

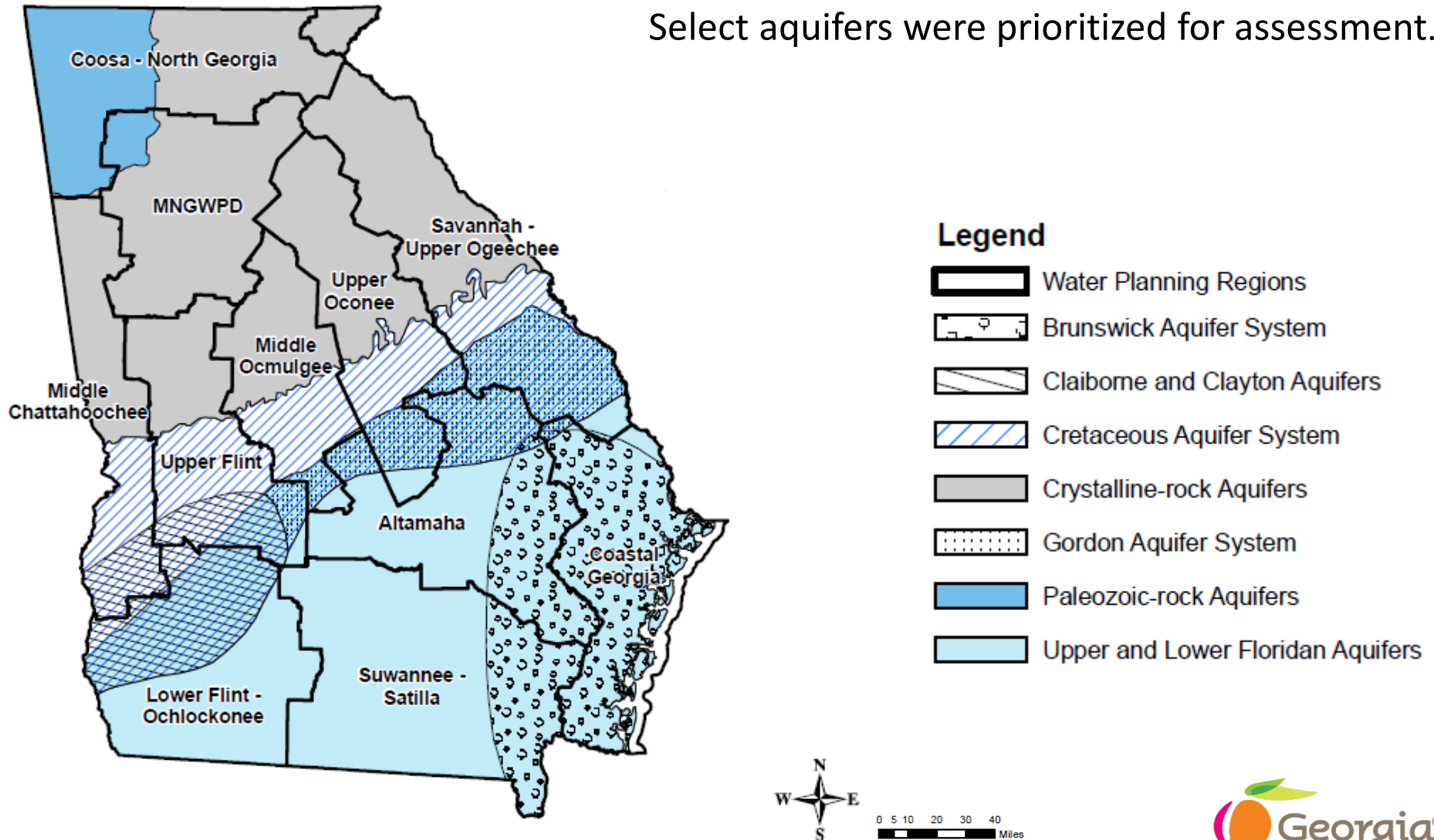
# Georgia EPD Updates – Groundwater Resource Assessment

Christine Voudy, Georgia EPD



# Water Planning Regions and Georgia's Aquifers

Select aquifers were prioritized for assessment.



# Sustainable Yield

- Amount of groundwater that can be withdrawn without causing unwanted results.
- Metrics were established
  - Drawdown between pumping wells not to exceed 30 ft.
  - Reduction in aquifer storage does not go beyond a new base level.
  - Groundwater recovers between periods of higher pumping.
  - No more than 40% reduction in stream baseflow
  - Groundwater levels do not go below top of confining layer.

# Prioritized Aquifers Selected for Groundwater Resource Assessment

**Ridge & Valley Region:**

**Paleozoic-rock Aquifer Study Basin**

**Blue Ridge & Piedmont Regions:**

**Crystalline-rock Aquifer Study Basins**

**Coastal Plain Region Aquifer Study Basins:**

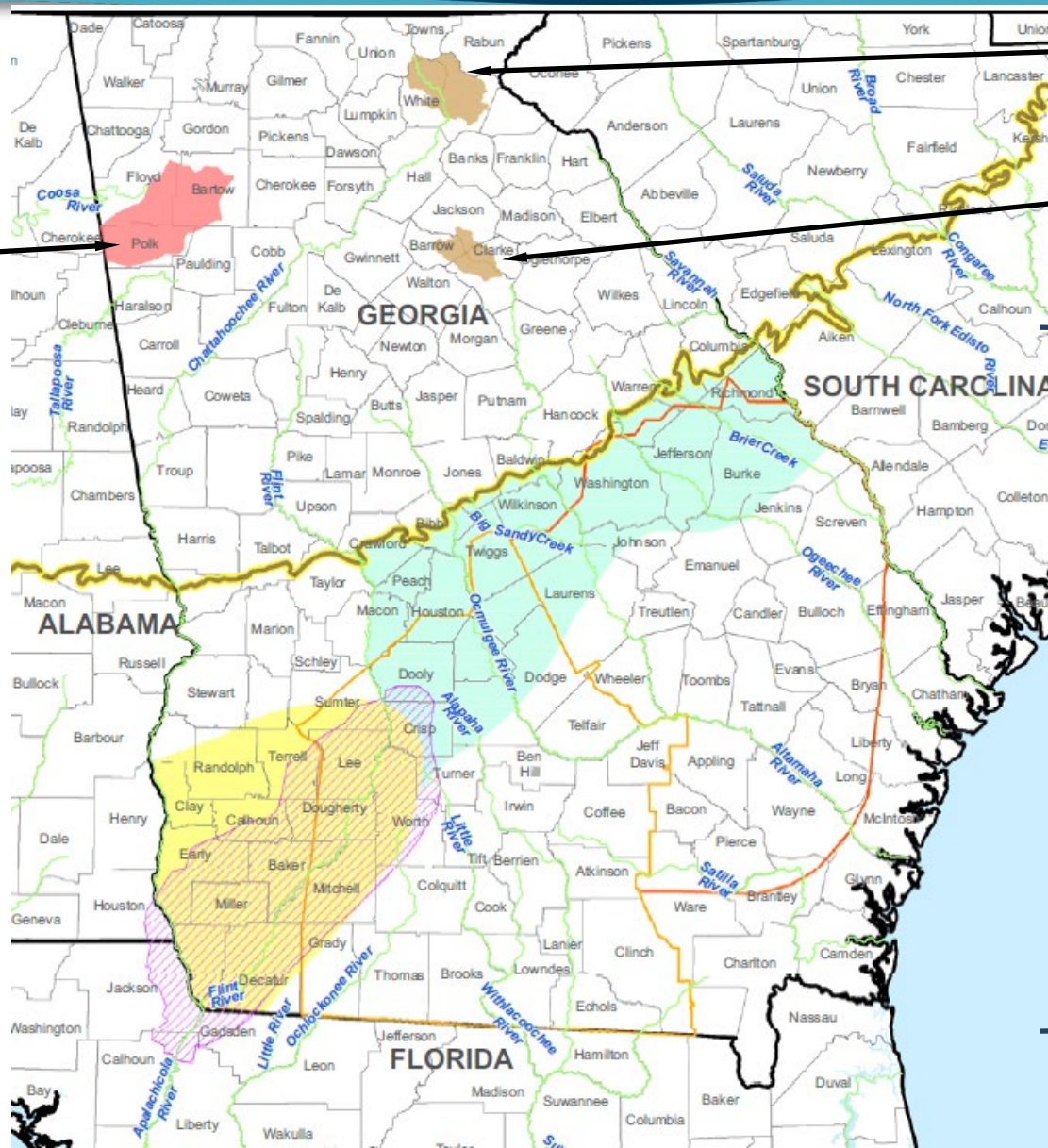
 **Upper Floridan: Eastern Coastal Plain**

 **Upper Floridan: South Central GA**

 **Upper Floridan: Dougherty Plain**

 **Cretaceous**

 **Claiborne**



# Crystalline Rock Aquifer

## Water Budget Approach

- Most appropriate way to provide a planning level assessment of groundwater resource sustainability this region of the State.
- Is an accounting of water movement within the hydrologic cycle, both natural and artificial.
  - $\text{Net gw consumption} = \text{gw withdrawals} - \text{gw recharge}$
- By comparing net groundwater consumption to the sustainable yield criteria, estimates of net groundwater availability were developed.

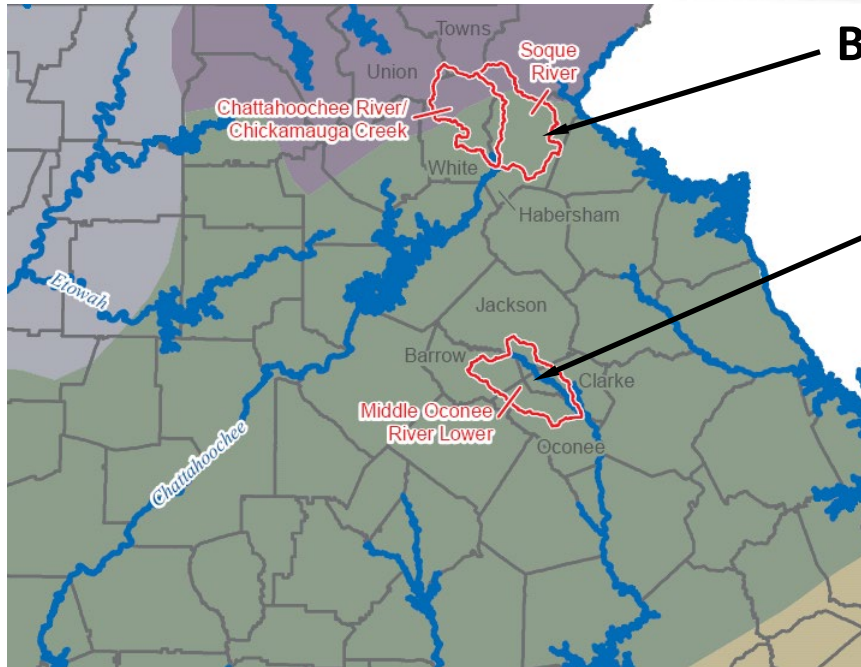
# Crystalline Rock Aquifer Study Basins

## Estimated Range of Sustainable Yield

- Because the water budget focuses on streamflow as the primary estimator of recharge and groundwater availability a variant of the Tennant Method was used to estimate sustainable yield.
- Daily streamflow data from the period 1989 – 2008 were used to calculate the mean annual streamflow and baseflow and a range of streamflow and baseflow reduction amounts (40% to 60%) were evaluated.
- The 50% mid-level streamflow was chosen as the criterion to estimate the net amount of groundwater available for use.



# Crystalline Rock Aquifer Water Budget Modeling Approach



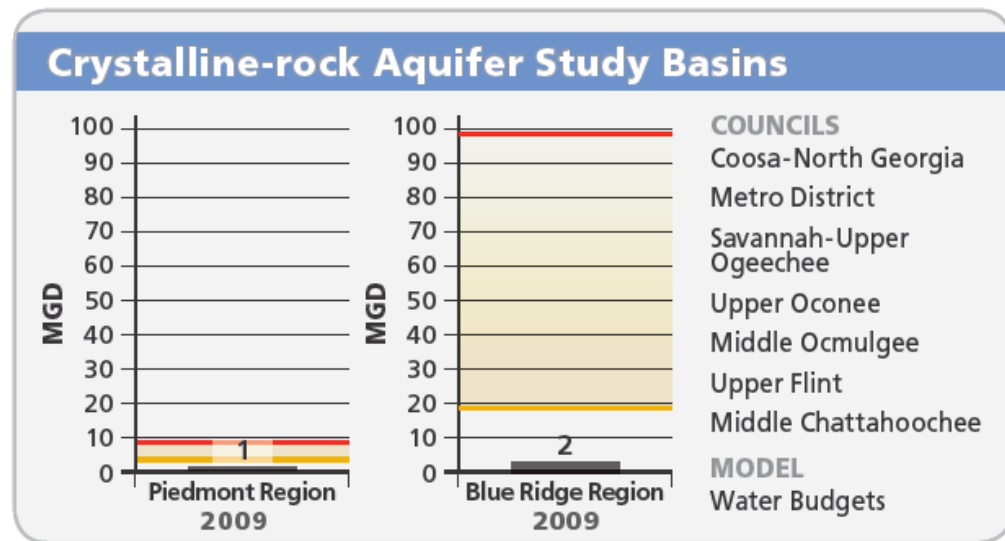
Blue Ridge Region

Piedmont Region

Forecasted Demands Crystalline Rock  
Aquifer:

