



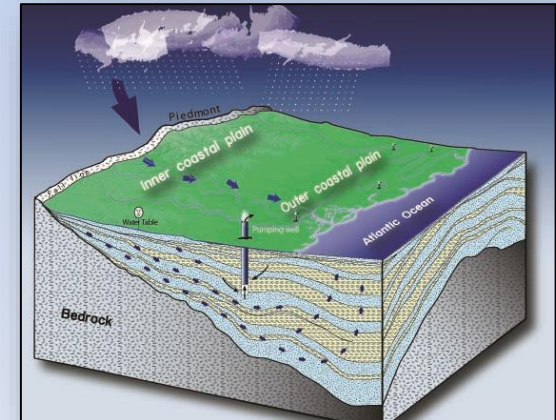
# South Carolina Atlantic Coastal Plain Groundwater Availability Model

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US Geological Survey – South Atlantic Water Science Center

**Alex Butler** - South Carolina Department of Health and Environmental Control

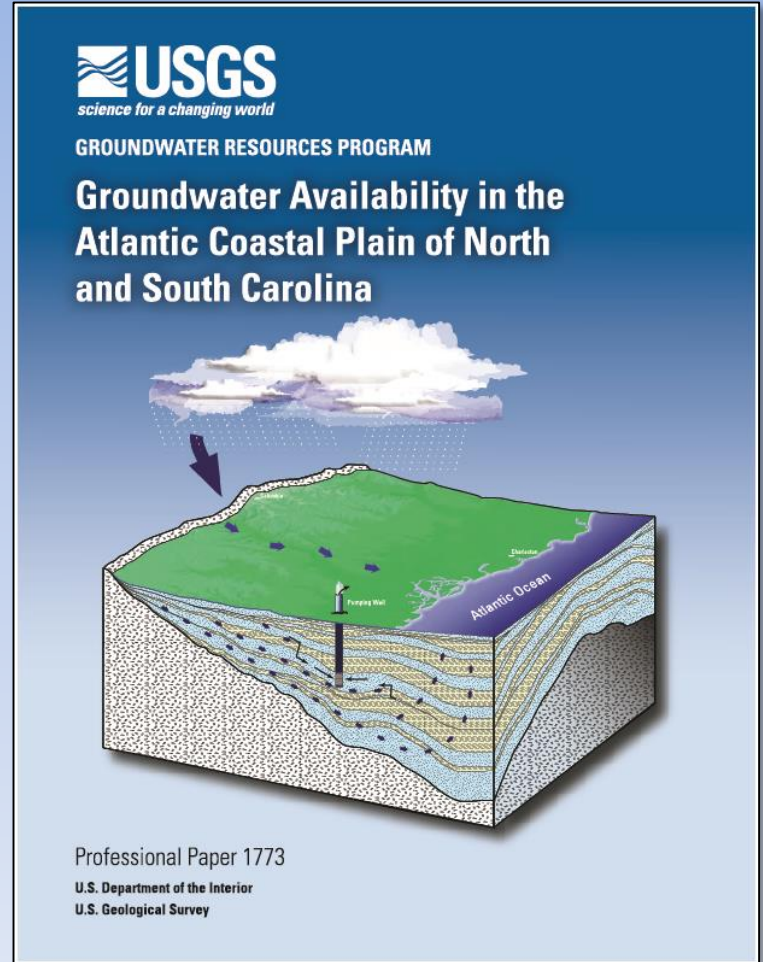
**Joe Gellici** - South Carolina Department of Natural Resources



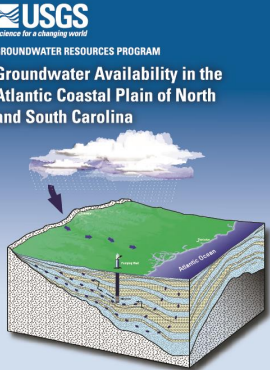
# USGS Groundwater Resources Program

## Groundwater Flow Model of the Atlantic Coastal Plain of NC, SC, eastern GA, southern VA

- Calibrated to 2004 conditions
- Revised hydrogeologic framework
- Analysis of GW monitoring networks
- Climate change predictions



# Groundwater Model Area

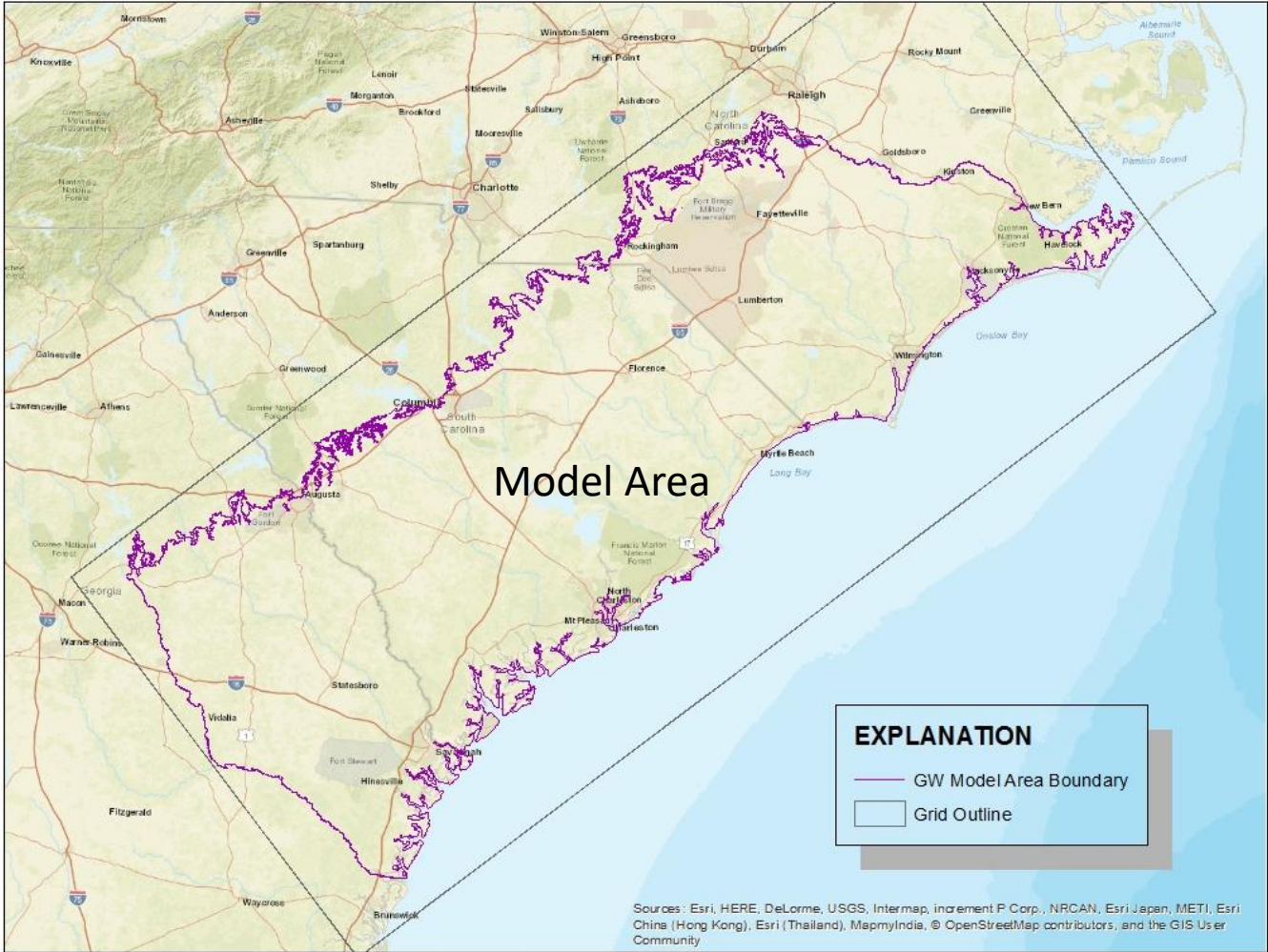


**USGS**  
science for a changing world

**GROUNDWATER RESOURCES PROGRAM**

**Groundwater Availability in the Atlantic Coastal Plain of North and South Carolina**

Professional Paper 1773  
 U.S. Department of the Interior  
 U.S. Geological Survey

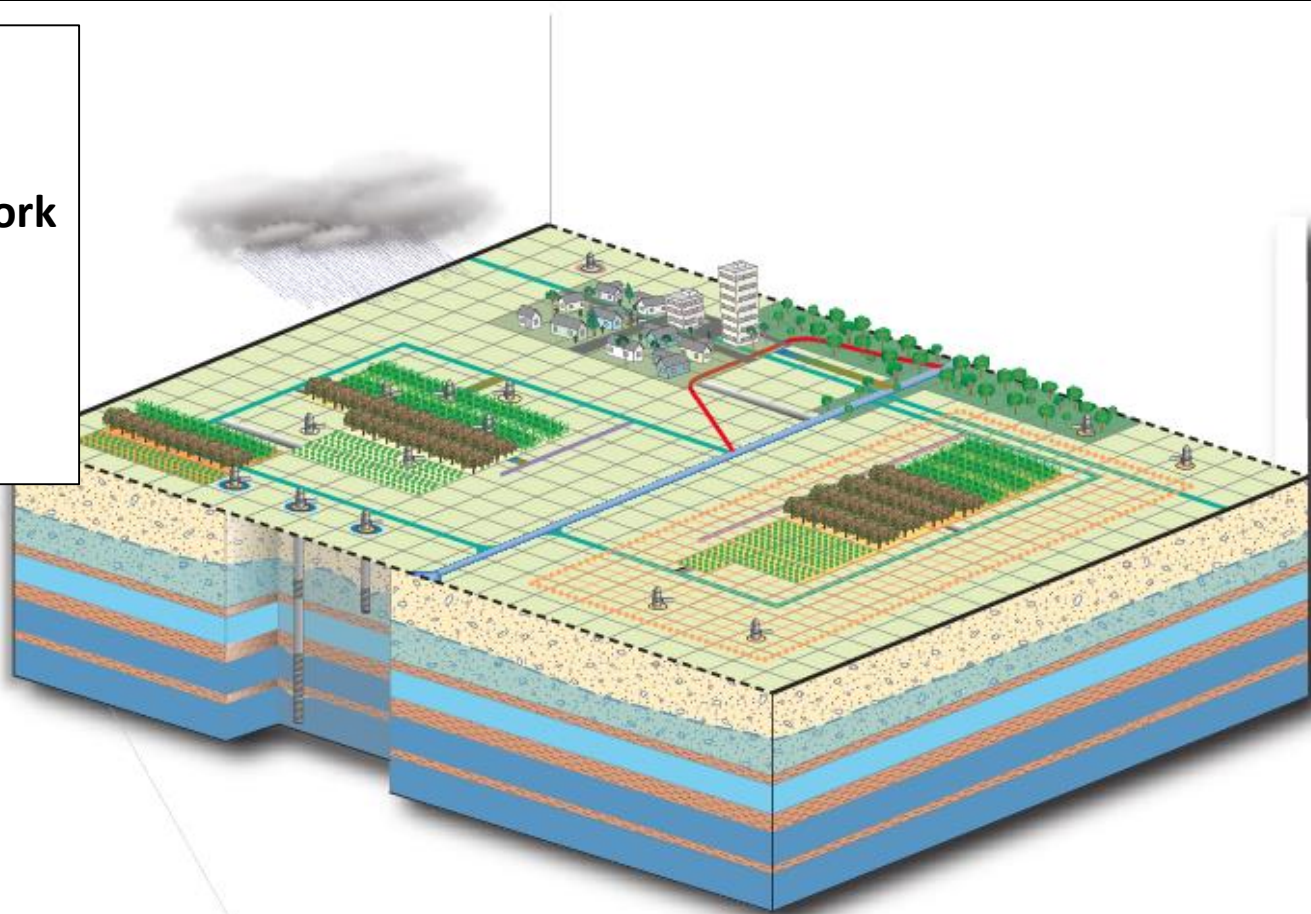


### Primary inputs:

- Model Grid
- Hydrogeologic Framework
- Aquifer Properties
- Observation Data
- Boundaries
- Wells – Water Use Data

