Central Springs Model (CSM) Stakeholder Review

October 2023

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St. Johns River Water Management District
Southwest Florida Water Management District

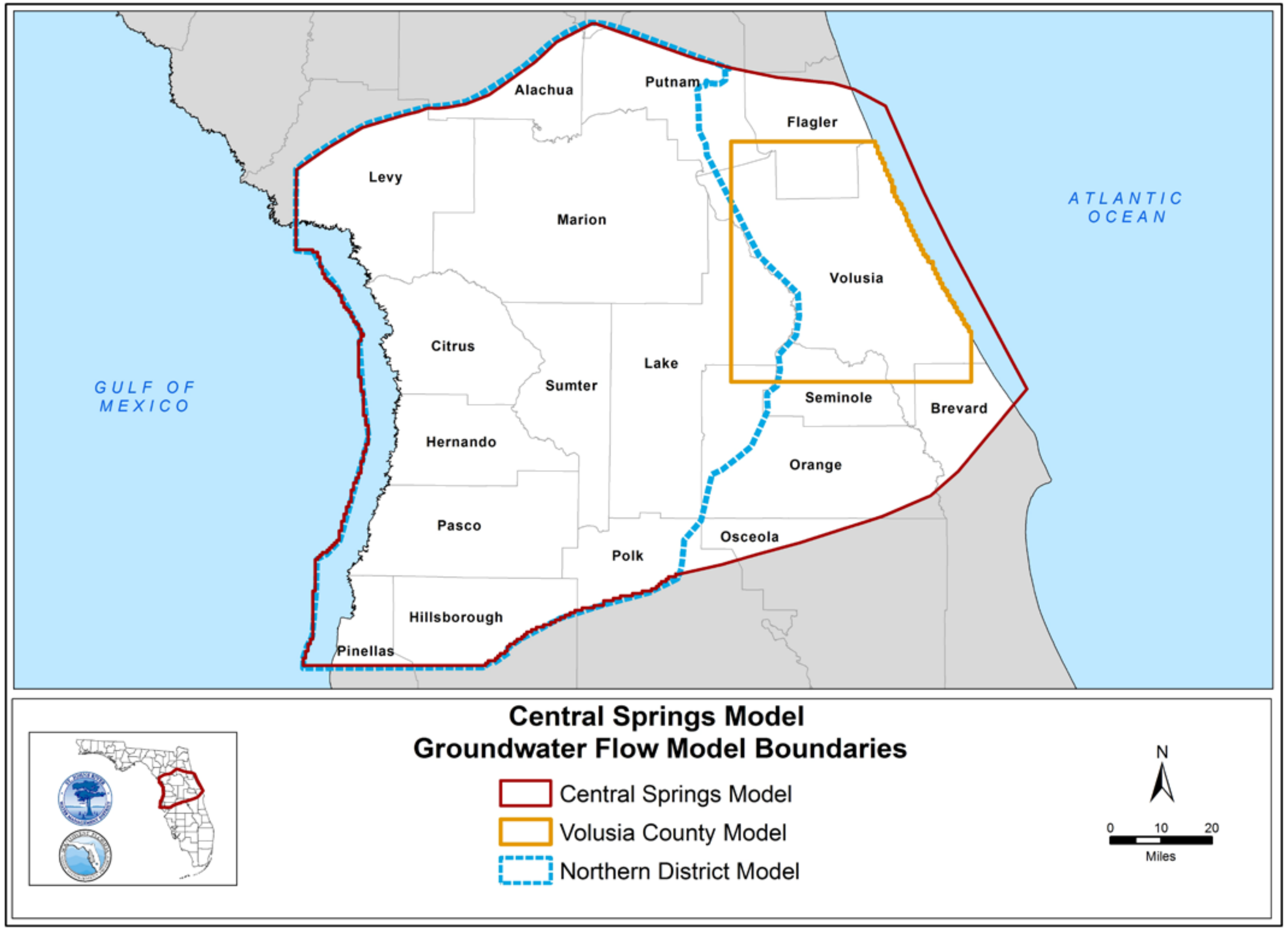
Agenda

- Background
- Model Overview
- Calibration Process
- Steady-State PEST Calibration
- Transient Model Calibration
- Model Highlights
- Technical Peer Review
- Stakeholder Review
- Next Steps

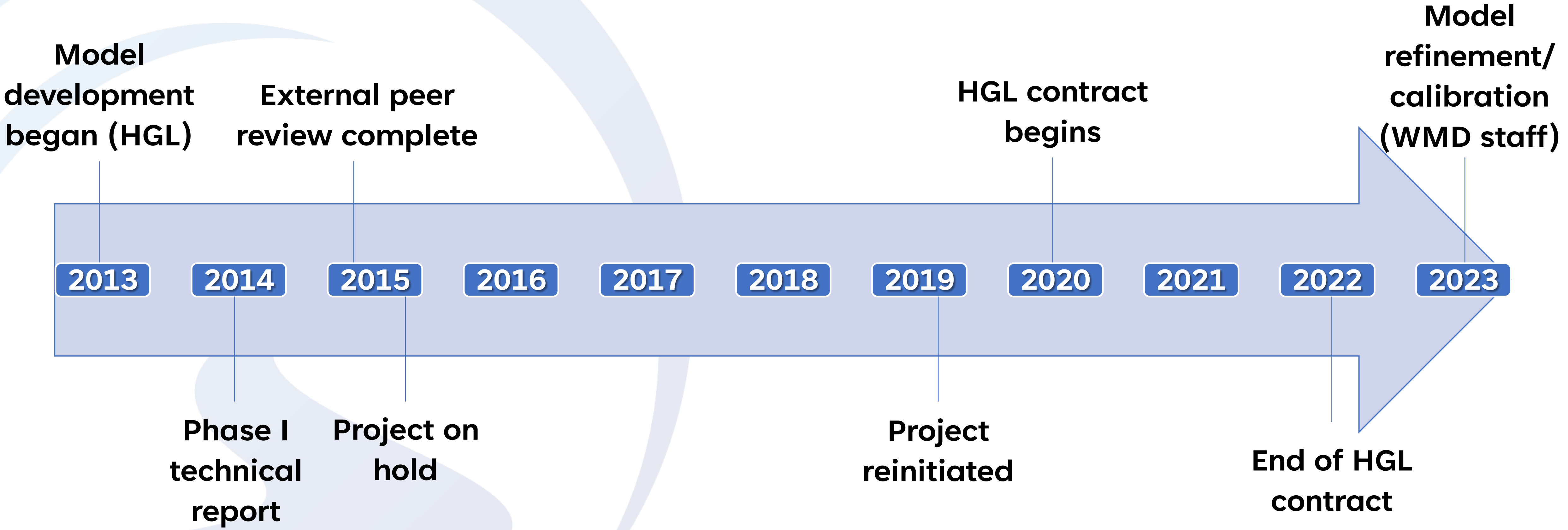
Background

Project Objective

- Single cohesive model for north-central Florida
  - Northern District Model
  - Volusia County Model
- Quantify changes to groundwater levels, springflows, and river baseflows
- Provide tool for regional water supply planning, minimum flows and levels (MFLs), and water use permitting



Project History



CSM Team

SJRWMD

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Model Overview

St. Johns River Water Management District

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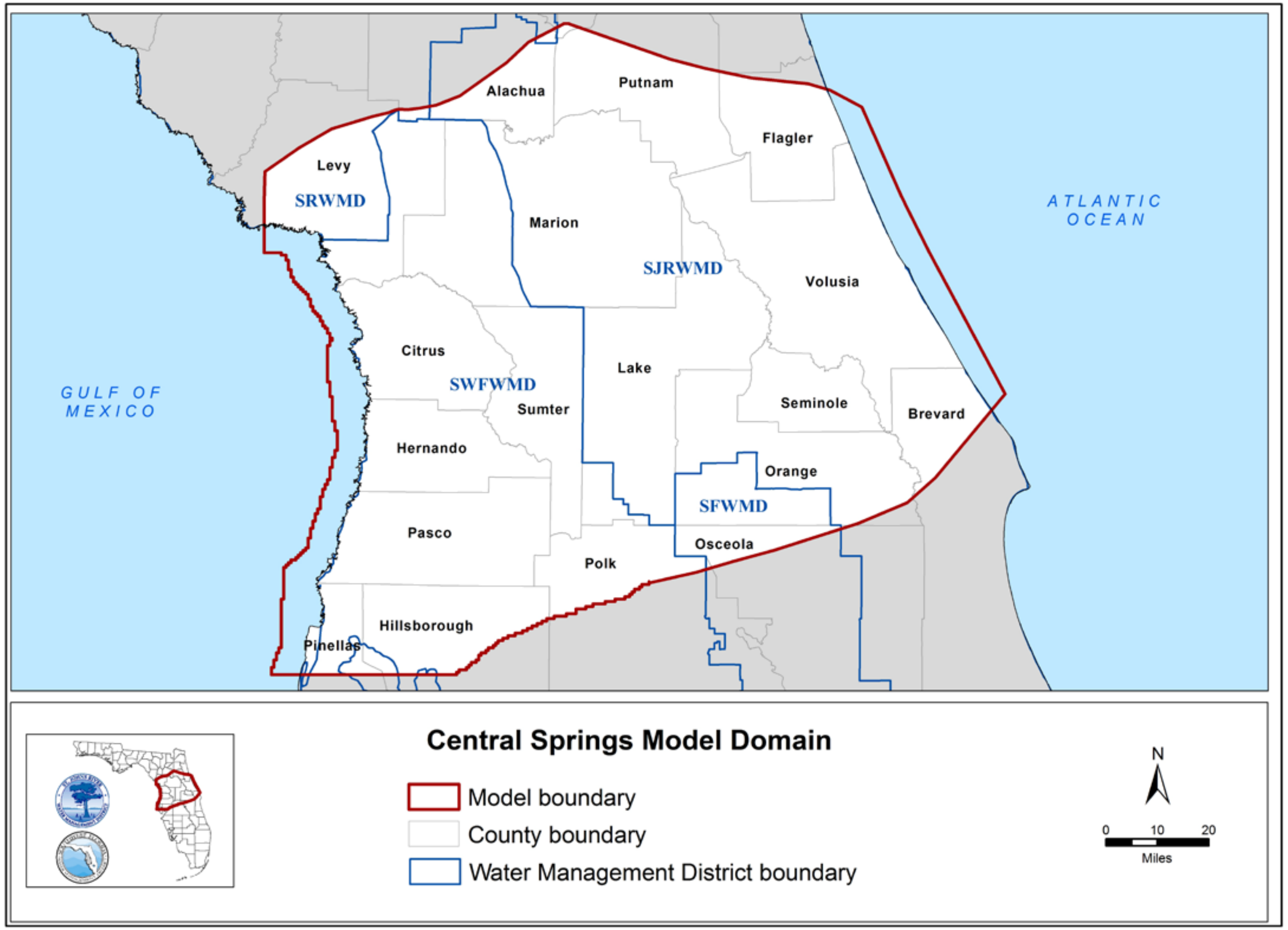
Model Overview

- Joint effort by SJRWMD, SWFWMD, and HydroGeoLogic, Inc. (HGL)
- Extends from the Gulf of Mexico to Atlantic Ocean in central Florida
- Three-dimensional groundwater flow model
- MODFLOW-NWT
- 2,500 ft x 2,500 ft grid
- 7 model layers
- Long-term steady-state model (avg 2005 to 2018)
- Transient model (2005 steady-state followed by monthly average from 2006 to 2018)



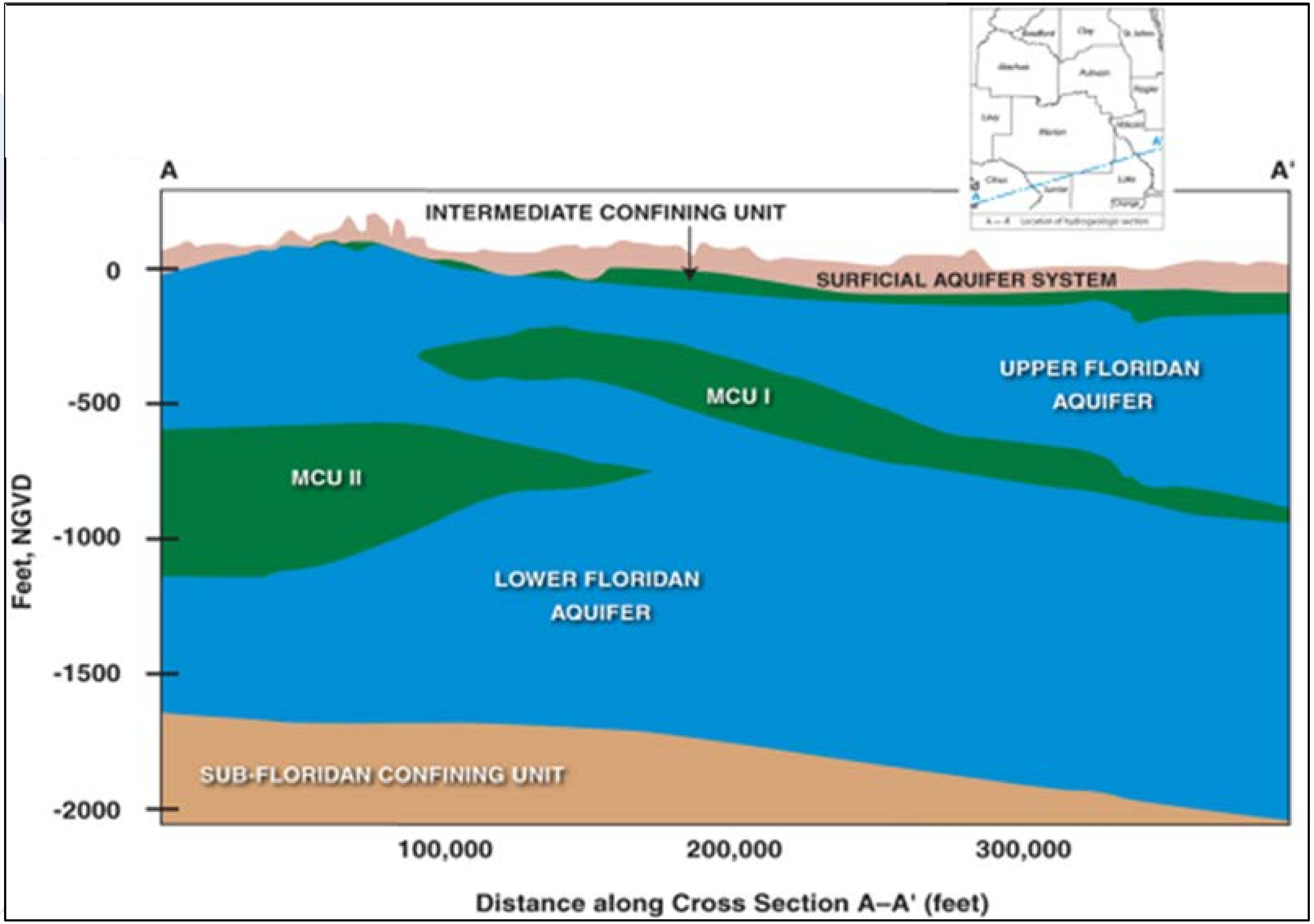
Stratigraphy and Model Layers

Layer No	SWFWMD	SJRWMD
1	Surficial Sand/Aquifer	Surficial Aquifer
2	Thin Layer Upper Floridan Aquifer/Intermediate Confining Unit*	Intermediate Confining Unit
3	Suwannee Limestone/Thin Layer Upper Floridan Aquifer**	Suwannee/Ocala Limestone
4	Ocala Limestone/ Avon Park Formation - upper	Ocala Limestone/ Avon Park Formation - upper
5	Avon Park Form. / Middle Confining Unit I	Middle Confining Unit I
6	Avon Park Formation – middle & bottom / Lower Floridan Aquifer I	Lower Floridan Aquifer I
7	Middle Confining Unit (MCU) II	MCU II / Lower Floridan Aquifer I

* Where UFA is regionally unconfined, ICU is converted to thin limestone layer

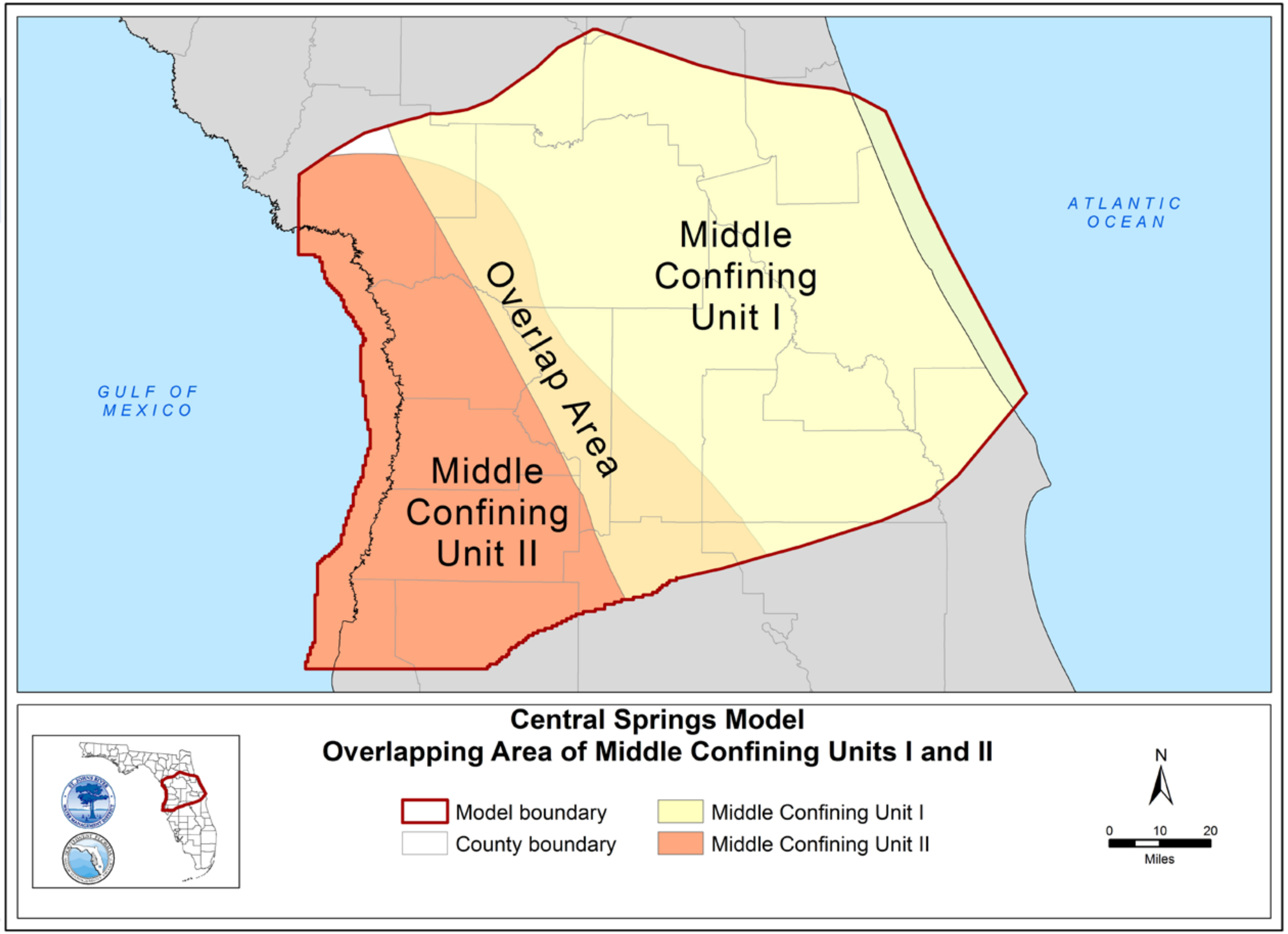
** Where Suwannee Limestone is absent, Layer 3 is converted to thin limestone layer

