Springsheds of the Santa Fe River Basin

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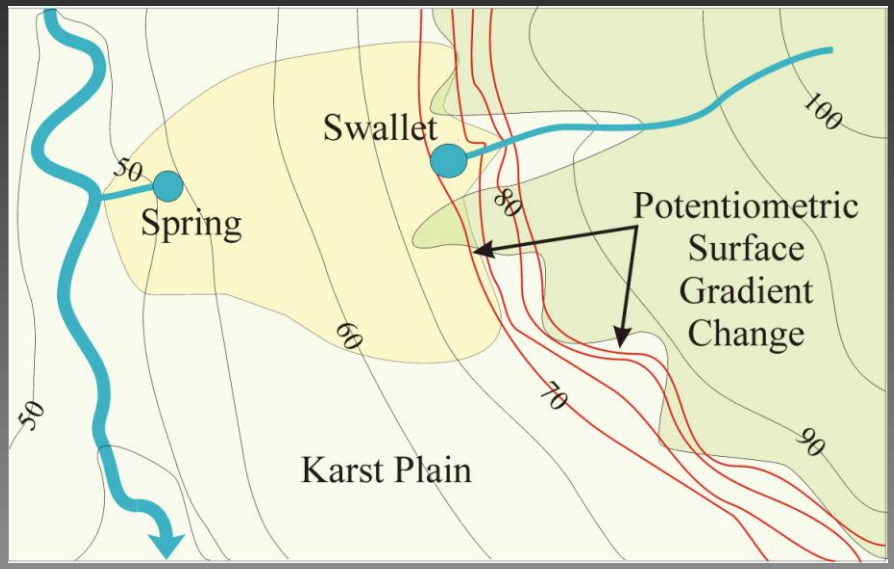
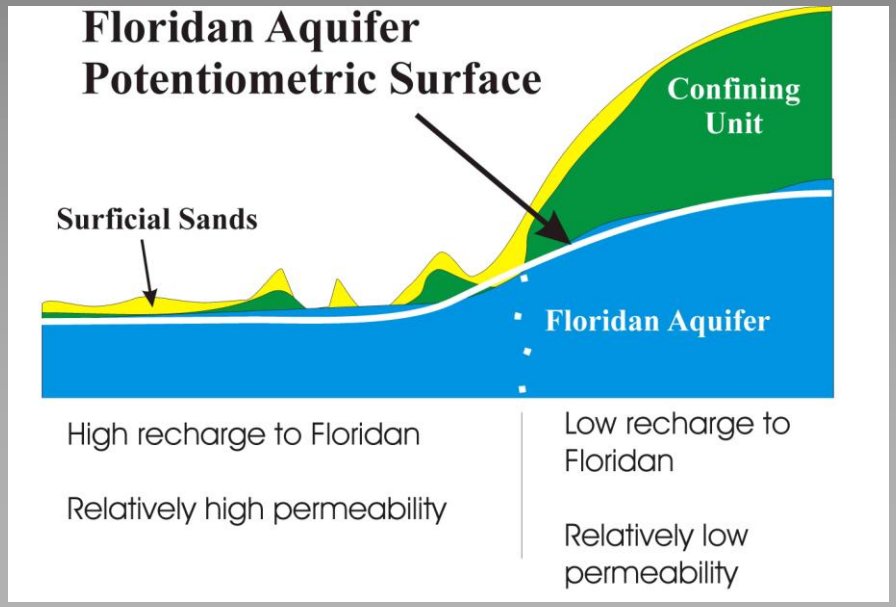
Springshed