### Primary Outputs:

- Groundwater Levels
- Budgets



# Coastal Plain Issues

- Increase in Atlantic Coastal Plain population
- Increased demand on groundwater resources
- Groundwater quality issues
- Increased agricultural withdrawals
- Impact of increased groundwater withdrawals on surface water flows



# Objectives

- Overall update the 2010 groundwater flow model
- Activating the entire surficial aquifer model layer
- Recharge from SWB Model
- Adding recent groundwater-related data (2005-2015)
- Refine the model grid from 2 x 2 miles to 2,000 x 2,000 ft
- Incorporate a more detailed representation of the Fall Line area
- Incorporate new MODFLOW packages – Newton Formulation, Multi-Node Well Package, SFR2 Package, etc
- Variable-density offshore boundary
- Re-calibration, and apply the model to a series of scenarios



# New Data

# Model Framework

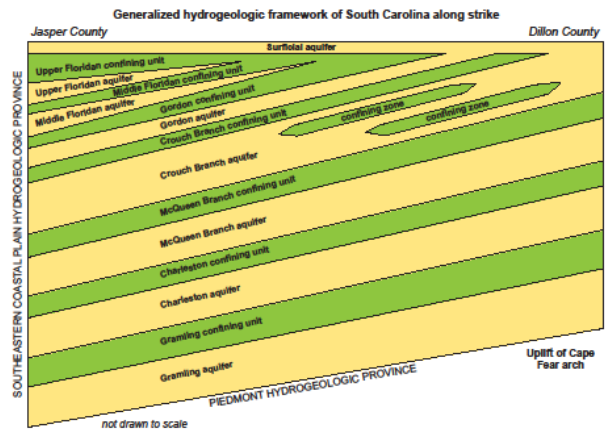
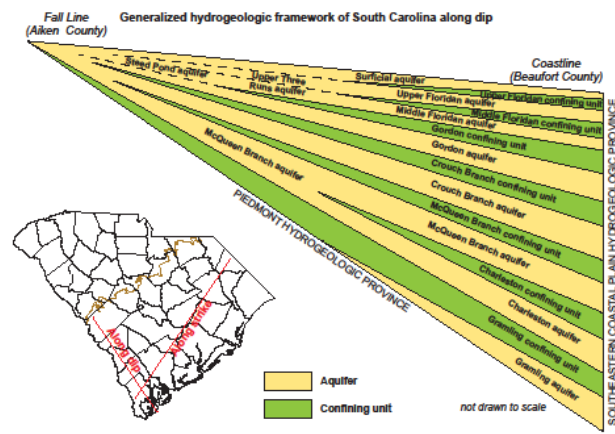


Figure 1. Generalized hydrogeologic framework of the South Carolina Coastal Plain (Gellicci and Lautier, 2010).

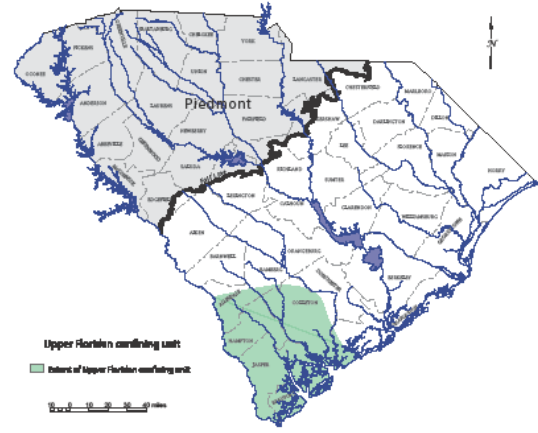
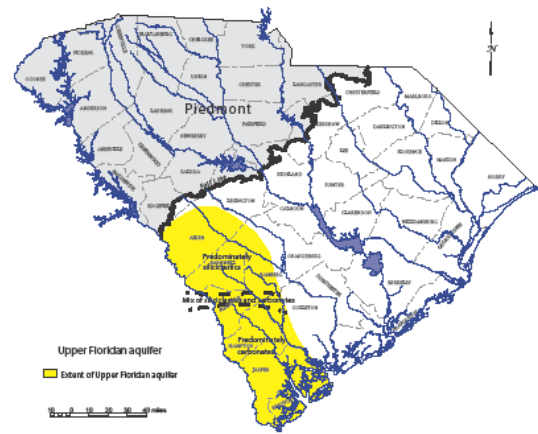
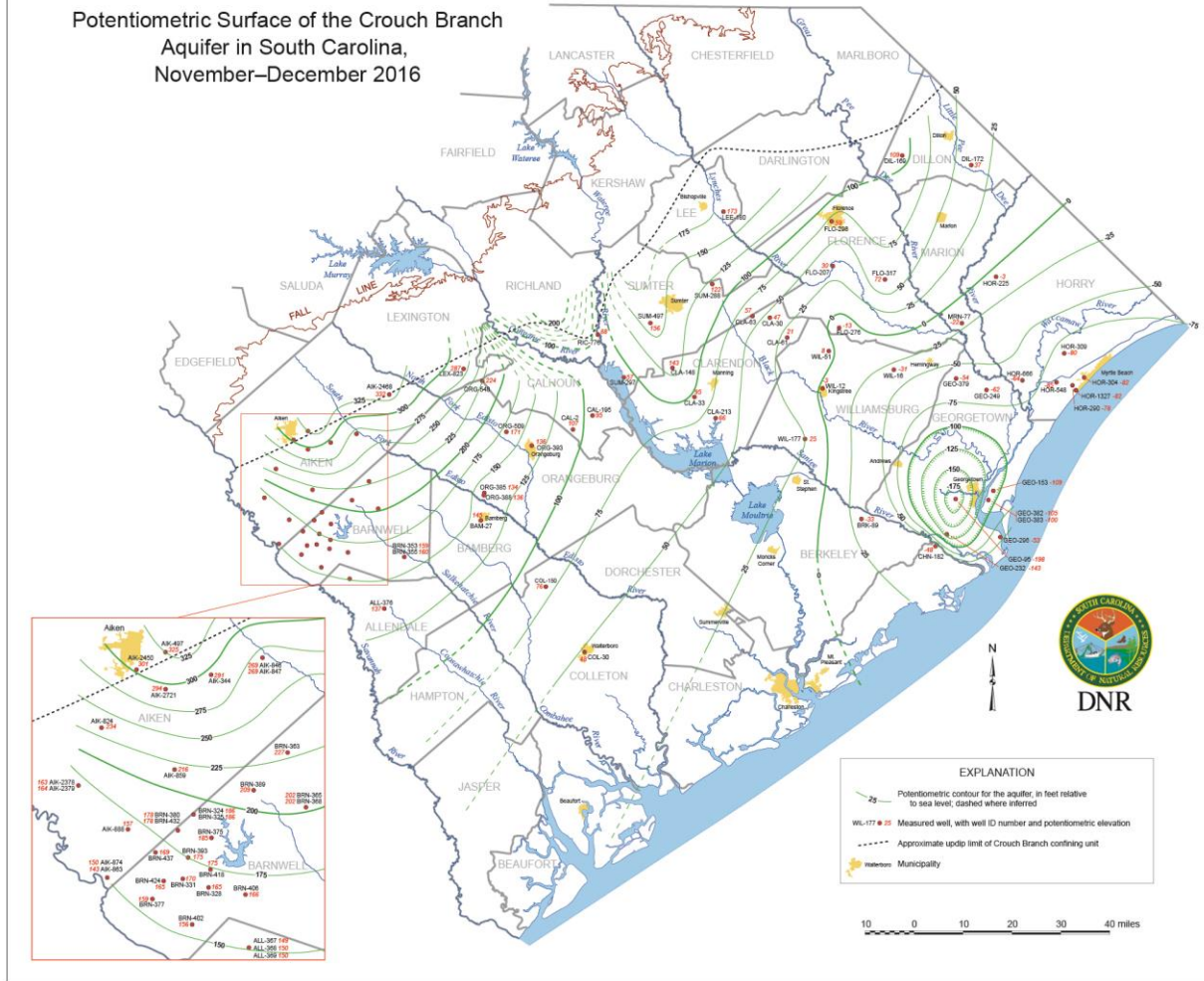


Figure 4. Approximate extent of the Upper Floridan aquifer and confining unit, as used in this report.



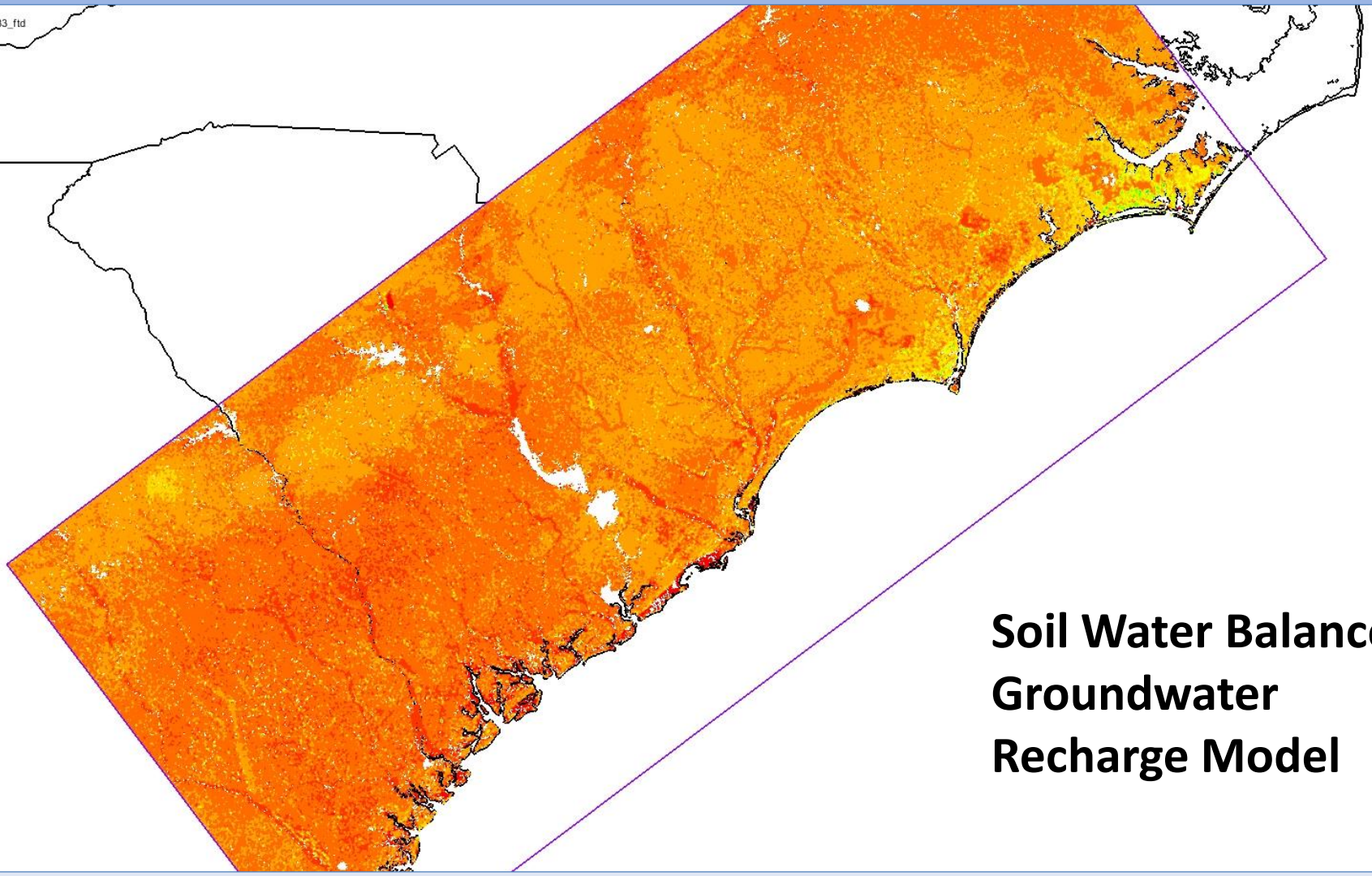
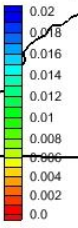
# Synoptic Potentiometric Surface Mapping