Cross-section of Groundwater Units Across Citrus, Sumter, Marion, Lake, and Volusia Counties



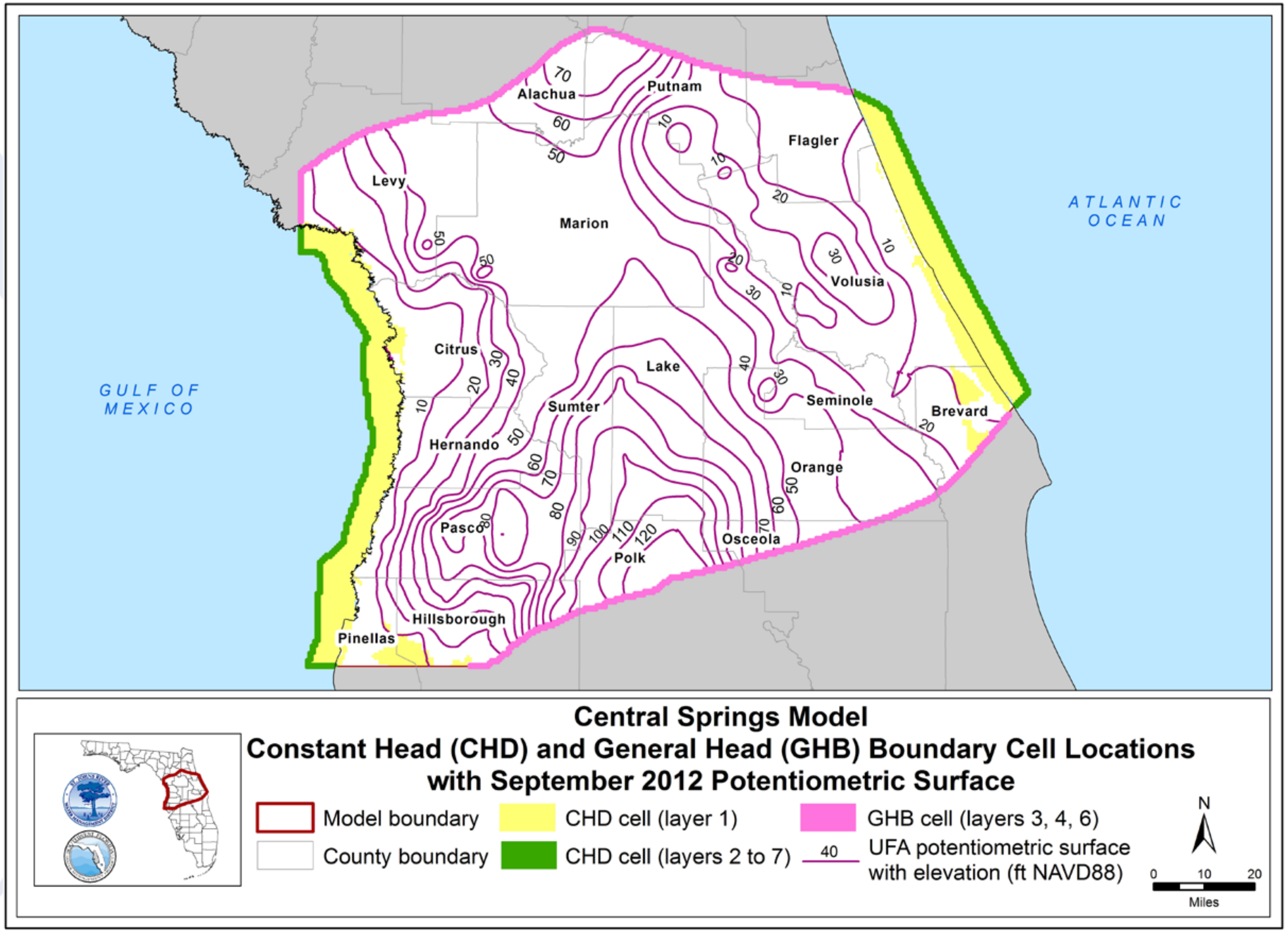
Extent of Middle Confining Units

- Overlap in Levy, Marion, Sumter, Lake, and Polk counties



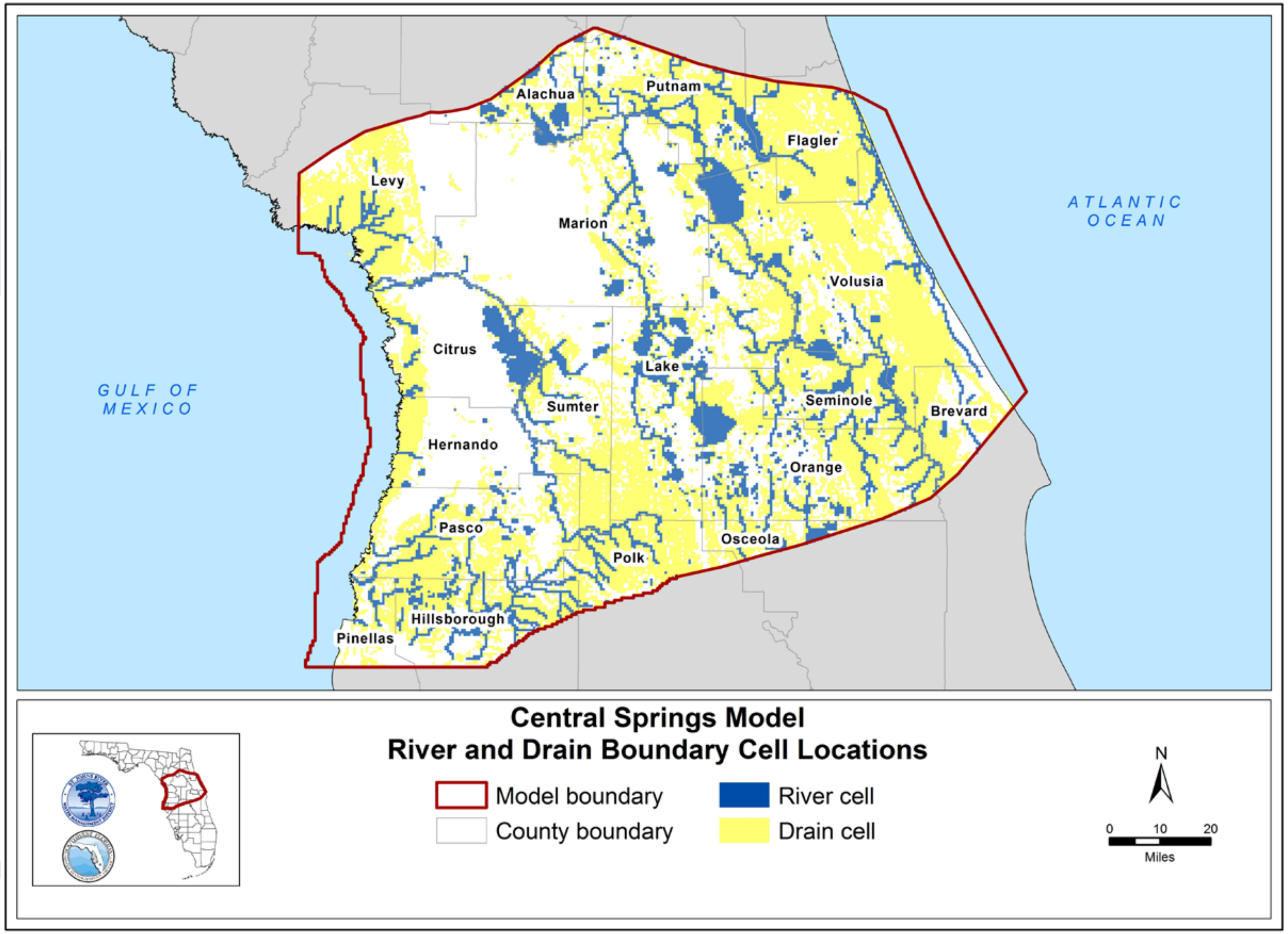
Boundary Conditions

- Constant Head
  - In layer 1, Tampa Bay, Indian River Lagoon, and extending 5 miles offshore
  - In layers 2 to 7, model cells 5 miles offshore
  - Estimated based on freshwater and saltwater densities of 1 and 1.025 grams per milliliter
- General Head
  - Layers 3, 4, and 6
  - Perpendicular to Upper Floridan Aquifer potentiometric surface



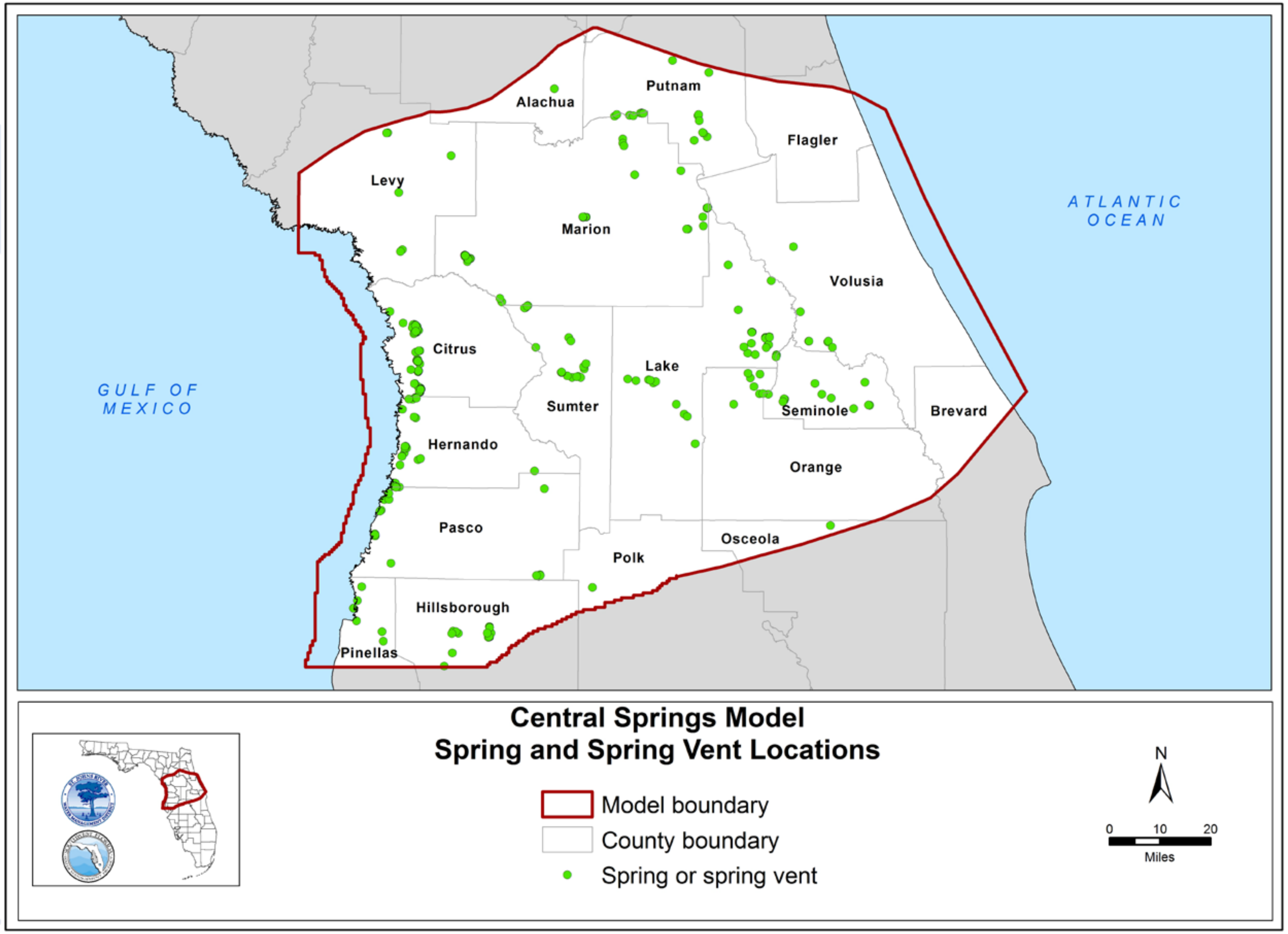
Surface Water Boundaries

- National Hydrography Dataset Plus (USGS 2019)
- RIV
  - Streams of Strahler orders ≥ 2 (likely perennial)
  - All Minimum Flows and Levels (MFL) lakes and lakes with area > half a grid cell
- DRN
  - Streams of Strahler order 1 (likely intermittent)
  - Coastal and interior wetlands



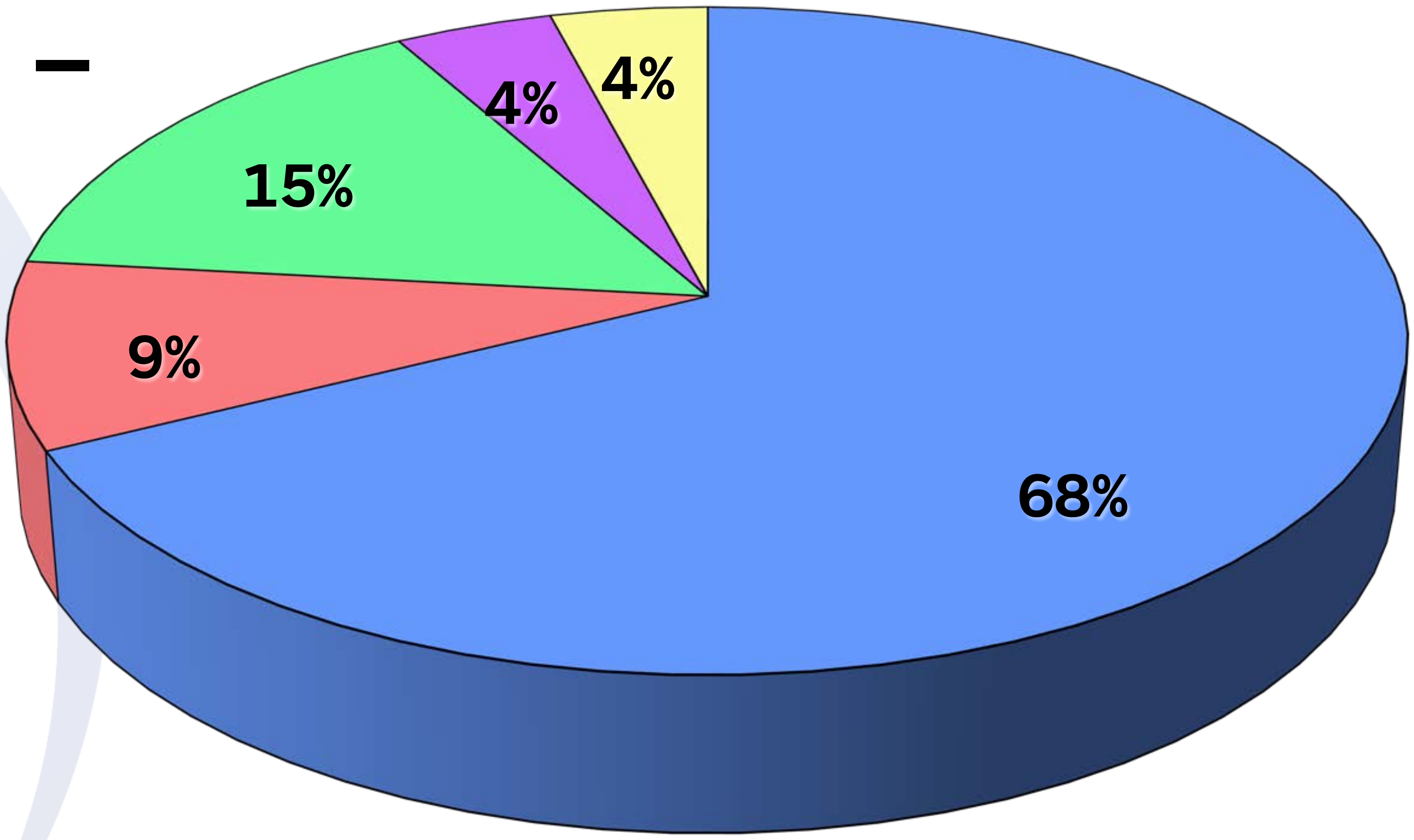
Springs

- Data from FDEP, WMDs, and USGS
- All MFL springs and springs with reported discharge
- Eight first-magnitude springs
- Simulated as DRN cells in layer 4



CSM Groundwater Withdrawals (2005 – 2018 average)