2020 – 2.770 MGD

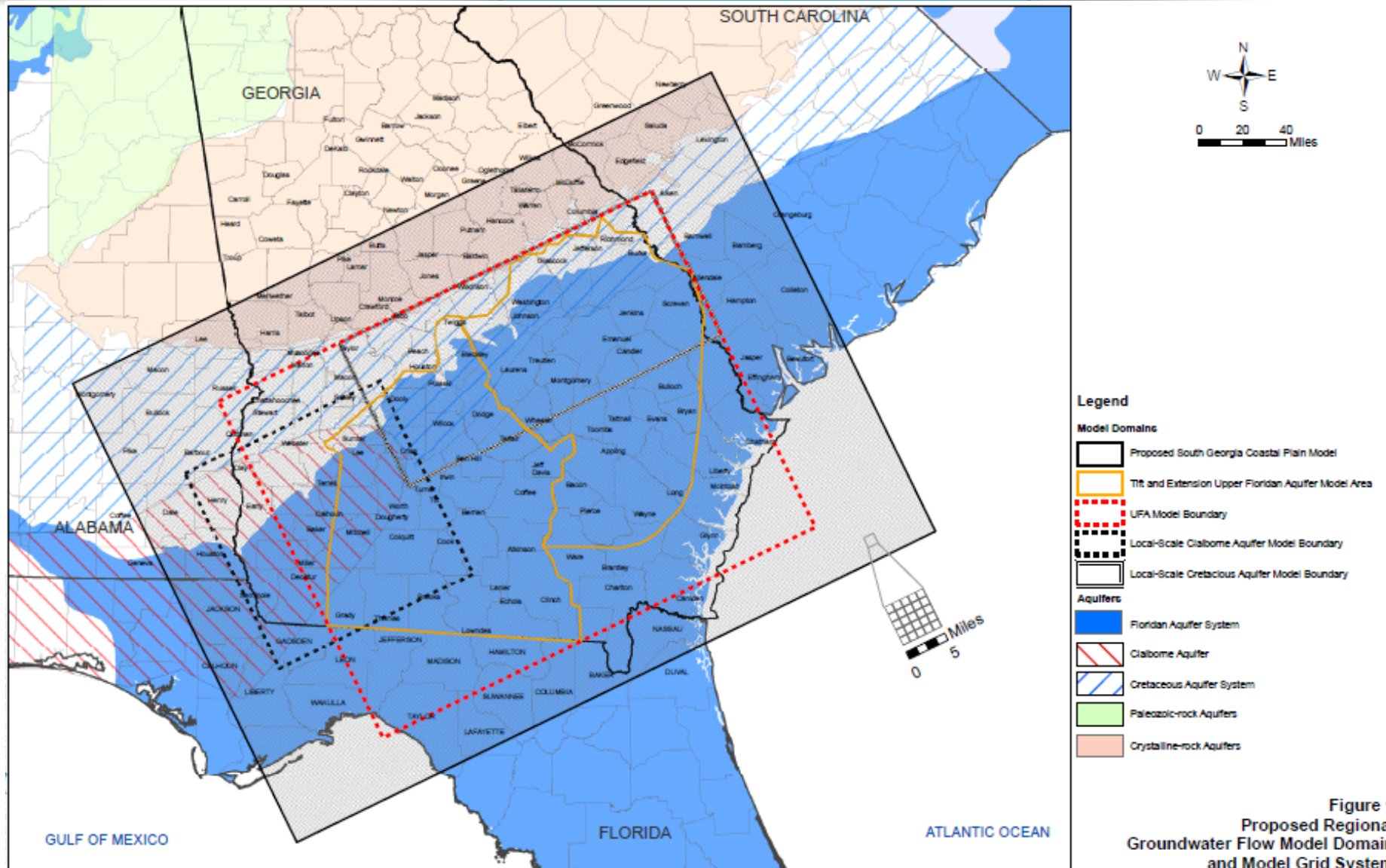
2060 – 4.871 MGD



Range of Sustainable Yield

Projected Demand in 2009

# Regional Coastal Plain Model and Select Sub-Regional Model Domains – 2011 Plan





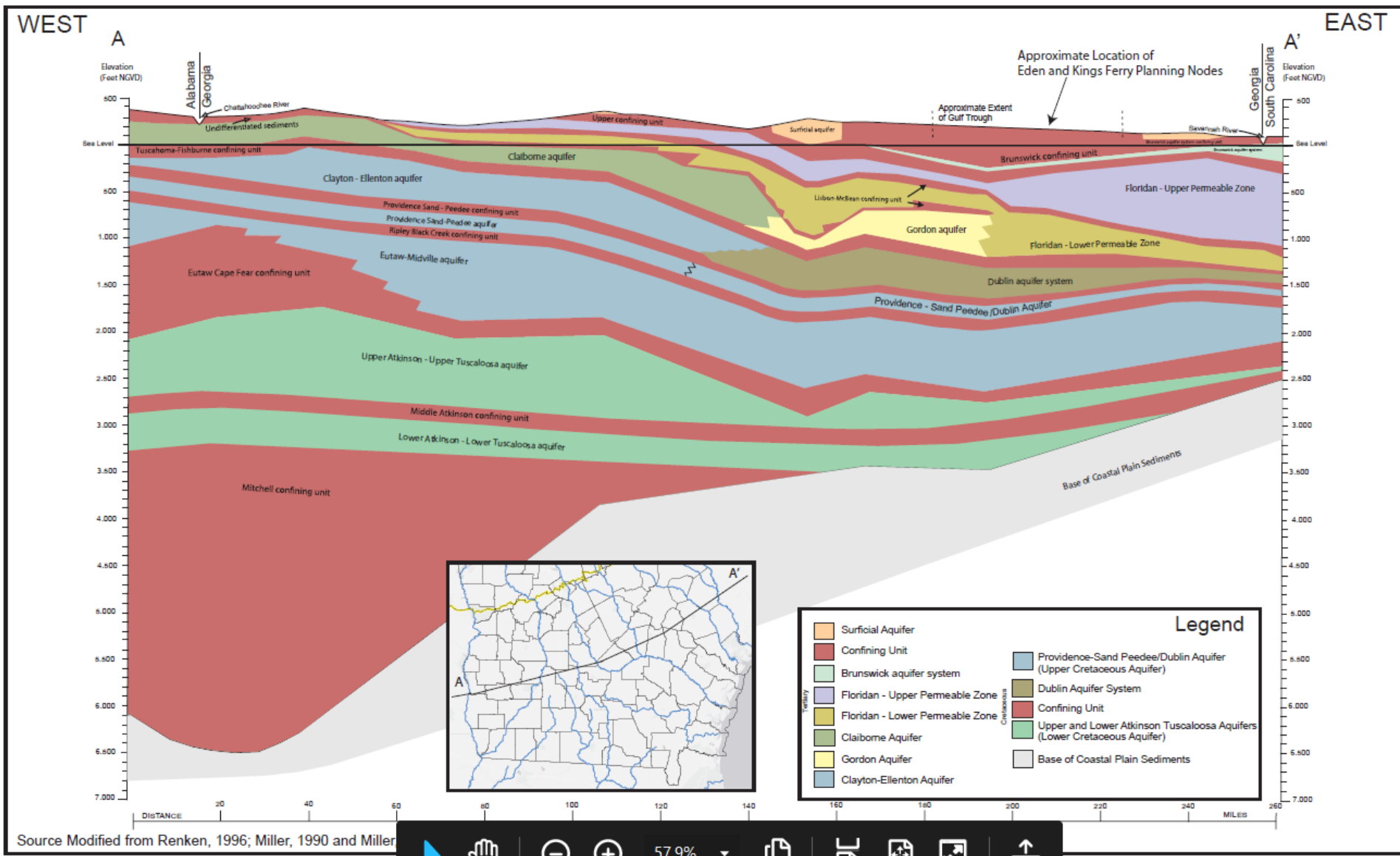
# Regional Coastal Plain Model

- MODFLOW three-dimensional finite difference model.
- Seven model layers depict prioritized aquifers
  - Layer 1 - Surficial
  - Layer 2 – Floridan
  - Layer 3 – Claiborne
  - Layer 4 – Clayton
  - Layers 5-7 - Cretaceous Sand
    - Providence
    - Eutaw-Midville
    - Upper/Lower Atkinson
- Grid spacing of model is 1-mile by 1-mile and all properties are centered.

# Regional Coastal Plain Model

- Model was run in steady-state mode.
- Model depicts all permitted well locations and pumping rates within the Georgia Coastal Plain.
- Baseline withdrawals
  - Municipal and Industrial pumping rates were provided by EPD.
  - No pumping data available on Ag wells, so pumping rates were estimated based on USGS water use data from 2000 to 2005. These were estimated by County.
  - Included withdrawals from portions of aquifers in AL, FL, and SC within model domain.

# Cross-Section of Hydrogeologic Units – Regional Coastal Plain Model



# Round 1 - Sustainable Yield Estimates

- Low end – Uniformly increase simulated withdrawals from existing well locations until criteria is met.
- High end – Non-uniformly increase simulated withdrawals from existing and hypothetical wells until criteria is met.
- Sustainable yield assumes withdrawals from aquifer are increased while withdrawals from other aquifers held constant.



# Cretaceous Aquifer Between Macon and Augusta

Low End of SY = 347 mgd  
High End of SY = 445 mgd

Savannah-Upper Ogeechee  
current use and forecasted  
demands:

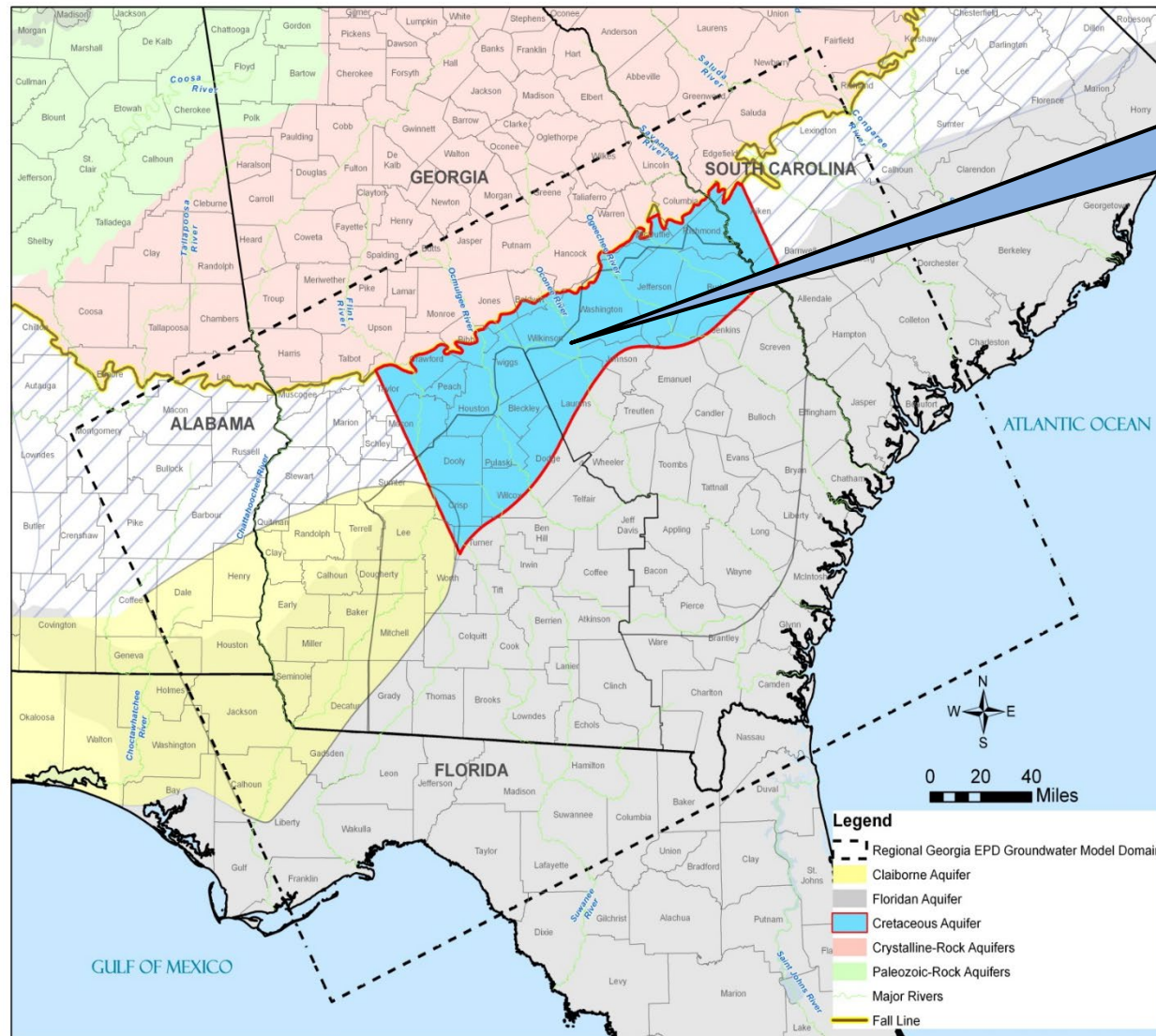
2020 – 54 mgd

2060 – 56 mgd

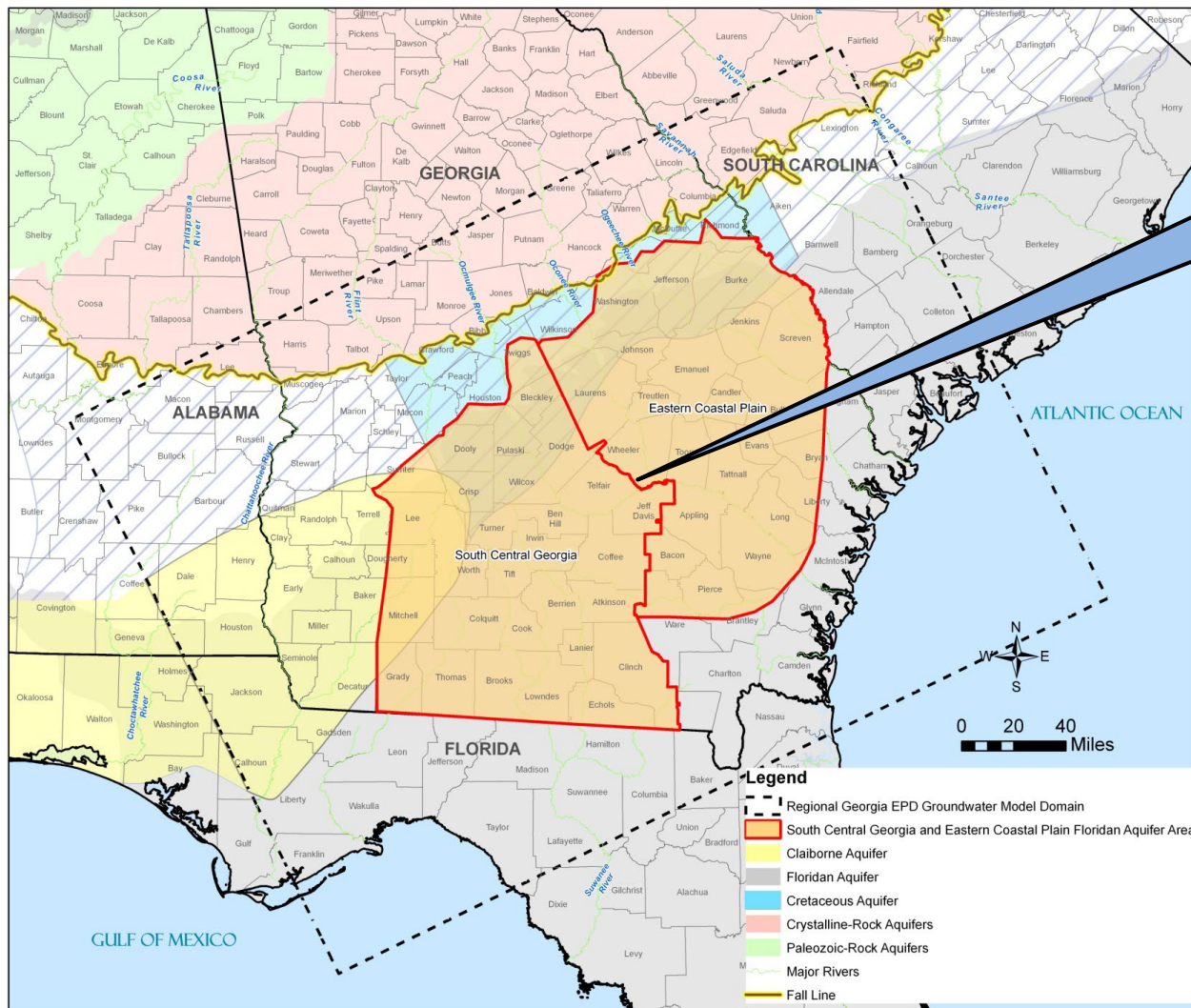
Aquifer-wide demand:

2020 – 170 mgd

2060 – 227 mgd



# Upper Floridan Aquifer – South Central and Eastern Coastal Plain



Low End of SY = 868 mgd  
High End of SY = 982 mgd

Savannah-Upper Ogeechee  
Current use and forecasted  
demands :

2020 – 39 mgd

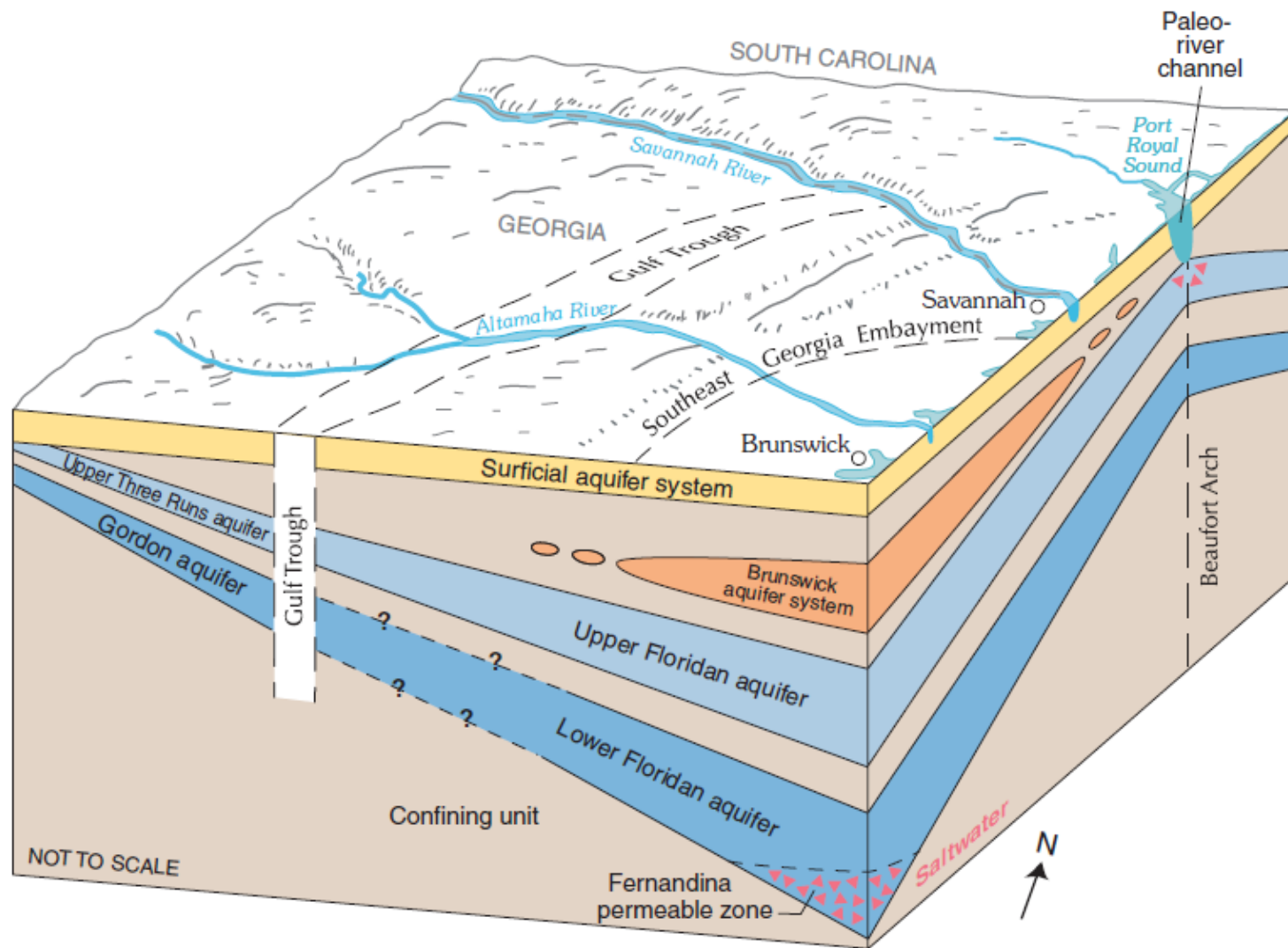
2060 – 48 mgd

Aquifer-wide demand:

2020 – 708 mgd

2060 – 913 mgd

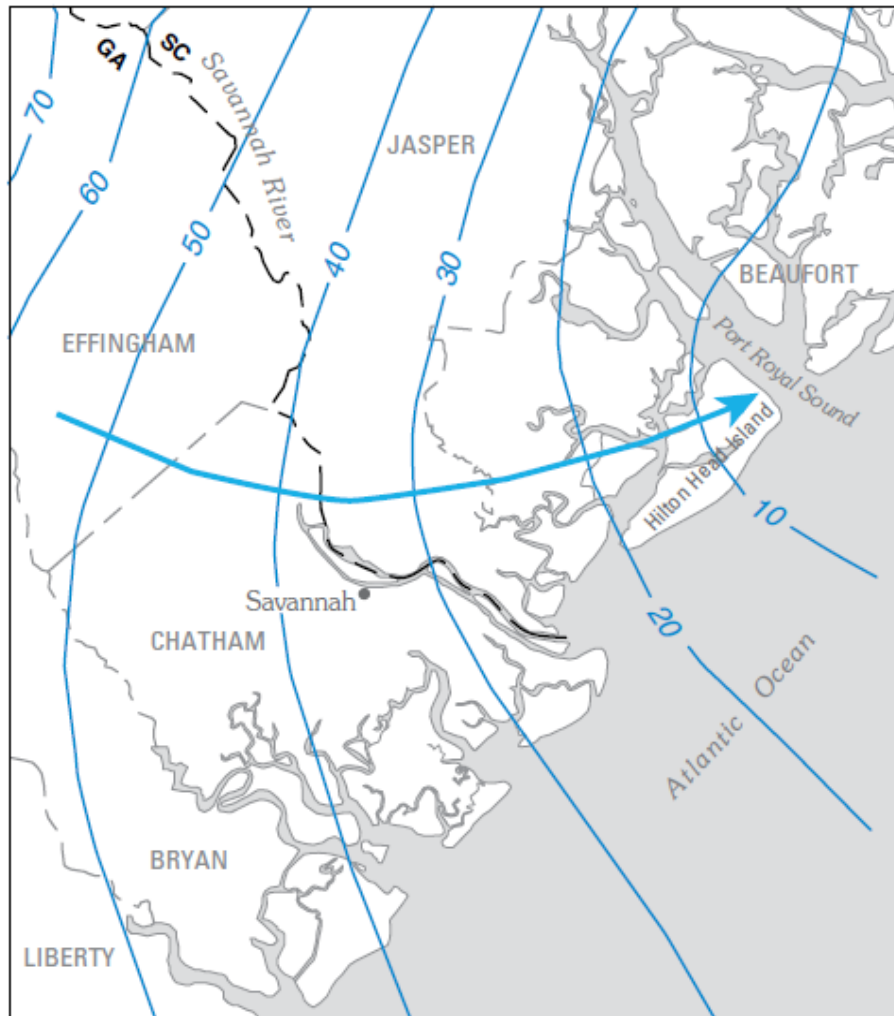
# Coastal Georgia Aquifers



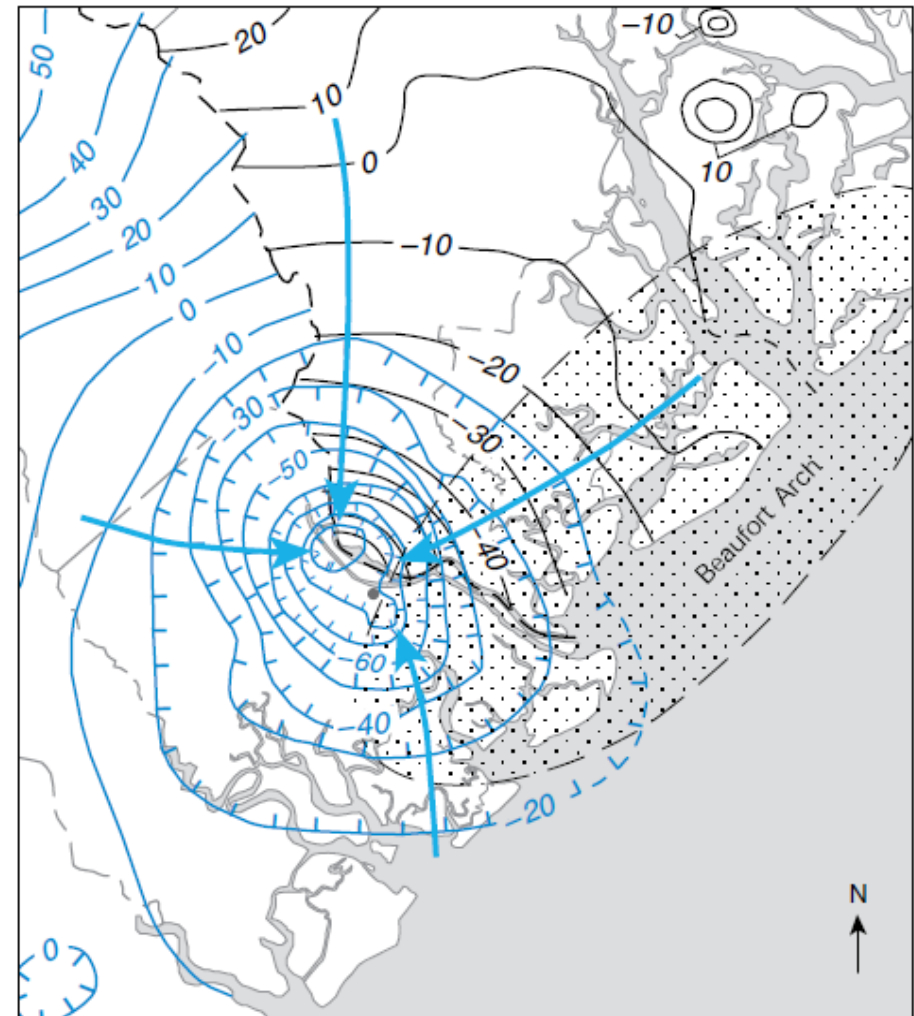


# Upper Floridan Potentiometric Surface

**A. Predevelopment**



**B. May and September 1998**



Base from U.S. Geological Survey  
1:100,000 and 1:250,000-scale data

USGS SIR 2006-5058

0 5 10 15 MILES  
0 5 10 15 KILOMETERS



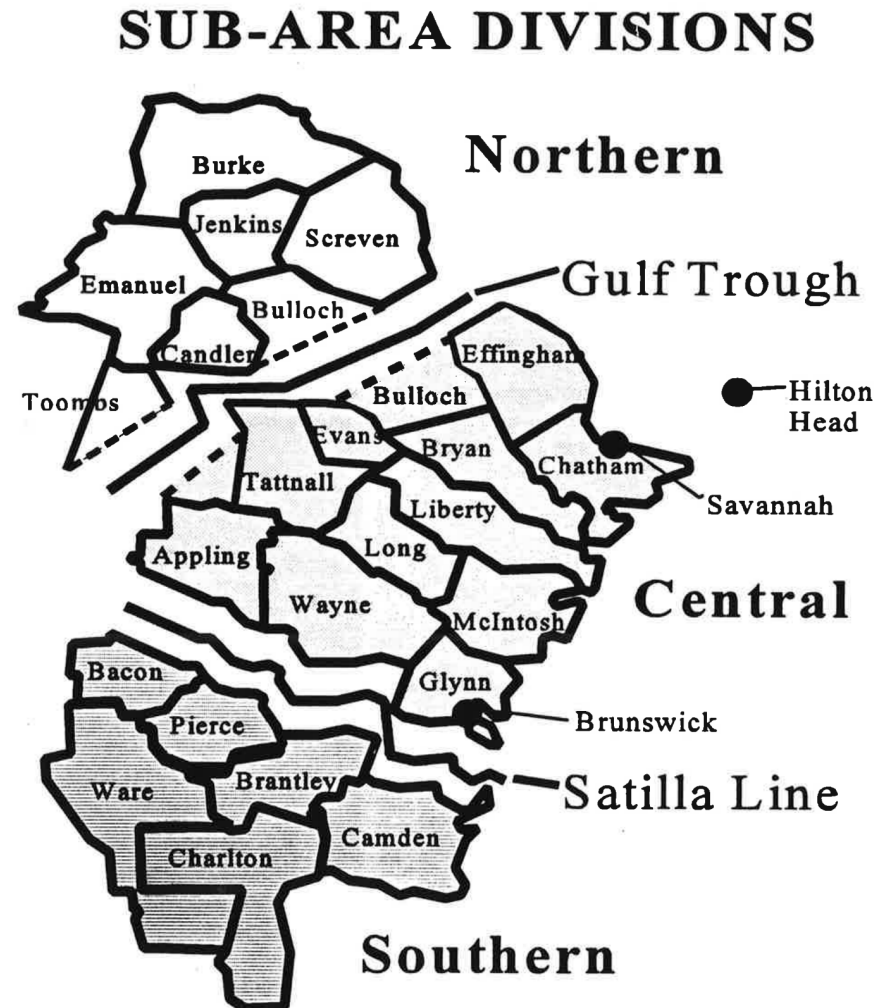
# Coastal Groundwater Use History

- 1960s and 1970s – Concerns about saltwater intrusion near Savannah and in Brunswick.
  - A saltwater wedge found on northern end of Hilton Head Island.
  - Eastern end of Bull Island – Some wells had higher salinity levels.
  - Saltwater from deeply buried brines was entering the Floridan aquifer in Brunswick, Ga.
- 1980s and 1990s
  - South Carolina DHEC and Georgia EPD begin discussions on Floridan Aquifer use.
  - Initial restrictions on withdrawals in Chatham County implemented
- 1995 – April 1997 – Development of and Release of the Interim Strategy for Managing Saltwater Intrusion in the Upper Floridan Aquifer in Coastal Georgia (Interim Strategy).
  - Impacted 24 Coastal Counties and was in effect until December 31, 2005.
  - Imposed caps on groundwater use in Glynn County, Chatham County, and portions of Bryan and Effingham Counties to avoid worsening the rate of saltwater intrusion at Hilton Head Island and Brunswick in Glynn County.
  - Reduction of groundwater use in Chatham County by at least 10 mgd by December 2005 through conservation and switching to surface water use.
  - Develop the information needed to assist Georgia stakeholders with the development and implementation of a final strategy that will acceptably address saltwater intrusion and encroachment problems along Georgia's coast.
    - Promote water conservation
    - Develop comprehensive water supply plans
    - Develop expanded scientific studies

# Interim Strategy for Managing Saltwater Intrusion

## Coastal Area divided into 3 subareas:

- Northern area – Limited additional withdrawals
- Central area:
  - Chatham and portions of Bryan and Effingham Co. – Withdrawals reduced by 10 mgd by December 2005.
    - No new withdrawals without associated reductions.
  - Glynn County – No additional withdrawals.
  - Other counties in Central area – Some limited increases would be allowed (up to 15 mgd).
- Southern area – Limited additional withdrawals
- All three subareas
  - Inactive groundwater permits will be canceled.
  - No new permits for golf course irrigation or non-contact cooling water, where alternate sources exist.
  - Total withdrawal increases would be limited to 36 mgd.



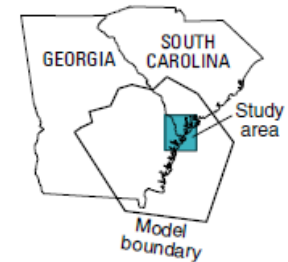
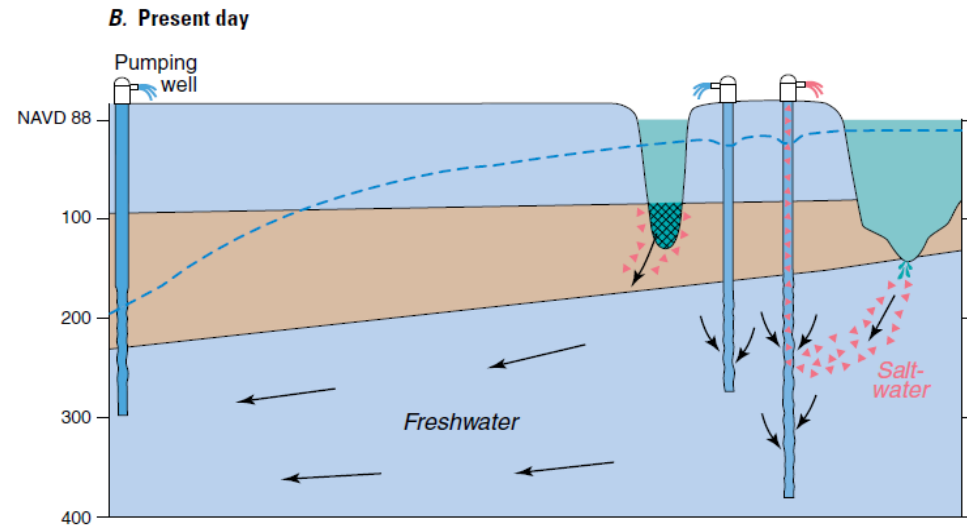
# Coastal Sound Science Initiative (CSSI)

- CSSI established by 1997 Interim Strategy.
  - \$18 million effort:
    - \$11,258,000 – State of Georgia
    - \$1,750,000 – USGS
    - \$200,000 – Glynn County
    - \$1,000,000 – State of South Carolina
    - \$500,000 – State of Florida
    - \$3,260,415 – Paper Industries in Coastal area
  - Technical Advisory Committee established
    - Included representatives from Georgia EPD, SCDHEC, USGS, and other Georgia stakeholders.
    - Gathered additional scientific data, undertook extensive hydrological modeling and had input on any initiatives and regulatory actions that would be a result of the CSSI.
  - June 2006 – Coastal Georgia Water & Wastewater Permitting Plan for Managing Salt-Water Intrusion (CPP)
    - Replaced the Interim Strategy.
    - Based on the findings of the CSSI.

# Coastal Georgia Water & Wastewater Permitting Plan for Managing Salt-Water Intrusion

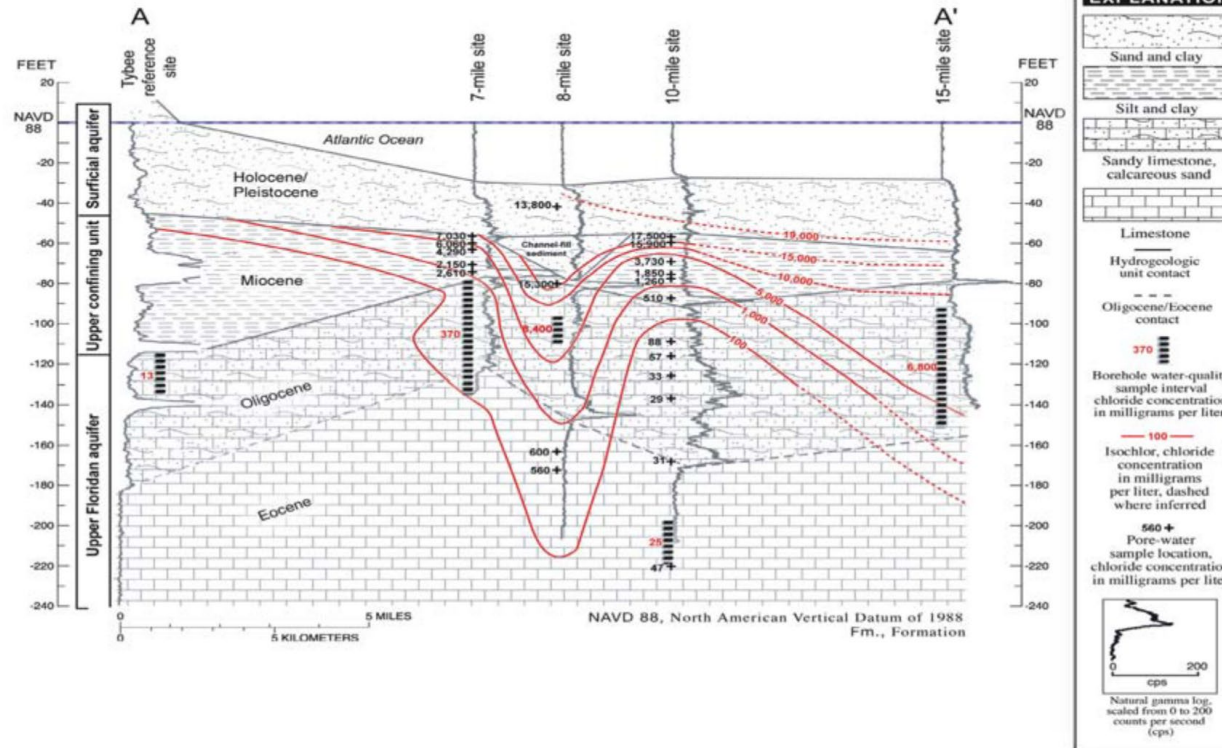
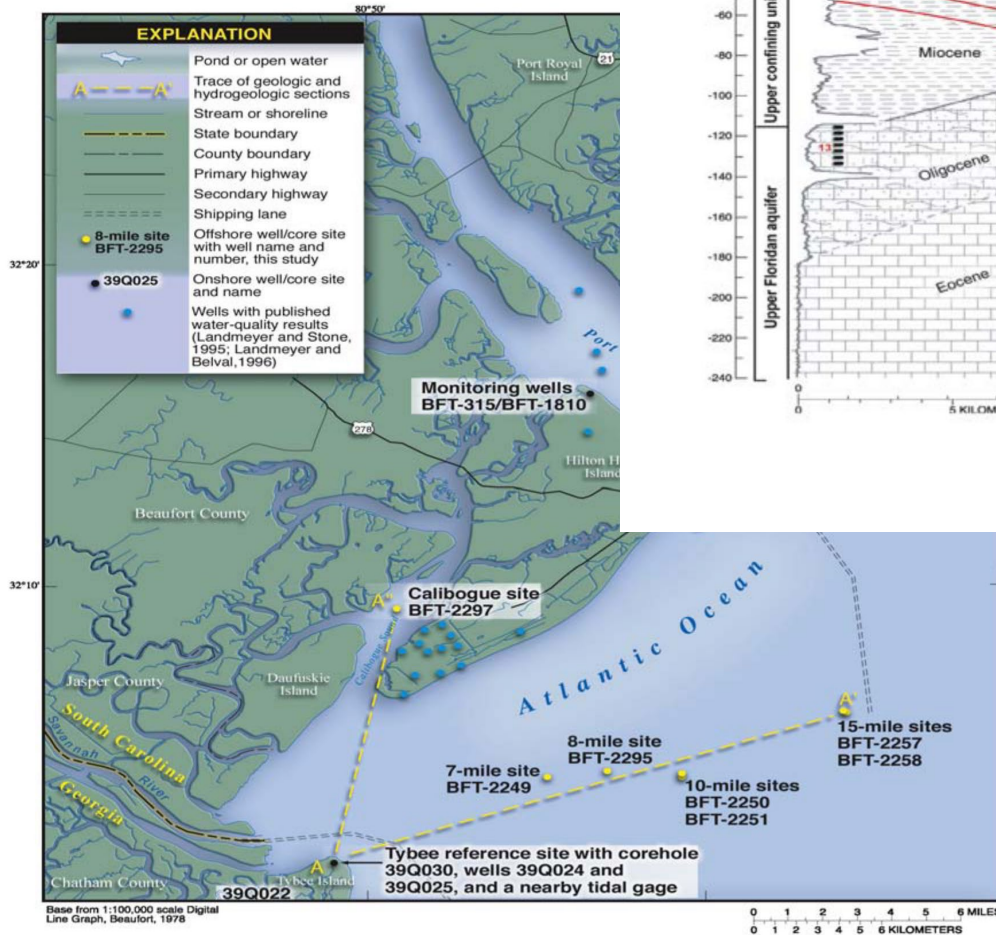
## Where is saltwater entering the Aquifer:

- T-shaped plume – Brunswick
  - Saltwater entering aquifer through fractures.
- Hilton Head Island area:
  - Saltwater is entering aquifer along the northern shore of Hilton Head Island, Pinckney Island, and Colleton River.
  - Saltwater is entering the Floridan aquifer through downward leakage through the confining layer where confining unit is thin or absent.





