Sustaining the Floridan Aquifer

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GeoHydros, LLC

The Floridan Aquifer

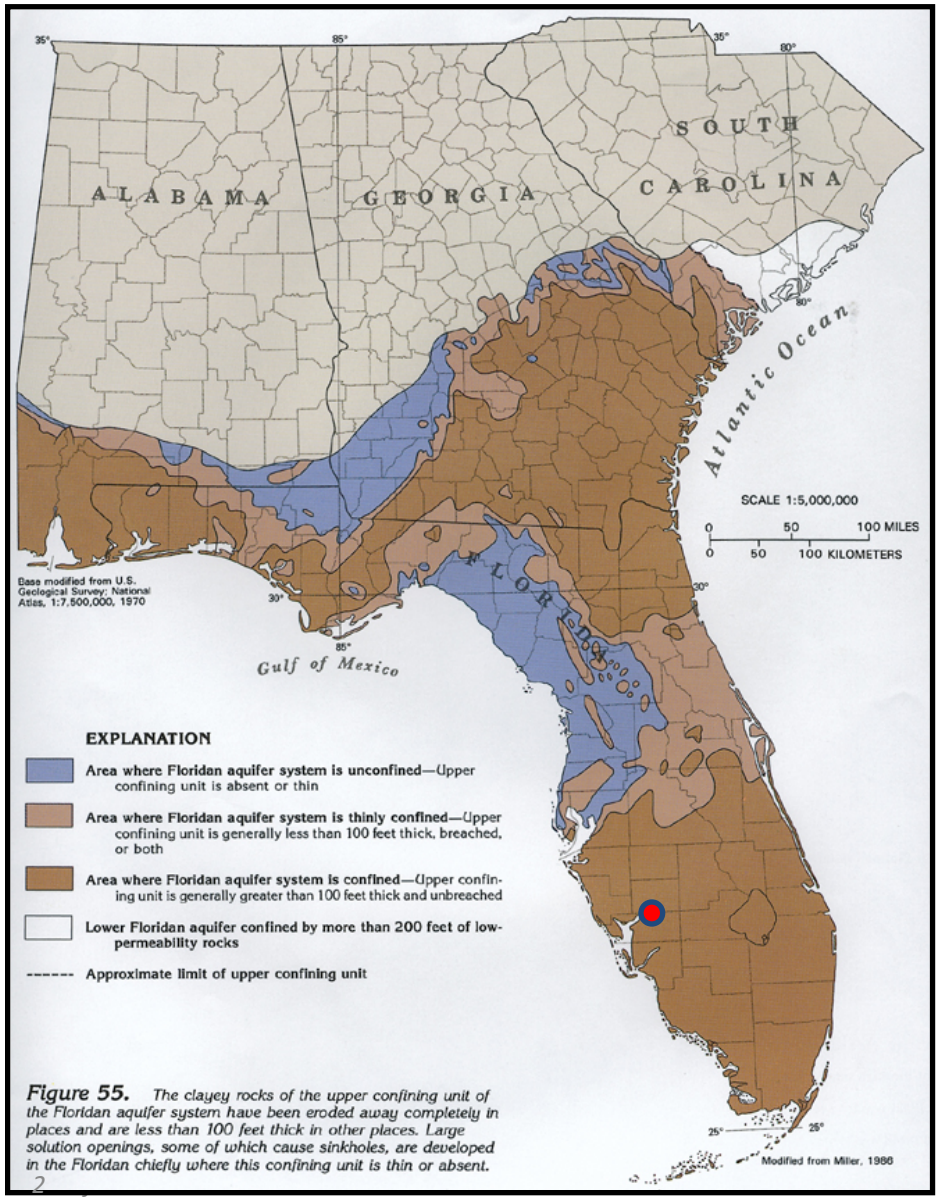

Figure 55. *The clayey rocks of the upper confining unit of the Floridan aquifer system have been eroded away completely in places and are less than 100 feet thick in other places. Large solution openings, some of which cause sinkholes, are developed in the Floridan chiefly where this confining unit is thin or absent.*

- 27 (>1/3) of the largest springs in North America discharge from the Floridan Aquifer
- Average discharge from those springs > 6.5 billion gpd
- All of those springs discharge from mapped underwater cave systems
- >90% of inhabitants use groundwater from Floridan Aquifer
- Conduit-dominated flow in unconfined sections
- Less known under confining layer

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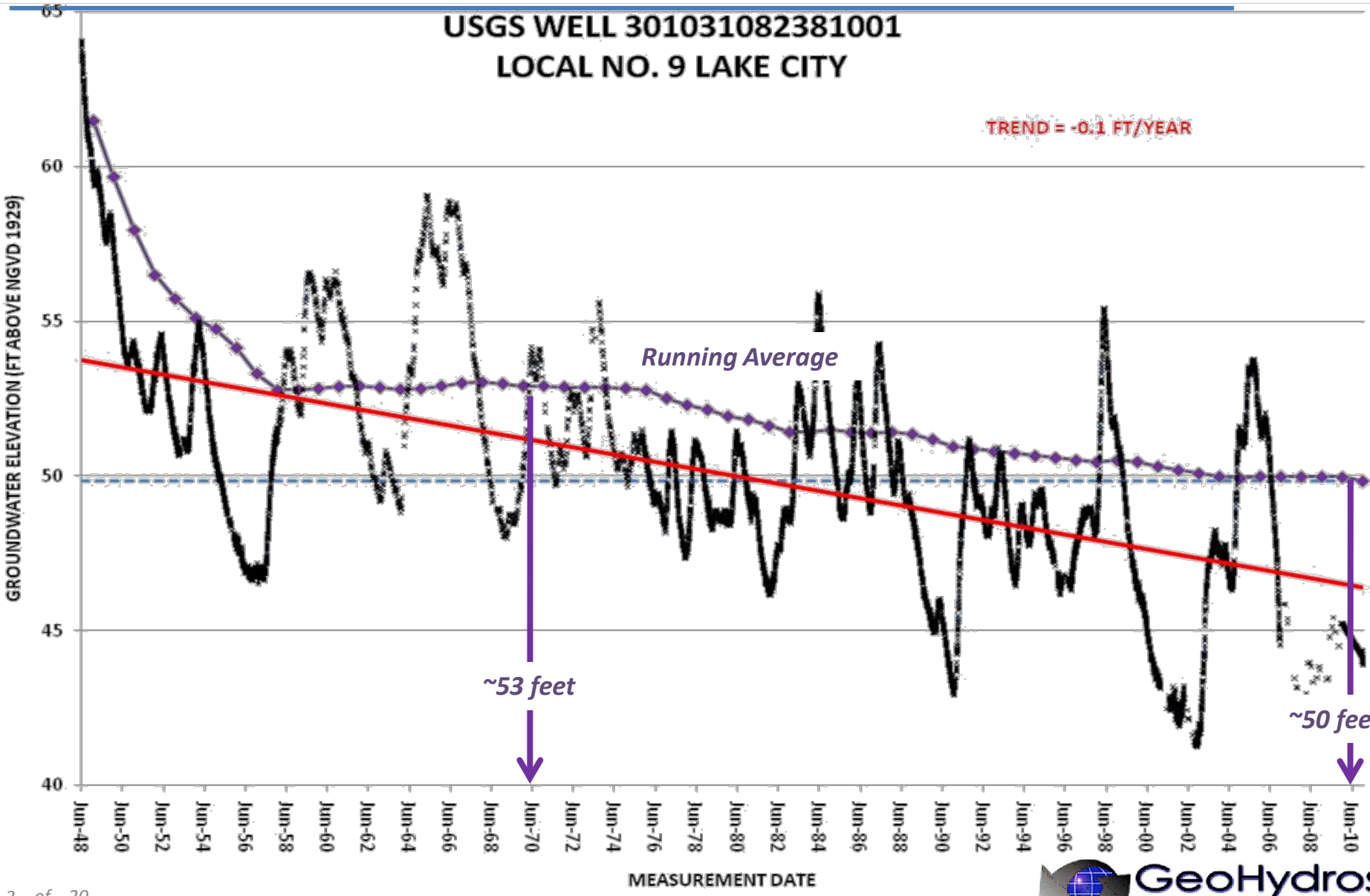
Persistent Decline in Groundwater Levels