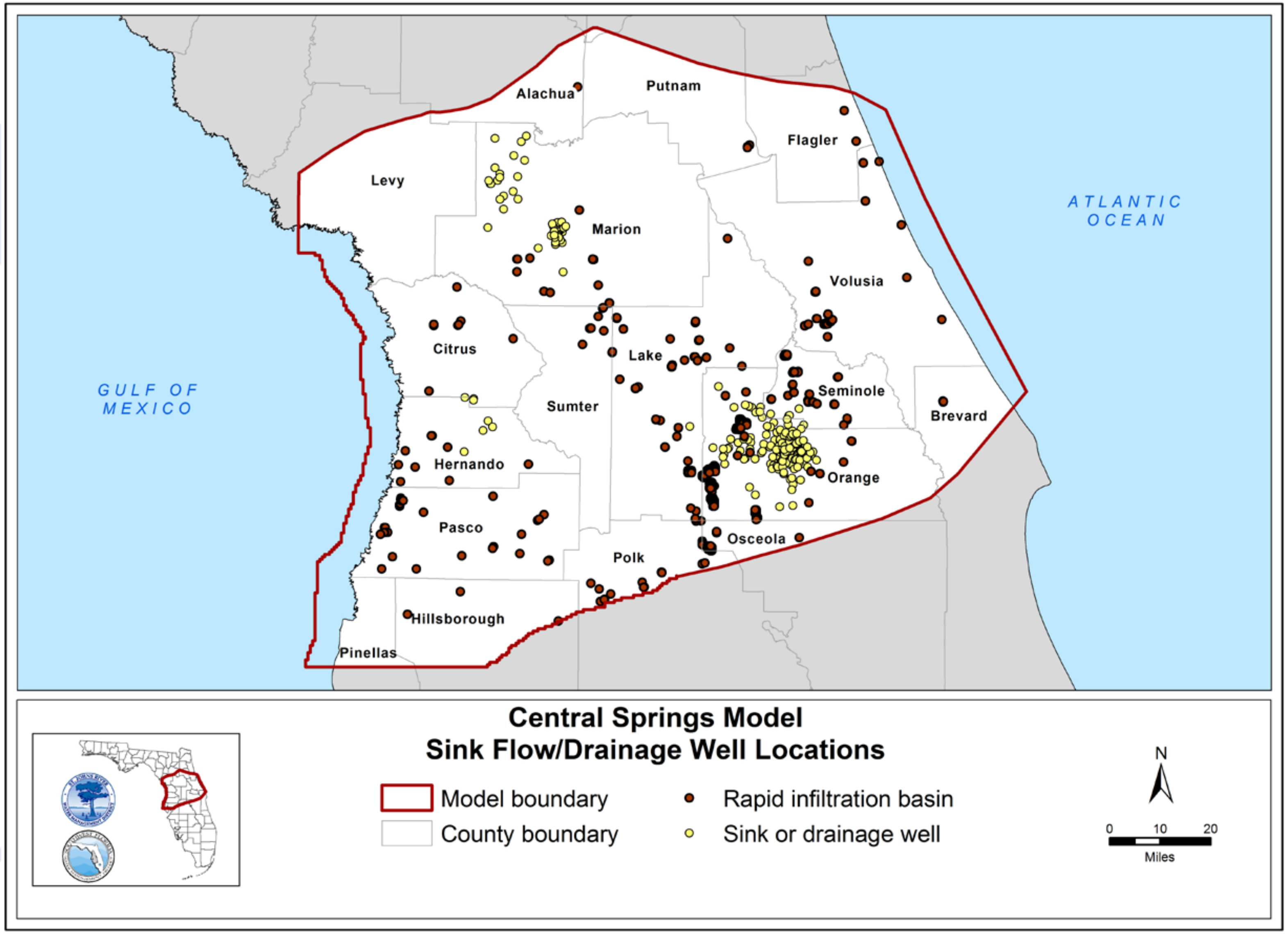
- Public Supply
- Domestic Self-Supply
- Agriculture
- Landscape/Recreation
- Commercial/Industrial/ Institutional & Mining/ Dewatering



~ 918 million gallons per day

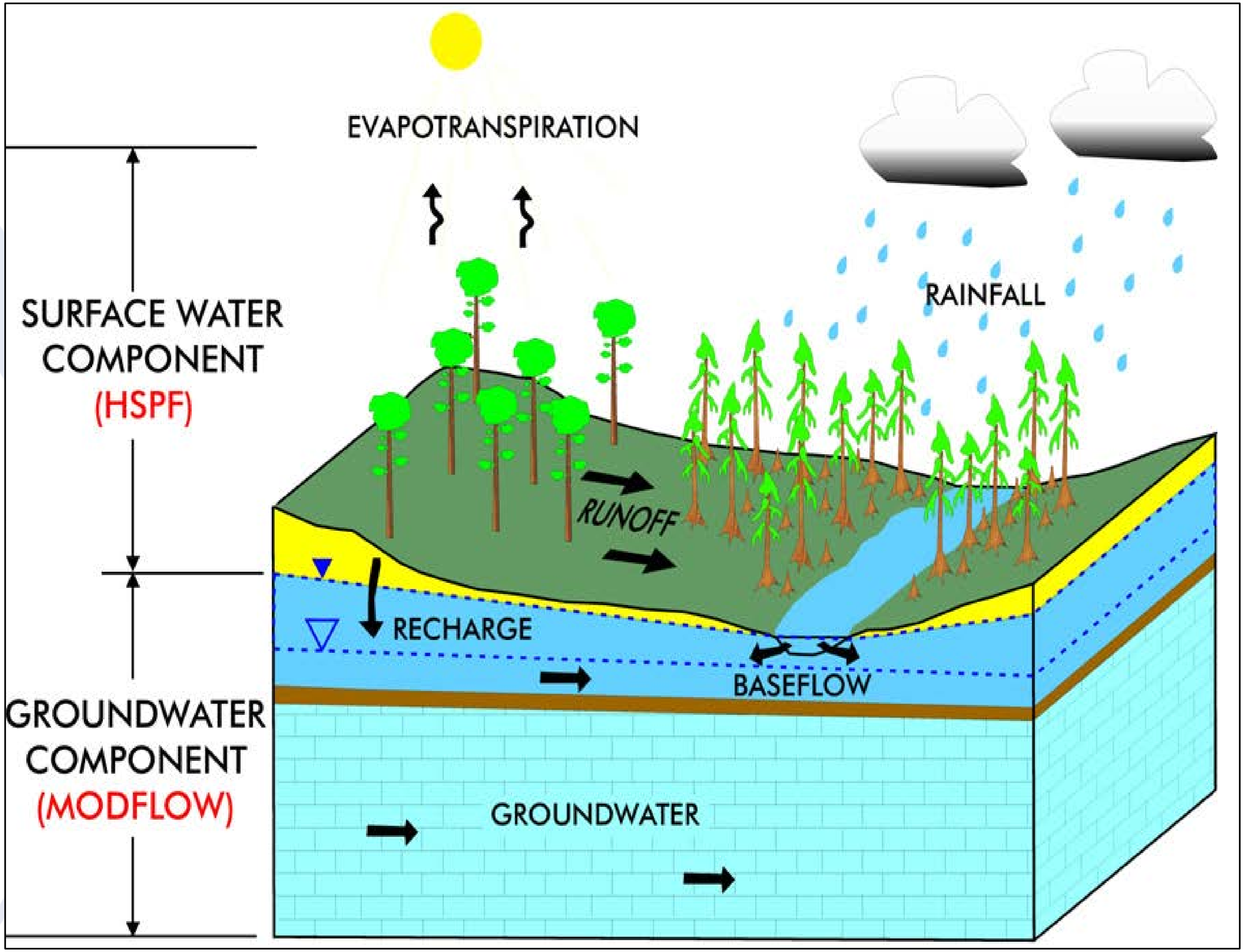
RIBs and Sink Flows/ Drainage Wells

- Rapid Infiltration Basins (RIBs)
  - Reclaimed water applied to land surface for recharge
  - Represented by injection wells in surficial aquifer
- Sink Flows/Drainage Wells
  - Natural flow from sinkholes
  - Wells to remove excess stormwater
  - Flow estimated from HSPF and applied to layer 1

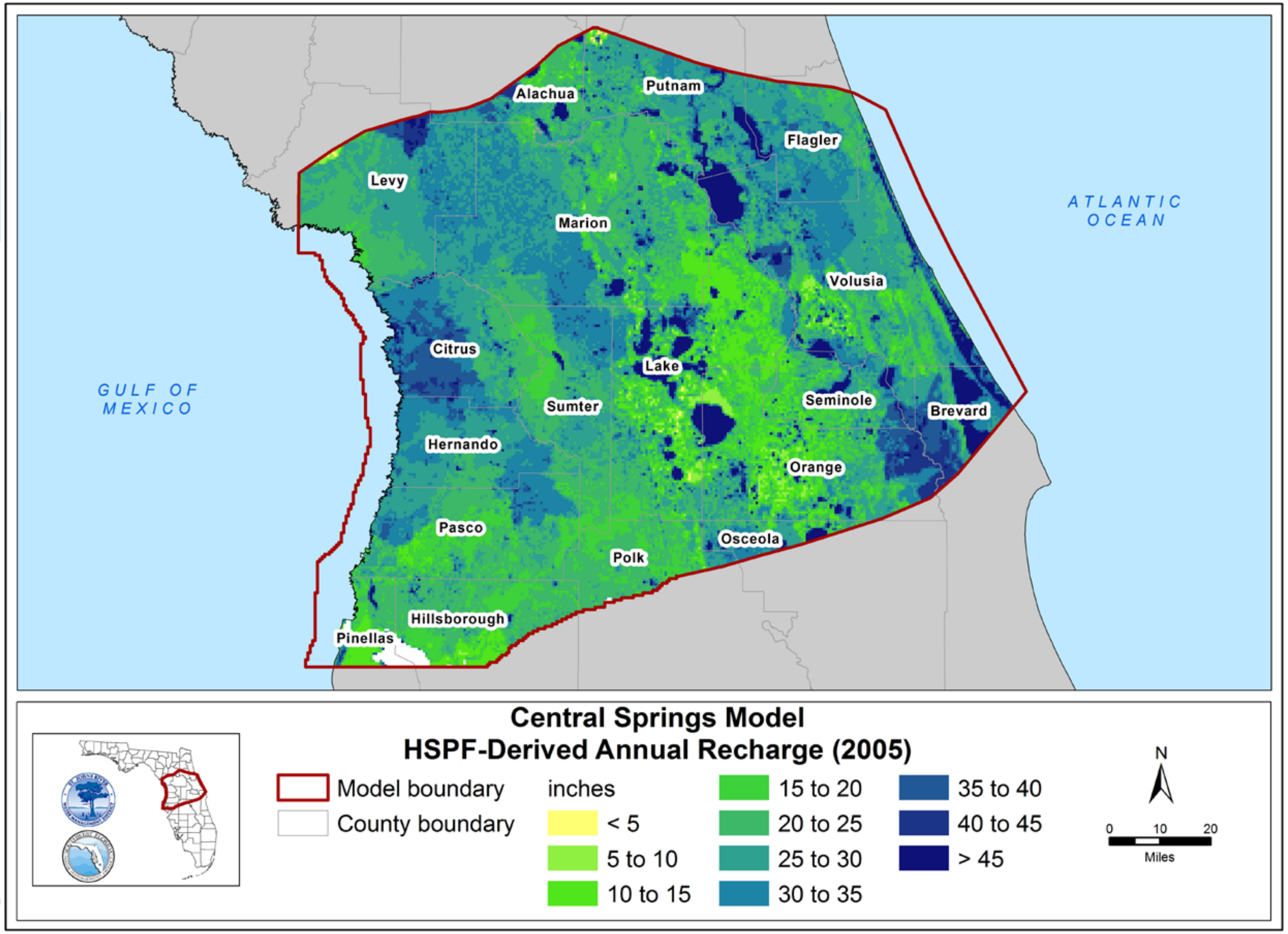


MODFLOW – HSPF Interaction

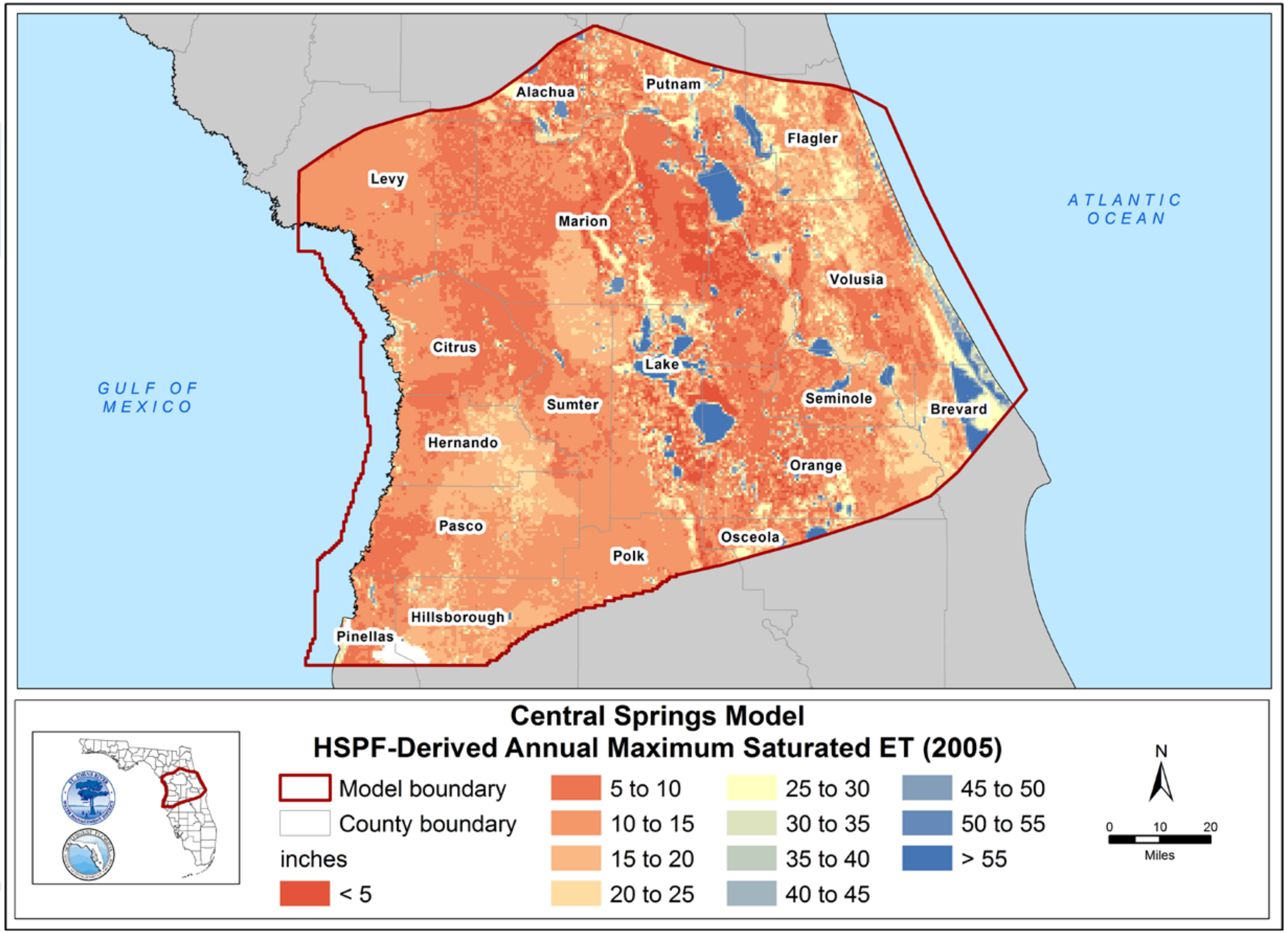
- Maximum saturated evapotranspiration for MODFLOW ET Package
- Recharge for MODFLOW RCH Package
  - Includes return flow from septic tanks and irrigation
- Sink and drainage well flow estimation



HSPF-Derived Annual Recharge for 2005



HSPF-Derived Maximum Saturated Evapo-transpiration (ET) for 2005



Calibration Process

Calibration Approach

Step 1
Calibration of the Long-Term 2005 to 2018 Average Steady-State Model

Hydraulic Properties

Feedback for additional iterations, if necessary

Hydraulic properties

Step 2
Calibration of the 2005 to 2018 Transient Model

Storage Properties

Calibration Targets

- Groundwater levels
  - Surficial = 410
  - Upper Floridan = 601
  - Lower Floridan = 37
- Groundwater level differences across confining units
  - Intermediate Confining Unit = 218
  - Middle Confining Unit = 27
- Spring discharges = 185
- River baseflows (qualitatively)
  - USGS GW Toolbox – 8 methods
  - Perry (USF) Method – 1 method
- Vertical lake leakages (qualitatively)

Steady-State Calibration Criteria (Spatial Statistics)

Category	Metric	Calibration Criteria
Groundwater levels	Mean Error (ME)	< ± 0.5 ft
	Mean Absolute Error (MAE)	All layers - 50% of MAE < 2.5 ft and 80% of MAE < 5 ft Surficial Aquifer System - evaluate depth to water table qualitatively
	Coefficient of Determination (R^2)	> 0.85 (Upper Floridan aquifer/Lower Floridan aquifer) > 0.75 (Surficial Aquifer System)
Spring discharges	MAE	First-magnitude springs < 5% of observed flow Second-magnitude springs < 10% of observed flow Second-magnitude springs (with limited data) < 20% of observed flow Third- or higher magnitude springs – within the same order of magnitude of observed flow
	R^2	> 0.75
River baseflows	NA	Within the range of baseflow estimated by several methods
Vertical head difference residuals (Intermediate Confining Unit and Middle Confining Unit)	NA	The same flow direction for targets ≤ 5 ft Simulated is within ± 50% of observed for targets > 5 ft