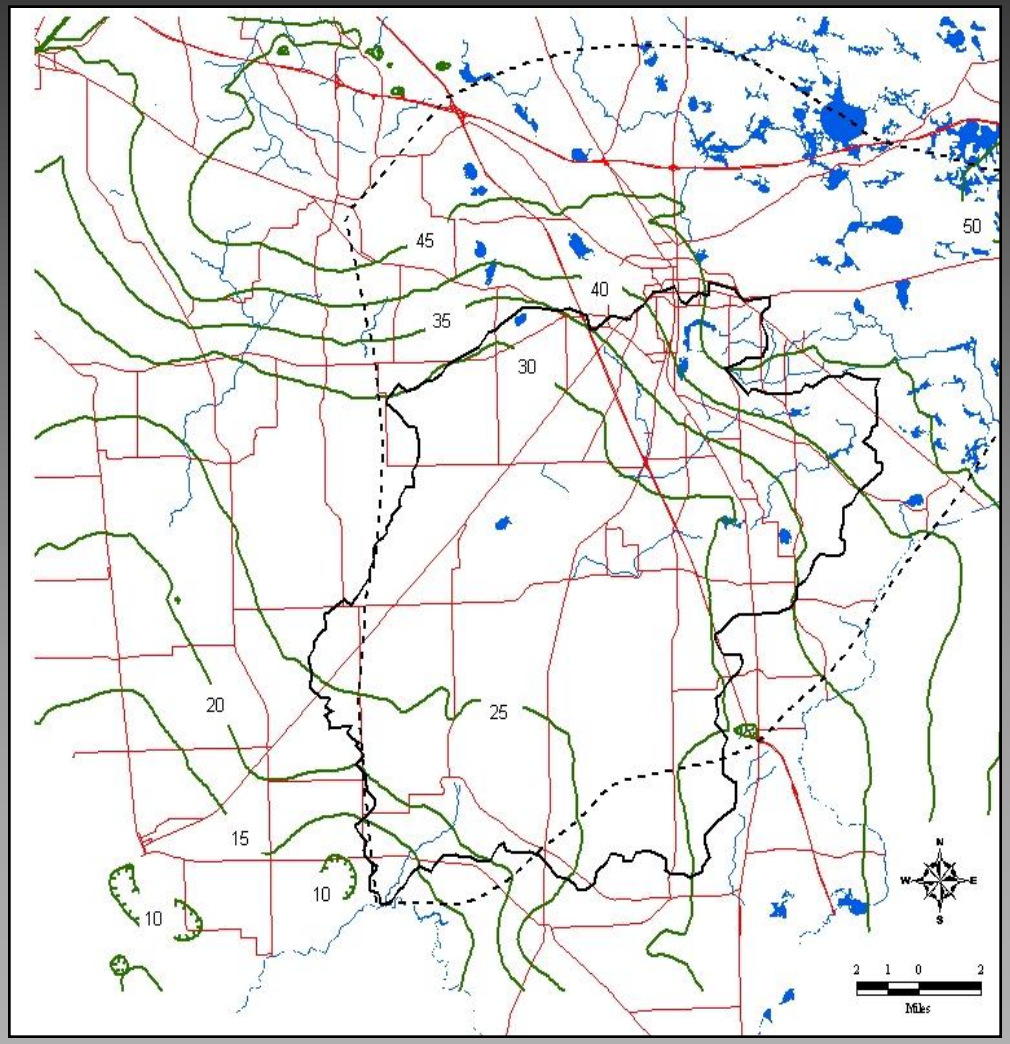
- Area contributing water to the discharge of a spring.
- Includes
  - Groundwater basin and
  - Surface water basin





Sample Map – Ichetucknee Springs

- Based on high resolution data
- 1-foot contour interval
- Note that basin appears to pass under the Northern Highlands



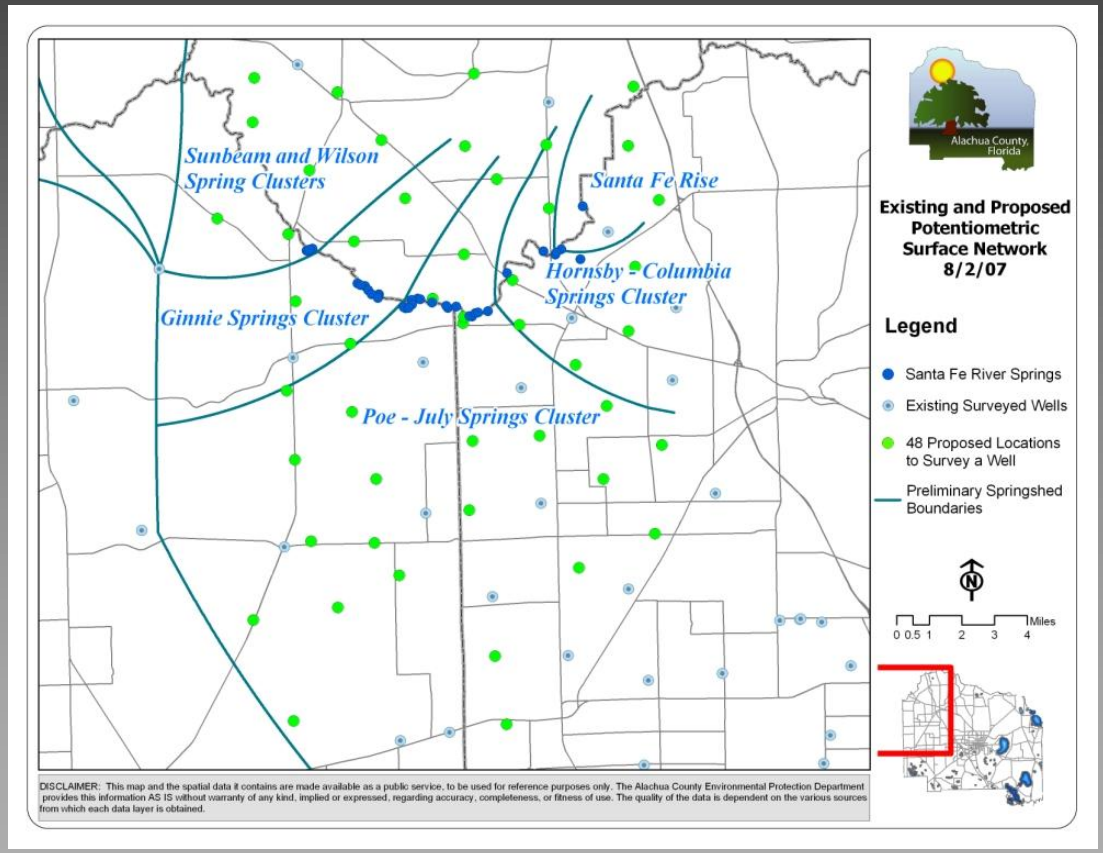
Upchurch and Champion (2005)