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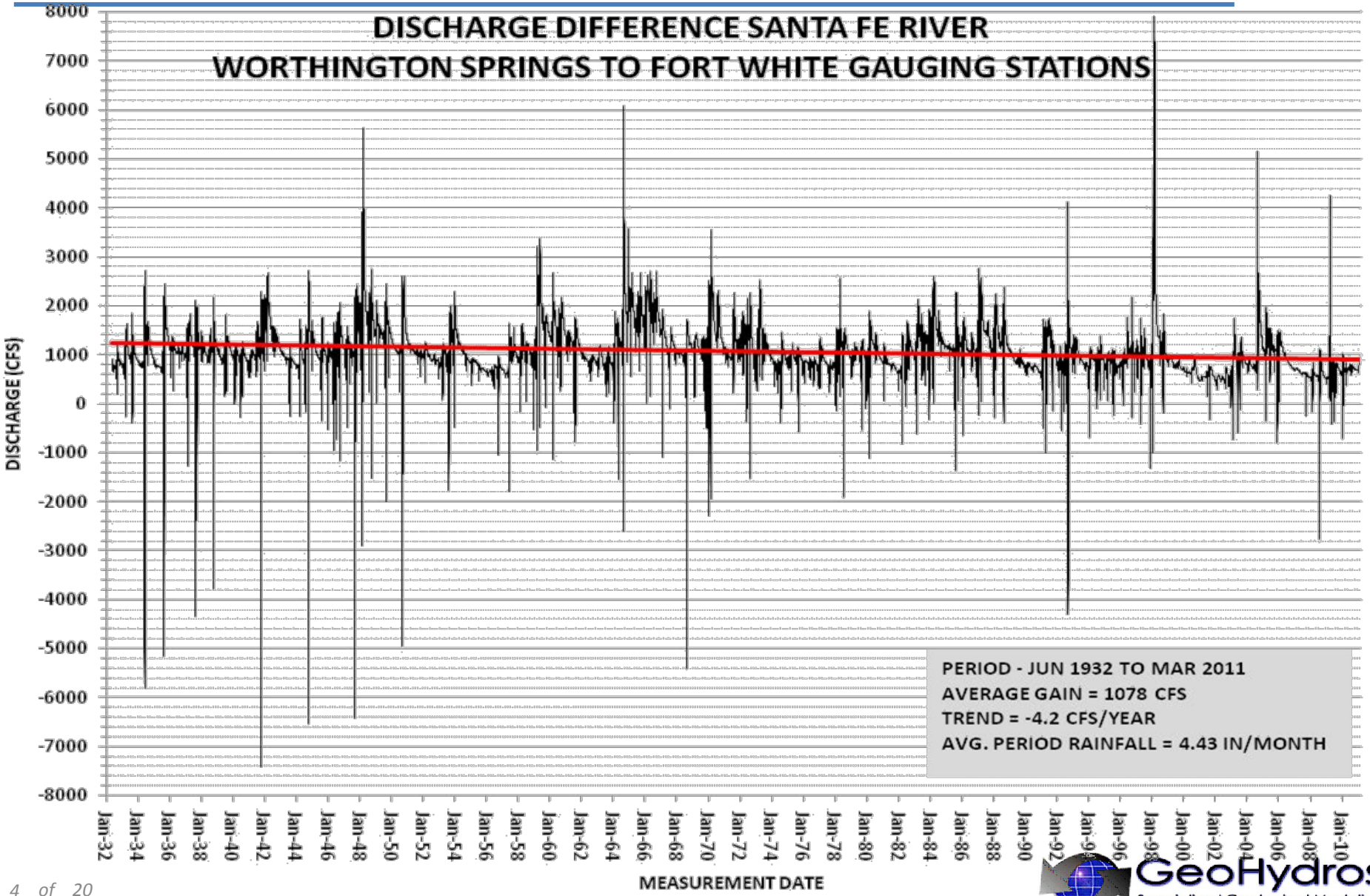
Persistent Decline in River Flows



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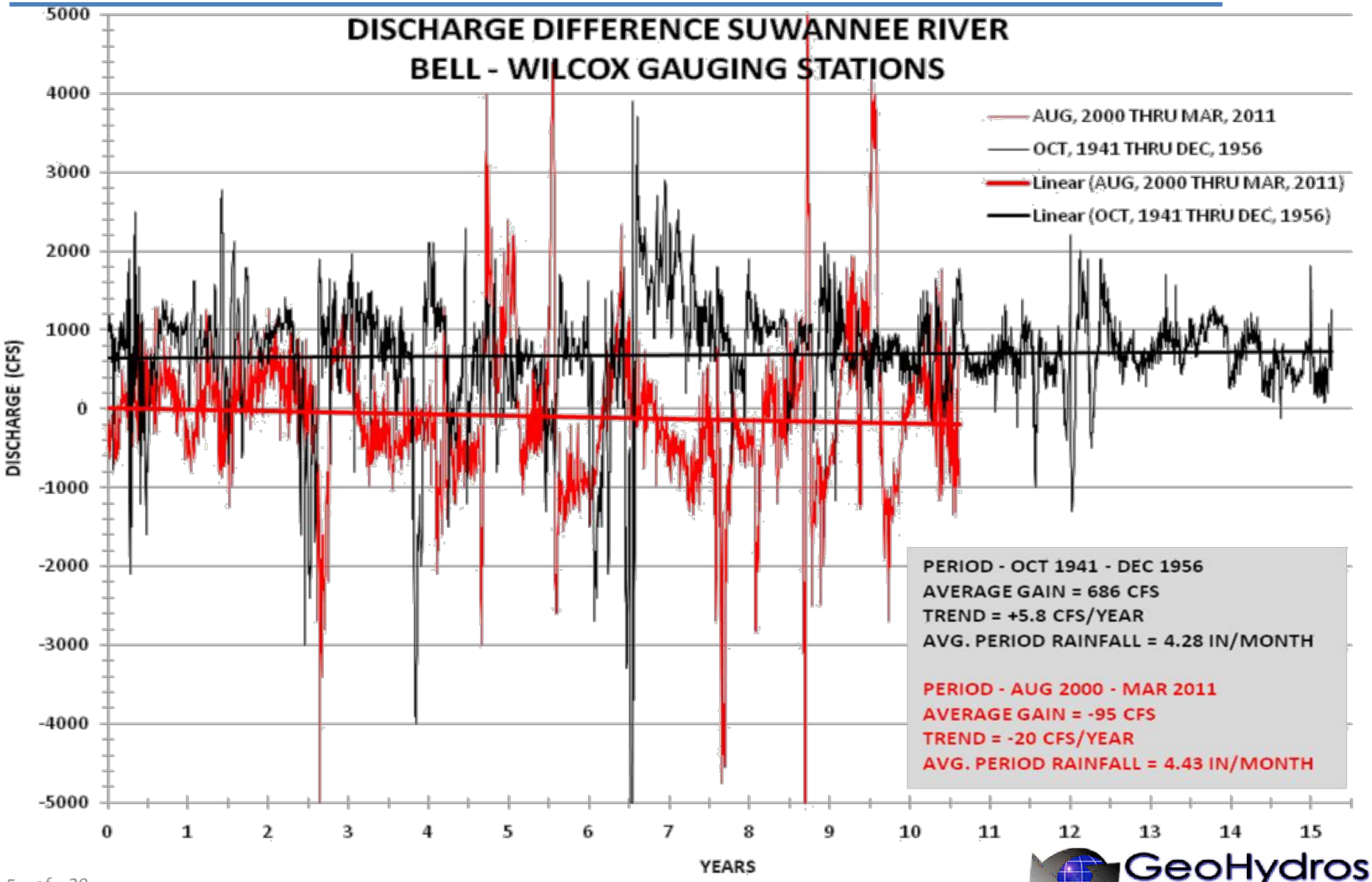
Persistent Decline in River Flows



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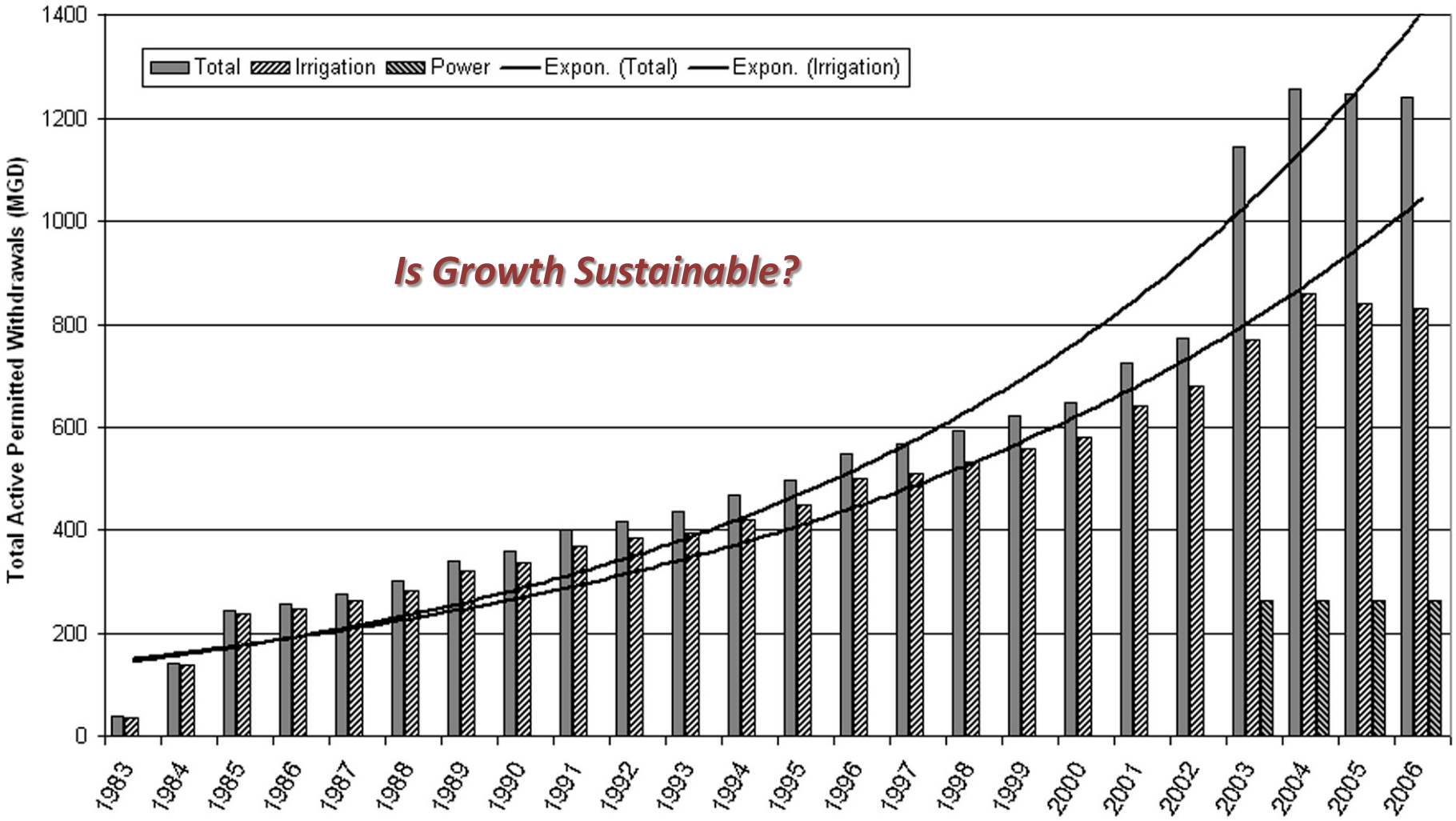
Continuously Increasing Extractions