# Coastal Georgia Water & Wastewater Permitting Plan for Managing Salt-Water Intrusion



Seismic studies show that east of Hilton Head Island and northeast of Tybee Island, the confining unit is thin.

# CSSI Model

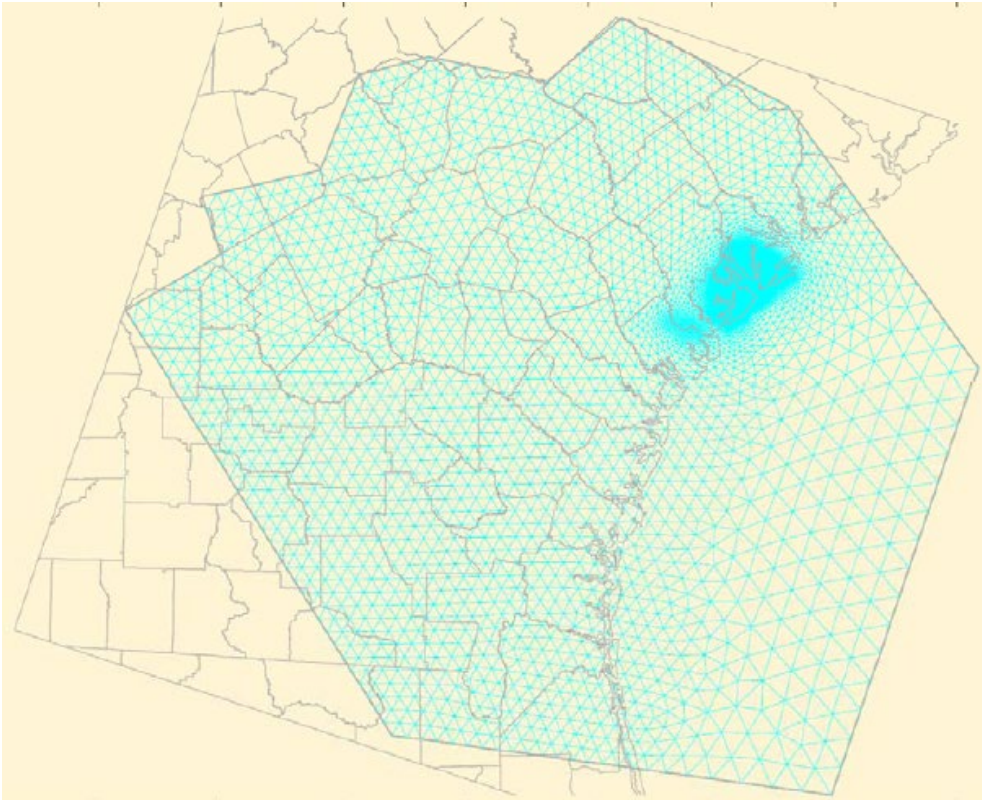
- CSSI model refined from the SHE model

- Finer grid spacing around Hilton Head
- Model was calibrated for steady state and transient conditions.

- Model was calibrated against 2007 chloride contours provided by SCDHEC.
- Model closely matched historical measurements of plume movement.
- GA EPD and SCDHEC approved the model for use in the CSSI.

- Baseline withdrawals:

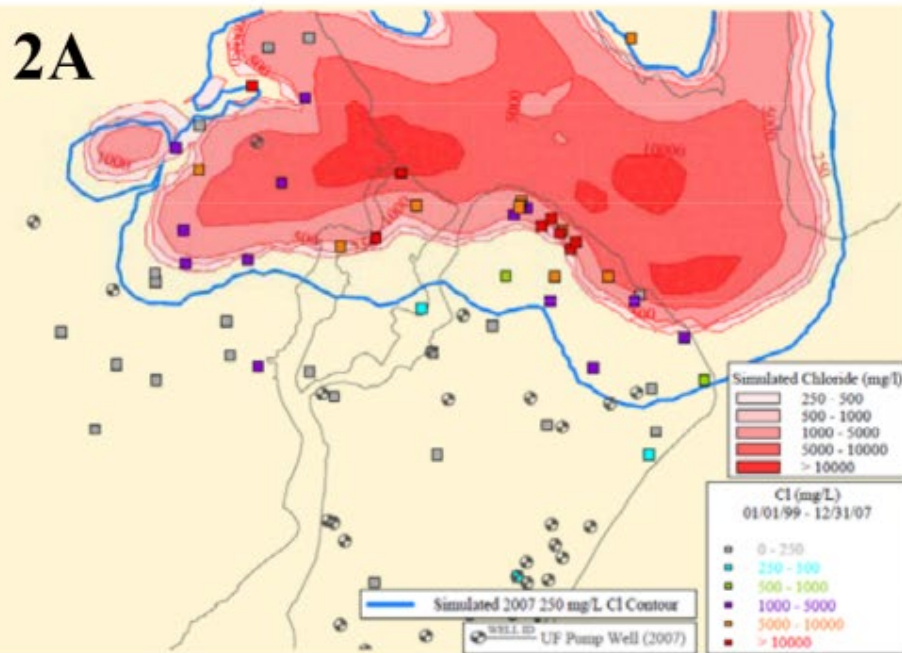
- Savannah Area – 69 mgd
- Hilton Head Island – 9 mgd



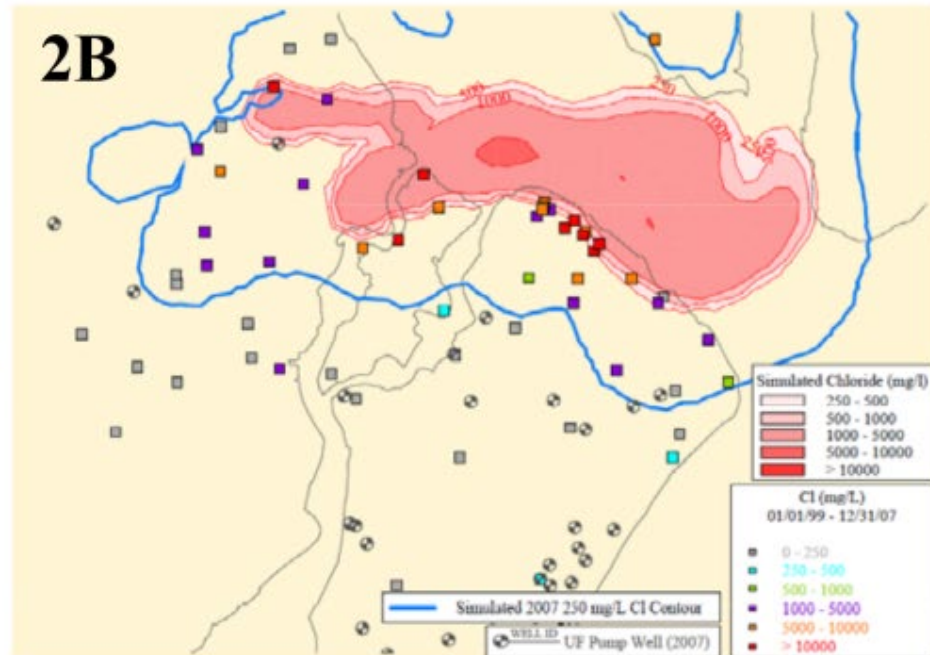


# Initial CSSI Model Simulations

**Historical Withdrawals in Savannah Area Only**



**Historical Withdrawals on Hilton Head Island Only**



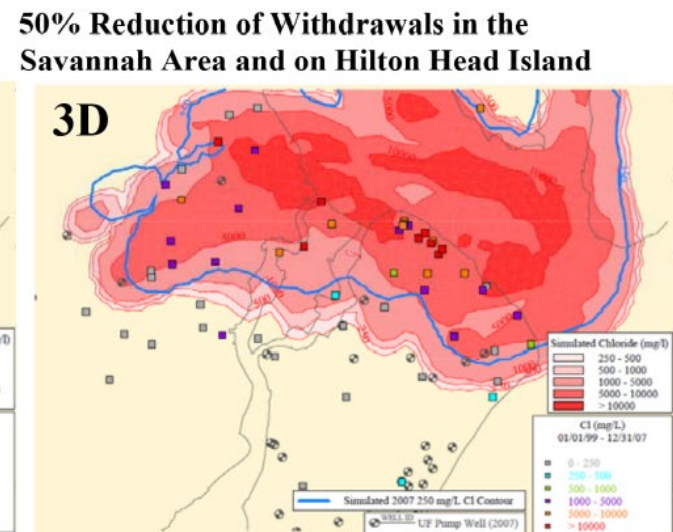
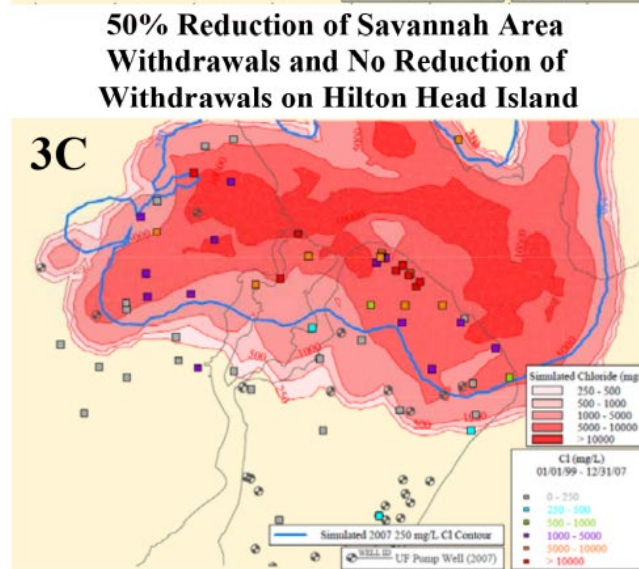
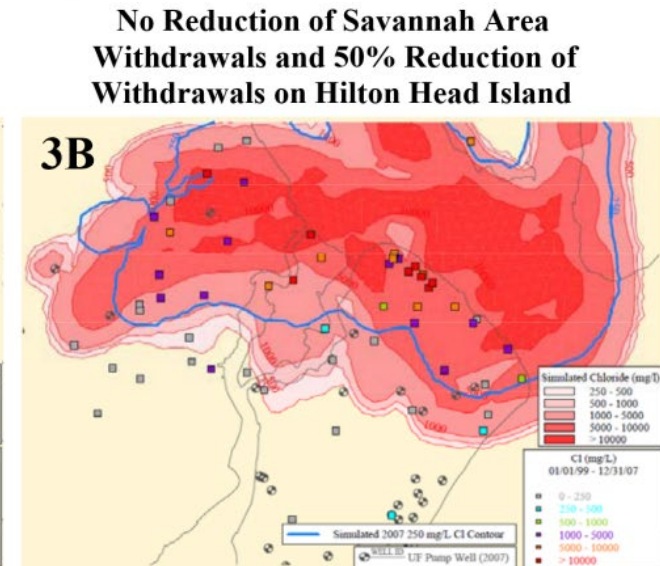
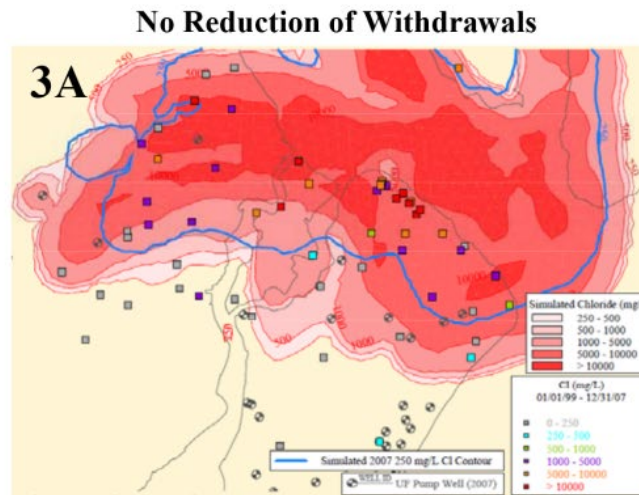
- 2A – Maintain historical withdrawals in Savannah area with no withdrawals on Hilton Head
- 2B – Maintain historical withdrawals on Hilton Head with no withdrawals in Savannah area.

**\*\* Neither simulation extended as far inland as the simulated initial plume (2007), so both contribute to the inland extent of the plume.**

# CSSI – Simulate Aquifer Management Scenarios

## CSSI model Scenarios:

- Scenario 3A
  - No reduction in either Savannah or Hilton Head withdrawals
- Scenario 3B:
  - No reduction in Savannah
  - 50% reduction at Hilton Head
- Scenario 3C:
  - 50% reduction in Savannah
  - No reduction at Hilton Head
- Scenario 3D:
  - 50 % reduction in Savannah
  - 50 % reduction at Hilton Head





# Conclusions of CSSI model simulations

- Groundwater withdrawals in both the Savannah and Hilton Head areas were needed to create the inland extent of the saltwater plume.
- Salt-water plumes would continue to exist well into the future even if all groundwater withdrawals were eliminated.
- Reducing groundwater withdrawals from the aquifer, even by large amounts, would not eliminate salt-water intrusion into the aquifer.