Potentiometric Surface of the Crouch Branch  
Aquifer in South Carolina,  
November–December 2016





Nardi\_RCH\_1983\_ftd

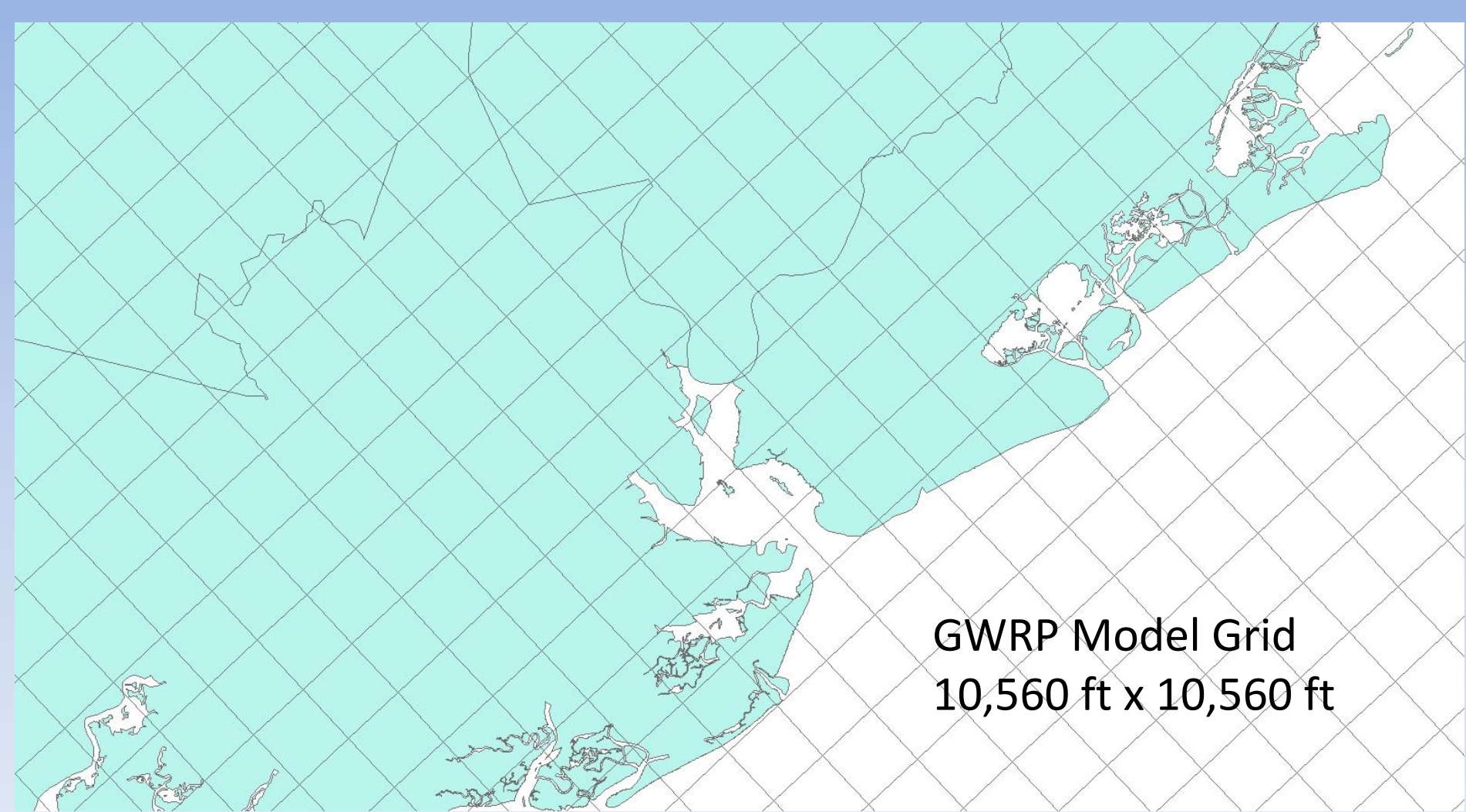


# Soil Water Balance Groundwater Recharge Model

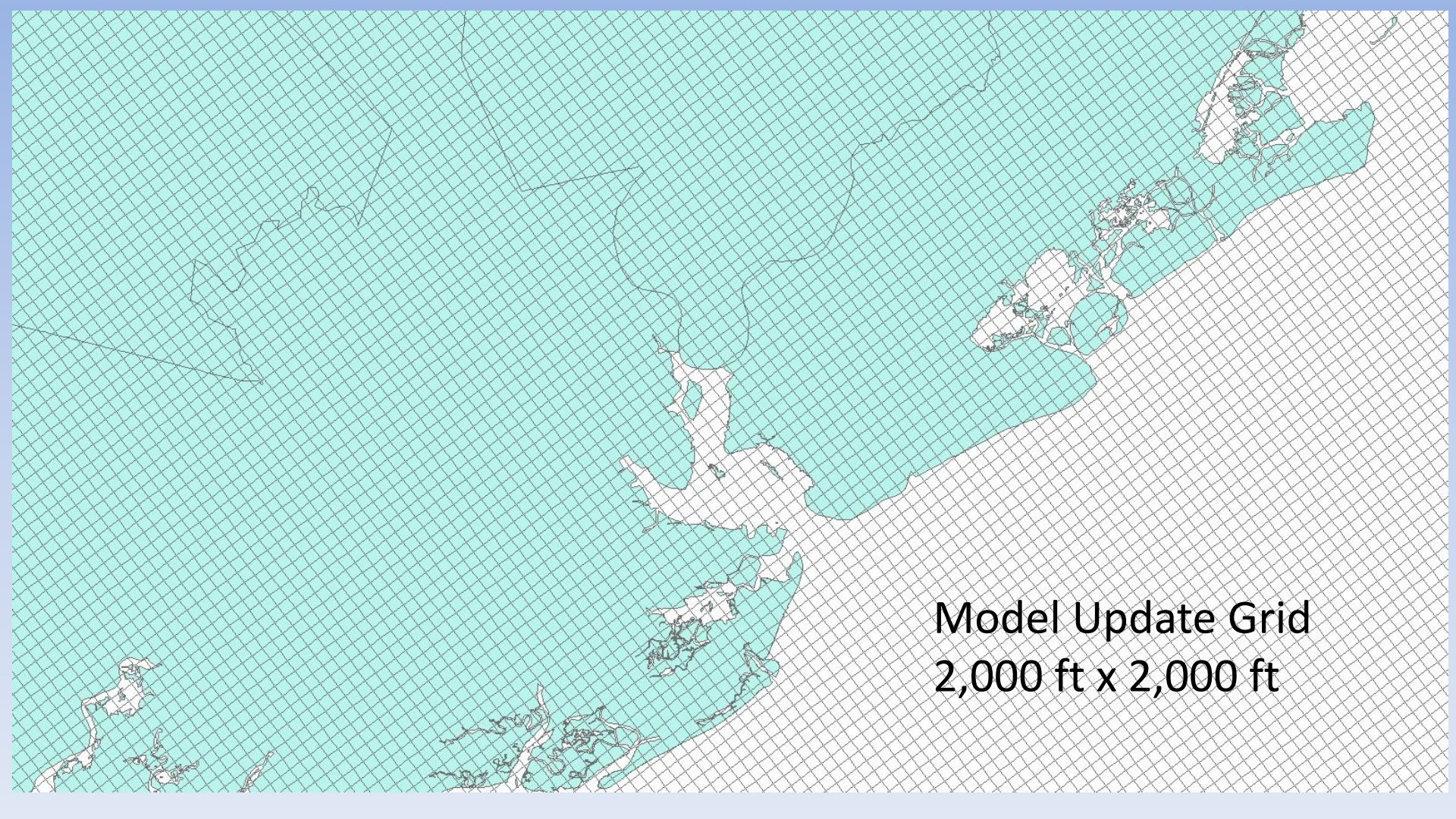




# Updates to the 2004 Groundwater Model

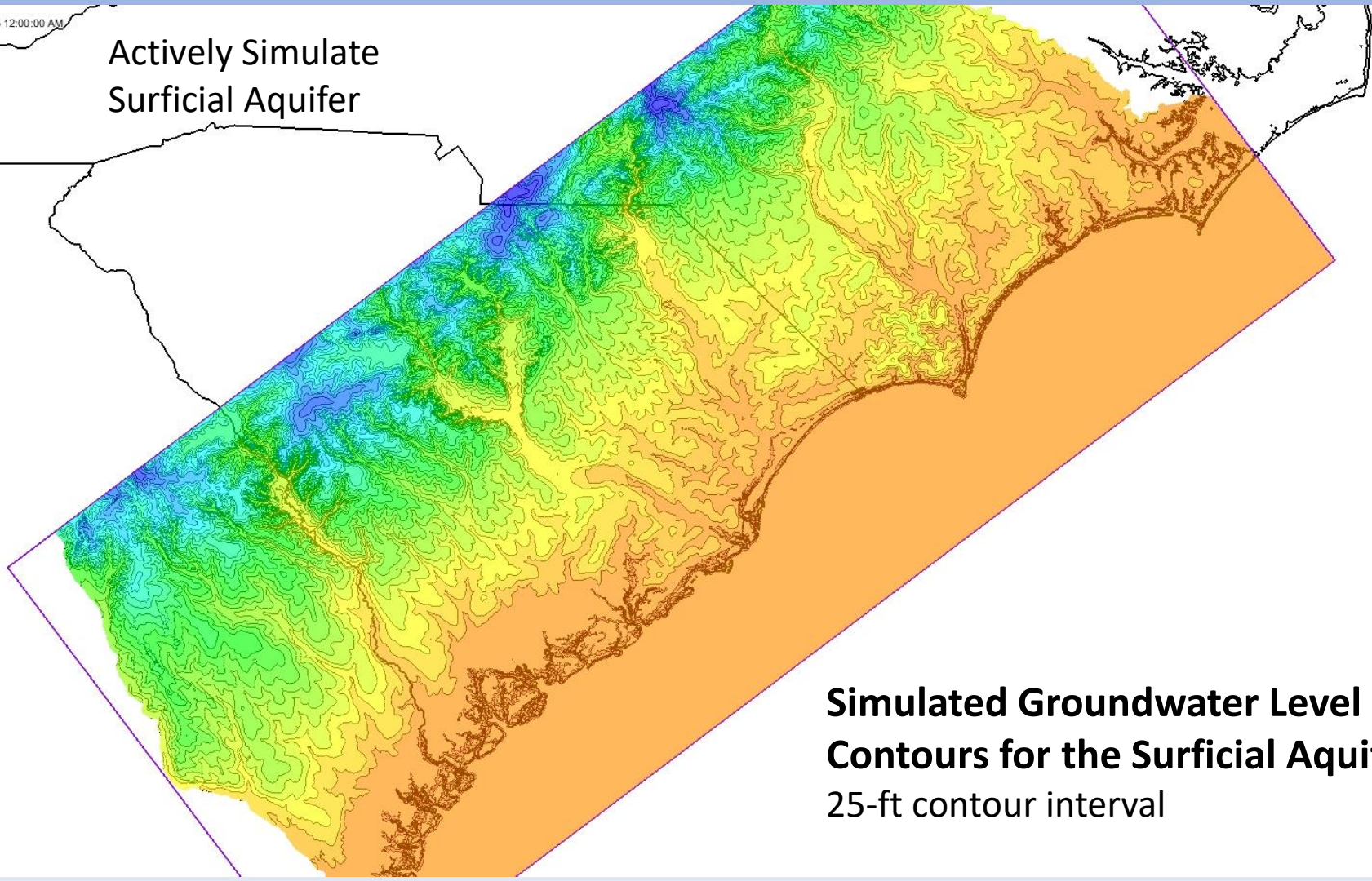