About 1250 MGD by 2006 (~1950 cfs = ~1/2 base flow at Wilcox)



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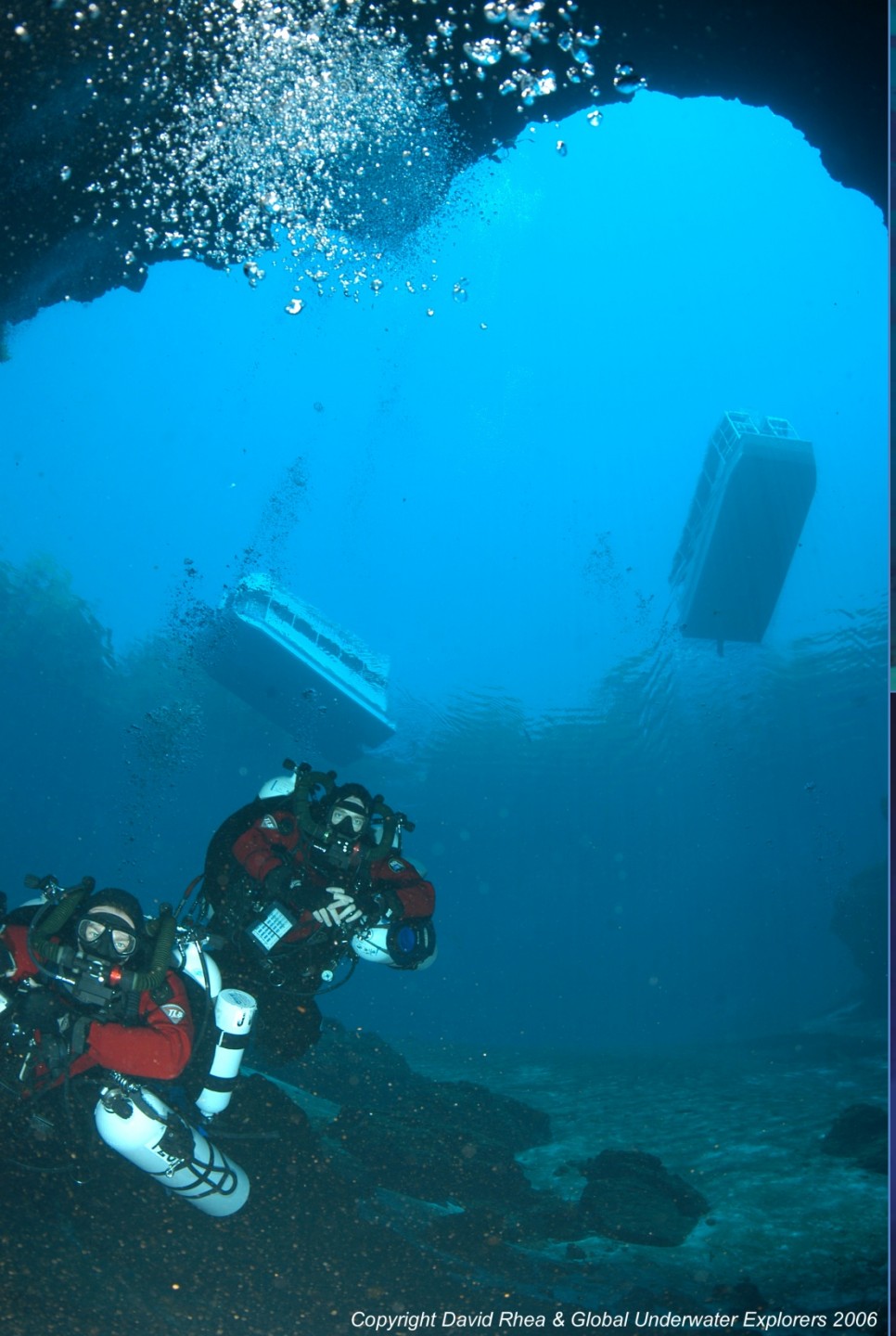
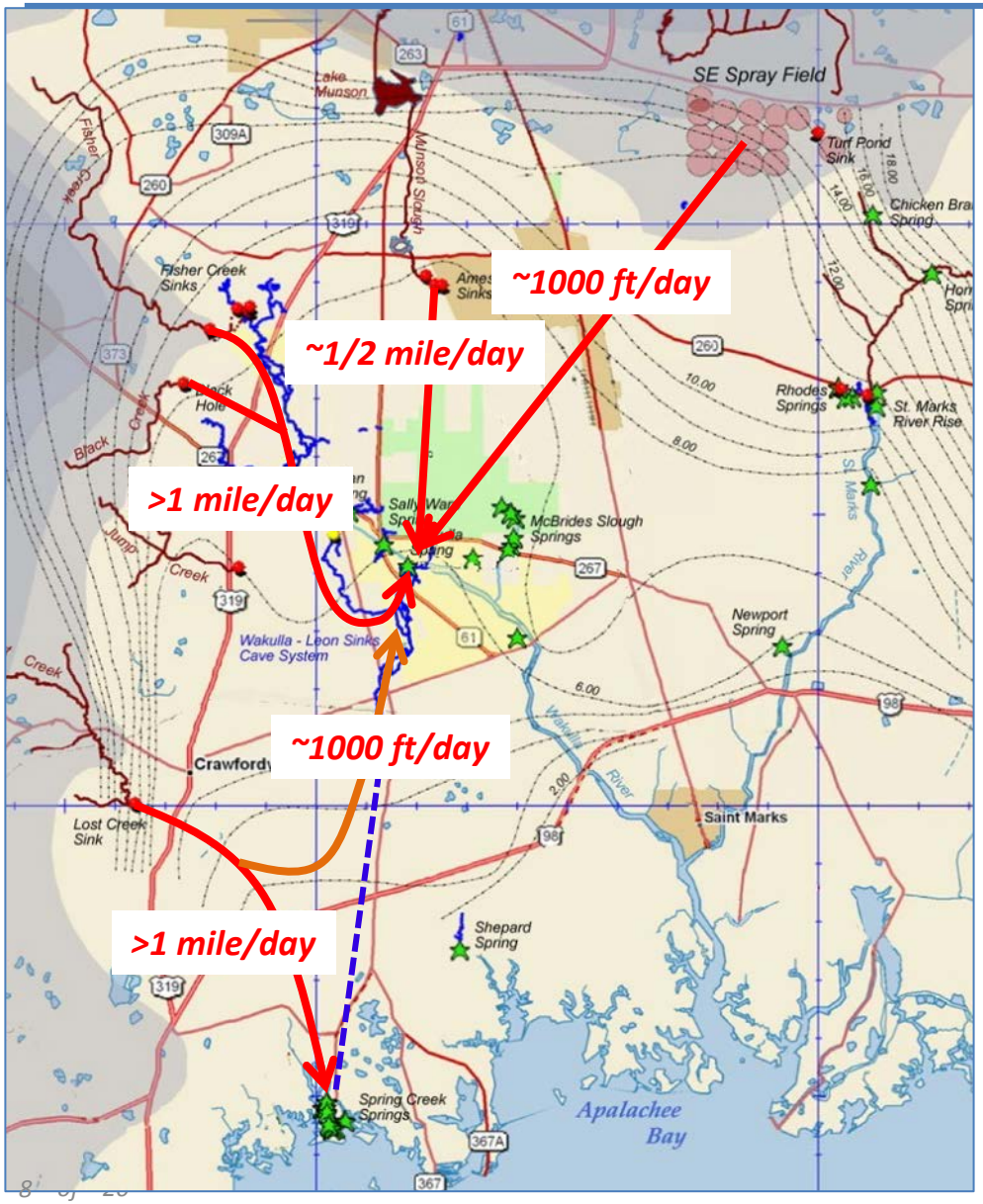