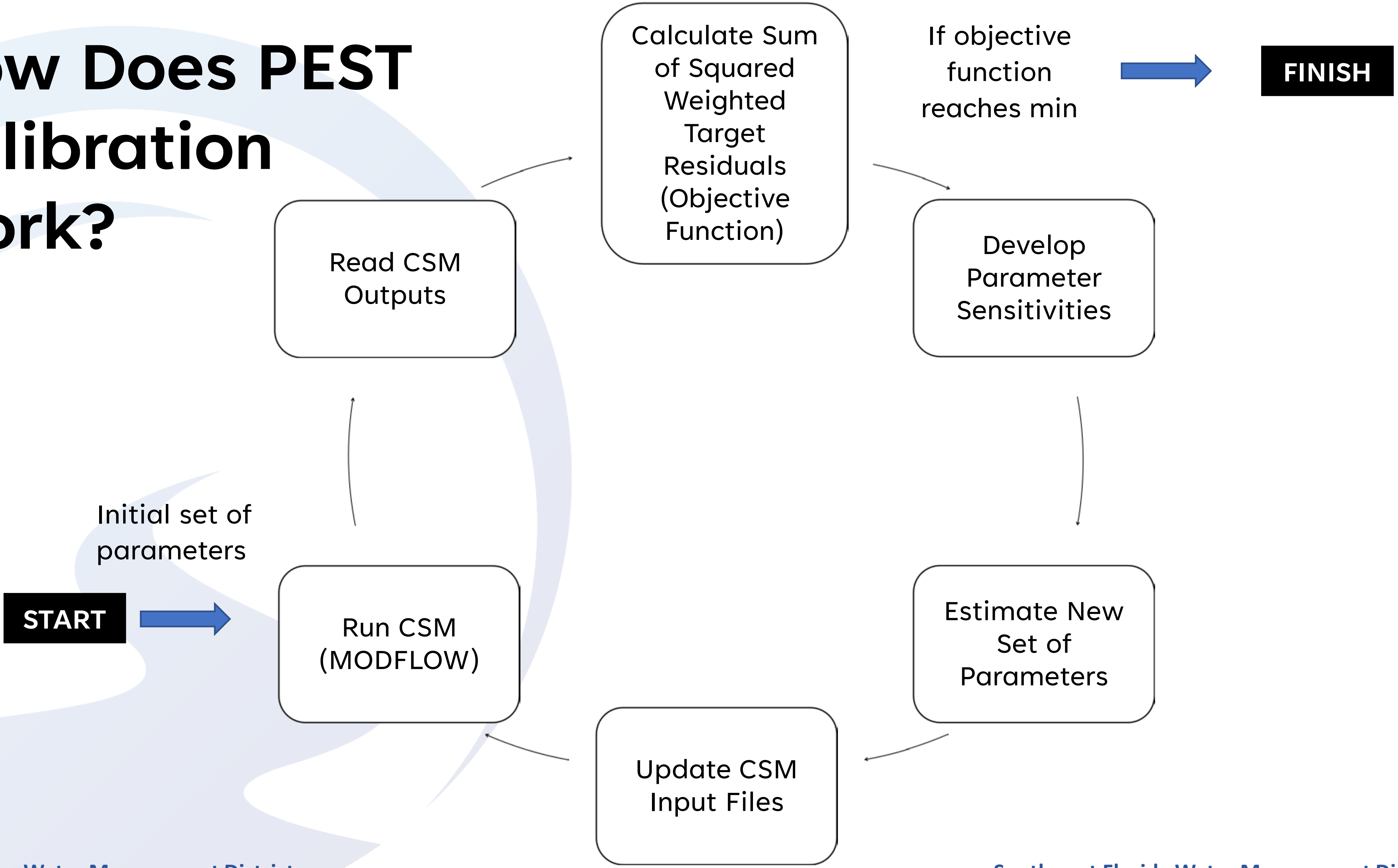
Transient Calibration Criteria (Temporal Statistics)

RSR = Ratio of root-mean-square error and standard deviation of observed data

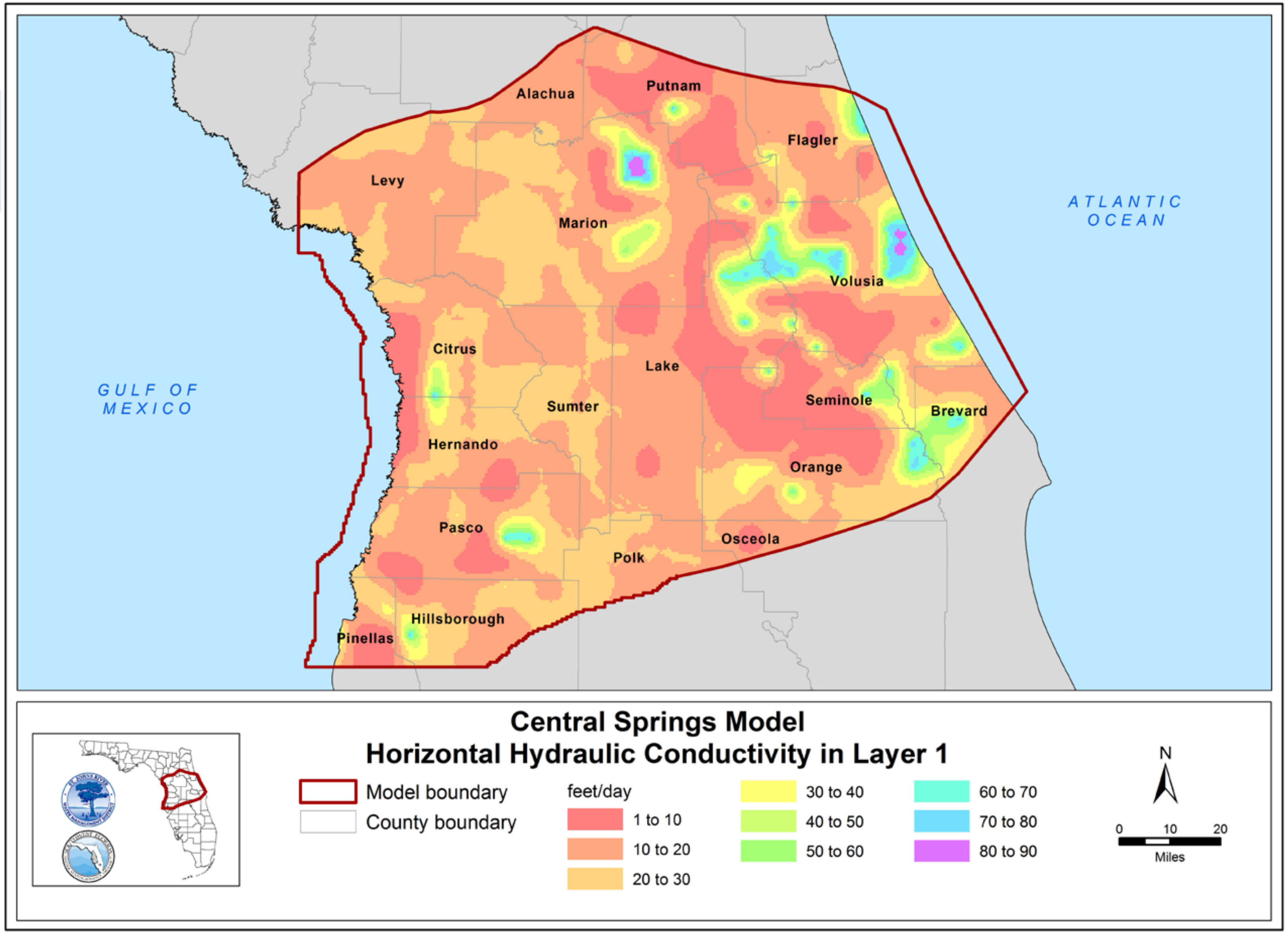
Category	Metric	Calibration Criteria
Groundwater levels	Percent bias	< ± 10 (Upper Floridan aquifer/Lower Floridan aquifer) < ± 15 (Surficial Aquifer System)
	MAE	All layers - 50% of MAE < 2.5 ft and 80% of MAE < 5 ft
	ME	< ± 0.5 ft
	RSR	≤ 0.5 (Upper Floridan aquifer/Lower Floridan aquifer) ≤ 0.7 Surficial Aquifer System
	R^2	> 0.85 (Upper Floridan aquifer/Lower Floridan aquifer) > 0.75 (Surficial Aquifer System)
Spring discharges	MAE	First-magnitude springs < 5% of observed flow Second-magnitude springs < 10% of observed flow Second-magnitude springs (with limited data) < 20% of observed flow Third- or higher magnitude springs – within the same order of magnitude of observed flow
	R^2	> 0.6 (springs > 10 cfs)
River baseflows	NA	Within the range of baseflow estimated by several methods
Vertical head difference residuals (Intermediate Confining Unit and Middle Confining Unit)	NA	The same flow direction for targets ≤ 5 ft Simulated is within ± 50% of observed for targets > 5 ft

Steady-State PEST Calibration

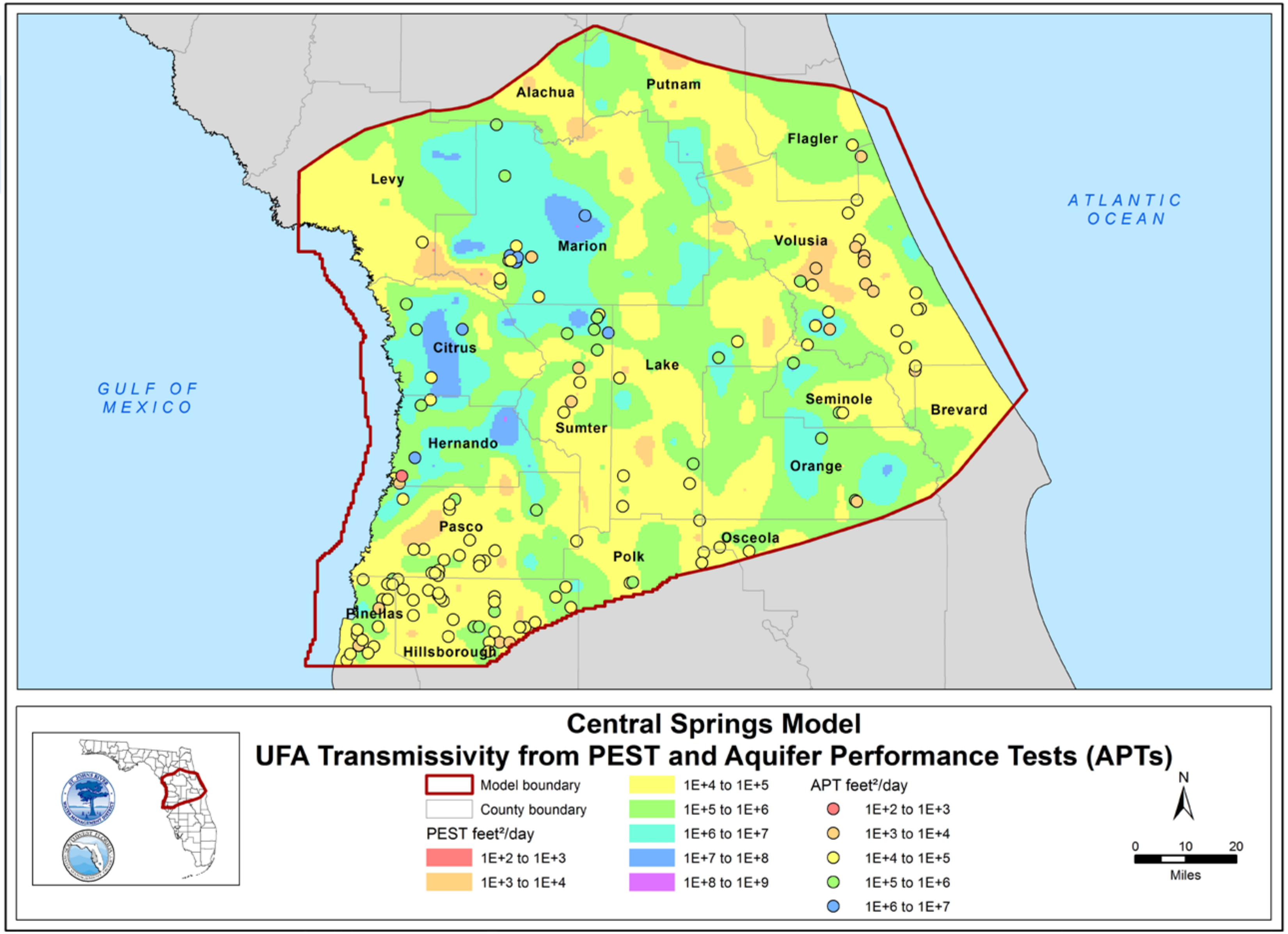
How Does PEST Calibration Work?



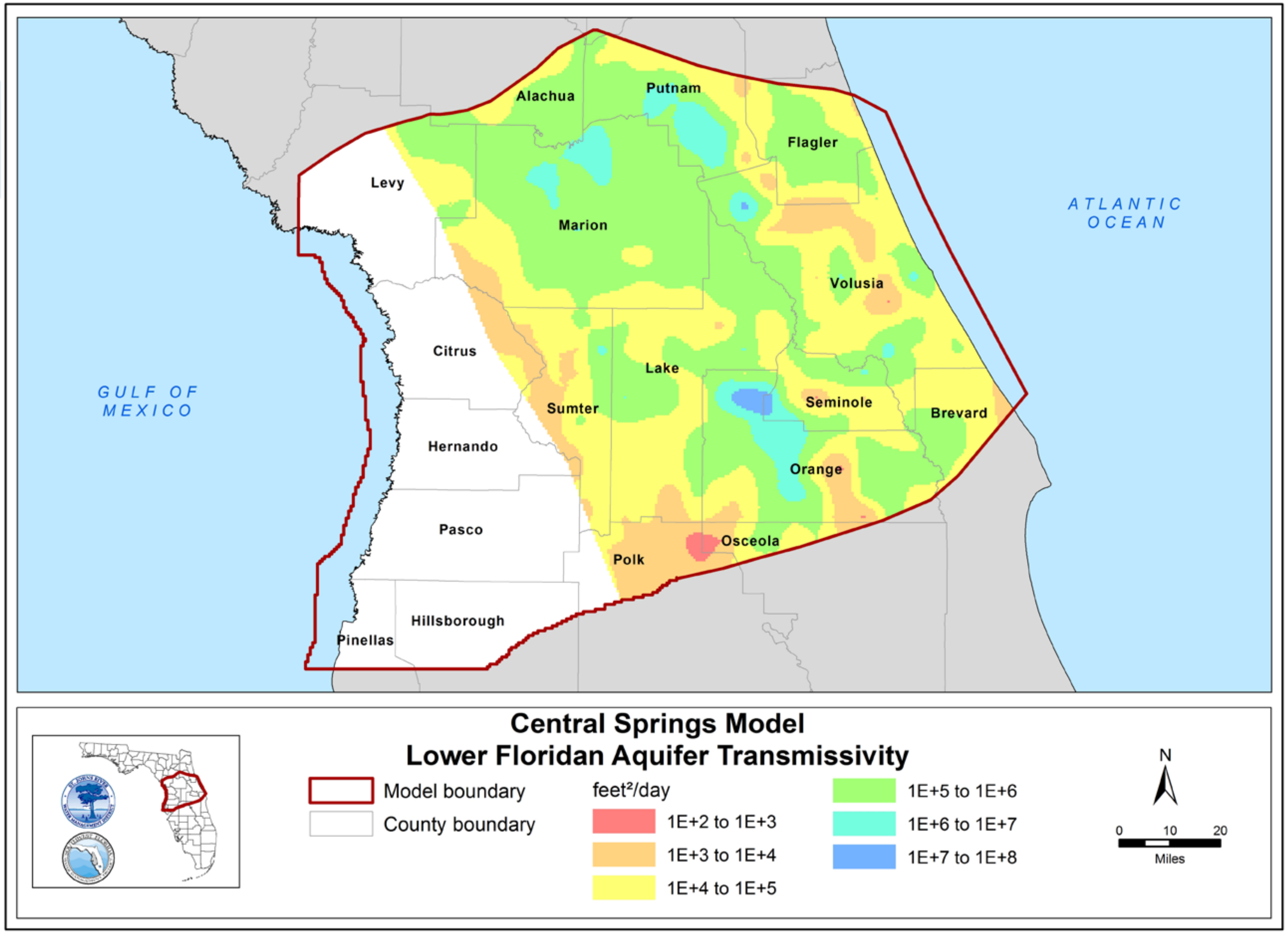
Surficial Aquifer System Horizontal Hydraulic Conductivity



