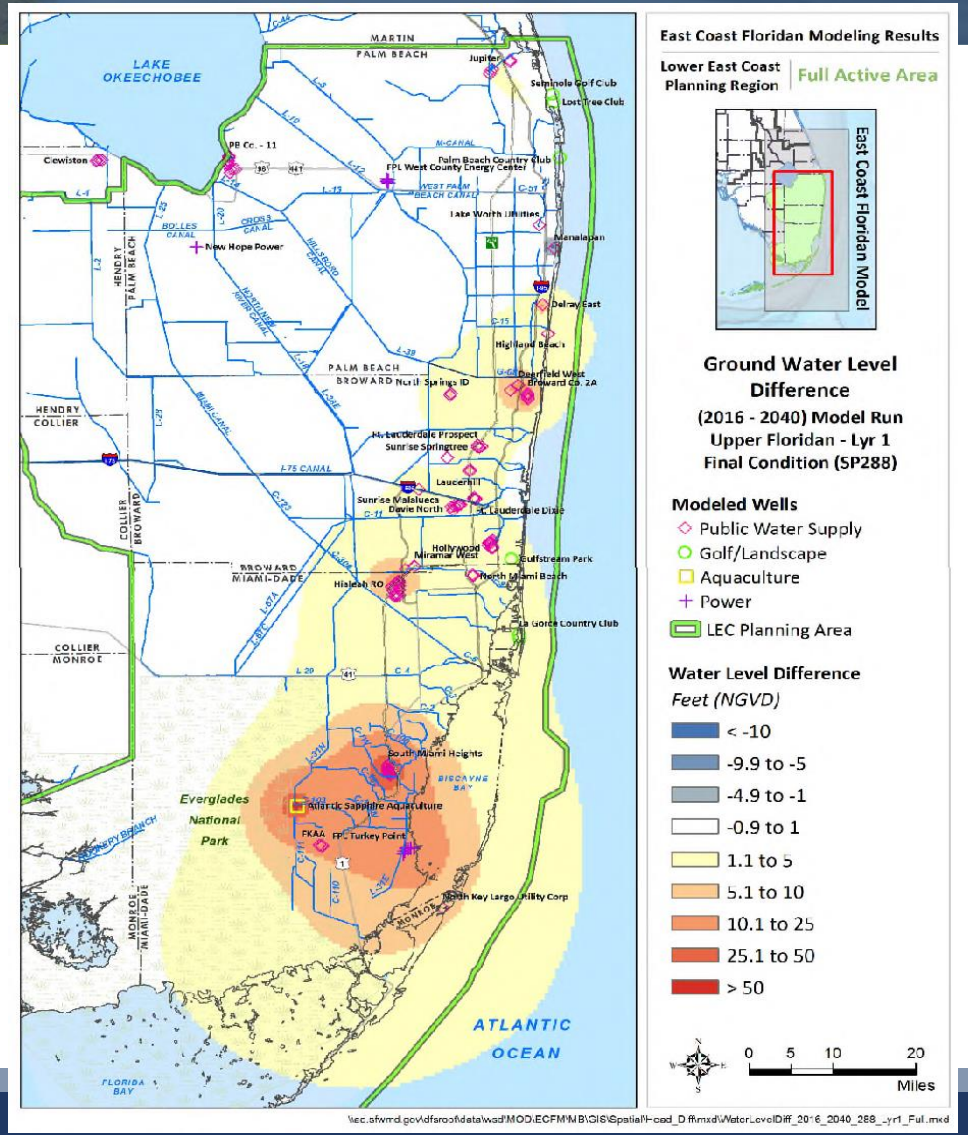
LEC Floridan Aquifer System Demand Summary by County

County	FAS Allocation (mgd)	2016 FAS Modeled (mgd)	2040 FAS Modeled (mgd)
Palm Beach	48.81	29.48	34.92
Broward	56.54	12.74	29.02
Miami-Dade	102.34	22.26	81.66
Monroe*	3.82	0.36	0.38
Total	**211.51**	**64.84**	**145.98**

* Wells for FKAA, the primary water supplier in Monroe County, are located in Miami-Dade County