Flow to Wakulla Spring



Western Woodville Karst Plain

- Flow is fast in caves and in surrounding aquifer (caves too small to map)
- Large part of Wakulla's discharge is inflow from swallets (surface water)
- Wakulla & Spring Creek are connected
- Spring Creek began reversing for appreciable durations in 2006
- Spring Creek reverses now every summer for weeks - months
- We're loosing the largest spring in Florida & the associated fresh water that flows to the Gulf of Mexico estuaries

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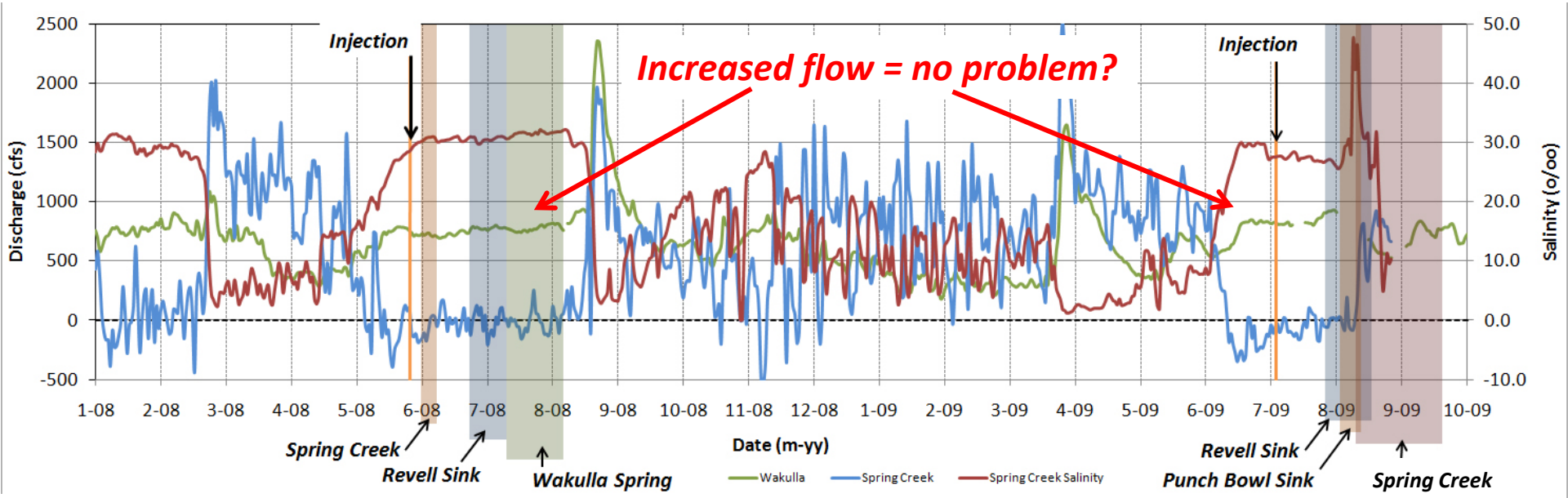
Wakulla / Spring Creek Flows

- Composite Spring Creek flow & salinity (USGS).
- Summers 2007 –: Spring Creek stops flowing / salinities rise to sea water levels.
- When Spring Creek stops flowing, Wakulla Spring flow increases
- When Spring Creek is flowing, Lost Creek water flows rapidly to Spring Creek.
- When spring Creek stops flowing, Lost Creek water flows slowly to Wakulla Spring.



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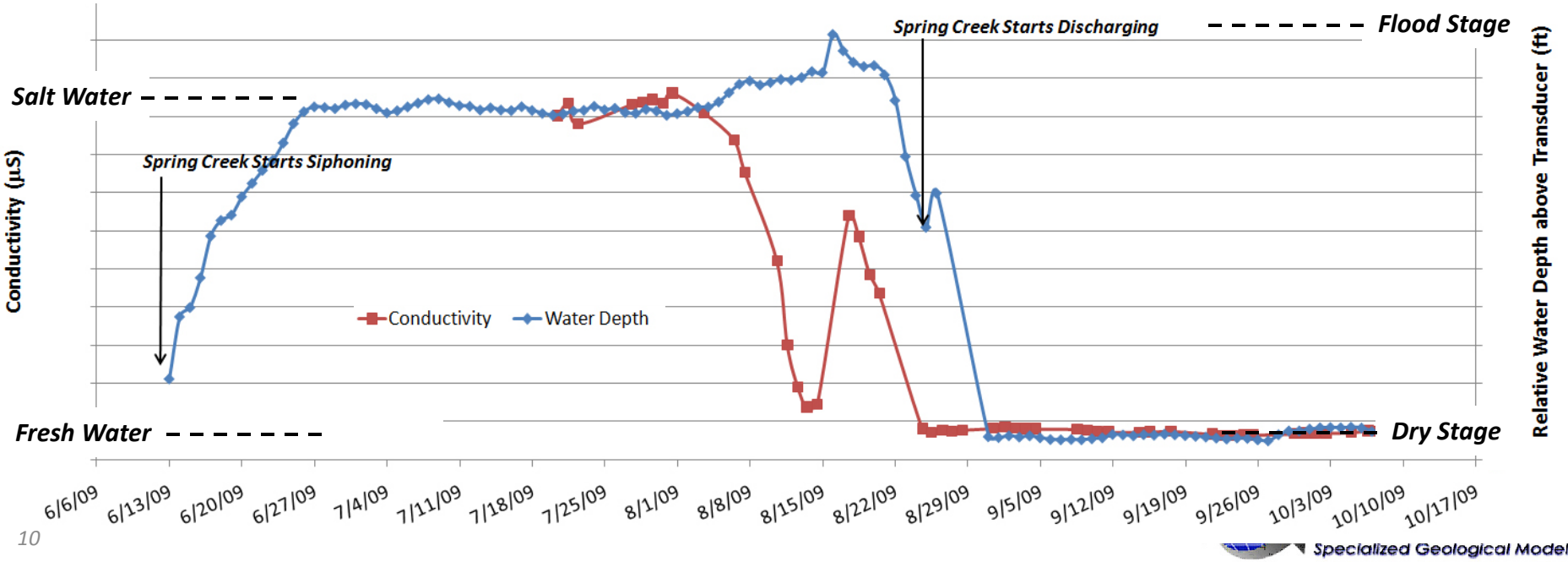
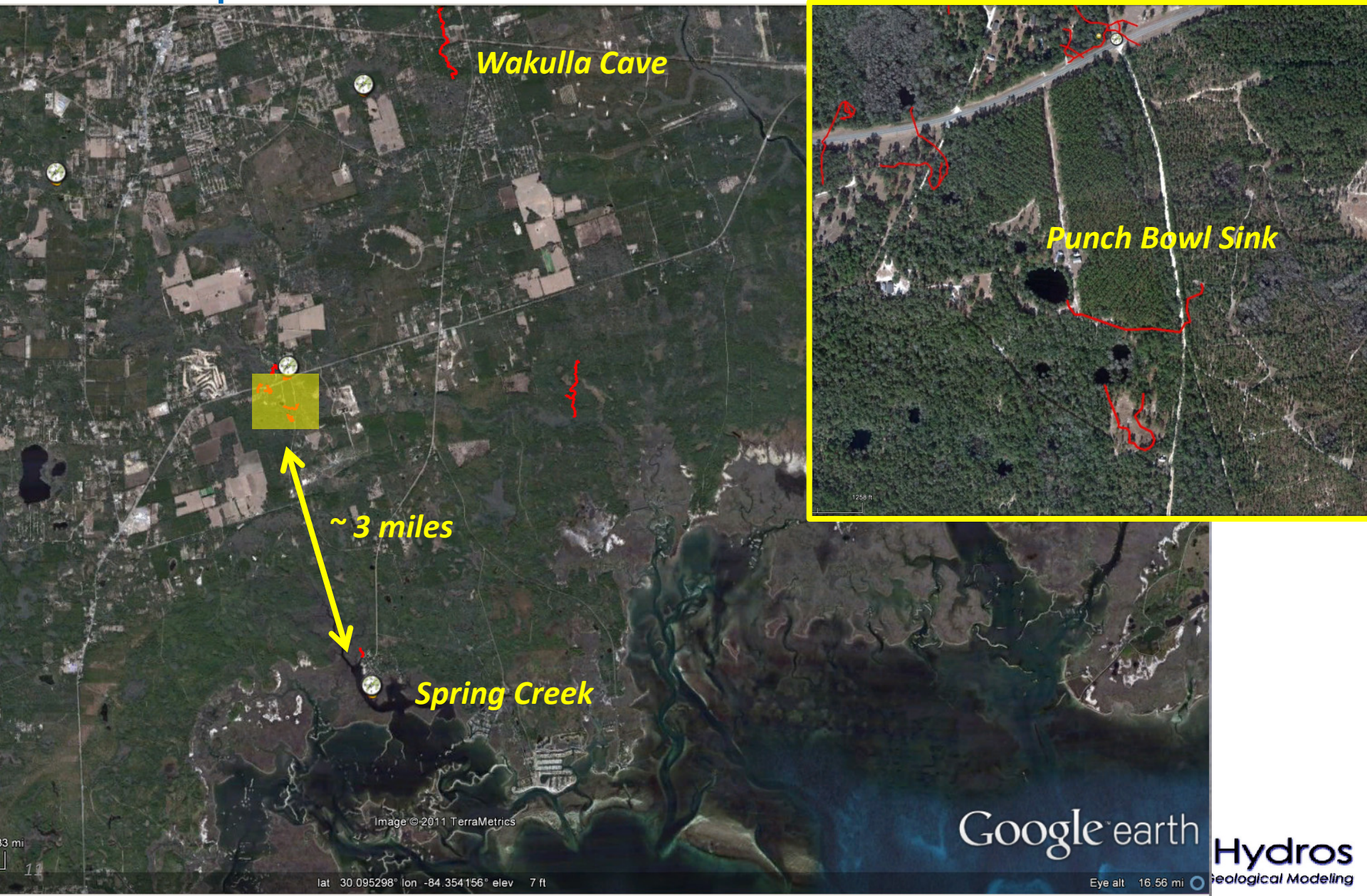
Consequences of Reversals…