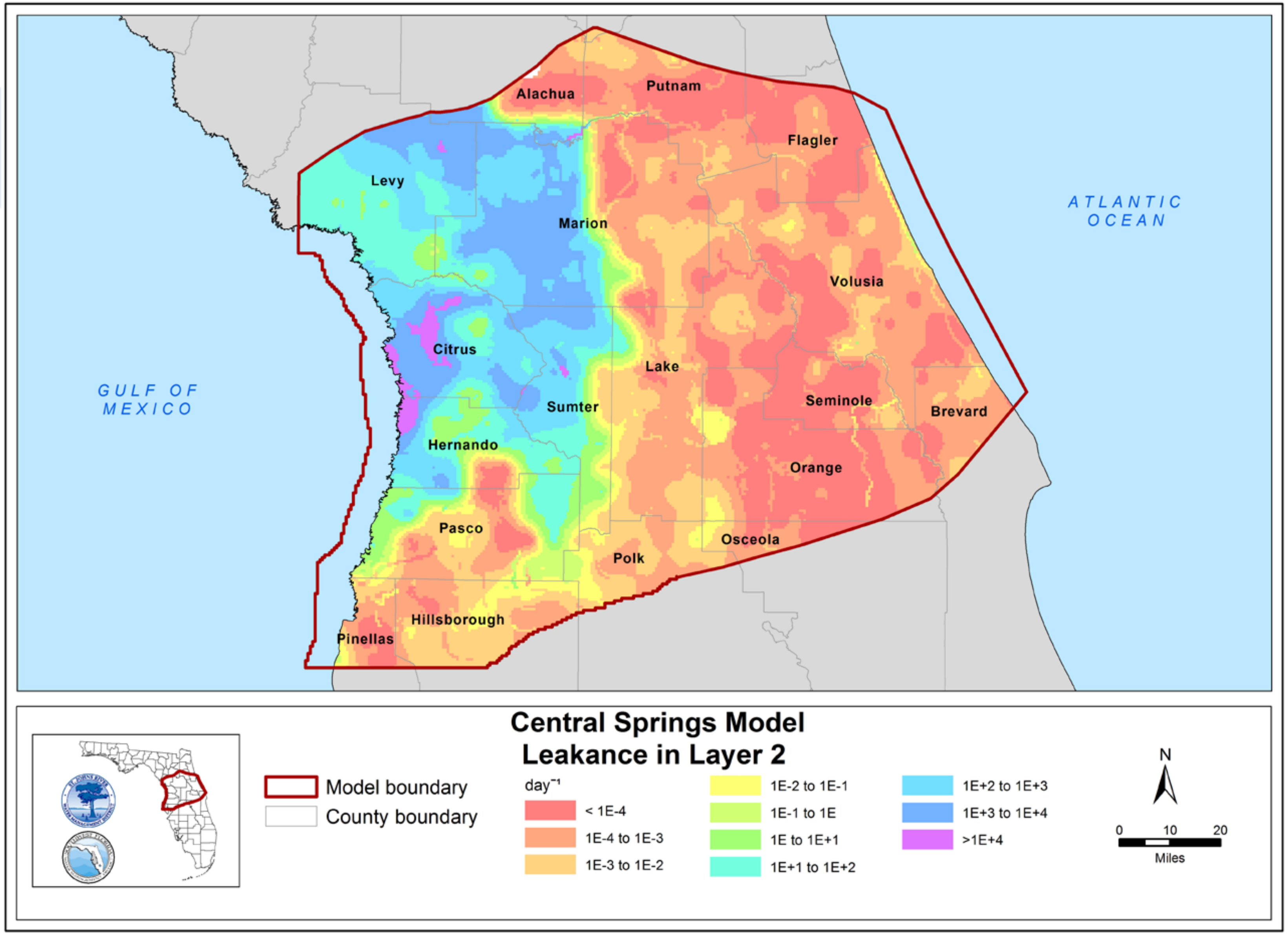
Upper Floridan Aquifer Transmissivity



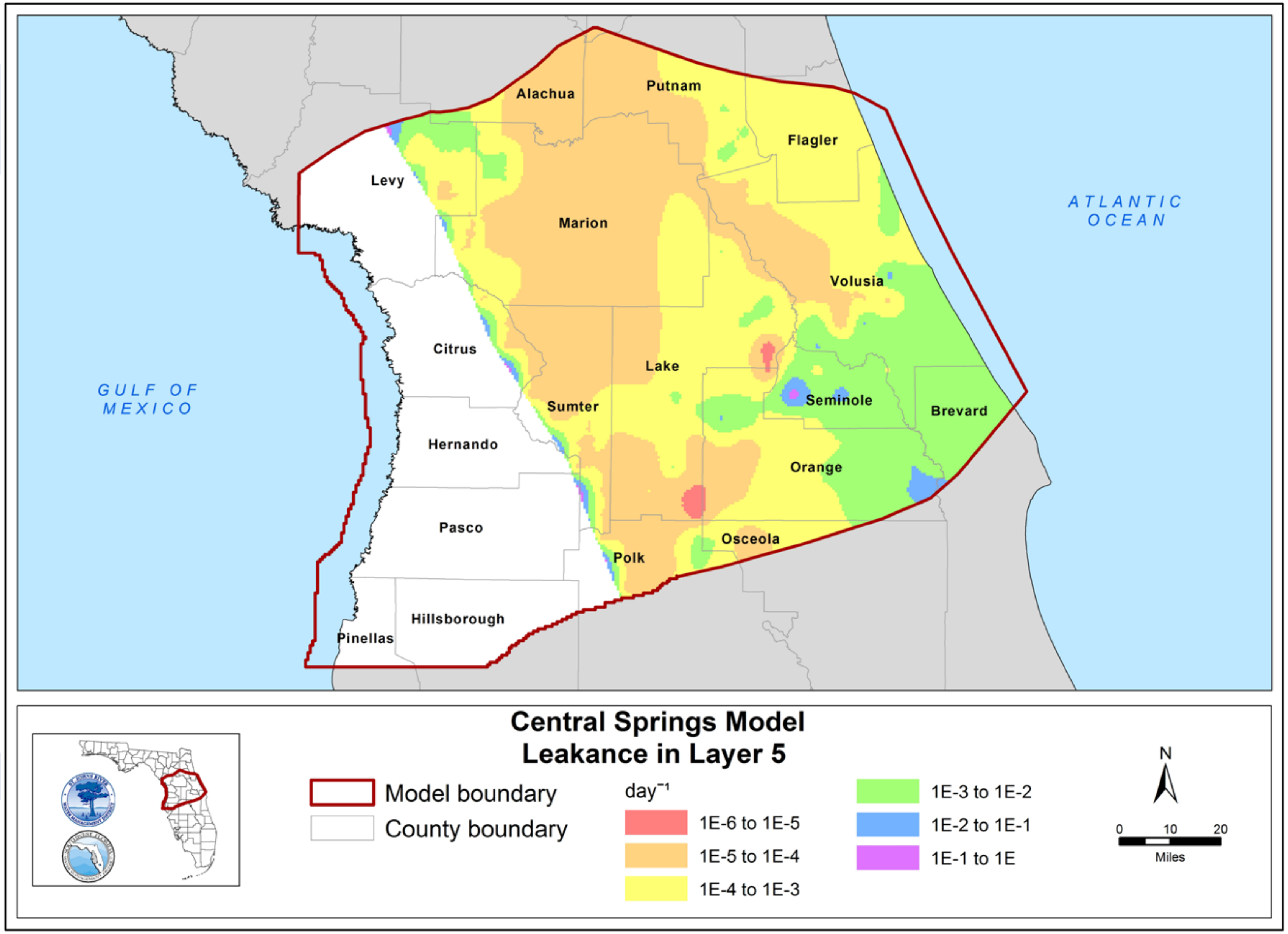
Lower Floridan Aquifer Transmissivity



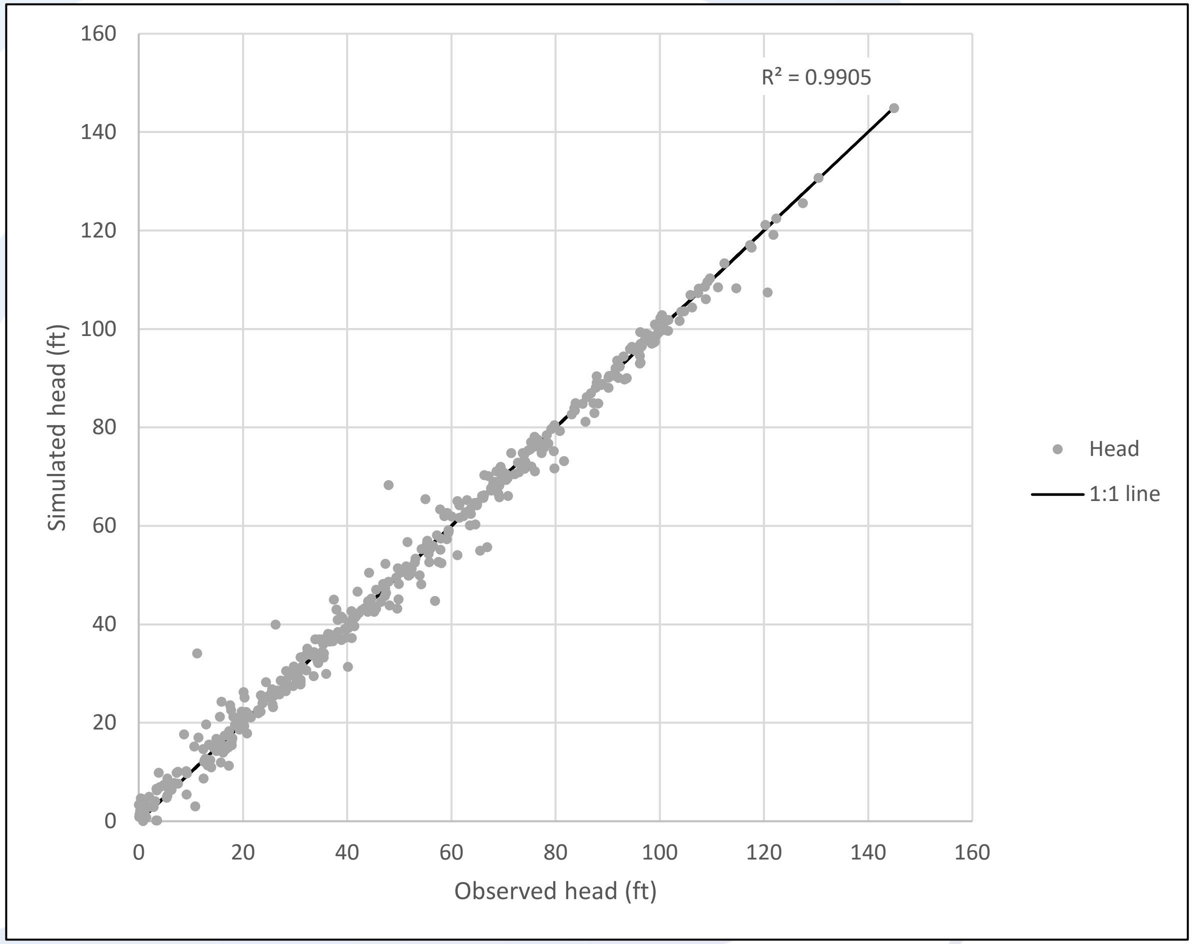
Intermediate Confining Unit Leakance

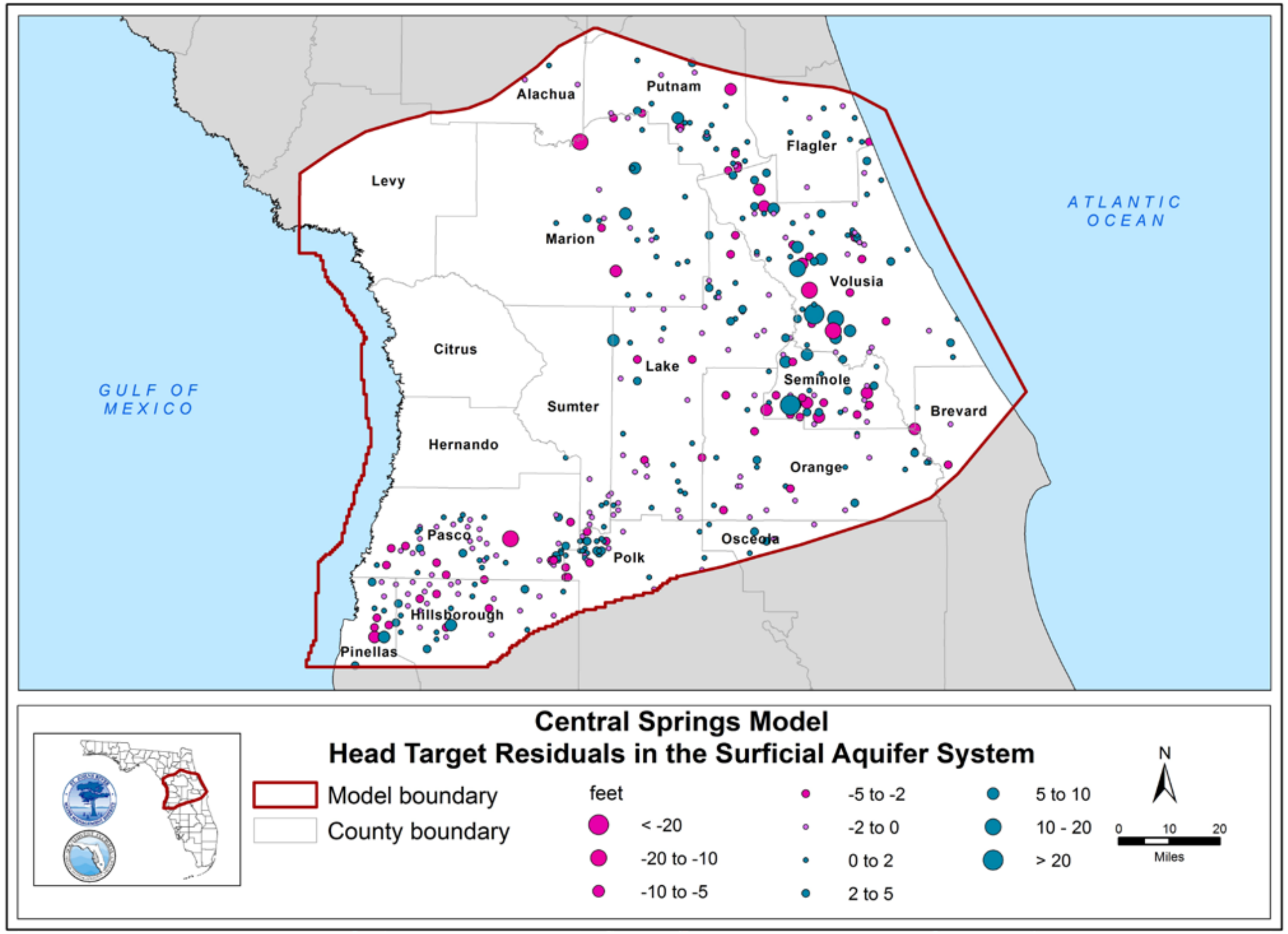


Middle Confining Unit I Leakance

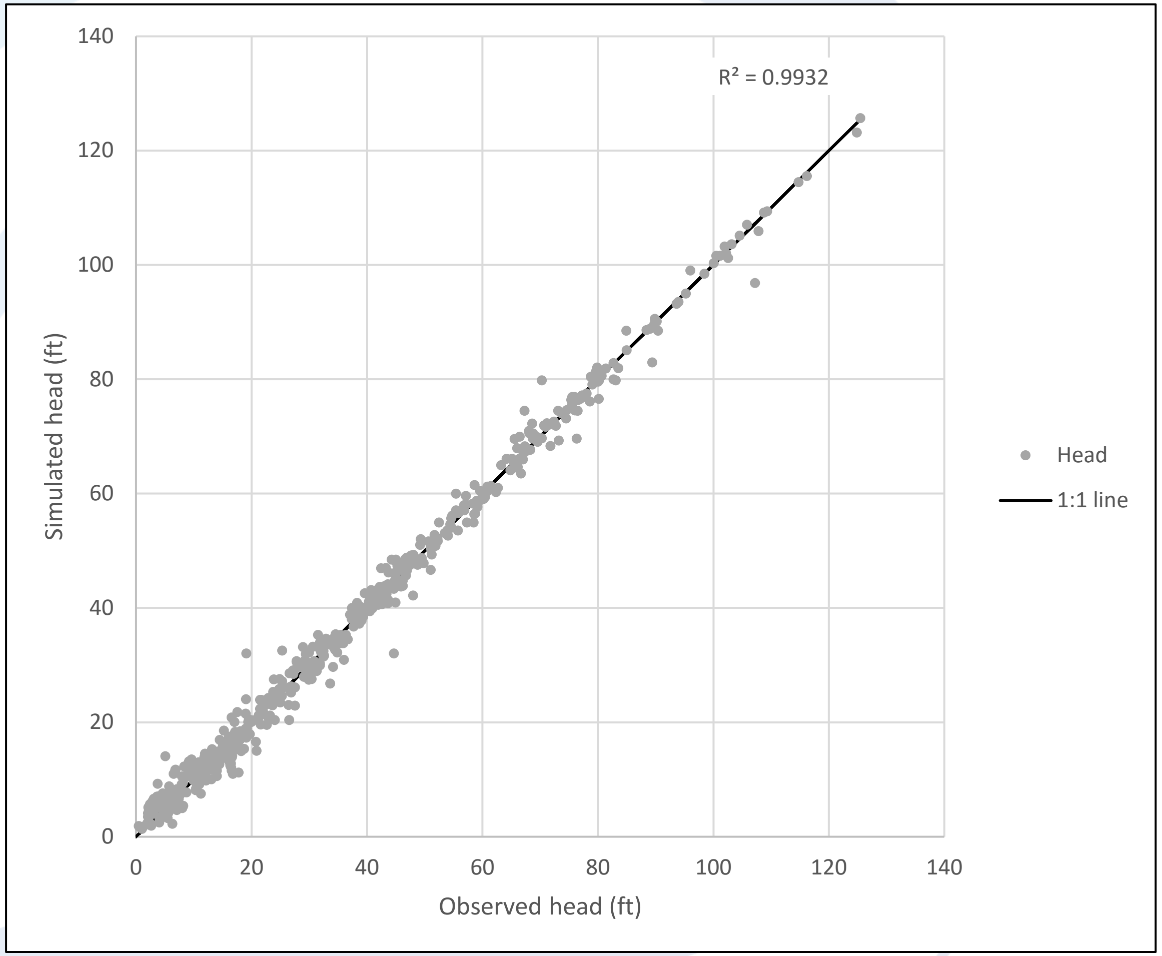


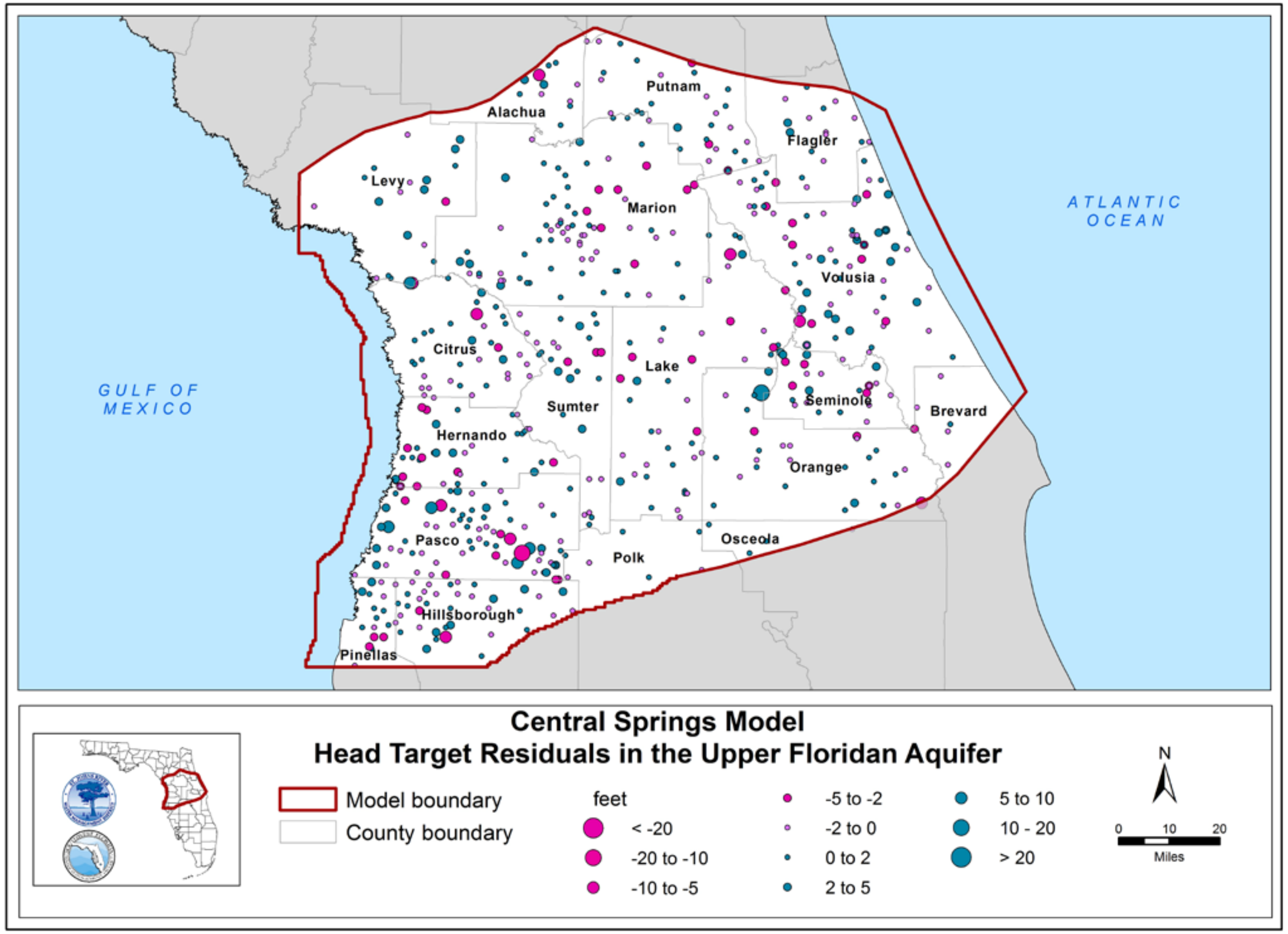
Surficial Aquifer System Head Targets



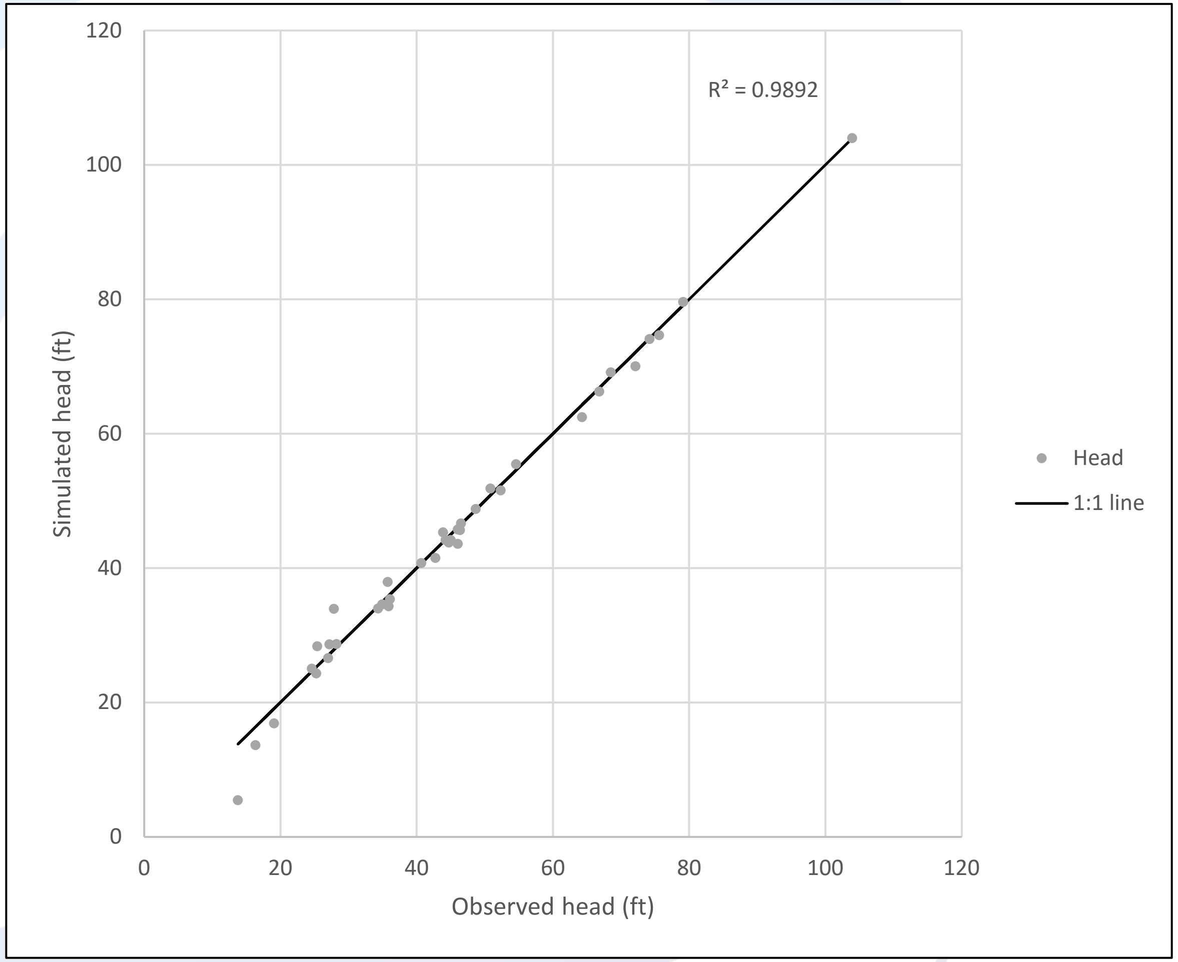


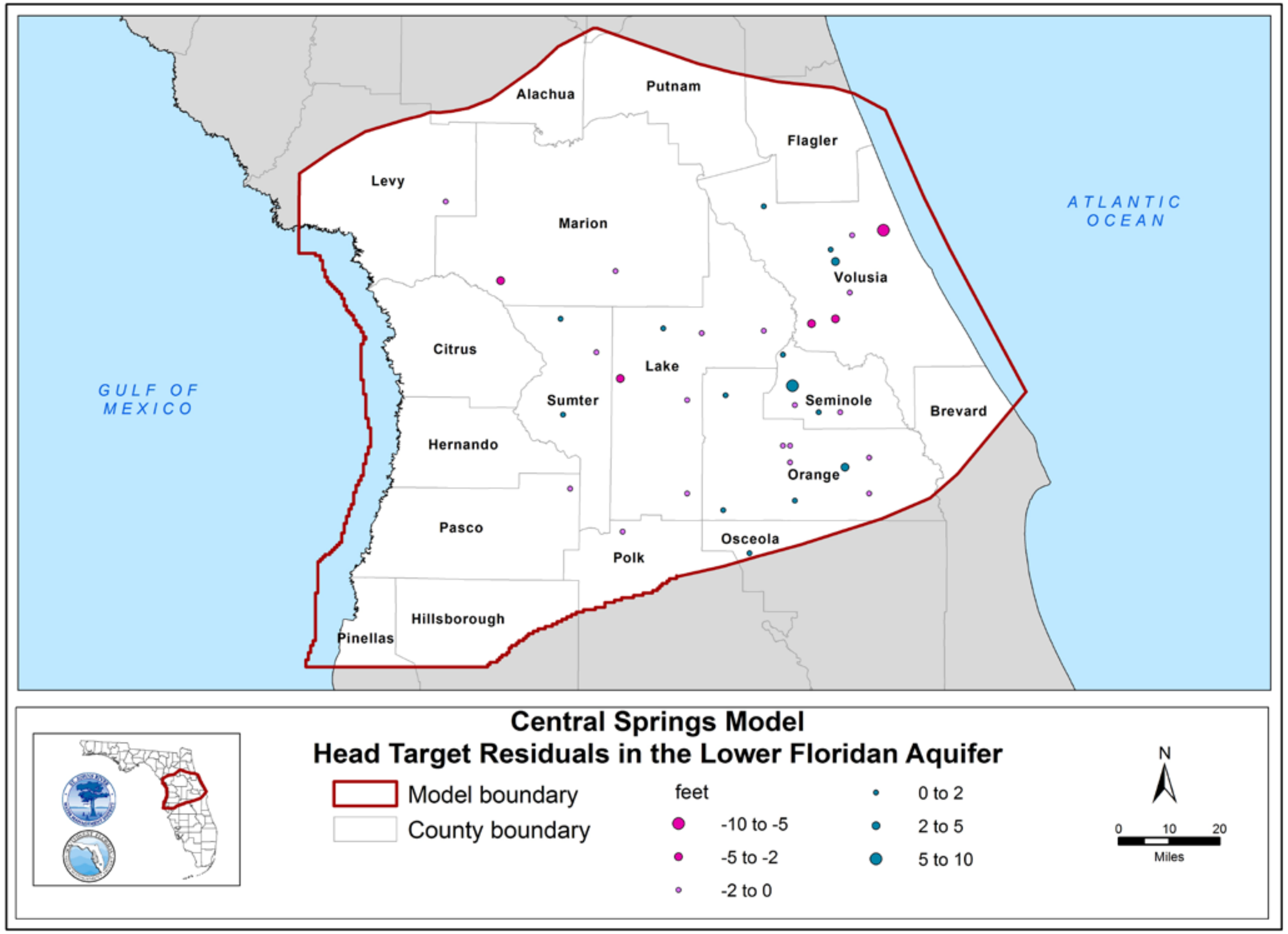
Upper Floridan Aquifer Head Targets





Lower Floridan Aquifer Head Targets