Project Expanded to Two Phases

- Phase I
  - Literature review
  - Springshed delineation using existing upper Floridan potentiometric surface data from 2000
  - Capture zones modeled using USGS and SRWMD groundwater flow models
  - Reported on in June 2007
  - Comments by Alachua County and FDEP

Project Expanded to Two Phases

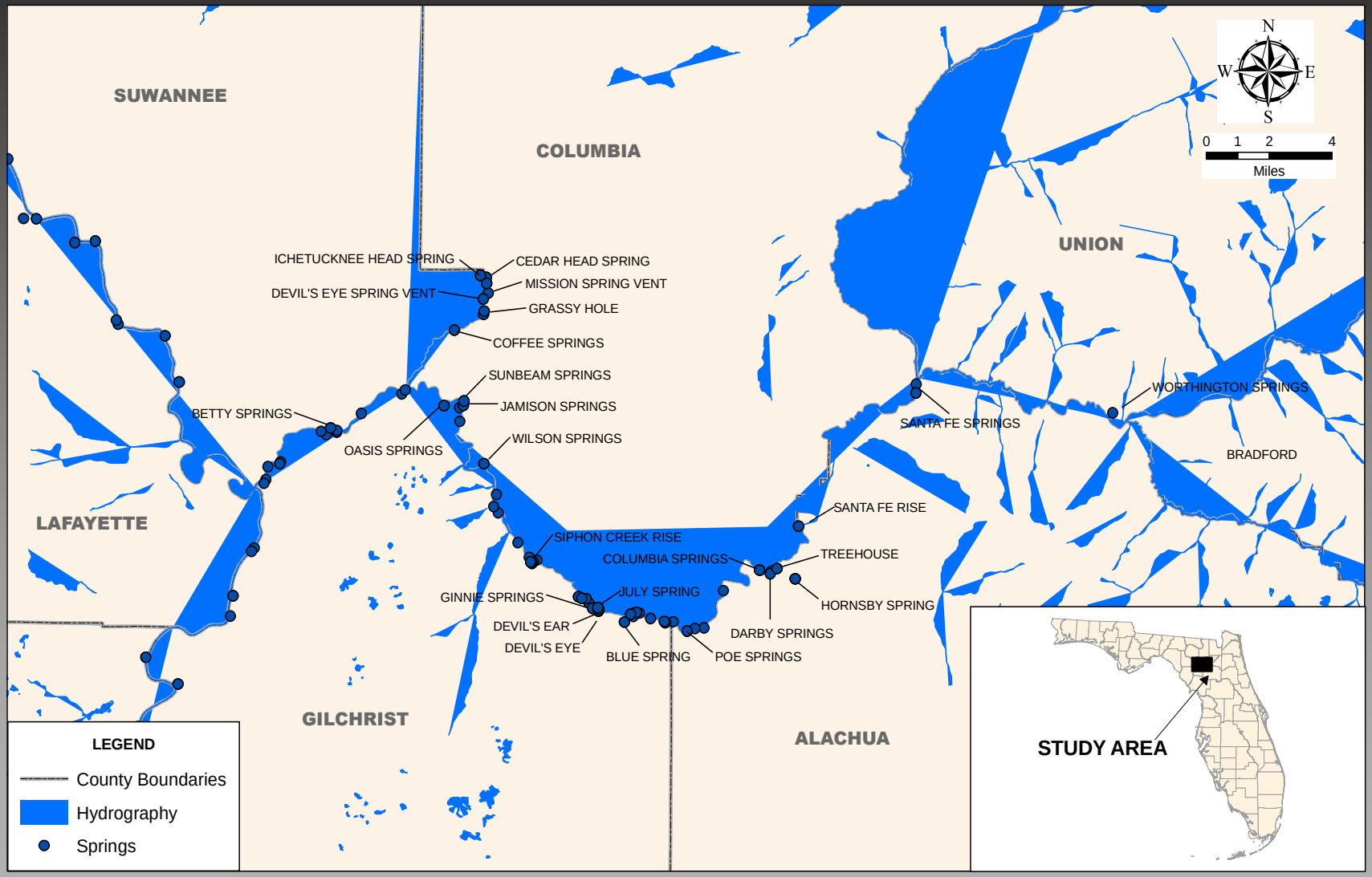
- Phase II
  - Alachua County developed
    - ***High-resolution monitoring network***
    - "Newberry Plain" of the Western Valley
  - Sites located and surveyed
  - Water levels measured in September 2007