- When Spring Creek stops flowing, water backs up into the aquifer matrix in the southern part of the WKP.
- Salt water travels rapidly for long distances (>= 2 miles to Punch Bowl Sink) in days.
- Sinkhole water levels rise to flood stage.
- When Spring Creek starts flowing, water levels drop precipitously and water in conduits returns to fresh water conductivities.



Consequences of Reversals Cont…



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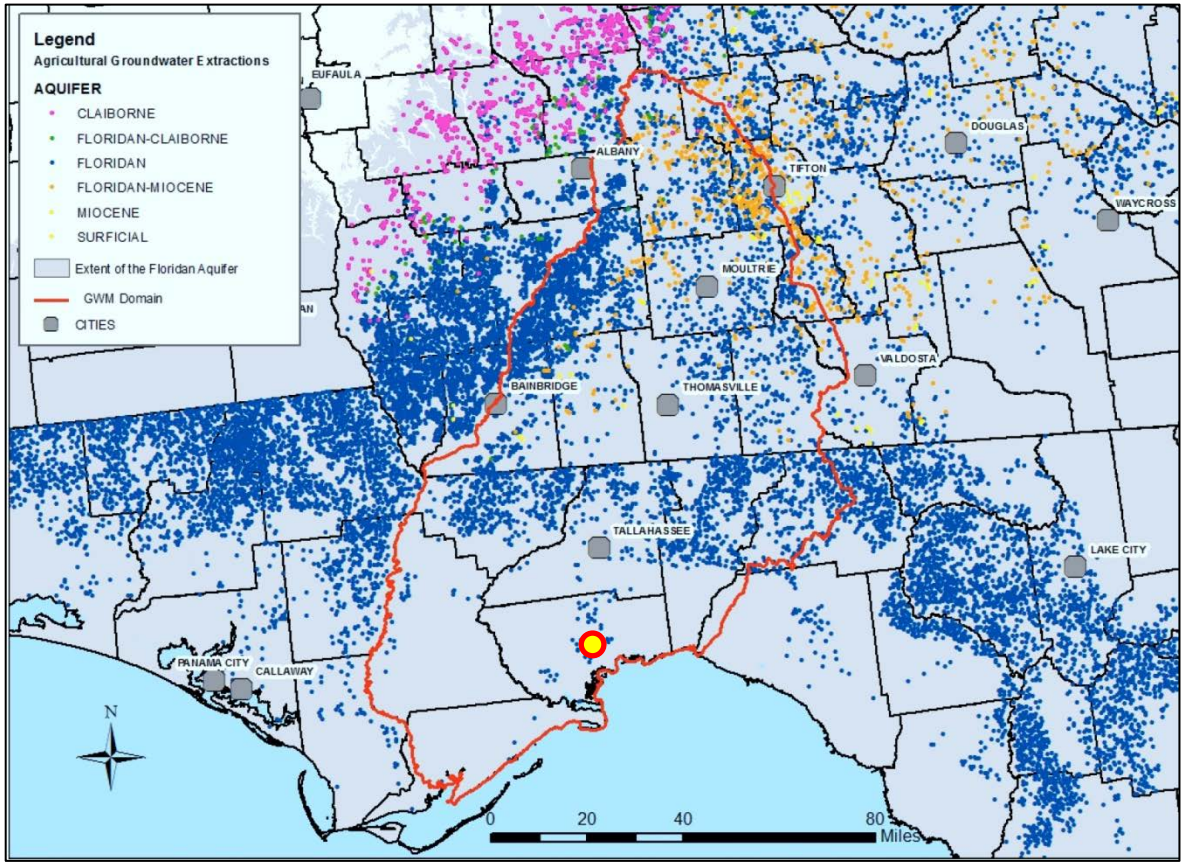
Agricultural Pumping



- o GA
  183 MGD – Con. Counties
  93 MGD – Model Domain
- o FL
  29 MGD – Con. Counties
  21 MGD – Model Domain

National Environmentally Sound Production Agriculture Laboratory (NESPAL)
University of Georgia's College of Agricultural and Environmental Sciences
Georgia EPD
NWFWMD
SRWMD

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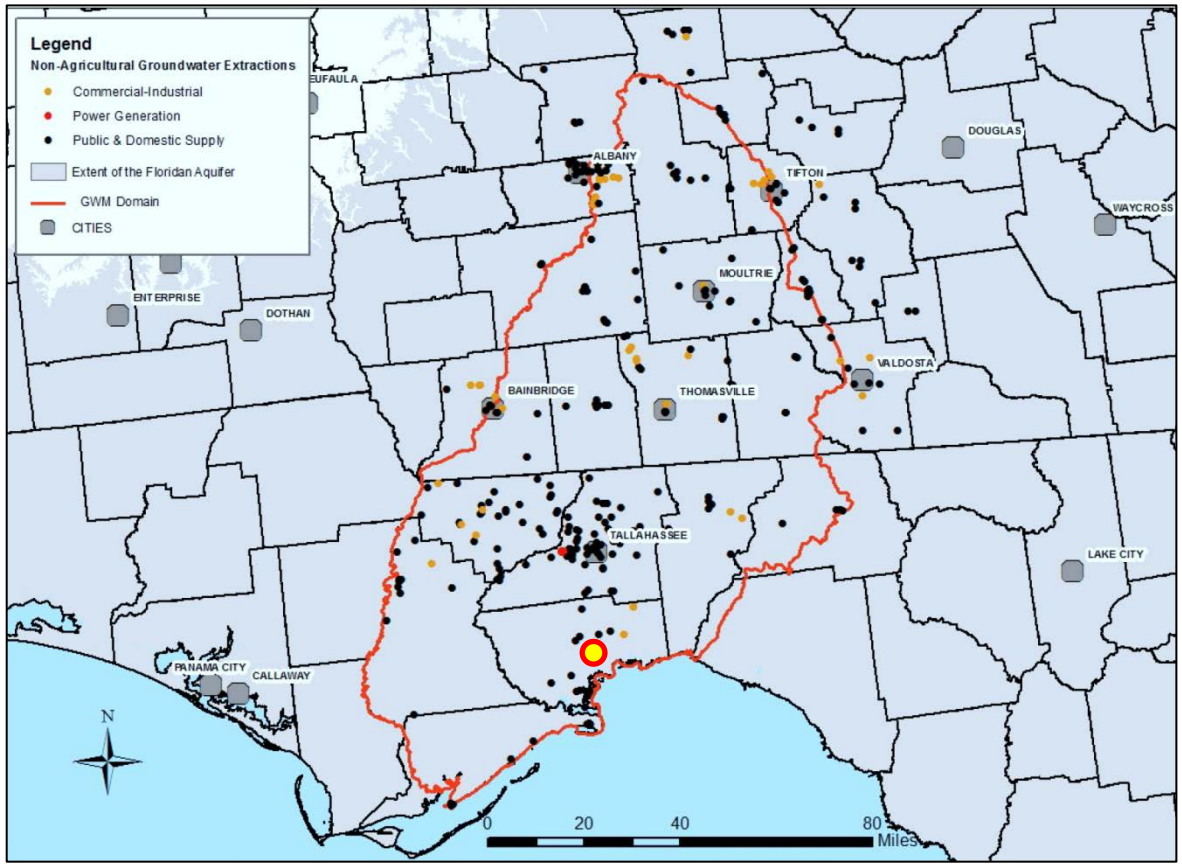
Municipal Pumping