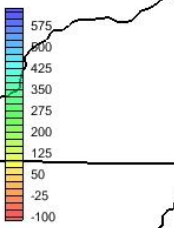


**GWRP Model Grid**  
**10,560 ft x 10,560 ft**



Model Update Grid  
2,000 ft x 2,000 ft

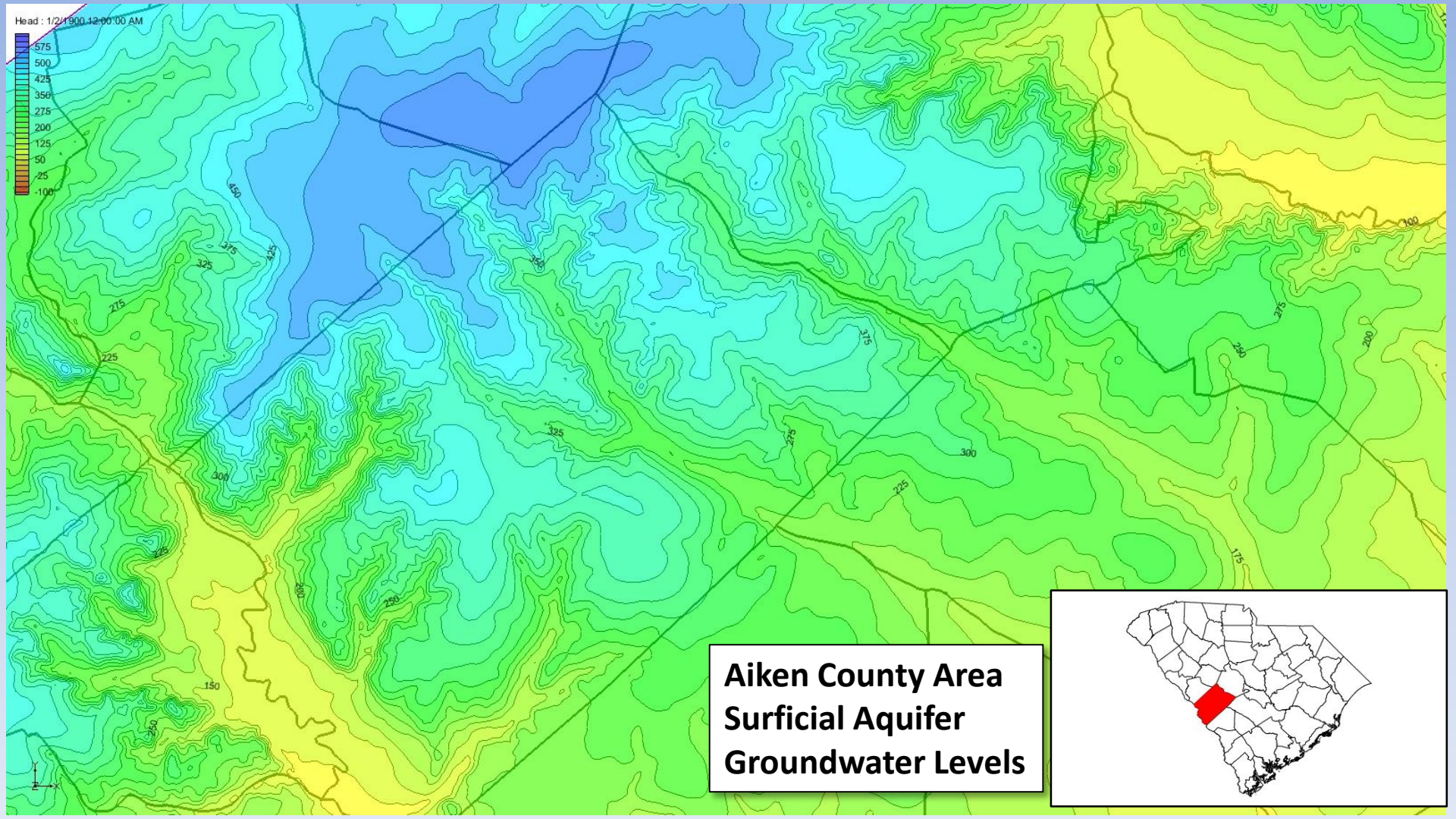
# Actively Simulate Surficial Aquifer



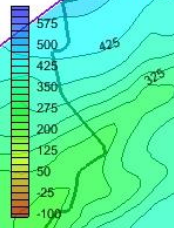
**Simulated Groundwater Level  
Contours for the Surficial Aquifer**  
25-ft contour interval