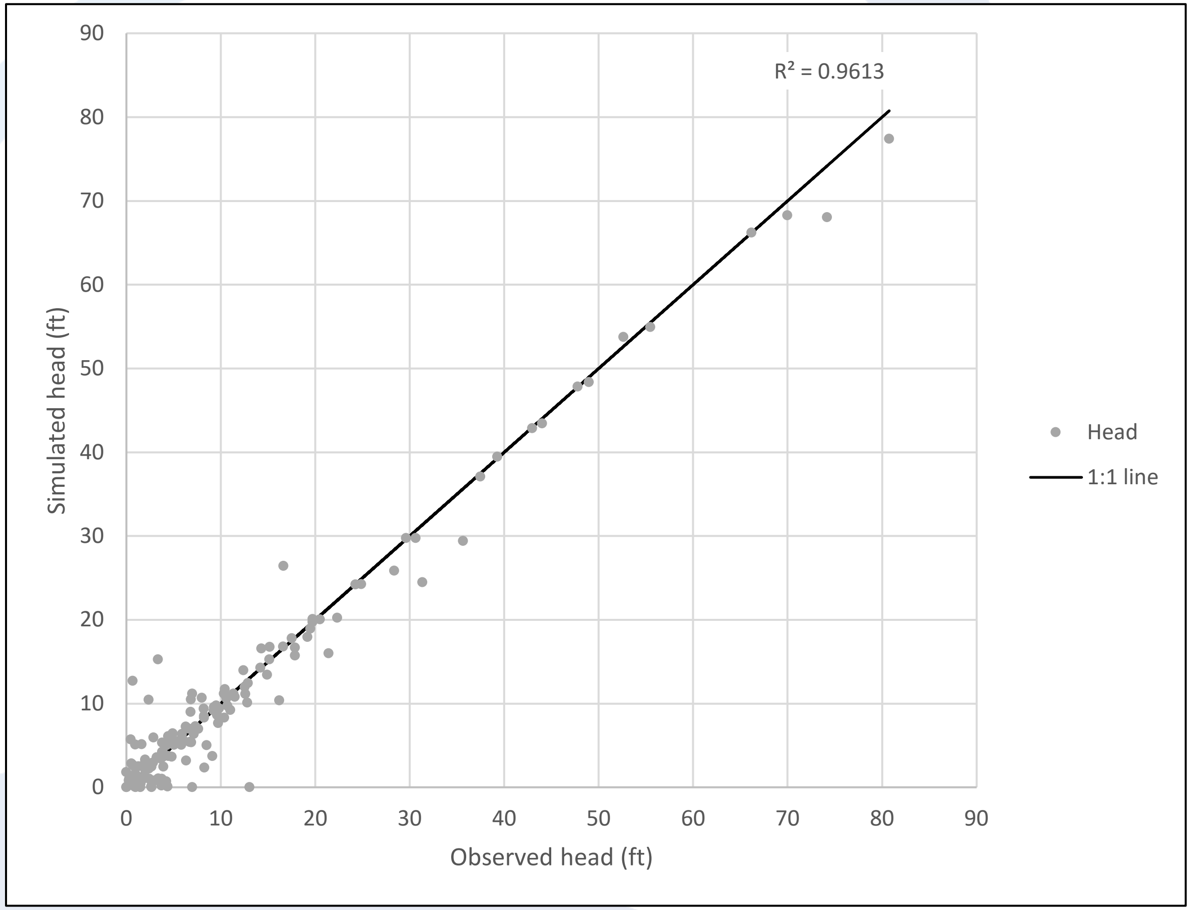


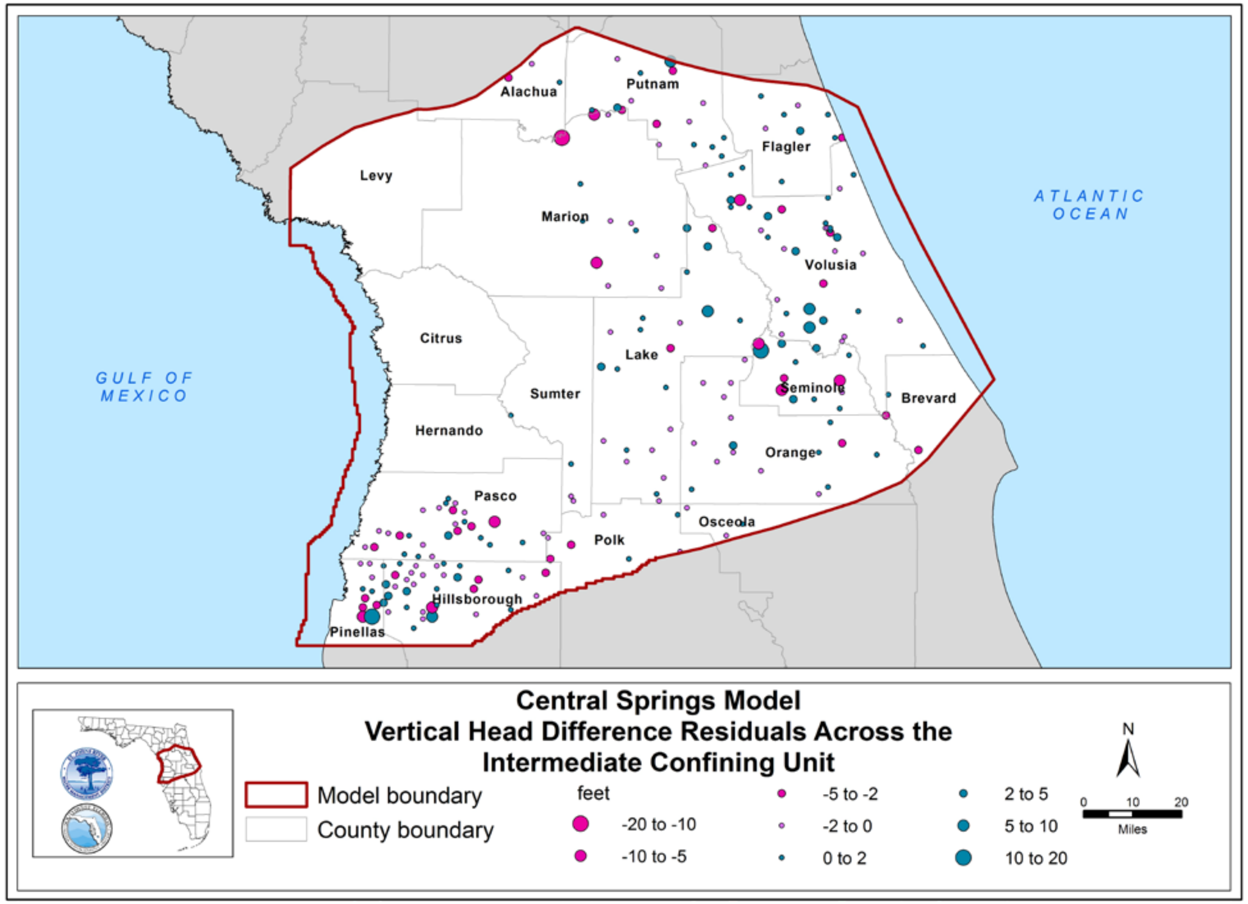
Groundwater Head Target Statistics

Metric	Criteria	Surficial Aquifer	Upper Floridan Aquifer	Lower Floridan Aquifer
Number of wells	NA	410	601	37
Mean Error (ft)	< ± 0.5ft	-0.1	0.1	-0.4
Mean Absolute Error (ft)		2.0	1.5	1.3
Percent of residual < 2.5 ft	> 50%	74.9%	82.2%	89.2%
Percent of residual < 5.0 ft	> 80%	92.0%	97.2%	94.6%
R^2	> 0.75 (surficial) > 0.85 (Upper/Lower Floridan)	0.9905	0.9932	0.9892

Vertical Head Difference Targets across the Intermediate Confining Unit

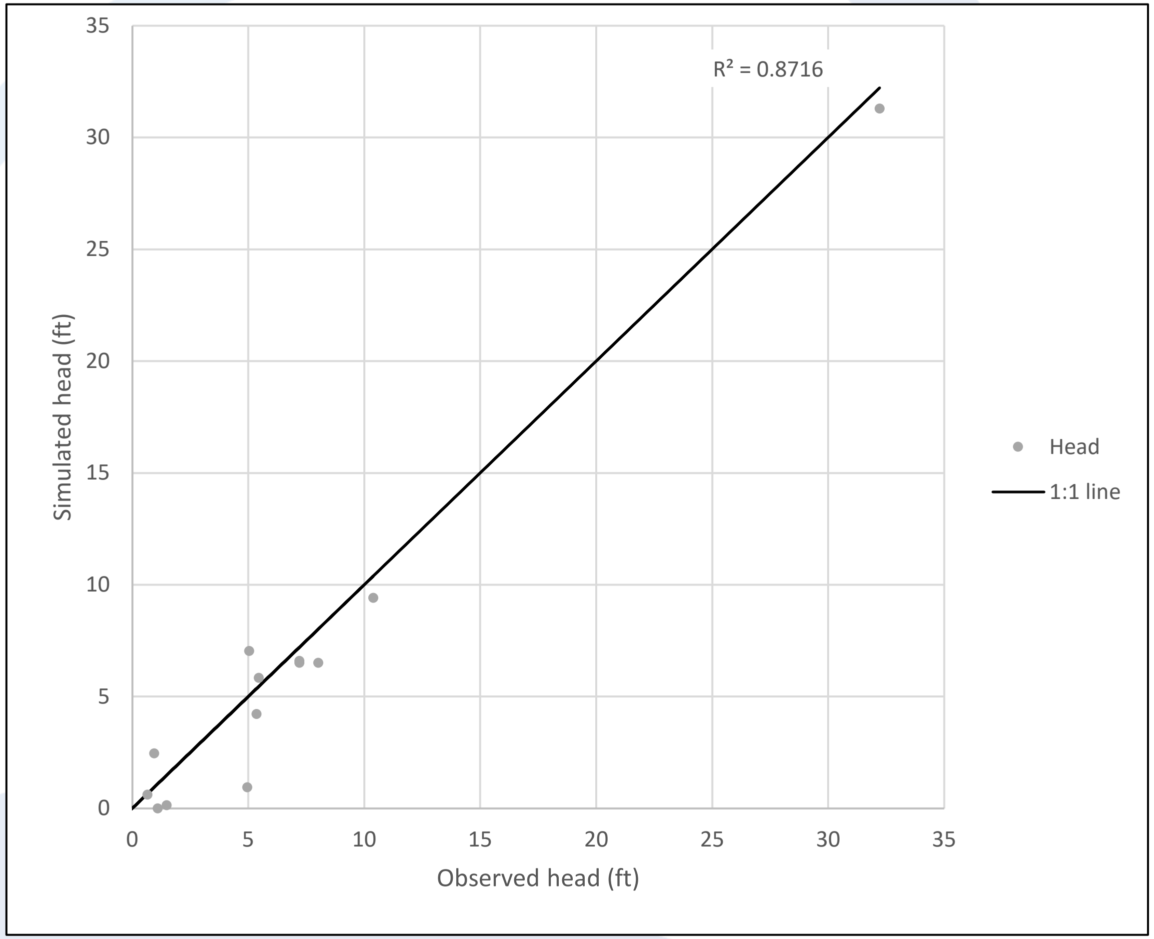
(Δ = Surficial – Upper Floridan)