- GA
  54 MGD – Con. Counties
- FL
  24 MGD – Con. Counties

GA: Fanning & Trent 2009
FL: Marella 2009
FL: NWFWMD

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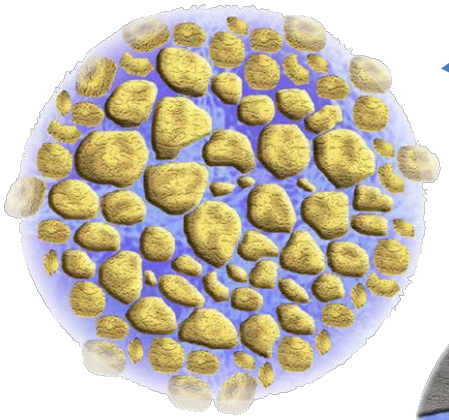
Modeling Approaches

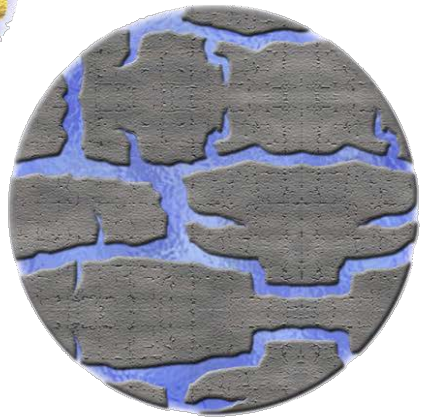
Porous Media



Standard Approach

sand / sandstone
easy to characterize
simplest math

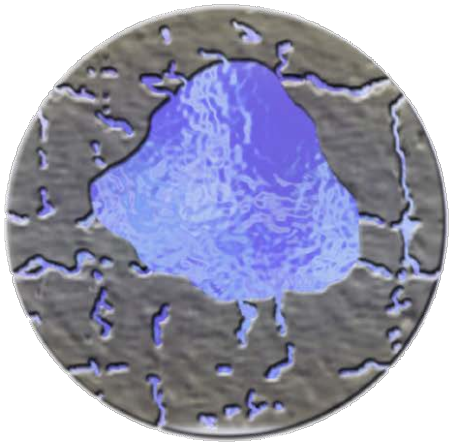
Fractered Rock



New Approach

hard rocks (shale, granite, etc)
can map from surface
harder to characterize
more difficult math

Karst (Conduits)



Limestone (Floridan Aquifer)
cannot typically be mapped
hardest to characterize
most difficult math

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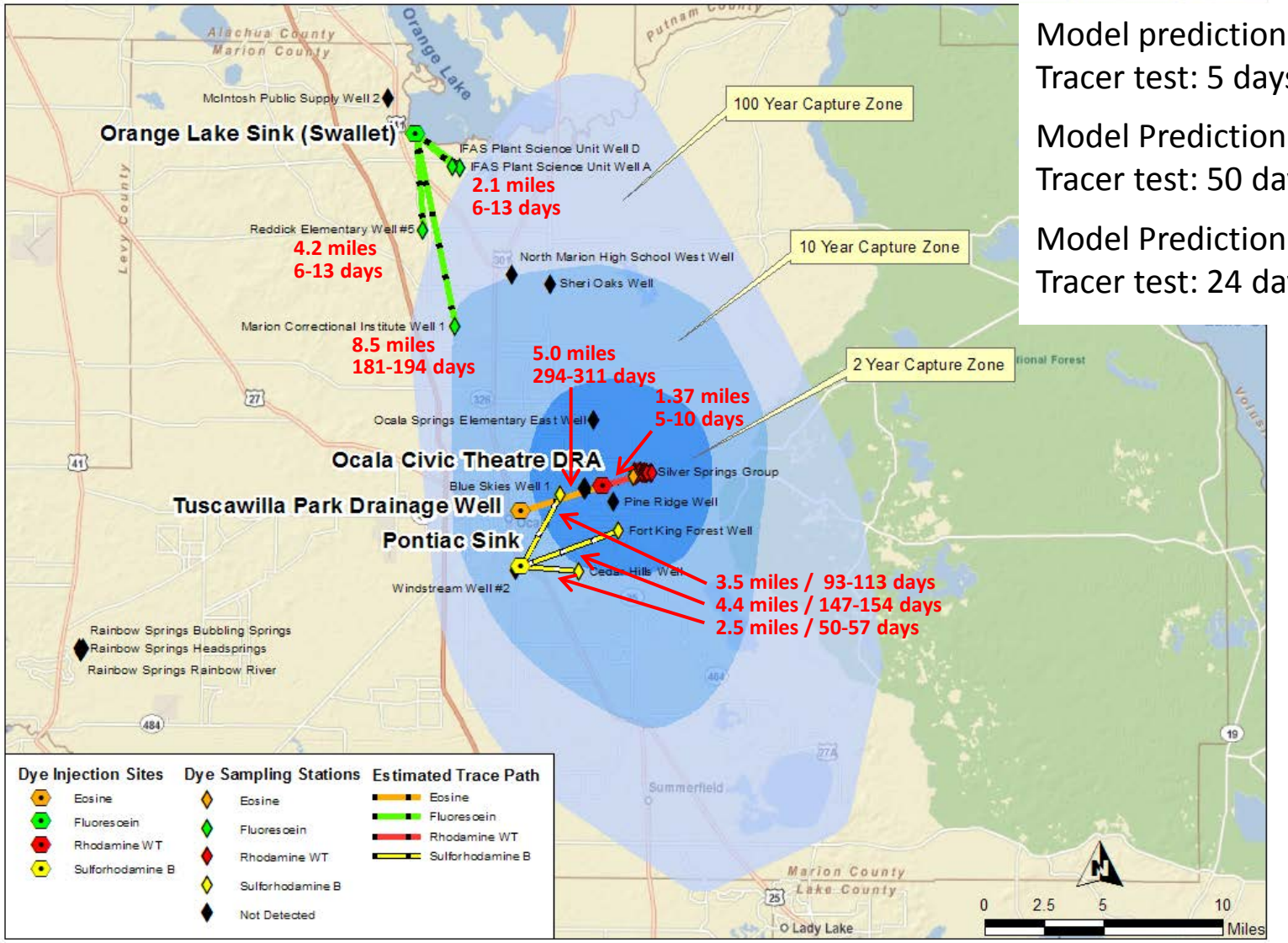
What's the Difference?



Model prediction: 2 years
Tracer test: 5 days – 10.5 months

Model Prediction: 10 years
Tracer test: 50 days – 10.5 months

Model Prediction: 100 years
Tracer test: 24 days – 12.5 months

Courtesy Karst Environmental Services

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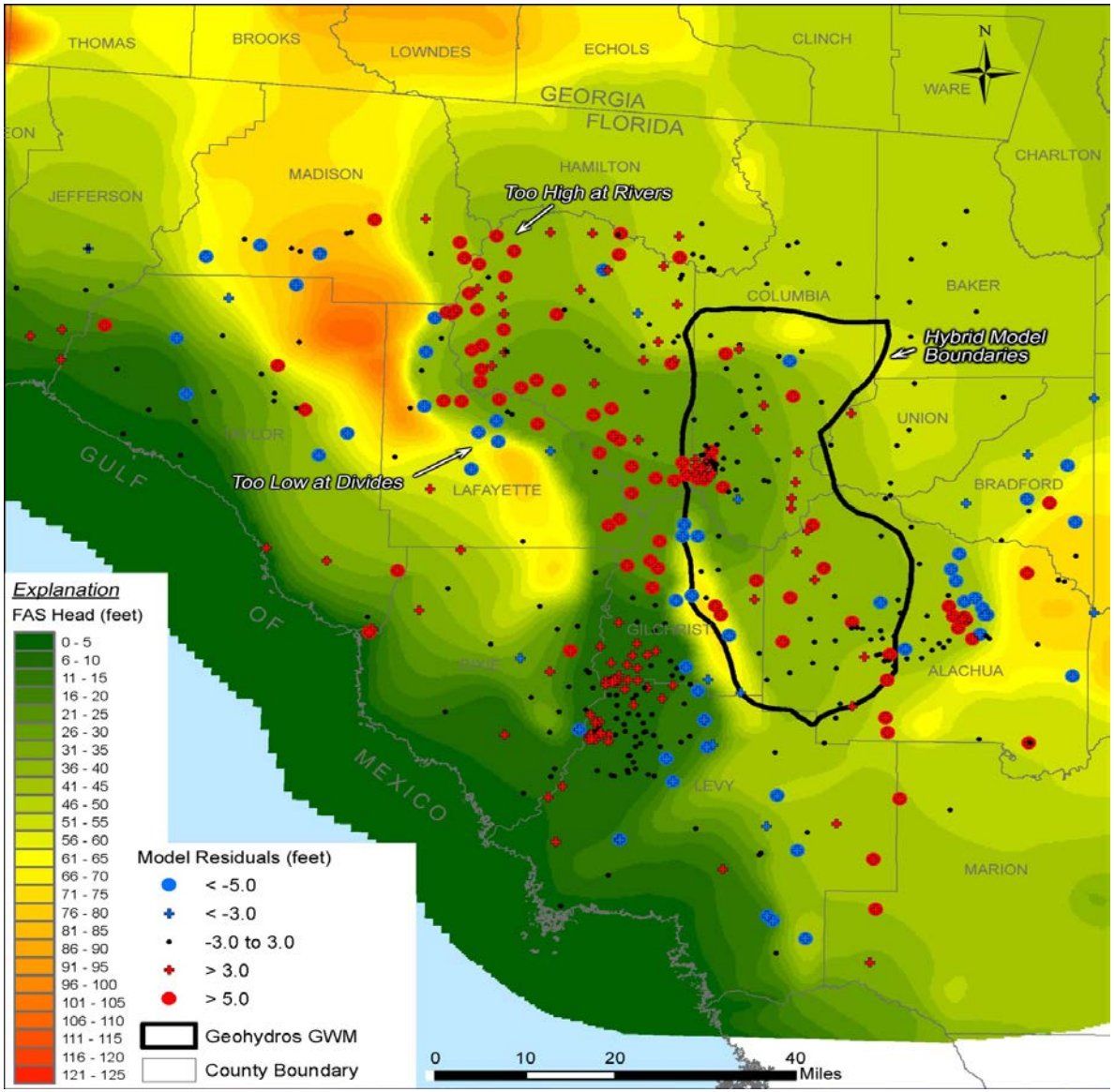
Calibration to Heads