# CSSI Findings - How Fast is Saltwater Traveling?


- Hilton Head Island area:
  - Since mid 1960s, the saltwater plume has moved about 2 miles south/southwest.
  - If year 2000 pumping rates are maintained – plume will move ~130 feet per year.
  - Offshore investigations indicate some saltwater has migrated into the Floridan aquifer in the area 7-10 miles northeast of Tybee Island.
- Brunswick, Glynn County area:
  - Monitoring data indicate plume at Brunswick is stable and is not moving.


\*\* Modeling shows that increases/decreases in pumping from the Upper Floridan in or near the Savannah/Hilton Head areas will change the potentiometric gradient in these areas and thus change saltwater intrusion velocities.

# Sub-Regional Management Areas

- Sub-Region 1:
  - Chatham County
  - Effingham County (south of Hwy 119)
  - Bryan County
  - Liberty County
- Sub-Region 2:
  - Glynn County
- Sub-Region 3:
  - The remaining 19 counties.
  - Effingham County (north of Hwy 119)

 No net increases in UF withdrawal amounts

 Allow up to 5 mgd to be withdrawn from UF through 2008

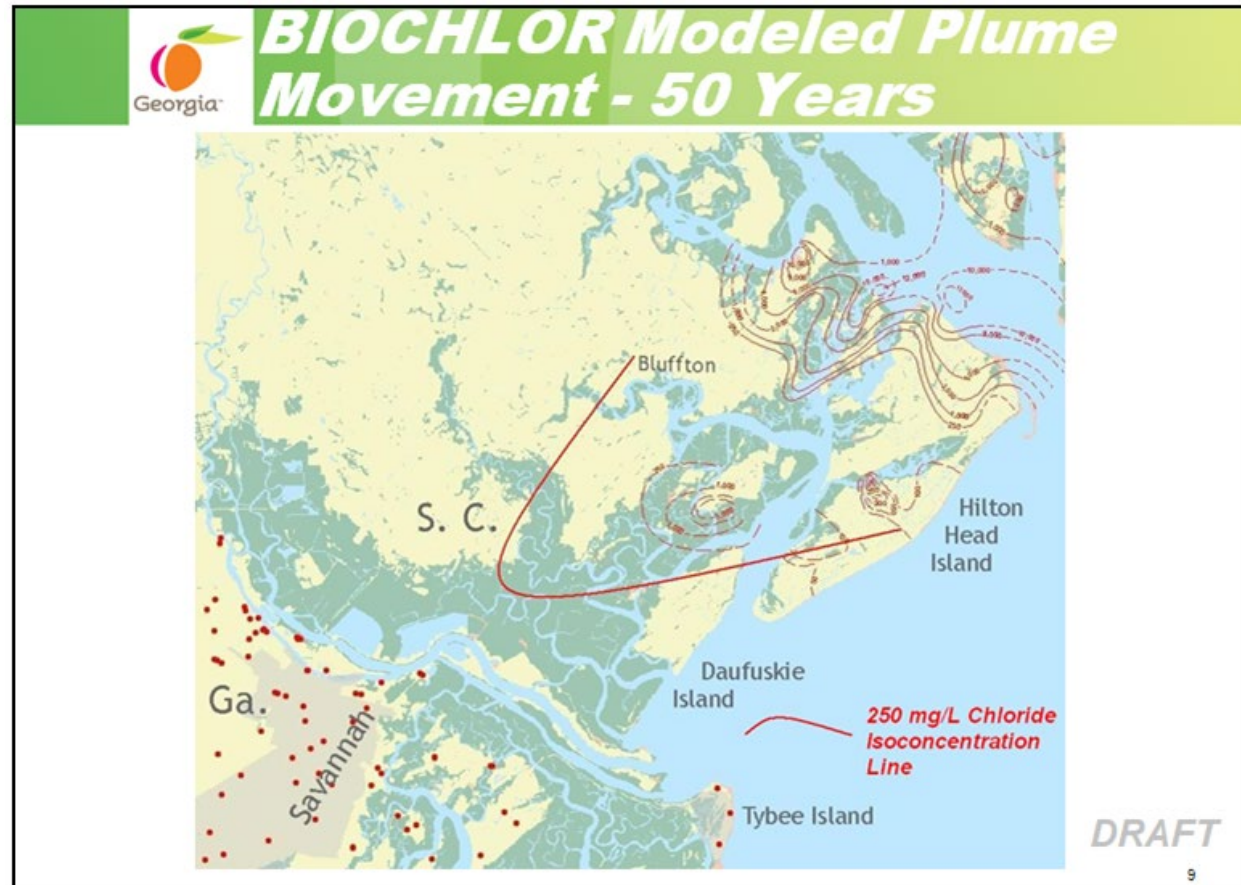
 No restrictions

# Elements of CPP Management Plan

- Sub-Region 1 Red Zone (Chatham and Southern Effingham County):
  - Restrict withdrawals from Upper Floridan aquifer to 2004 actuals.
  - Reduce withdrawals by at least an additional 5 mgd by 2008.
    - City of Savannah -2.111 mgd
    - International Paper – 1.289 mgd
    - Other users – 1.600 mgd
  - Require implementation of water conservation and reuse measures.
- Sub-Region 1 Yellow Zone (Bryan and Liberty Counties):
  - Allow up to an additional 5 mgd of Upper Floridan aquifer to be withdrawn through 2008.
  - Require implementation of water conservation and reuse measures.
- Sub-Region 2 (Glynn County):
  - Manage withdrawals from the Upper Floridan aquifer in such a manner so that the current “t-shaped” plume doesn’t change.
  - Require implementation of water conservation and reuse measures.
- Sub-Region 3 (19 Counties plus Effingham Co. north of Hwy 119):
  - Require implementation of water conservation and reuse measures.

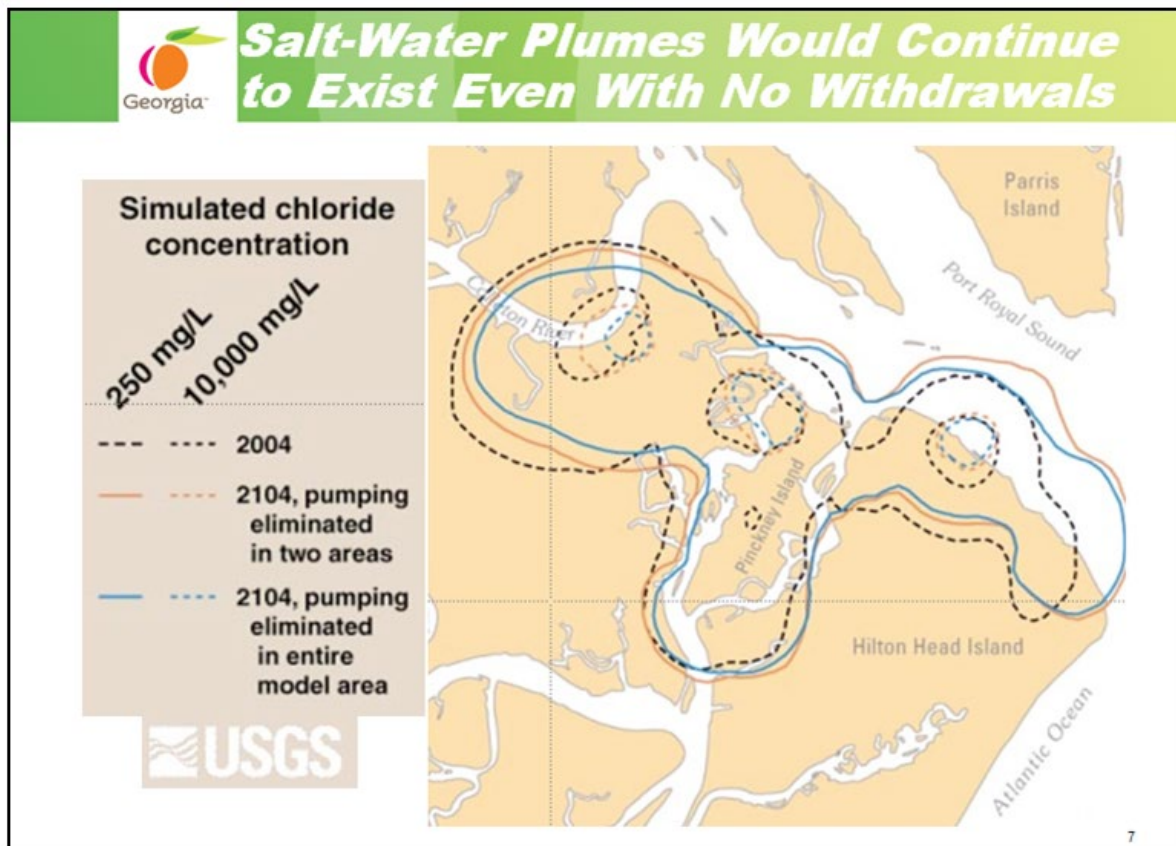
# Coastal Activities Since 2008

- In 2011, EPD was asked to simulate how long it would take salt-water plumes to reach Savannah:
  - Model assumed Savannah pumping of 69 mgd (2000).
  - Savannah's pumping in 2012 was 50.6 mgd.
  - Simulations indicated ~125 yrs for saltwater to reach Savannah wells (2000).
  - Chlorides are moving toward cone of depression and will not reach Tybee Island.



# Saltwater Plume Movement Study

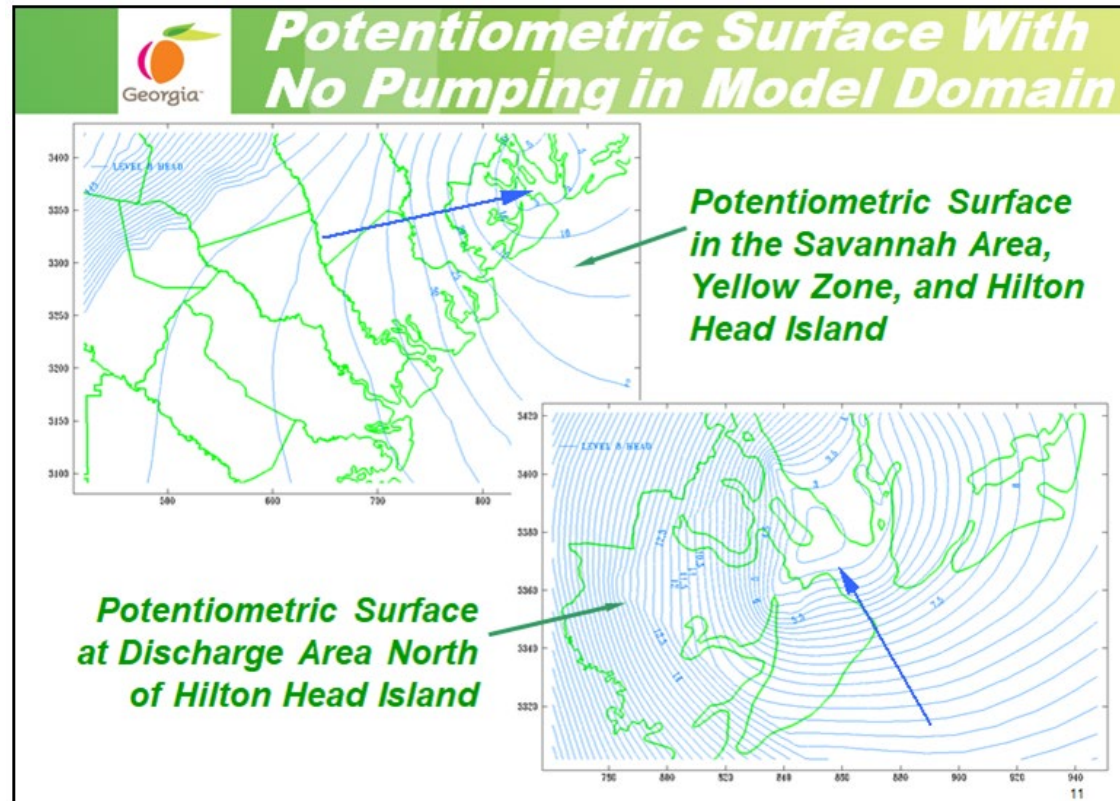
- 2013 – EPD presents modeling work done by USGS:
  - USGS modeling of plume movement when pumping ceases.
    - 100 years of pumping (2004-2104) where pumping in Savannah and Hilton Head Island were eliminated.
    - 100 years of pumping (2004-2104) where pumping in the entire model domain was eliminated.
  - USGS simulations show that even with pumping eliminated for an extended period of time the saltwater plume pretty much stays in place.