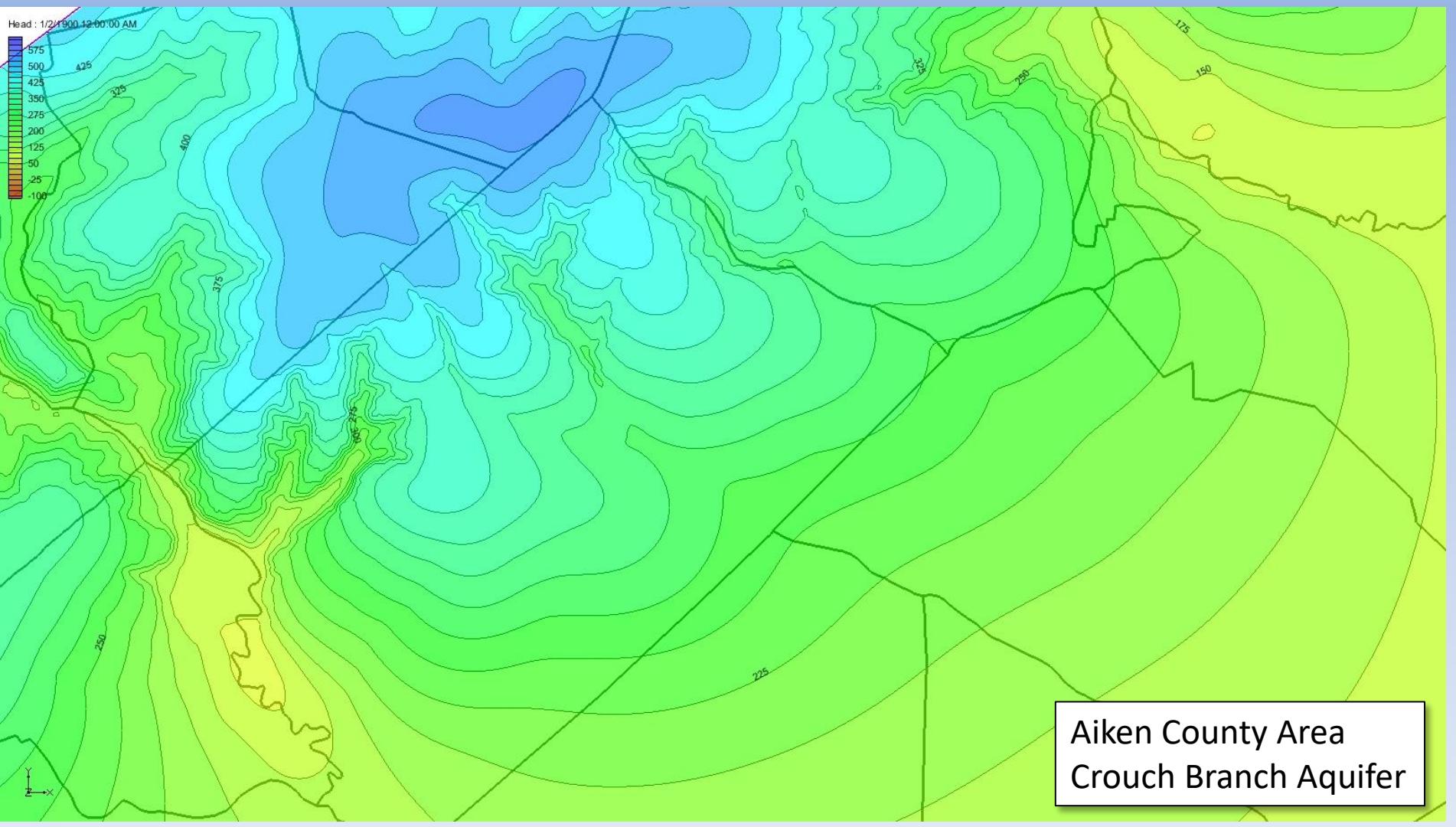


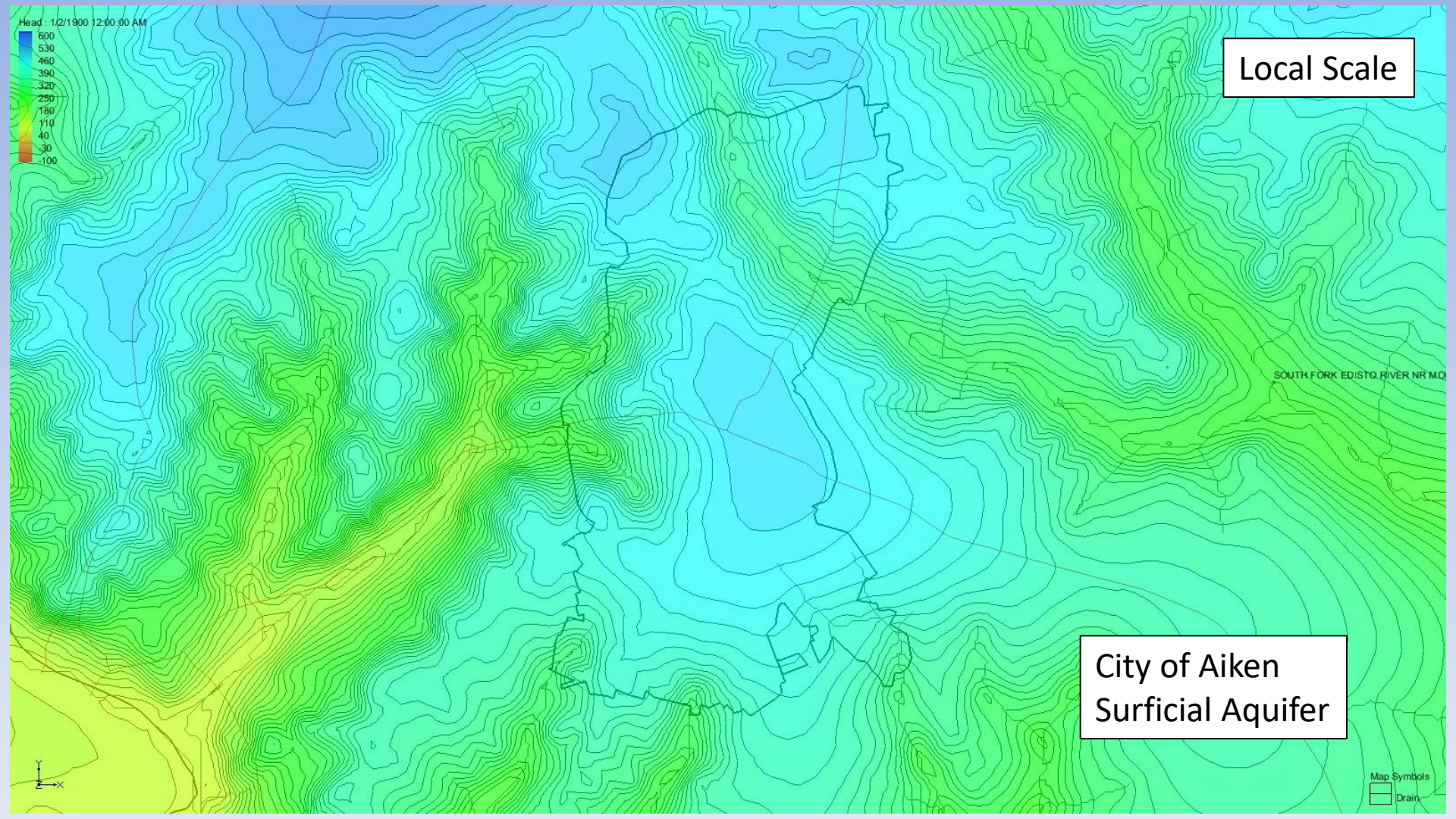


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Aiken County Area  
Crouch Branch Aquifer



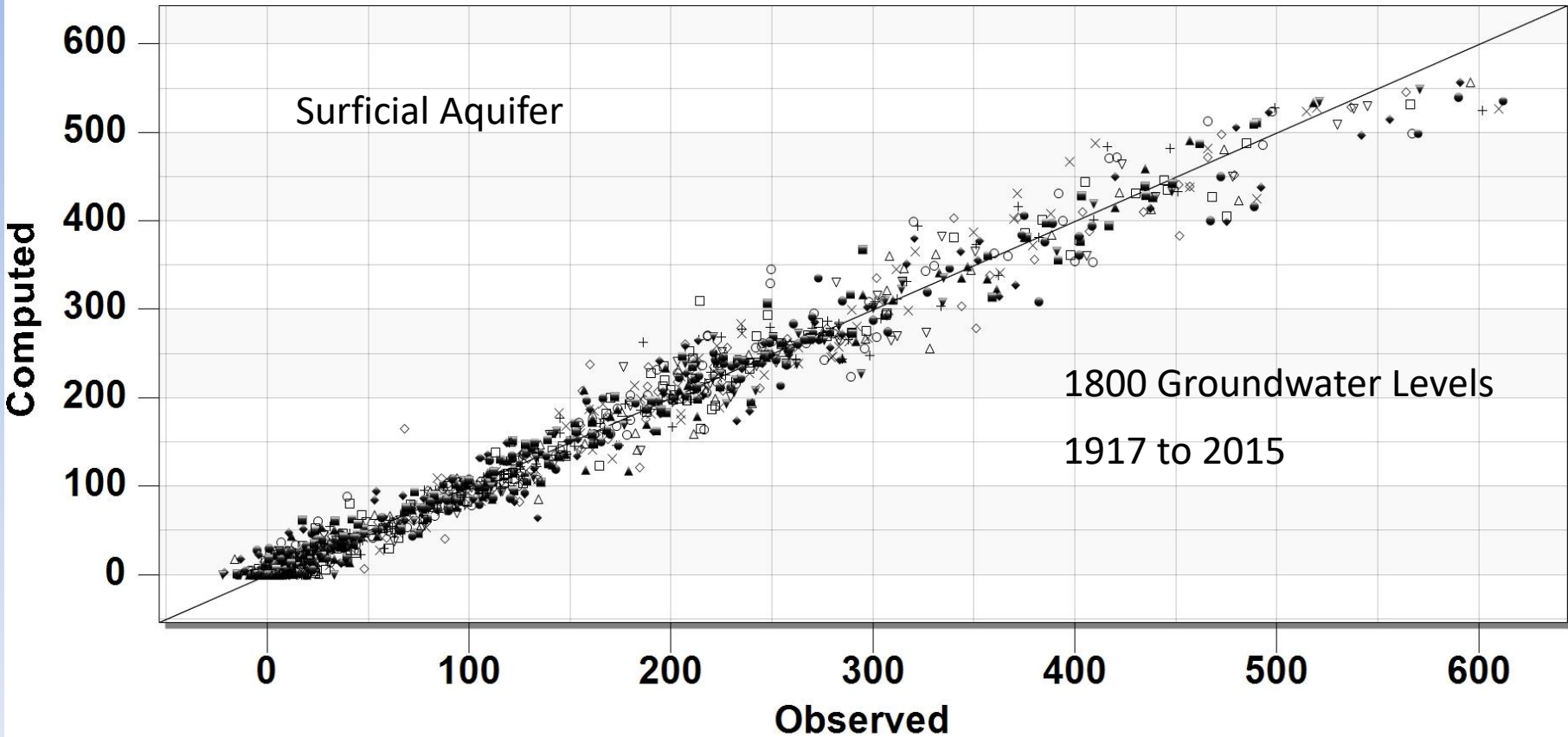


# Model Calibration

- Parameter Estimation (Inverse Modeling)
- 63,000 Groundwater Levels from 1904-2015
- 1685 Annual Base-Flow Calculations from 46 Stream Gages
  - Period of Gaging: 1930's - 2015
- 16 Model Layers – Aquifers and Confining Units