Error >3 ft @ 50% of wells

Error >5 ft @ 27% of wells

Max error: ~32 feet

Too high at rivers

Too low at ridges

Gradient is too flat

Permeabilities are too high

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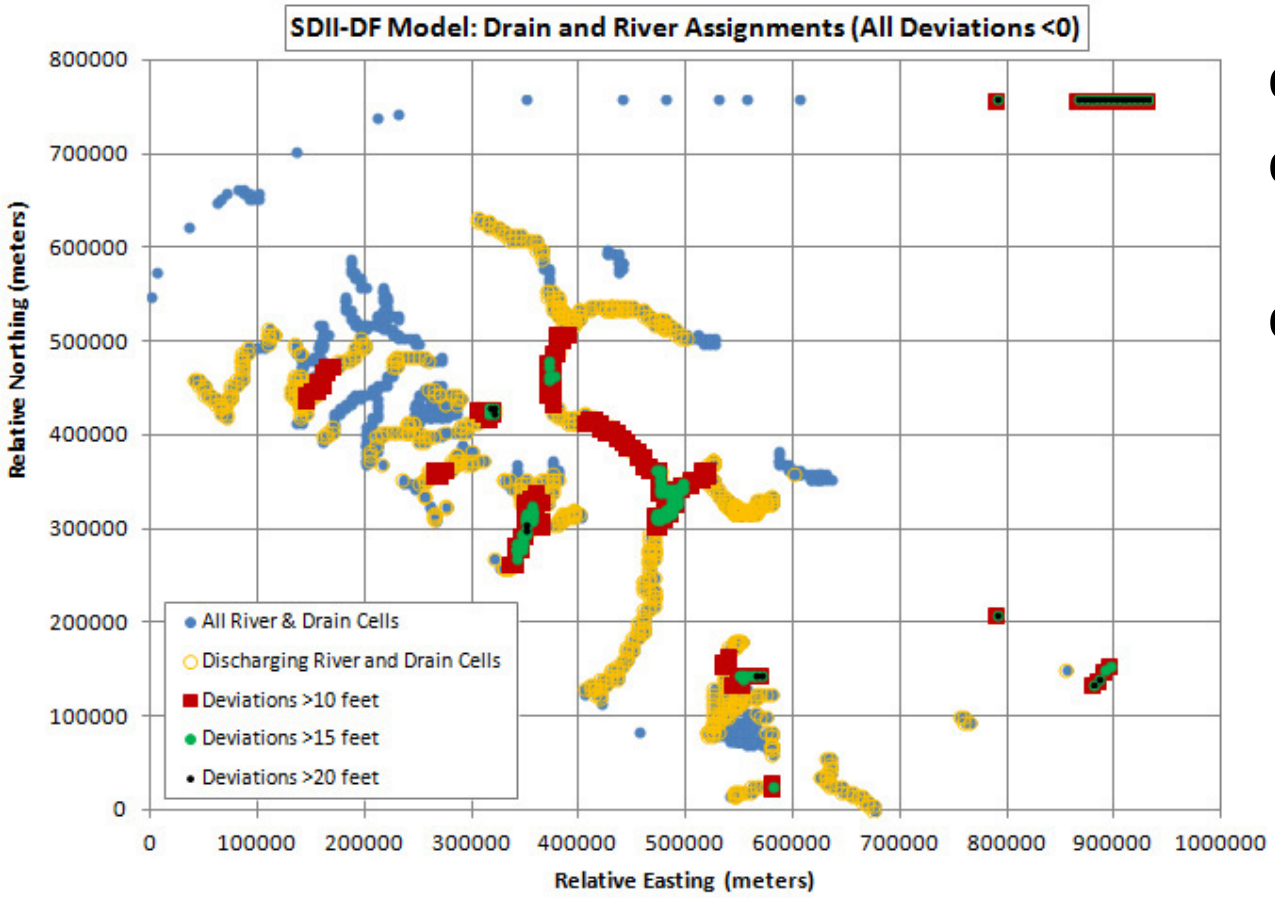
Calibration to River Elevations



- UFA is Unconfined
- River stage = groundwater surface
- Model grossly over-predicts river stage

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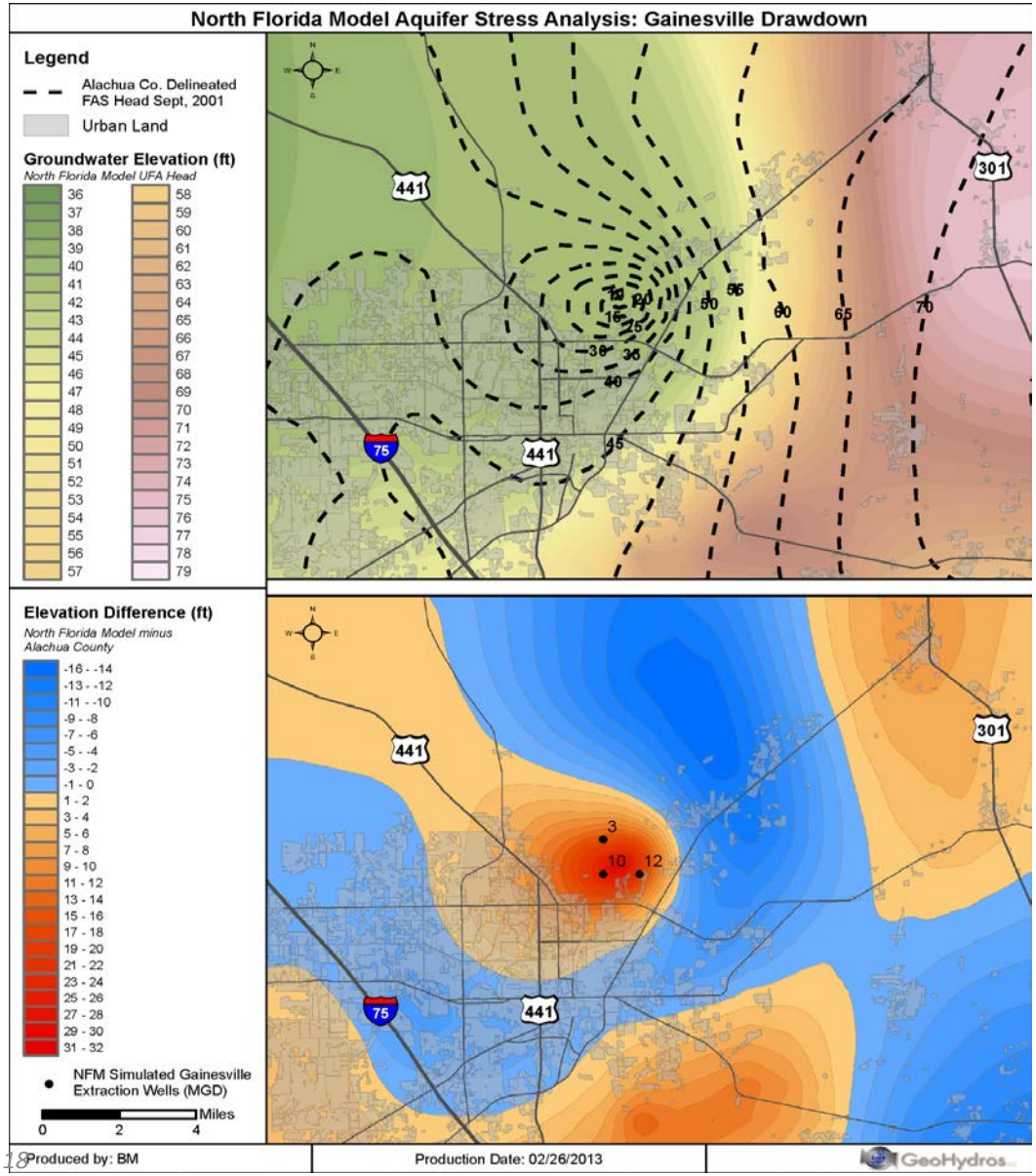
Consequences