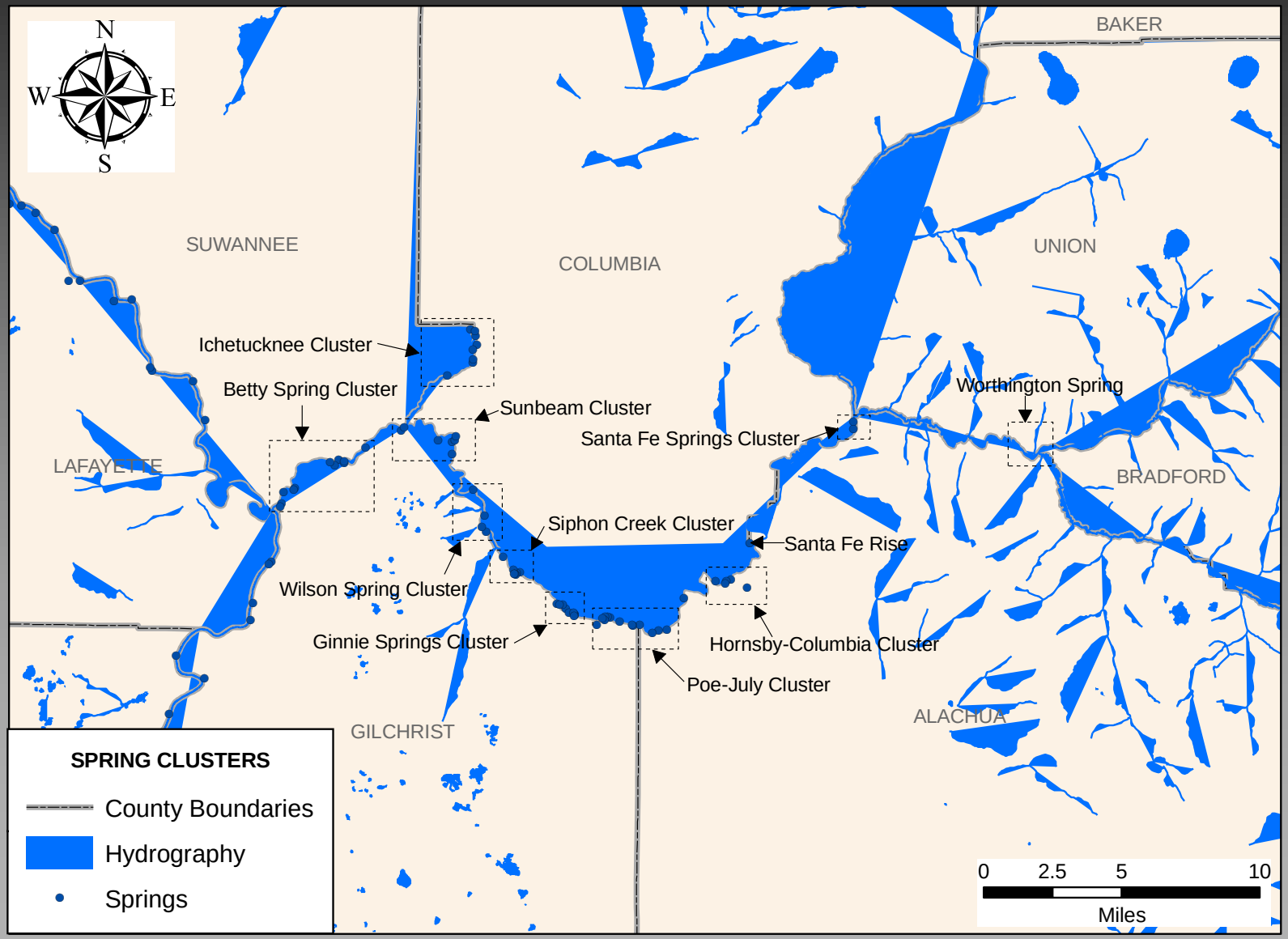
Project Expanded to Two Phases

- Phase II Continued
  - Geostatistical analysis to evaluate adequacy of monitoring network
  - Delineation of springsheds using high-resolution monitoring network and 1 foot contours
  - Revision of report