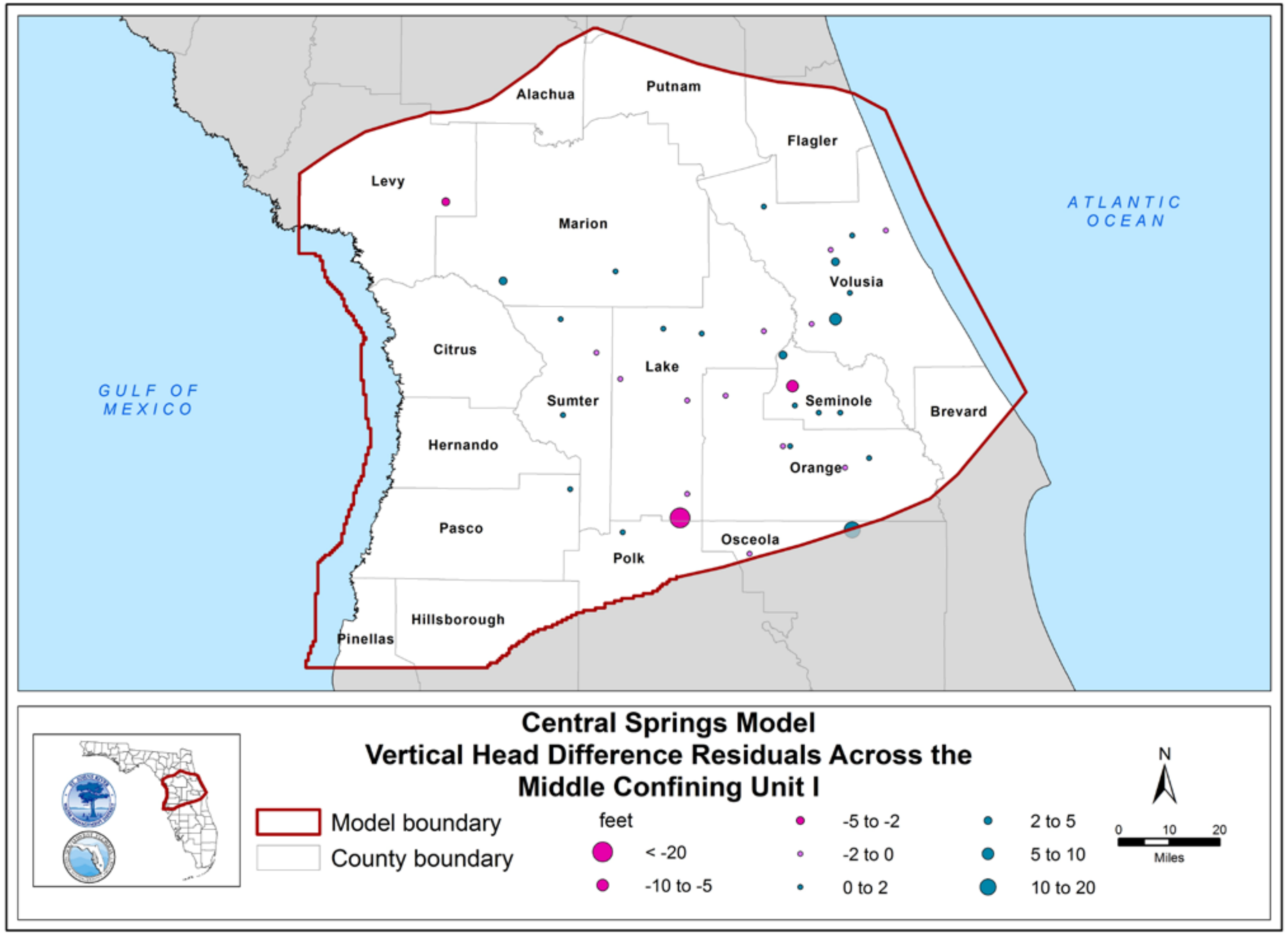




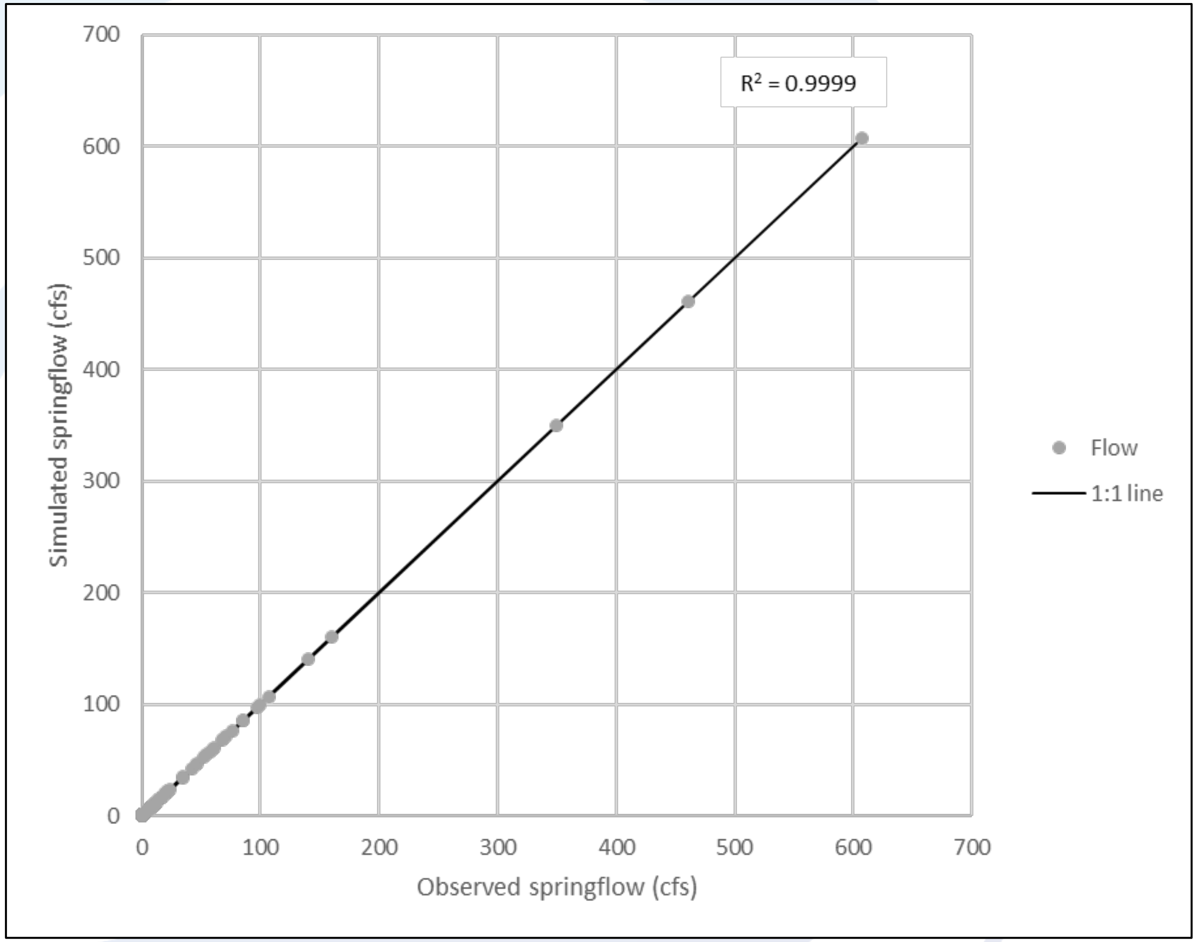
Vertical Head Difference Targets across Middle Confining Unit I

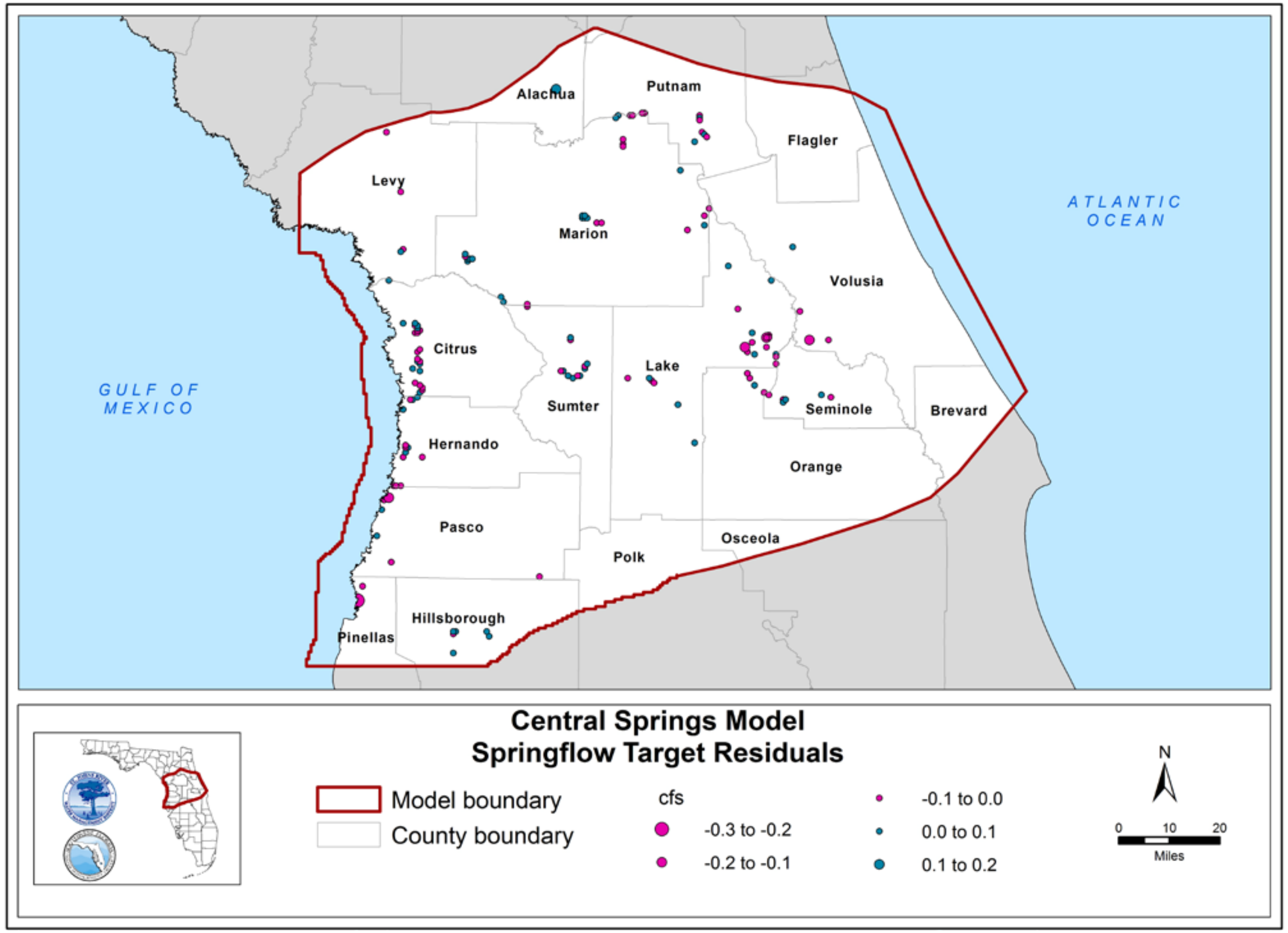
(Δ = Upper Floridan – Lower Floridan)



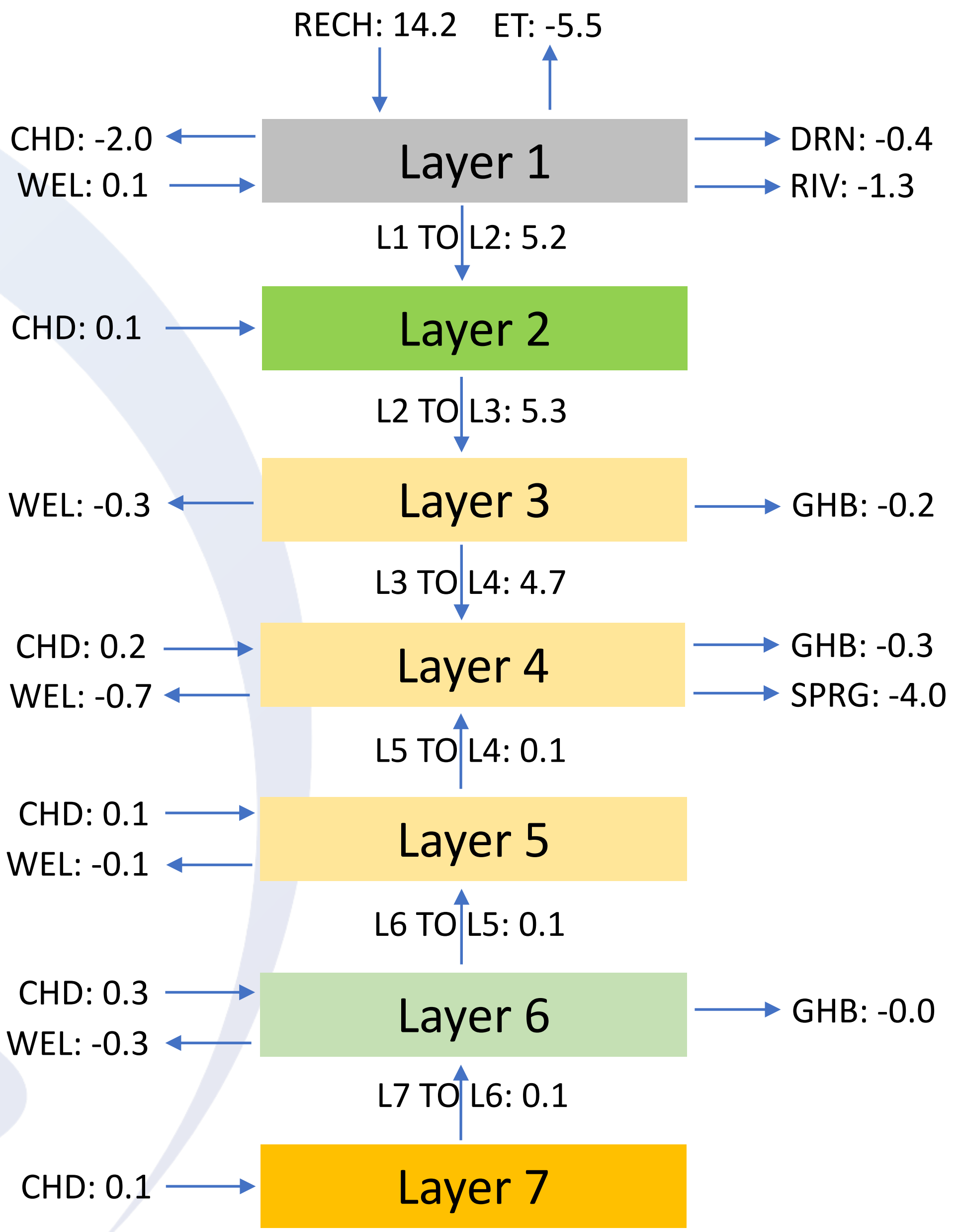


Springflow Targets





Water Budget (2005–2018)



Units in inches/year

CHD = Constand head
DRN = Drain
GHB = General head
L# = Layer number
RIV = River
SPRG = Spring
WEL = Well

Rounding of fluxes may account for nominal discrepancies.