- Cannot accurately simulate impact of pumping
- High K = small cone-of-depression

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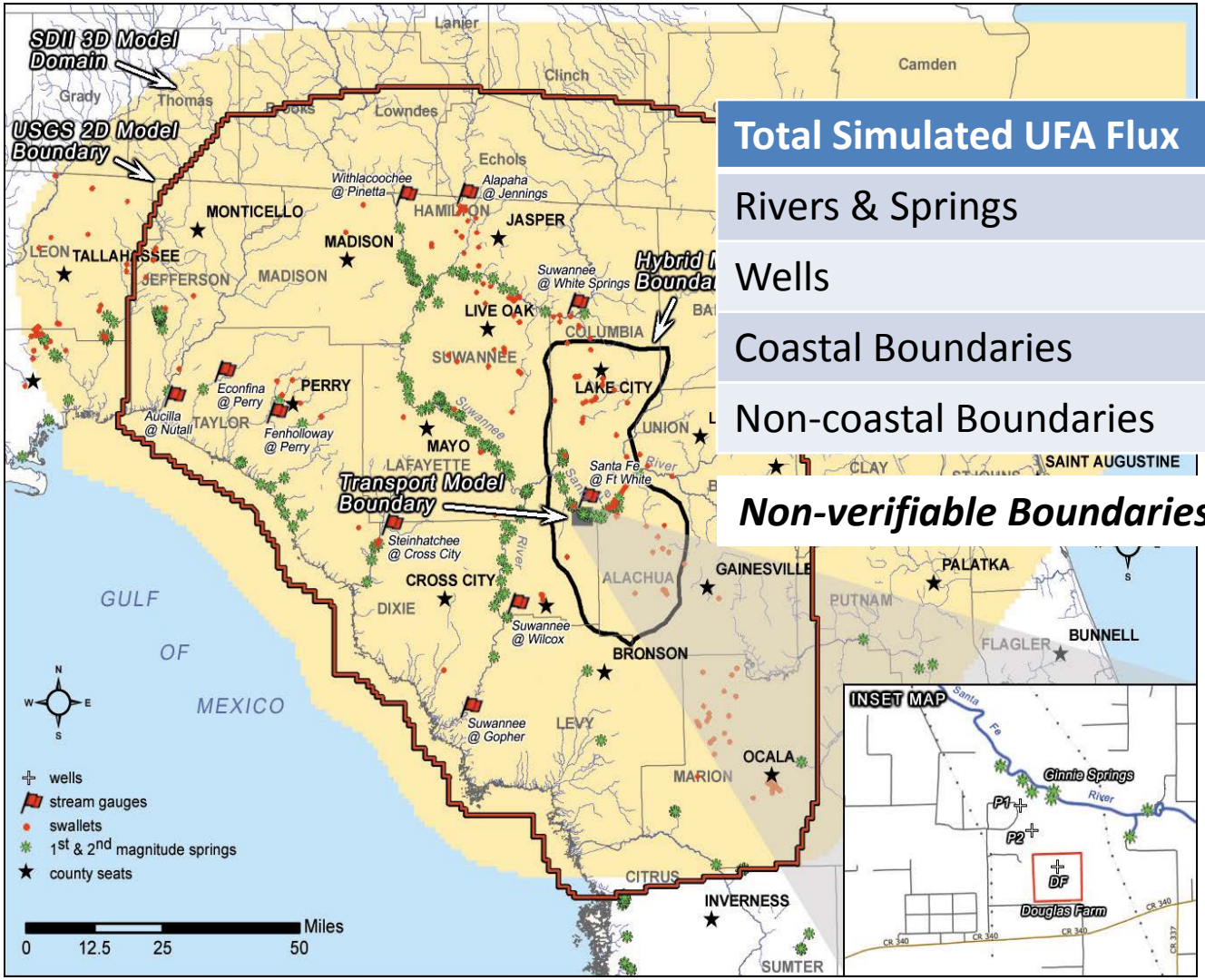
Consequences



	CFS	%
Total Simulated UFA Flux	**13,130**	
Rivers & Springs	7,163	55%
Wells	1,005	8%
Coastal Boundaries	1,809	14%
Non-coastal Boundaries	3,153	24%

Non-verifiable Boundaries = 38% of Total UFA Flux

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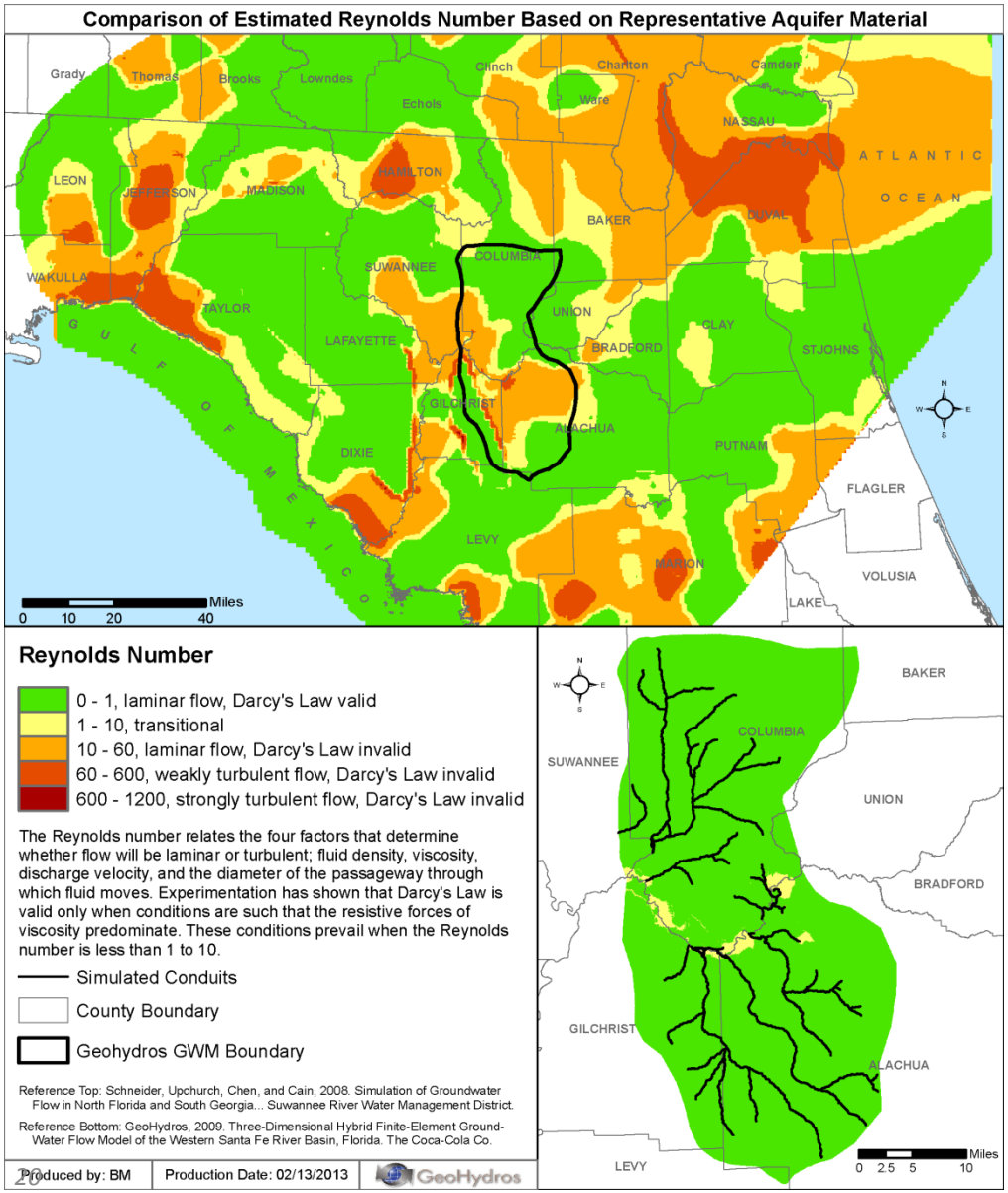
Model Validity



- Porous media models simulate flow using Darcy's law
  $q = K * \delta h/\delta s$
- Darcy's law requires laminar flow
- Reynolds number < 10
- Super-high permeabilities result in high Reynolds numbers
- Model becomes invalid over much of domain

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Summary

- Persistent long-term decline in UFA groundwater levels
- Resulted in persistent long-term decline in spring & river flows
- UFA is an extremely karstified aquifer where the spring and river flows are supplied by conduits that drain the aquifer matrix
- Models have not predicted the declines or the location of impacts
- Aquifer is not a porous media
- Sustainability requires reduced groundwater extractions
- Effective planning requires better models
- No more porous media models

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