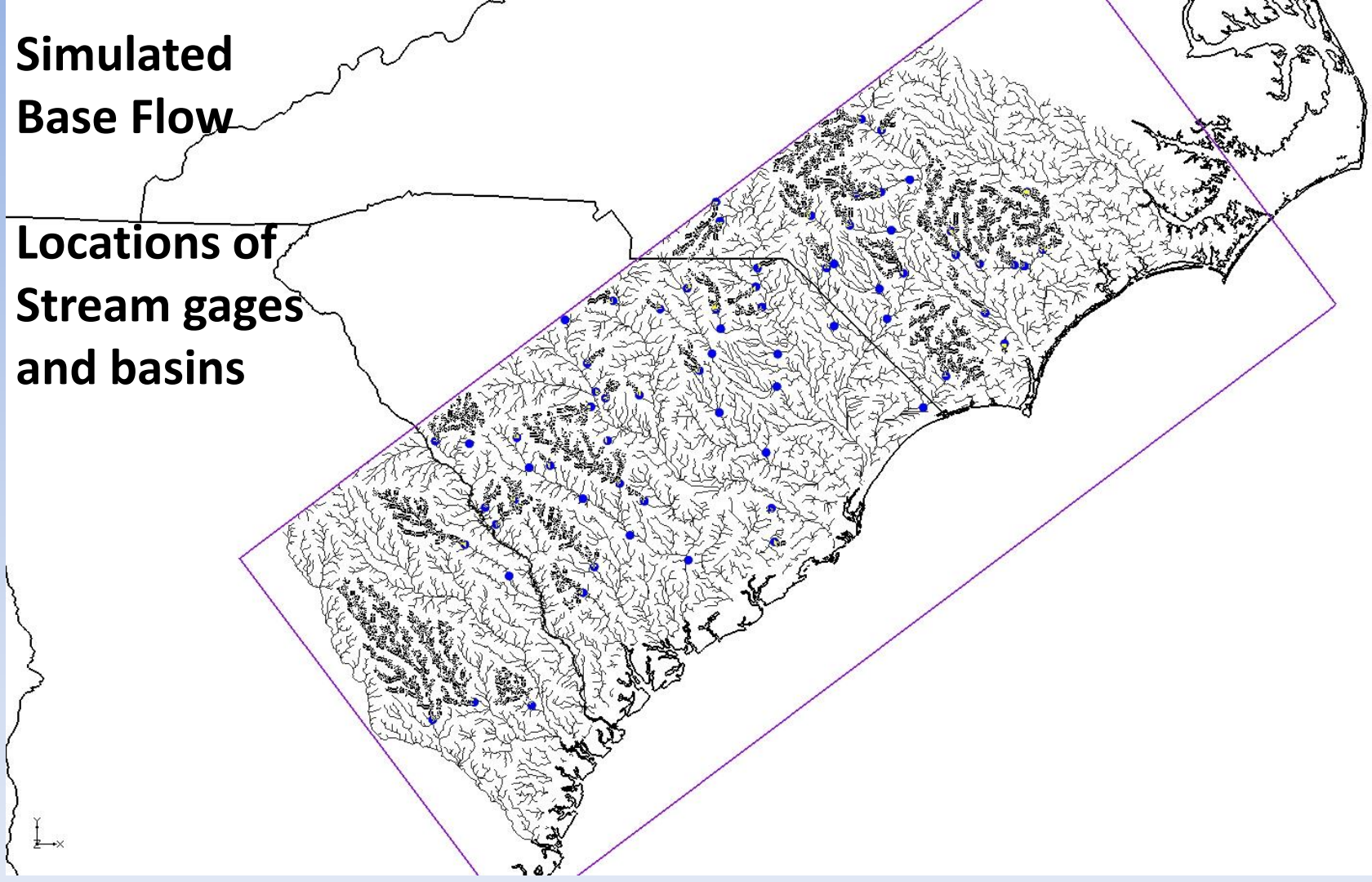
# Computed vs. Observed Values

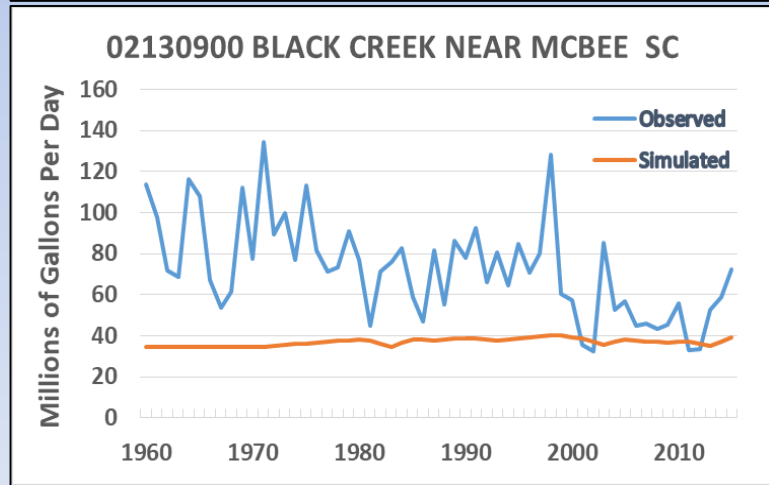
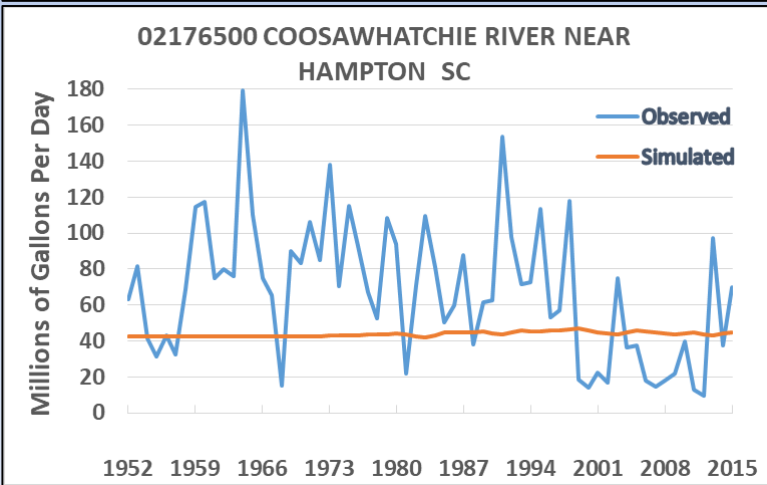
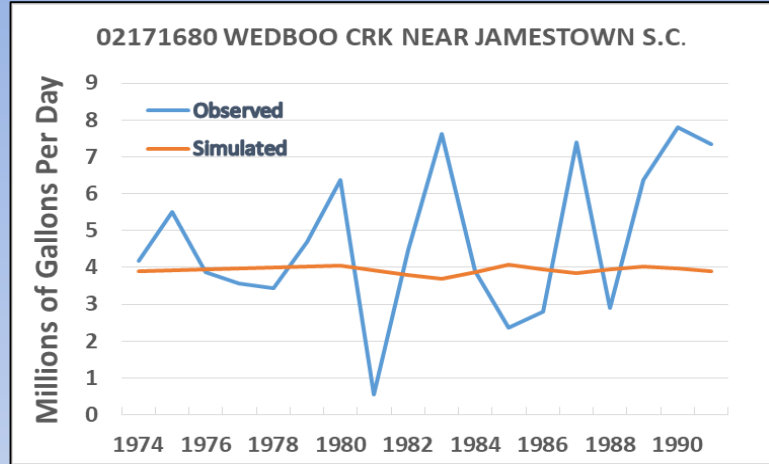
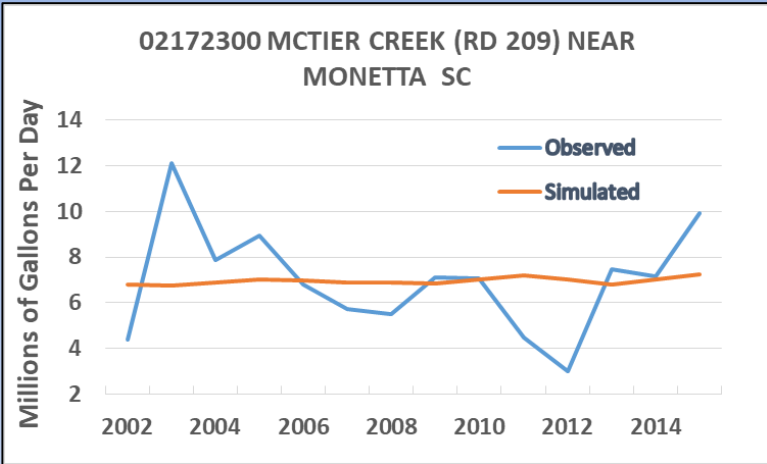
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**Simulated  
Base Flow**

**Locations of  
Stream gages  
and basins**





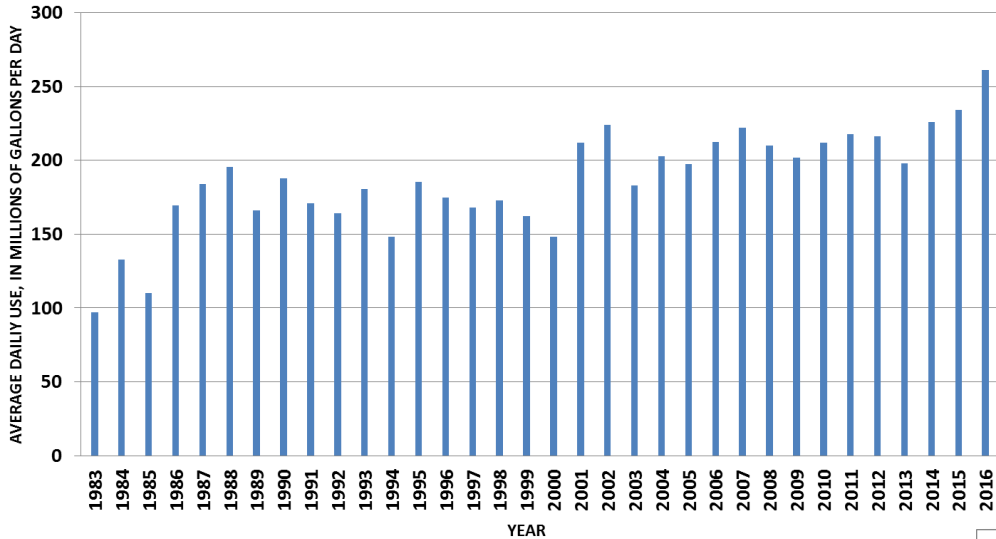
## Groundwater Base-Flow Calibration Examples

# Water-Use Data

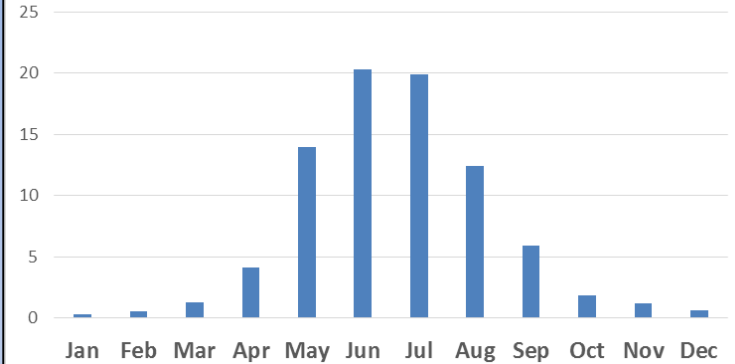


A

South Carolina Coastal Plain Groundwater Use 1983 - 2016



2015 Monthly Irrigation Water Use



## South Carolina Groundwater Use

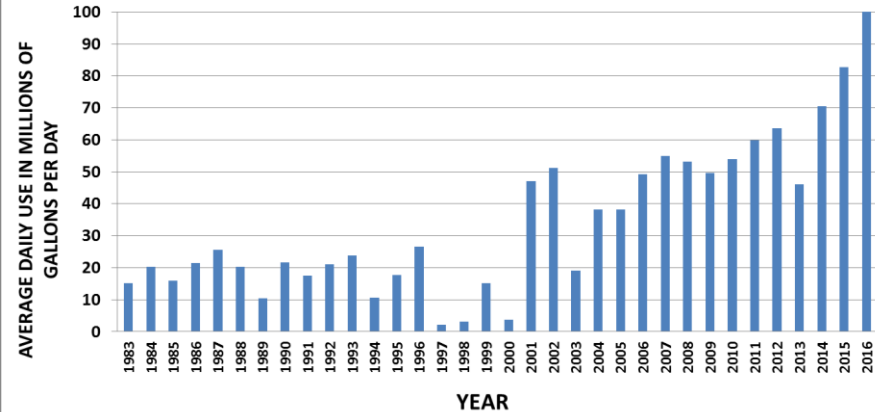
A) South Carolina groundwater use, 1983-2016;

B) Reported irrigation groundwater use, 1983 – 2016.