# Saltwater Plume Movement Study

- Simulations were done to determine what amount of water could be pumped from the Floridan aquifer without causing movement of the saltwater plume toward Savannah.
  - Baseline model was run with no pumping in the Savannah area or on Hilton Head Island.
  - Simulate what amount of water could be pumped from the aquifer and still have the direction of groundwater movement pointing to the north (away from Savannah).
  - Pumping scenarios included pumping from Savannah, Hilton Head, and the Yellow Zone.
- Hilton Head Island pumping by itself (1.7 mgd)
- Savannah pumping by itself (10.3 mgd)
- Yellow Zone pumping by itself (34.9 mgd)

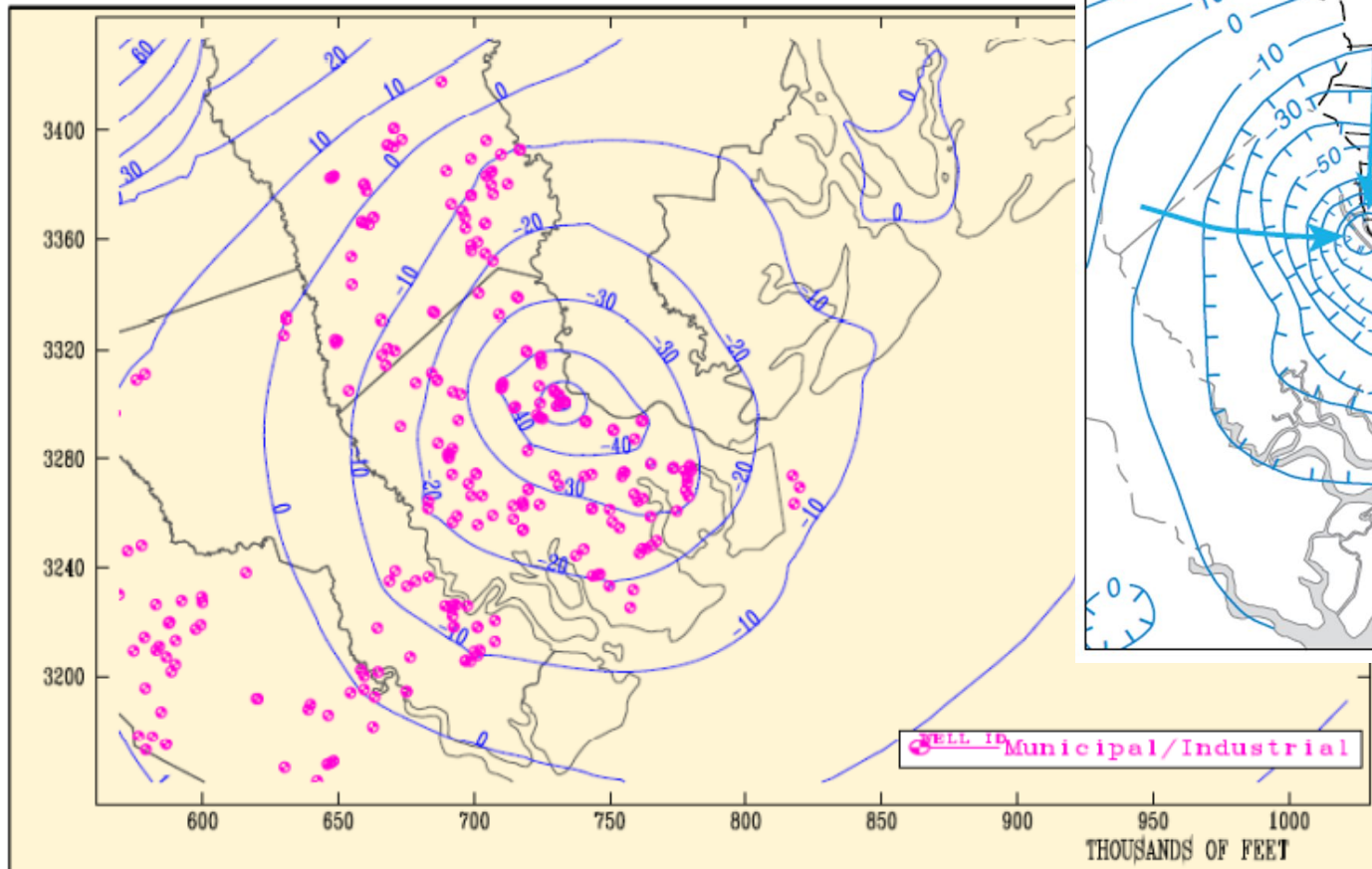


# CSSI Model Updates (2017-2018)

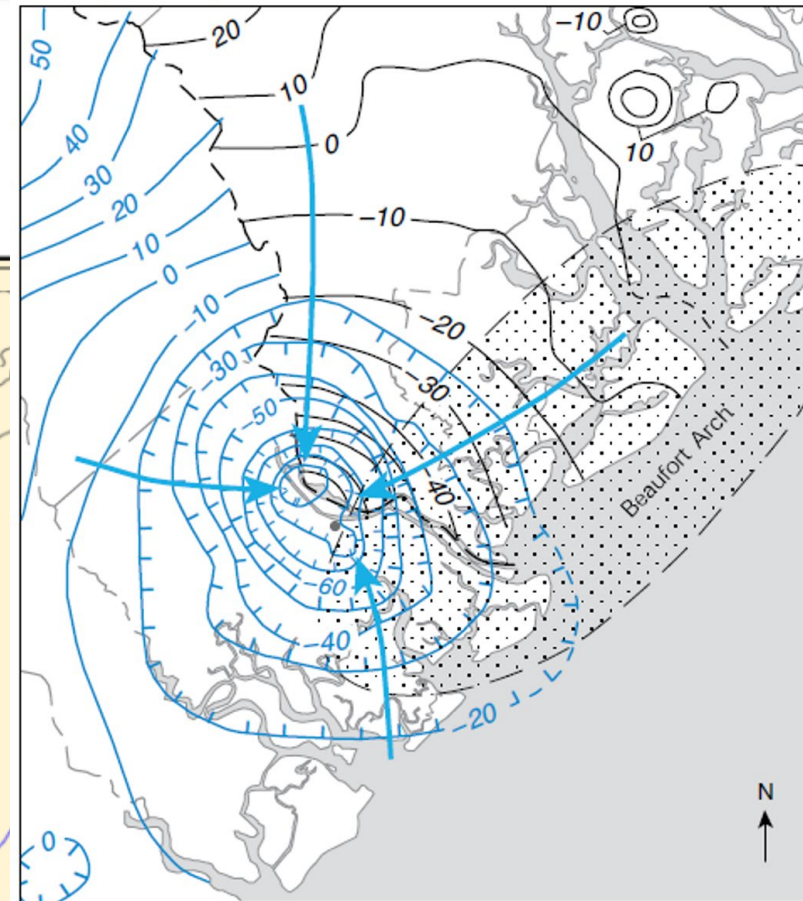
- Grid discretization reduced to 1,200 – 1,700 ft:
  - Red Zone
  - Yellow Zone
  - Southern half of Bulloch County, Evans County, Long County, McIntosh County, and eastern portion of Tattnall County.
- Grid spacing for remainder of model adjusted to avoid numerical instability.
- Transient simulation period extended through 2016 (1915-2016). Steady state simulation of 2016 pumping conditions was developed.
- Model updated to include 2008-2016 reported withdrawals (M&I and Ag use):
  - Model update eliminated distributed fluxes for years 2008-2016 in areas where Ag withdrawal information was available. Withdrawals now assigned to coordinates.
    - Appling, Bacon, Brantley, Bryan, Bulloch, Burke, Candler, Chatham, Effingham, Evans, Emanuel, Jenkins, McIntosh, Pierce, Screven, Tattnall, Toombs, Ware, and Wayne)
- Model used to simulate steady state groundwater conditions under December 2015 permitted groundwater withdrawals.

# CSSI Model Updates (2017-2018)

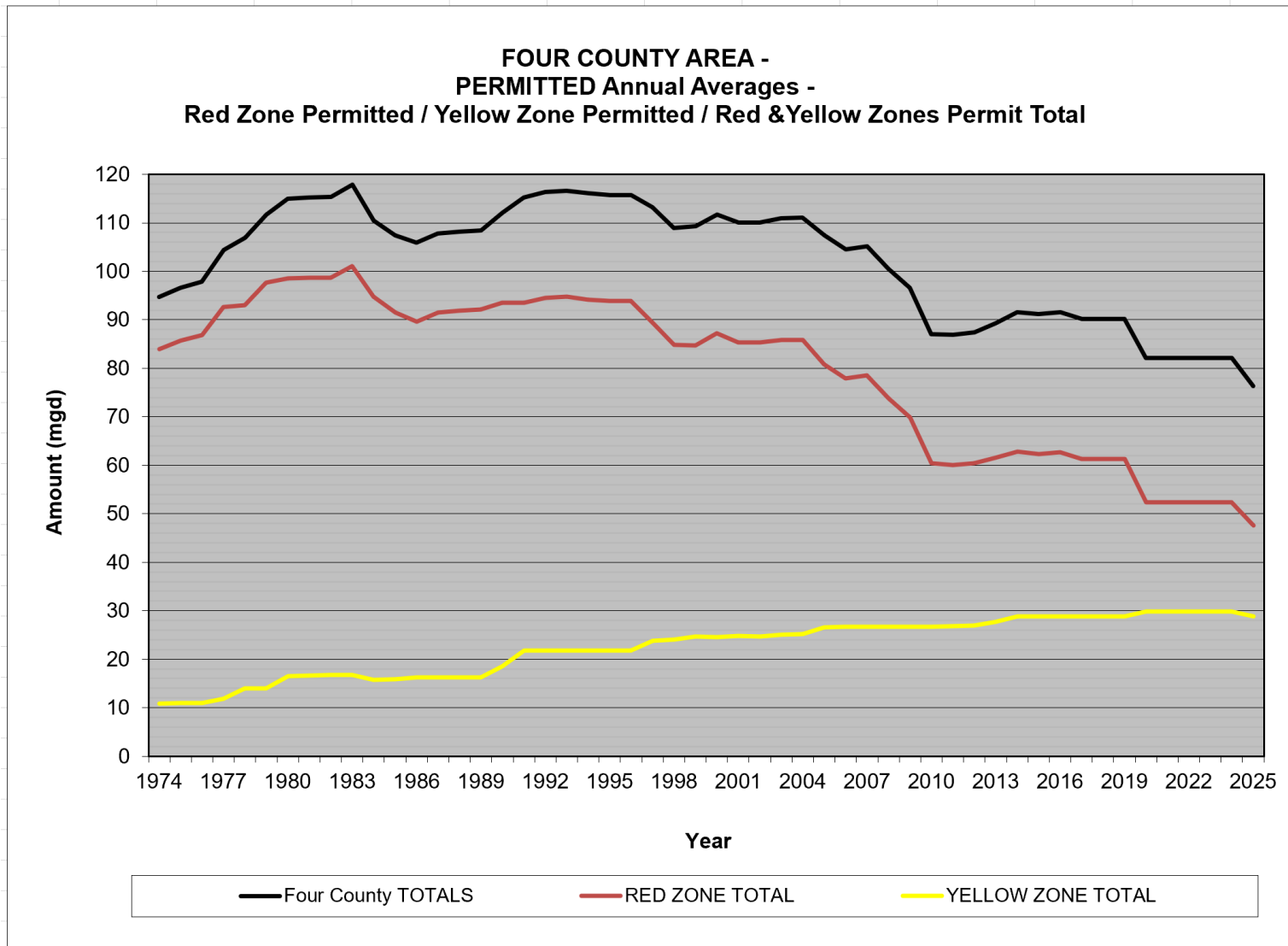
- Red Zone – 50.1 mgd
- Yellow Zone - 19.6 mgd