Transient Model Calibration

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Southwest Florida Water Management District

Transient Model Setup

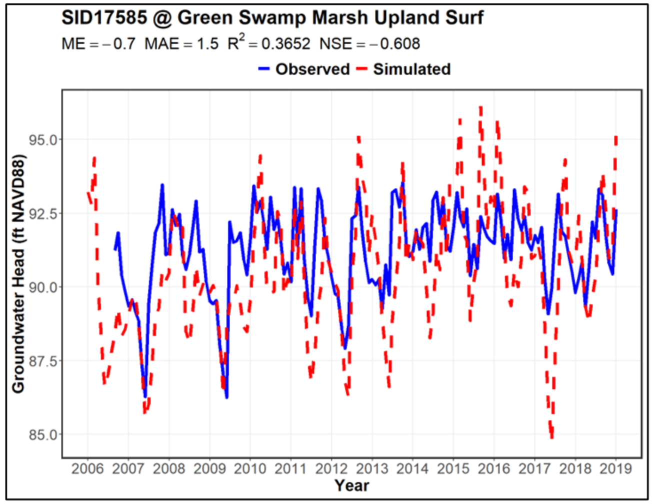
- 157 stress periods
  - Average 2005 steady state followed by 2006-2018 monthly
- Hydraulic conductivities from PEST calibrated steady-state model
- Initial storage parameters from reported values in the hydrogeologic layers
- RIV and DRN conductance from steady-state model with seasonal adjustment based on recharge variation

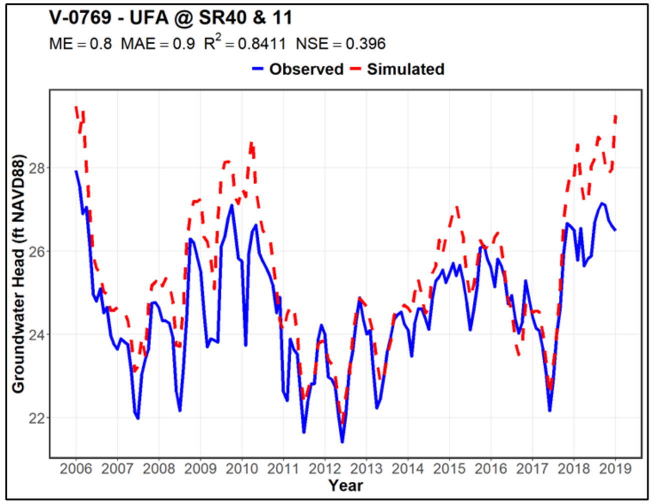
Range of Specific Yield/Specific Storage Values by Hydrogeologic Unit

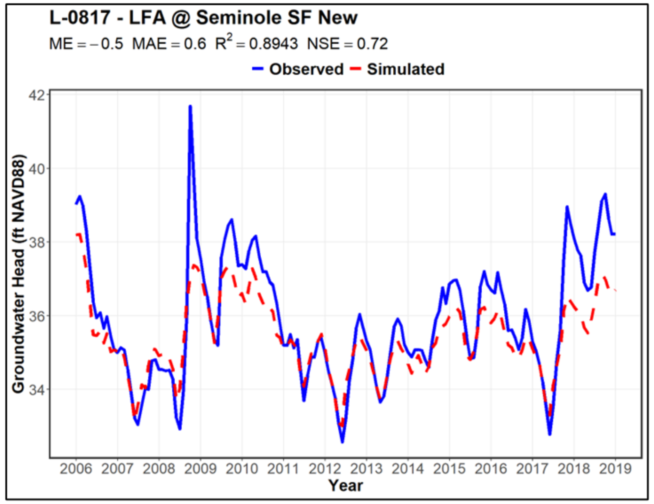
Aquifer/Confining Unit	Specific Yield		Specific Storage (1/ft)	
	Low	High	Low	High
Surficial Aquifer System	0.1	0.2	---	---
Intermediate Confining Unit	---	---	$1\ E^{-6}$	$1\ E^{-5}$
Upper Floridan Aquifer	---	---	$5\ E^{-6}$	$1\ E^{-5}$
Middle Confining Unit I	---	---	$1\ E^{-6}$	$3\ E^{-6}$
Lower Floridan Aquifer	---	---	$1\ E^{-6}$	$2\ E^{-6}$

Groundwater Head Targets

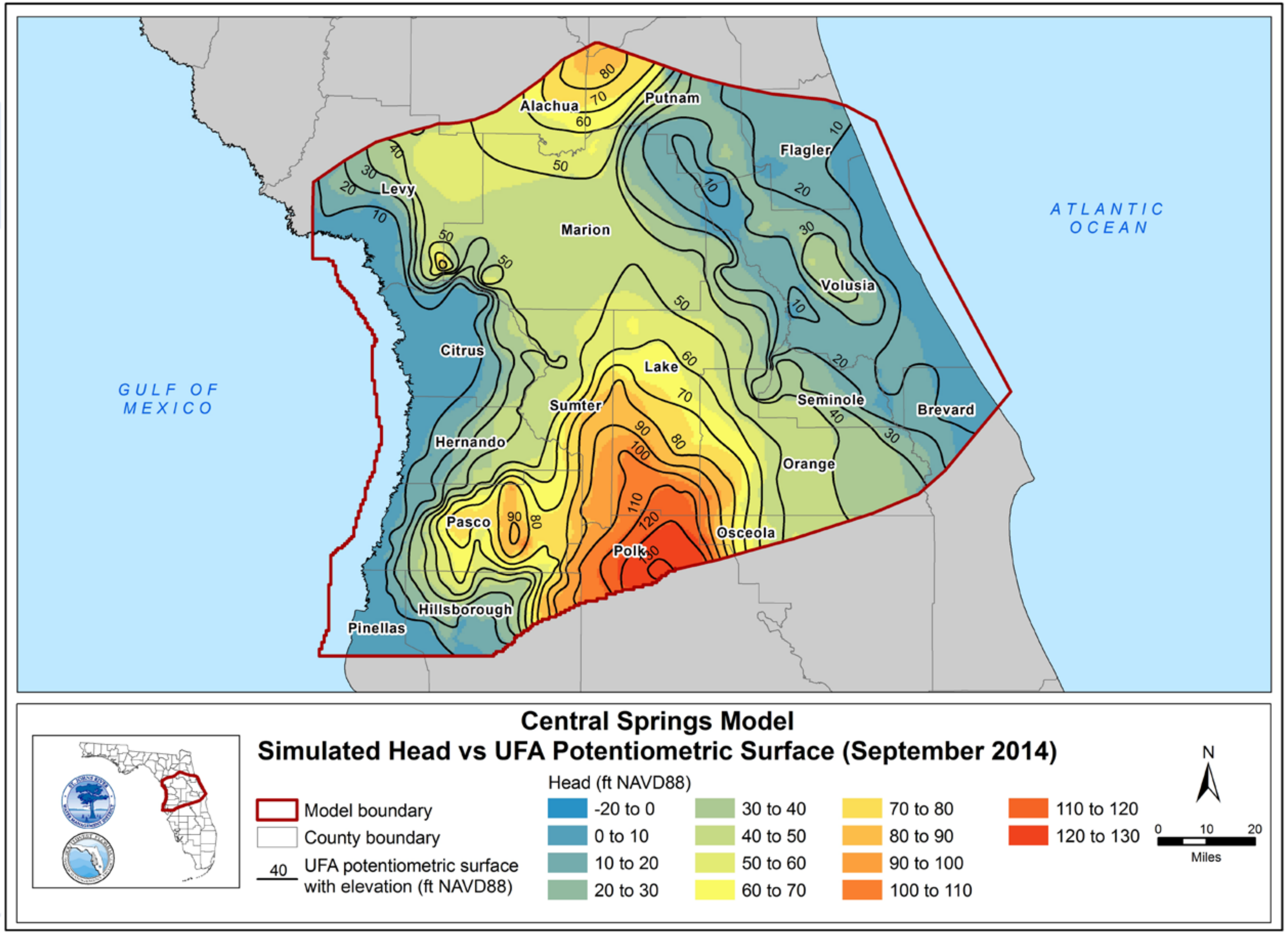
Metrics	Transient Statistics		
	SA	UFA	LFA
Mean Error (ME)	0.5	0.3	-0.3
Error Standard Dev	3.6	2.2	2.2
Mean Absolute Error (MAE)	2.6	1.8	1.7
RMS Error	3.6	2.2	2.2
Minimum Residual	-12.2	-12.4	-8.4
Maximum Residual	24.5	13.1	6.4
Number of Observations	403	601	38
Percentage with MAE < 2.5 ft	72.0%	82.7%	89.5%
Percentage with MAE < 5.0 ft	90.6%	96.5%	94.7%
Percentage with R^2 > 0.4	59.8%	86.2%	94.7%



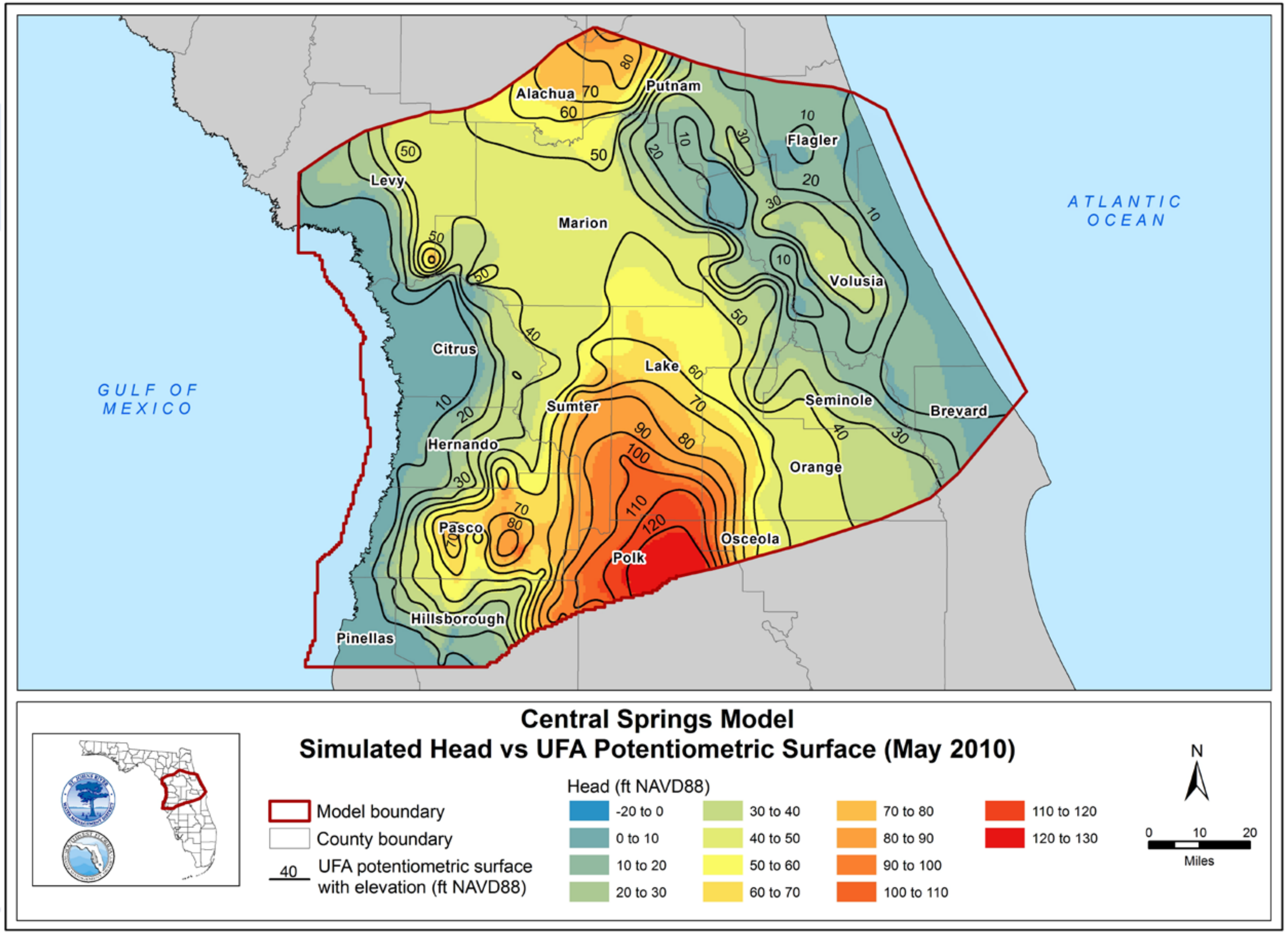




Simulated Heads and Observed Potentiometric Surface in September 2014 (wet season)

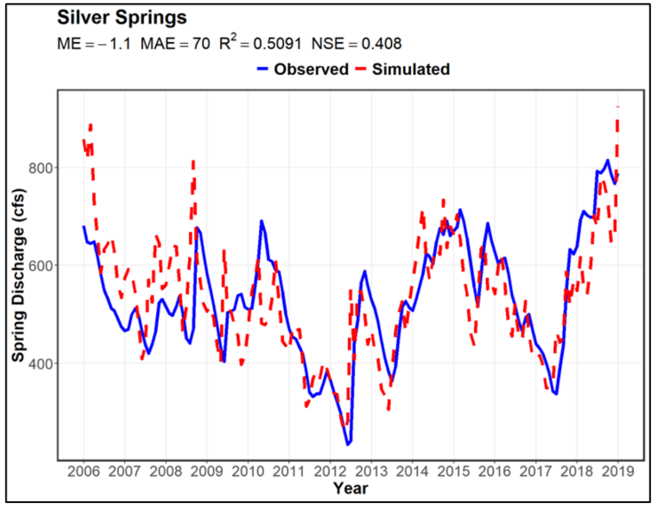


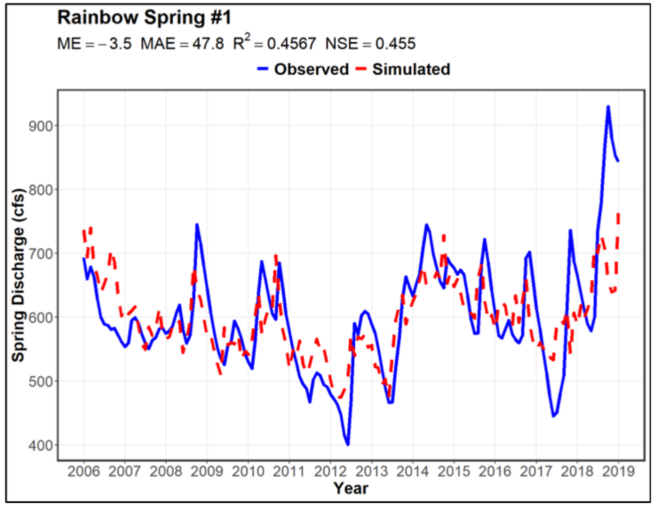
Simulated Heads and Observed Potentiometric Surface in May 2010 (dry season)

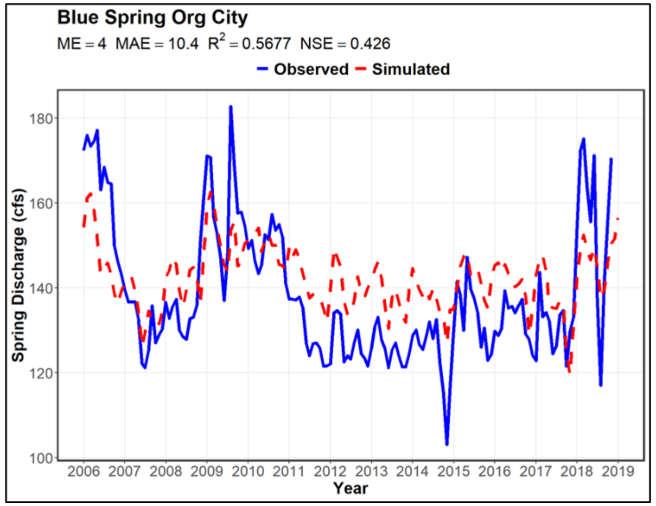


Springflow Targets

Spring Name	Observed Flux (cfs)	Simulated Flux (cfs)	% Difference
Alexander Springs	98.5	95.9	2.8%
Blue Spring (Orange City)	142.5	138.4	3.0%
Chassahowitzka Spring	59.7	59.9	-0.3%
Crystal Spring (Pasco)	52.8	46.0	14.7%
Gemini Springs	9.5	9.7	1.8%
Gum Spring	69.6	64.1	-8.6%
Homosassa Springs	83.1	84.5	-1.7%
Ponce De Leon Spring	23.1	22.7	1.5%
Rainbow Springs	597.4	601.0	-0.6%
Silver Glen Springs	87.4	85.2	2.6%
Silver Springs	531.8	532.9	-0.2%
Sulphur Spring (Hillsborough)	20.3	20.1	-1.1%
Weeki Wachee Spring	157.3	158.5	-0.7%







Model Highlights

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Model Highlights

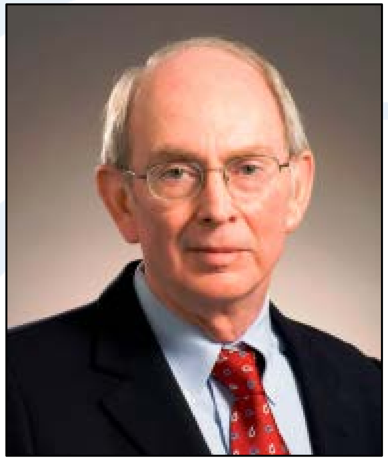
- A rigorous model calibration process using PEST
- A robust model performance in matching the monthly variations in groundwater levels and springflows from 2005 through 2018
- Reasonable aquifer parameters consistent with known hydrogeology of the area and local APTs
- Simulated UFA level contours in good agreement with published UFA potentiometric surface maps
- Most simulated baseflows within the min/max range of estimates
- Net water budget fluxes reasonable and within acceptable ranges

Technical Peer Review

St. Johns River Water Management District

Southwest Florida Water Management District

Technical Reviewers and Schedule



Louis Motz, Ph.D, P.E.

Associate Professor Emeritus

Dept. of Civil and Coastal Engineering

University of Florida

Patrick Tara, P.E.

Principal Engineer

INTERA, Incorporated

- September 2022 – technical peer review begins
- November 2022 – completed review of conceptual model and other documents
- June 2023 – completed review of interim model
- October 2023 – review final draft of model
- November 2023 – complete technical peer review

Stakeholder Review

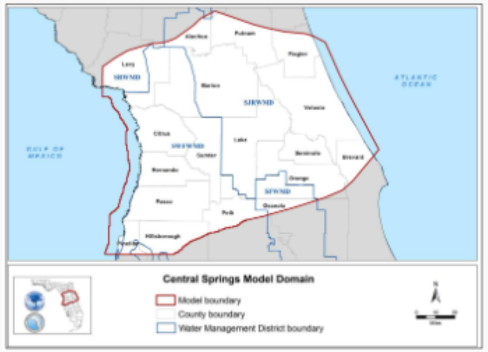
St. Johns River Water Management District

Southwest Florida Water Management District

Stakeholder Review

- Draft model files and documents available for review
- Comments can be submitted at www.sjrwmd.com/water-supply/planning/csec-rwsp/#central-springs

  or to CentralSpringsModel@sjrwmd.com
- November 13, 2023 – comment period closes



The Central Springs Model (CSM) is a groundwater model being developed through a collaboration between the St. Johns River Water Management District (SJRWMD) and the Southwest Florida Water Management District (SWFWMD). This model is being designed to quantify the effects of current and future groundwater withdrawals on the precious water resources within the Central Springs Region. In SJRWMD, the CSM will replace the Northern District Model (NDM) and the Volusia Model for water supply planning, minimum flows and levels (MFL) development and consumptive use permitting. In SWFWMD, the CSM will be utilized for MFL development and for groundwater evaluations previously performed with the NDM for larger quantity permits to assess potential adverse impacts to springs.

A draft version of the Central Springs Model will be complete and ready for review in October, and the districts would like to solicit comments and feedback from interested stakeholders. Once the draft model is released for review, the following documents and files will be posted to this webpage.

- CSM overview recording
- CSM overview presentation (pdf)
- Draft CSM report
- Draft CSM model files

Once released for review, the districts will accept comments on the draft Central Springs Model through 5 p.m. on November 13, 2023. Stakeholders will be able to submit comments using an online comment tool or via email.

If you would like to receive notifications on activities related to the Central Springs Model, please email your name and affiliation (if applicable) to **CentralSpringsModel@sjrwmd.com**.

Next Steps

CSM Schedule

November 13, 2023

- Stakeholder review ends

November 20, 2023

- Technical peer review ends

December 2023

- Updates to model
- Finalize model report
- Prepare resolution document

January 2024

- Post final model files, report, and resolution document to CSM webpage

Thank you

Draft model documents available for review at
www.sjrwmd.com/water-supply/planning/csec-rwsp/#central-springs

Comments can be submitted via the webtool at the above webpage or by email to CentralSpringsModel@sjrwmd.com

St. Johns River Water Management District

Southwest Florida Water Management District