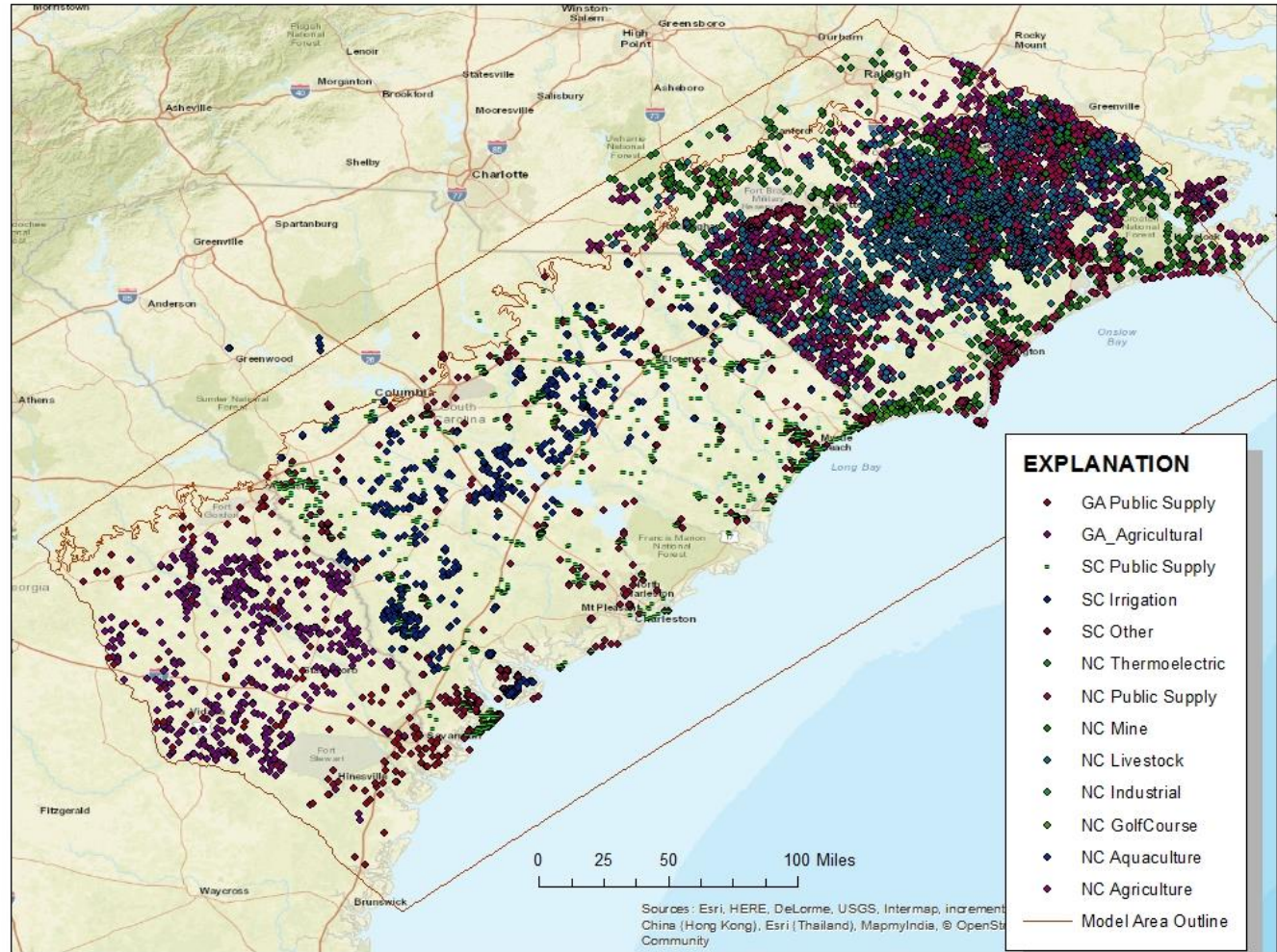


Source of Data - SCDHEC

Reported Irrigation Water Use 1983 - 2016



# Well Locations - Public Supply Irrigation Other



# Climate Variability Simulations

- Future Precipitation and Temperature obtained from Global Climate Models
- Future Land Use from Simulations
- Combined into Soil Water Balance (SWB) Model
- Simulations of Future Recharge will be input into the MODFLOW model

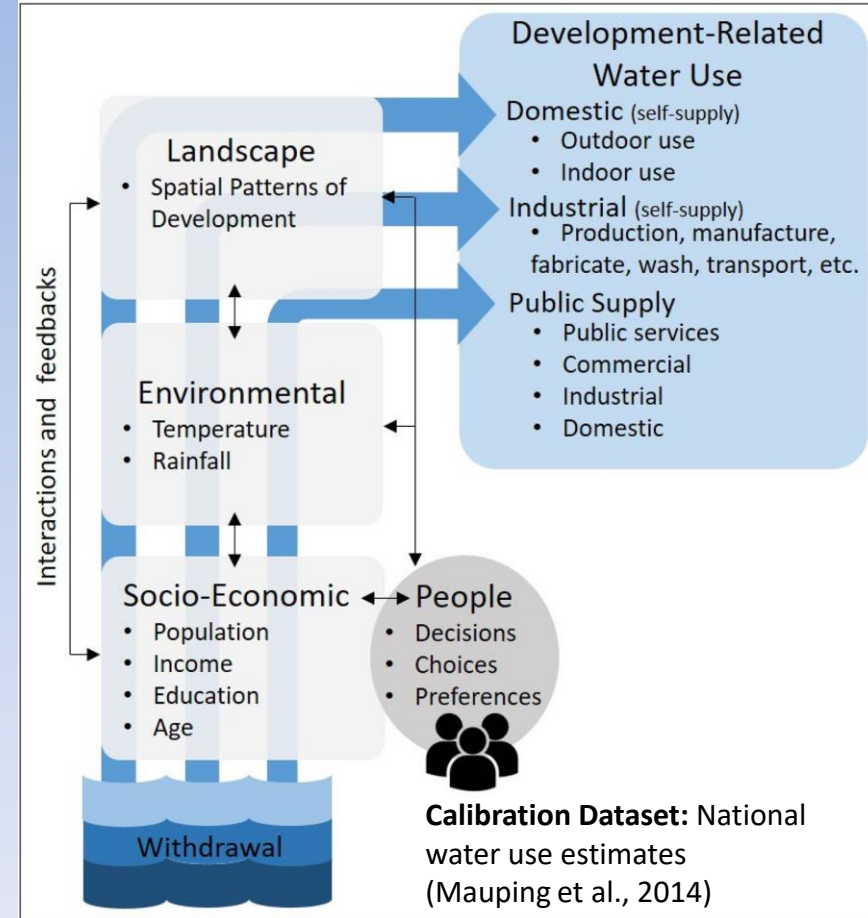
## Groundwater Models

Time		Status Quo	WaterSmart
Present	Current emissions	X	X
<b>2030</b>	High emission	X	X
<b>2065</b>	High emission - Dry	X	X
	High emission - Median	X	X
	High emission - Wet	X	X

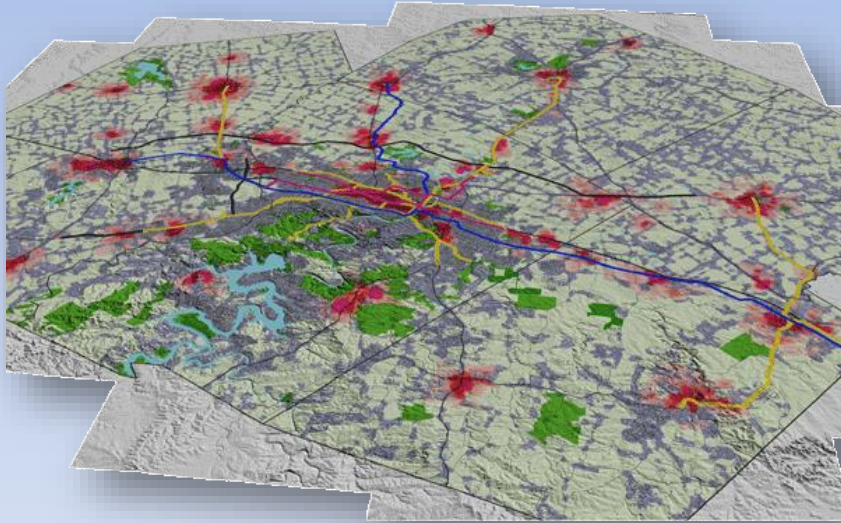
# Forecast urbanization and the associated future water demand

# Conceptual framework

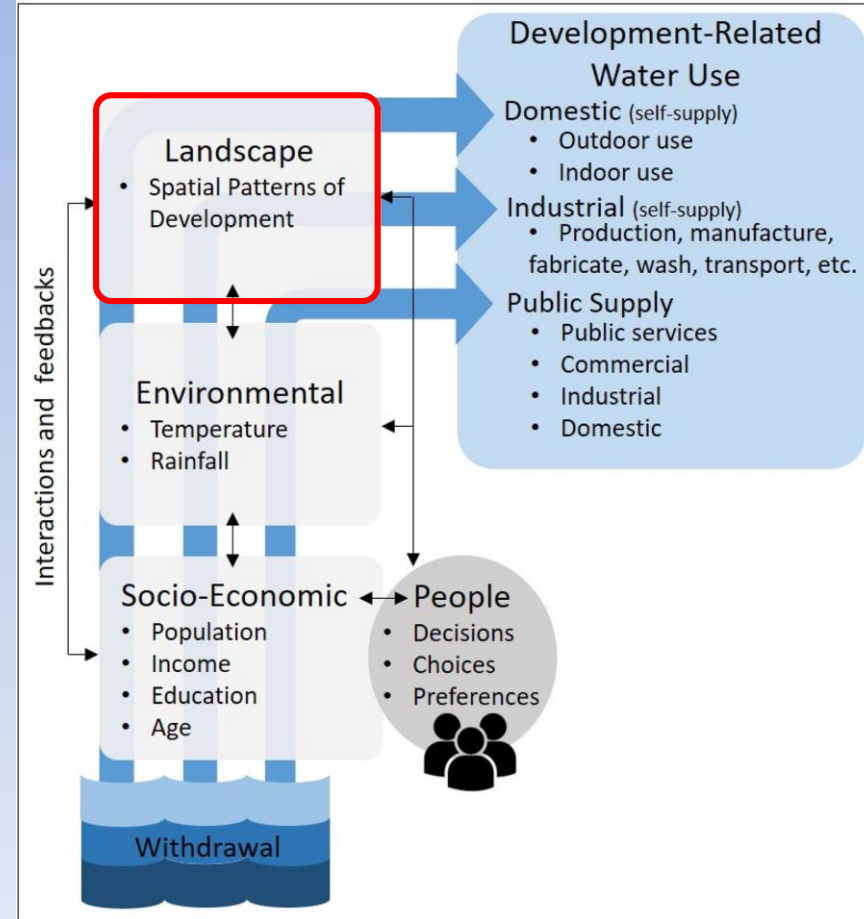
We developed an integrated land- and water-use modeling approach to forecast urbanization and the associated future water demand under different development patterns.



# Land change simulations



**Land change model:** FUTure Urban-Regional Environment Simulation (FUTURES; Meentemeyer et al., 2013).



# Two urbanization scenarios

	Status-Quo
Population	24 M
Per capita land consumption	2.5 people/unit
Spatial patterns of development	historical pattern of growth
Protected areas	N/A

Projected year: 2065

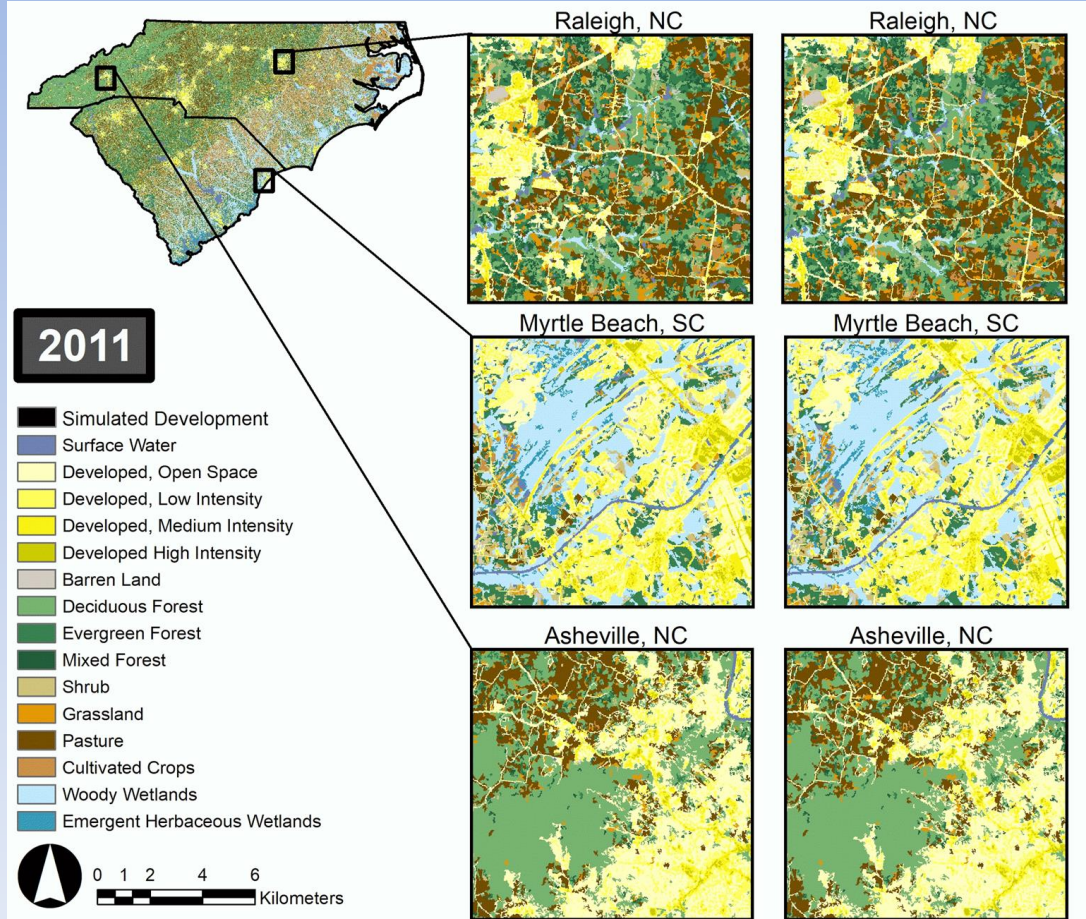
	WaterSmart
Population	24 M
Per capita land consumption	3 people/unit
Spatial patterns of development	infill (simple, cohesive patches)
Protected areas	riparian buffers, wetlands