B. May and September 1998

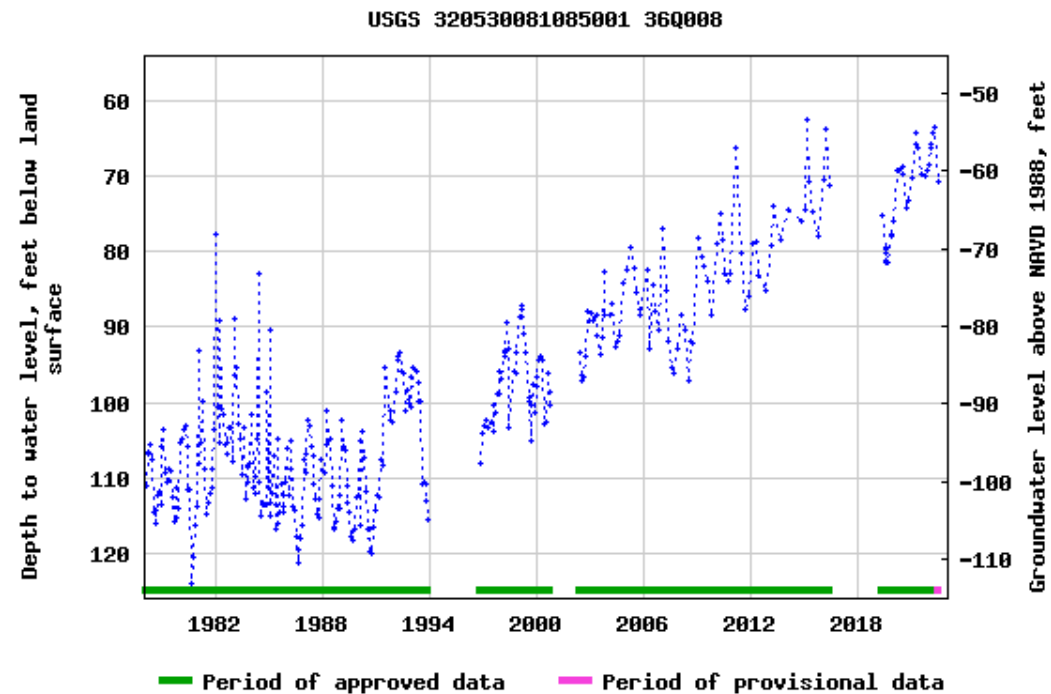
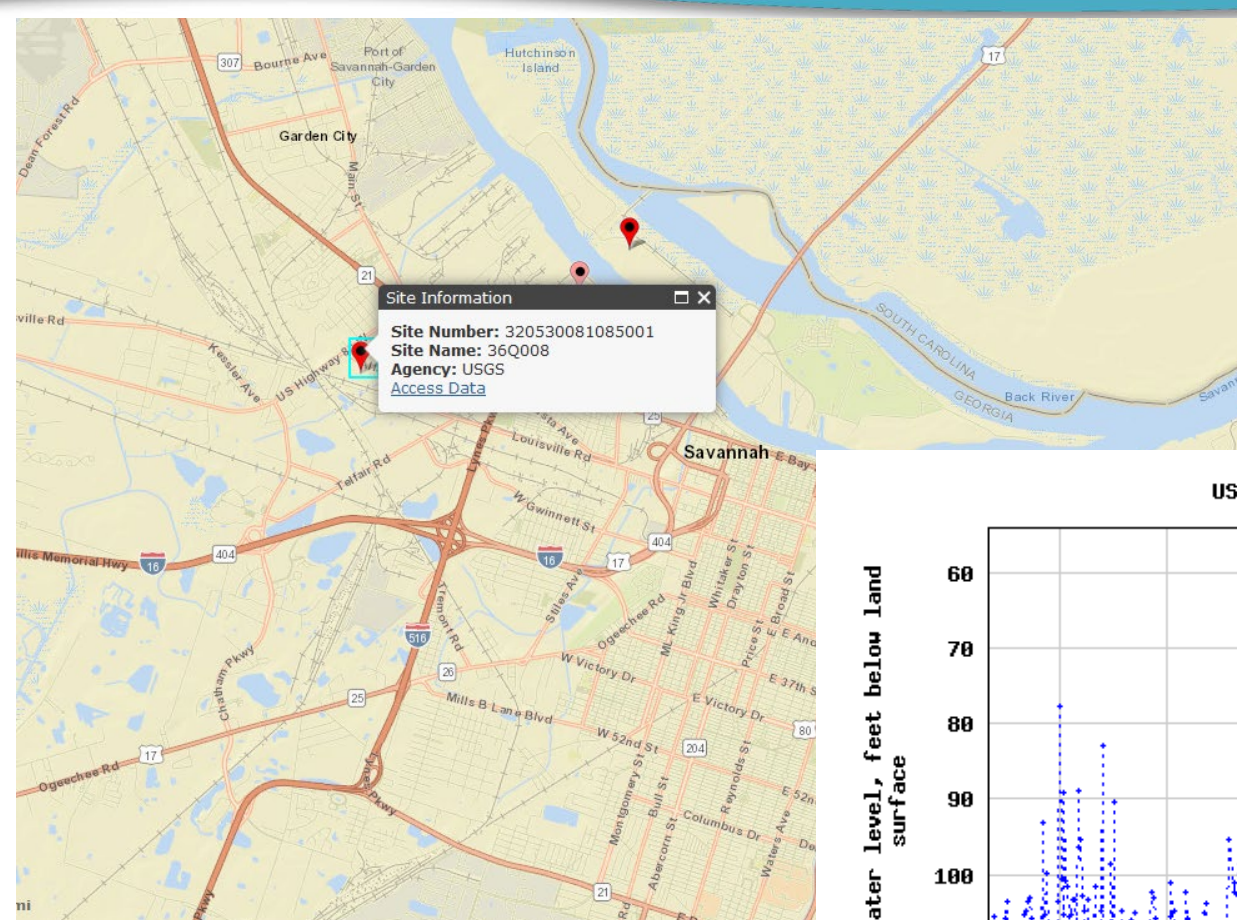


# Red and Yellow Zone Permitted Annual Averages

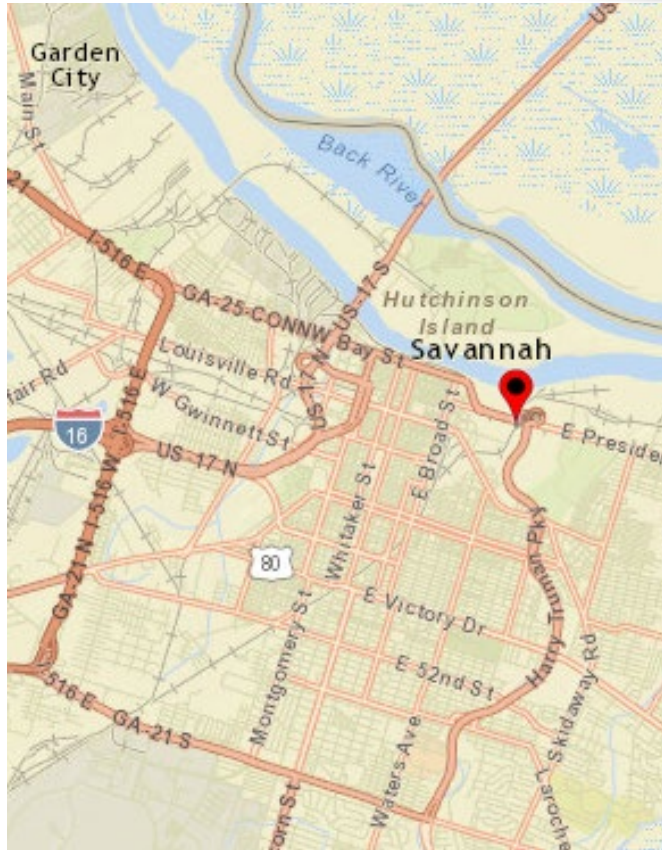




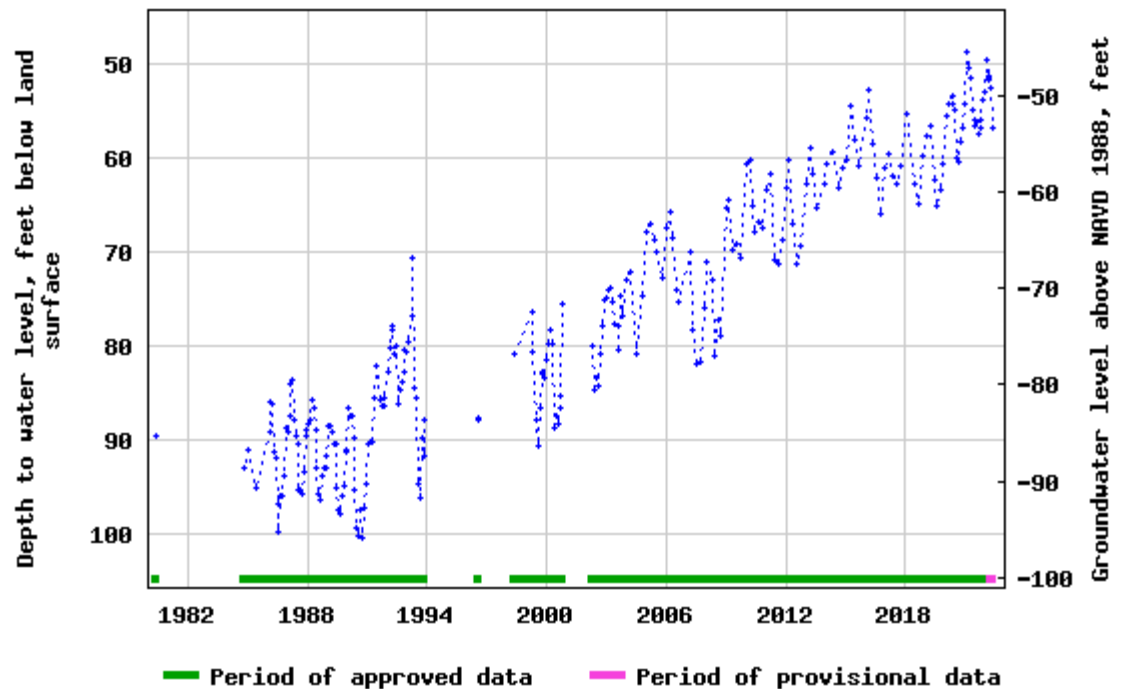
# USGS Groundwater Level Measurements – Savannah Area



# USGS Groundwater Level Measurements – Savannah Area

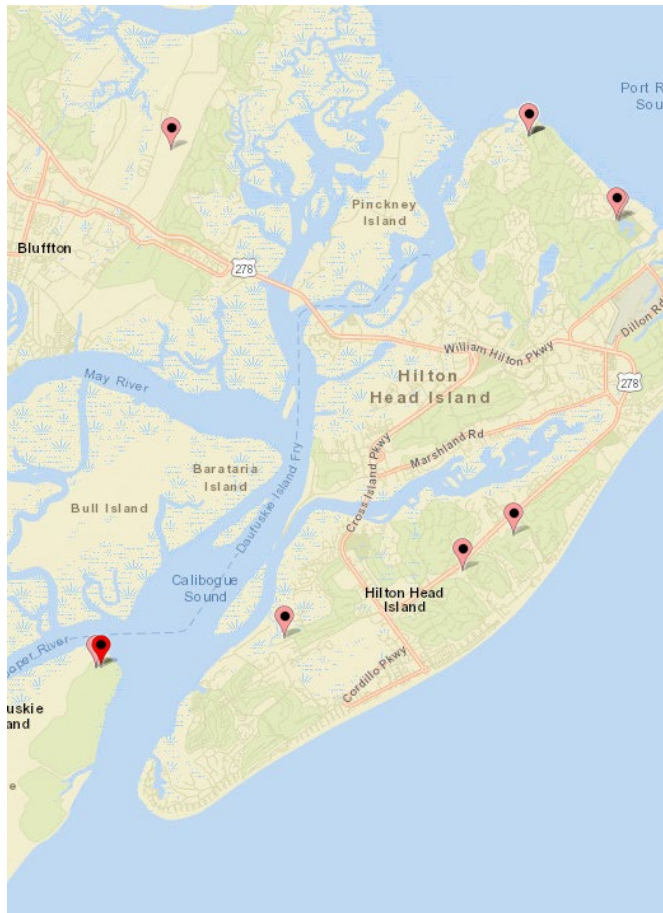


USGS 320433081042701 37Q016



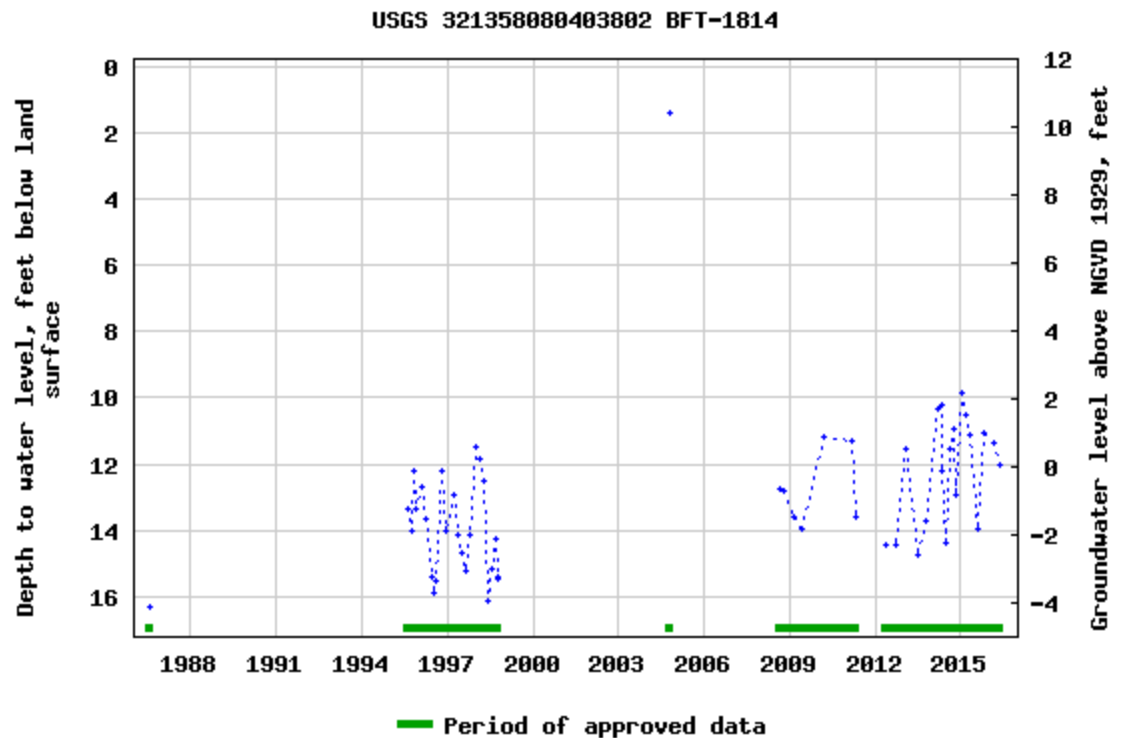


# USGS Groundwater Level Measurements – Hilton Head Island Area



Site Information

Site Number: 321358080403802  
Site Name: BFT-1814  
Agency: USGS  
[Access Data](#)



# Ongoing Information of Coastal Resources

- Georgia EPD – Coastal Water Study
  - <https://epd.Georgia.gov/coastal-water-study>
  - Background information and Coastal Permitting Plan Guidance documents
  - Information on the Technical Advisory Committee work
  - Information on the Sound Science Initiative
- USGS South Atlantic Water Science Center – Coastal Sound Science Initiative:
  - <https://www2.usgs.gov/water/southatlantic/ga/projects/coastal/index.html>
  - Real Time monitoring of wells in Coastal Georgia
  - Background information on Coastal history
  - Coastal Sound Science Initiative Publications

Christine Voudy  
Georgia Environmental Protection Division  
(470) 607-2621

[christine.voudy@dnr.ga.gov](mailto:christine.voudy@dnr.ga.gov)