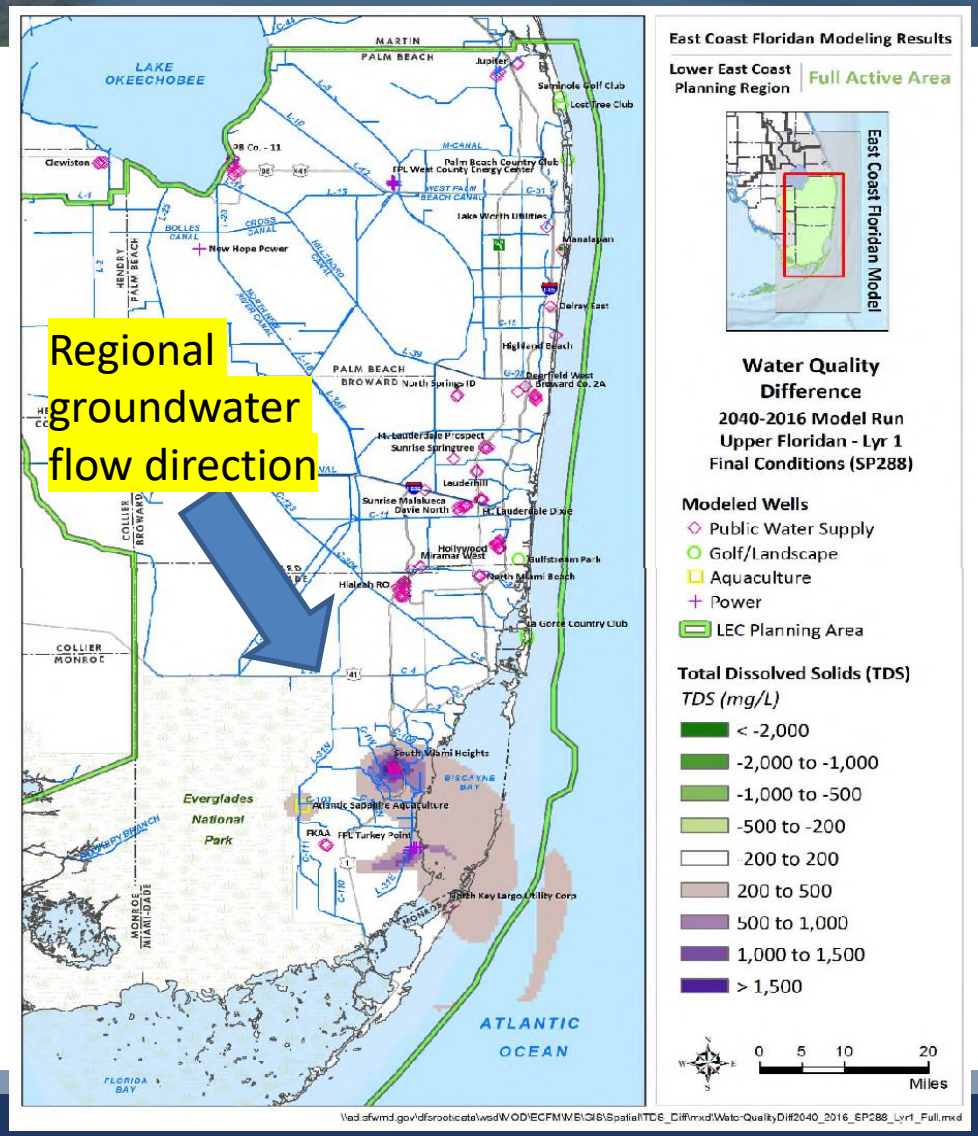
Water Level Differences

- Head difference: 2040-2016 runs
- Layer 1 (Upper Floridan Aquifer)
- Stress period: 288
- Existing & proposed wells shown
- In feet NGVD
- Range: -10 ft to above 50 ft
  - Negative values reflect increased water levels



Water Quality Differences

- Water quality difference: 2040-2016 runs
- Layer 1 (Upper Floridan Aquifer)
- Stress period: 288
- Existing & proposed wells shown
- TDS in mg/L
- Range: >-2,000 to >1,500



Future directions

- Improve sustainability of the aquifers to meet projected water need
  - Increase coordination with PWS utilities and AG users
  - Encourage conservative wellfield design and operation
    - Additional wells with greater spacing between them
    - Change operation schedules to minimize up-coning of poor-quality water
- Encourage water users for alternative water resources
  - Increase recycle water use
  - Desalination of brackish water use from deeper aquifers (mixing with freshwater)
- Conservation and Aquifer recharge
  - Aquifer Storage Recovery-ASR

Thank you!

Many Thanks to Groundwater Modeling Staff at the SFWMD