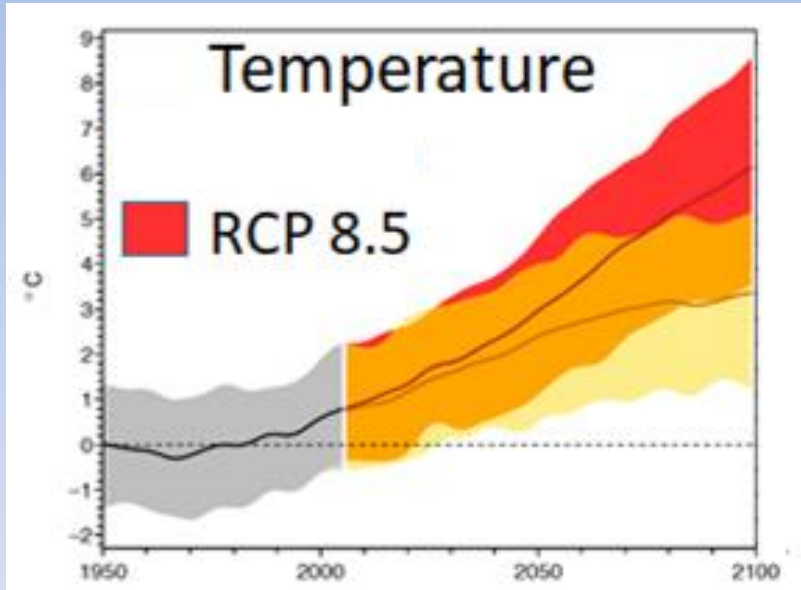
Example simulation of progressive growth to the year 2065 for our two urbanization scenarios.

**Status-Quo**

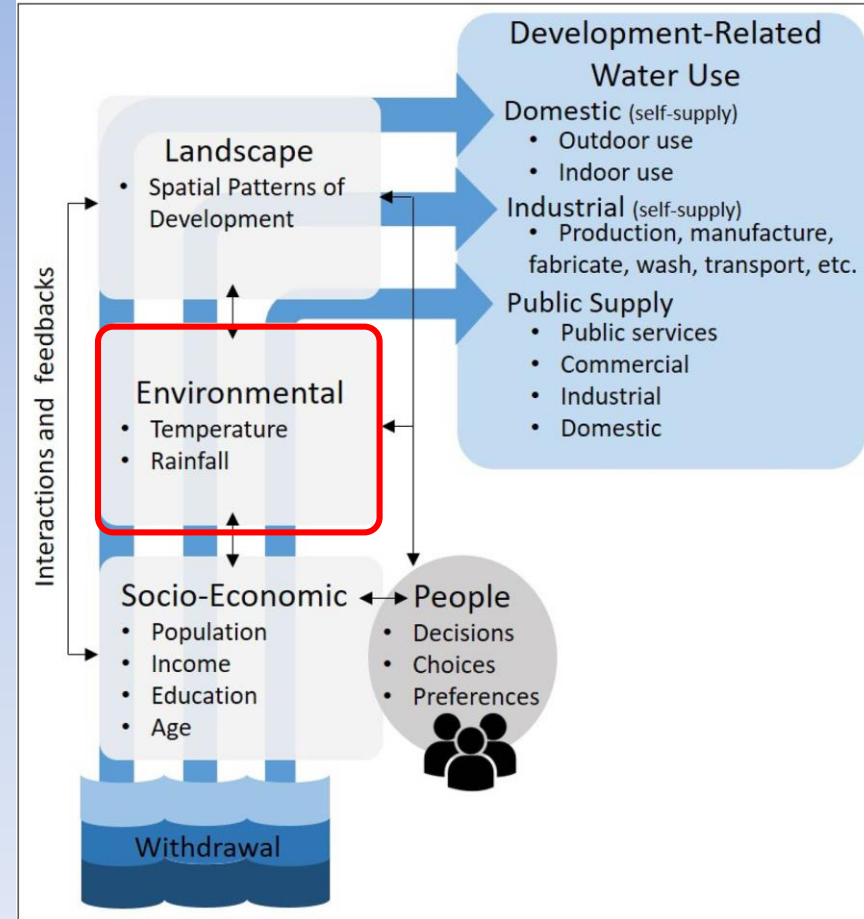
**WaterSmart**



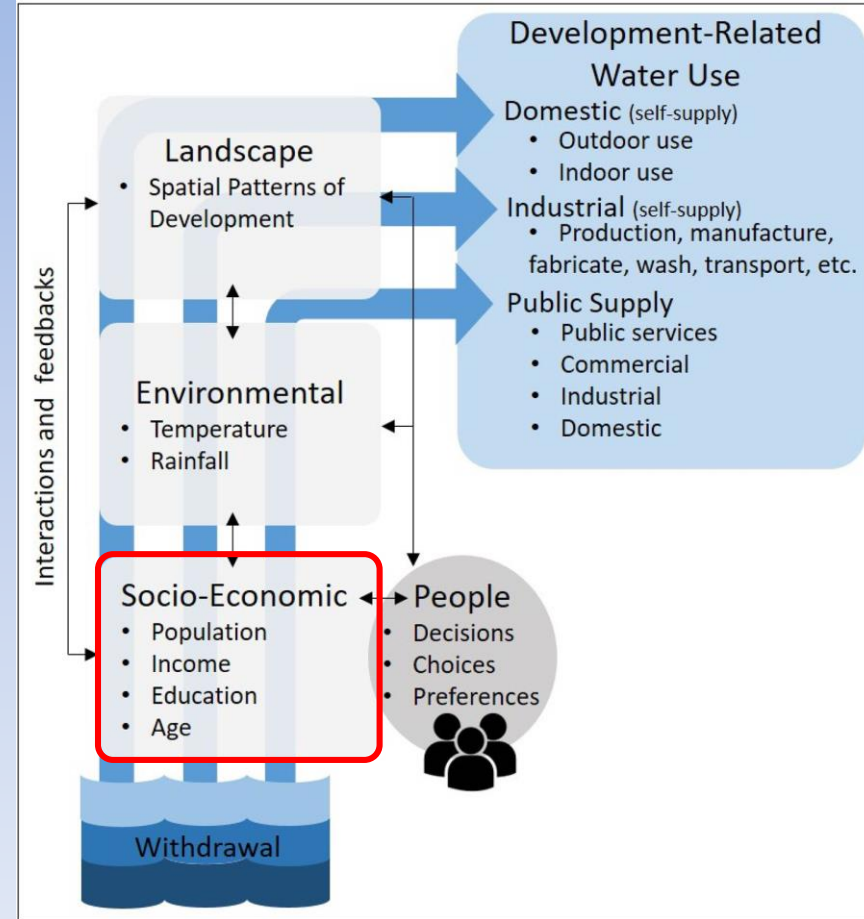
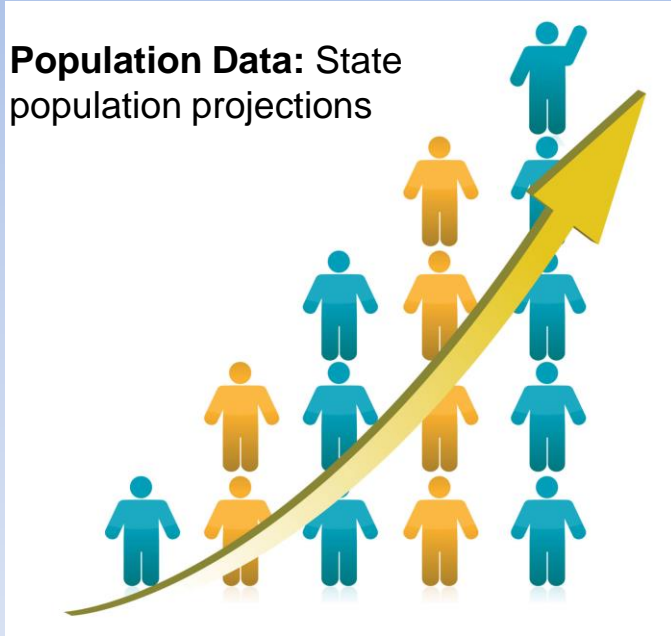
# Emission trajectory



**Climate Data:** MACAv2-METDATA dataset



# Population growth



# Model Uses

- Water Resources Planning
- Evaluate New Well Permits by Regulatory Agencies
- Simulate Potential Future Climate Variability

# Questions?

[bcampbel@usgs.gov](mailto:bcampbel@usgs.gov)

803-750-6161

# Model Scenarios

- Will be determined by the State Cooperators
- Will involve additional potential future withdrawals
- Climate variability
- Projected land use changes



# Focus Area Study / SCDNR Model Update

## Combines funding sources:

- Internal USGS Water Census Program / Focus Area Study
- Cooperative funding from South Carolina Department of Natural Resources/USACOE
- Cooperative funding from South Carolina Department of Health and Environmental Control

## 1) Water Census Program / Focus Area Study:

- Internal USGS funding from the SECURE Water Act
- Southeastern Atlantic Coastal Basins of the Carolinas

## 2) SCDNR/US ACOE Project

Funding to expand groundwater model area to include all of the SC Coastal Plain



# Questions for Stakeholders

- How do you see your future groundwater use changing?
- Do you currently have groundwater-use issues?
- Are you seeing surface water flow problems that could be related to groundwater declines?
- Are you dealing with groundwater quality problems – such as radium or man-made contaminants?
- Do you know the age of your groundwater?



# South Carolina Water Plan

South Carolina Department of Natural Resources

## Recommendation:

*“A comprehensive ground-water flow model of the Coastal Plain should be developed and used to predict the effect of future pumping and to determine optimal well spacing's.”*



# South Carolina Water Plan

Second Edition

South Carolina Department  
of Natural Resources

Land, Water and Conservation Division