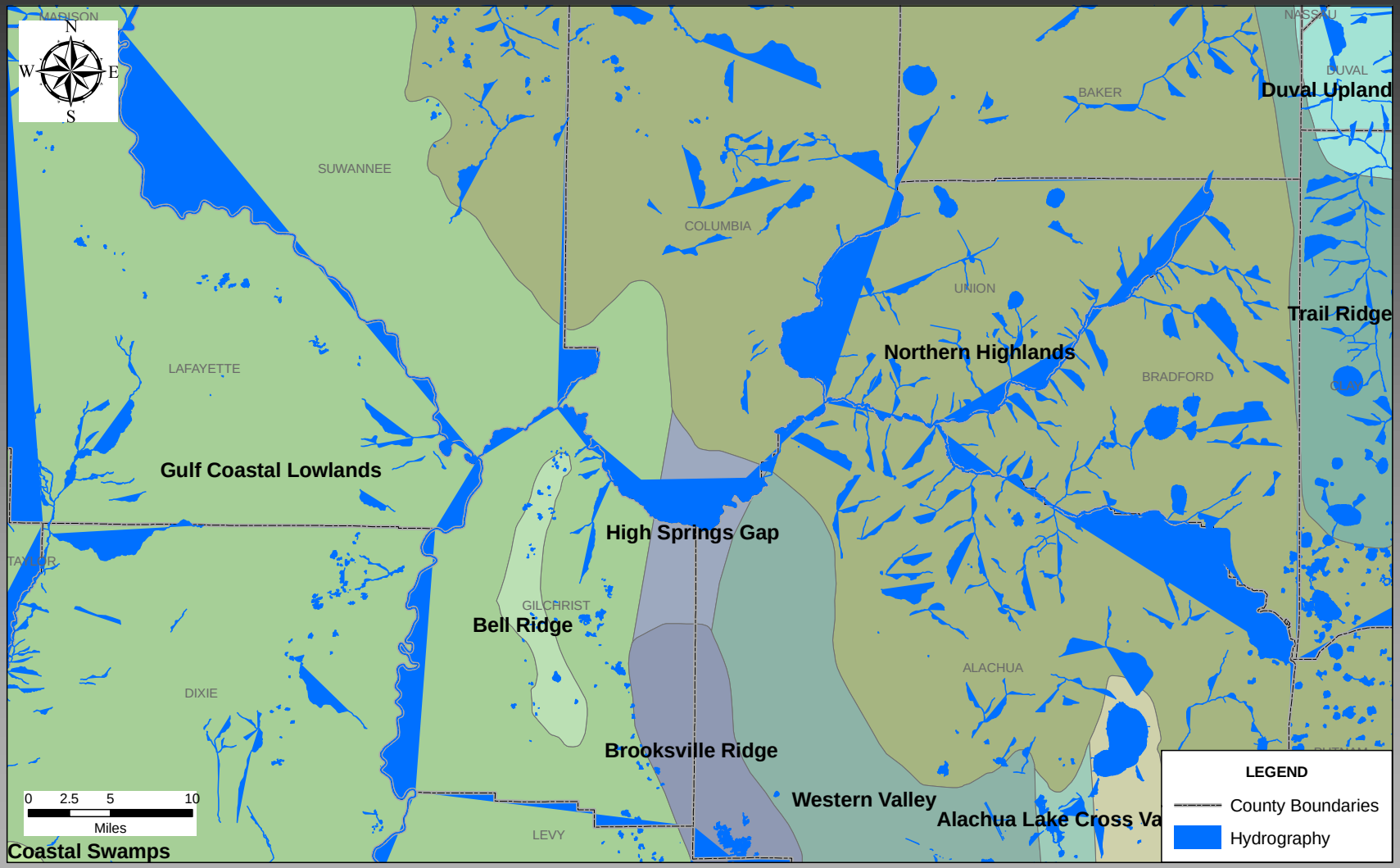
Area Overview



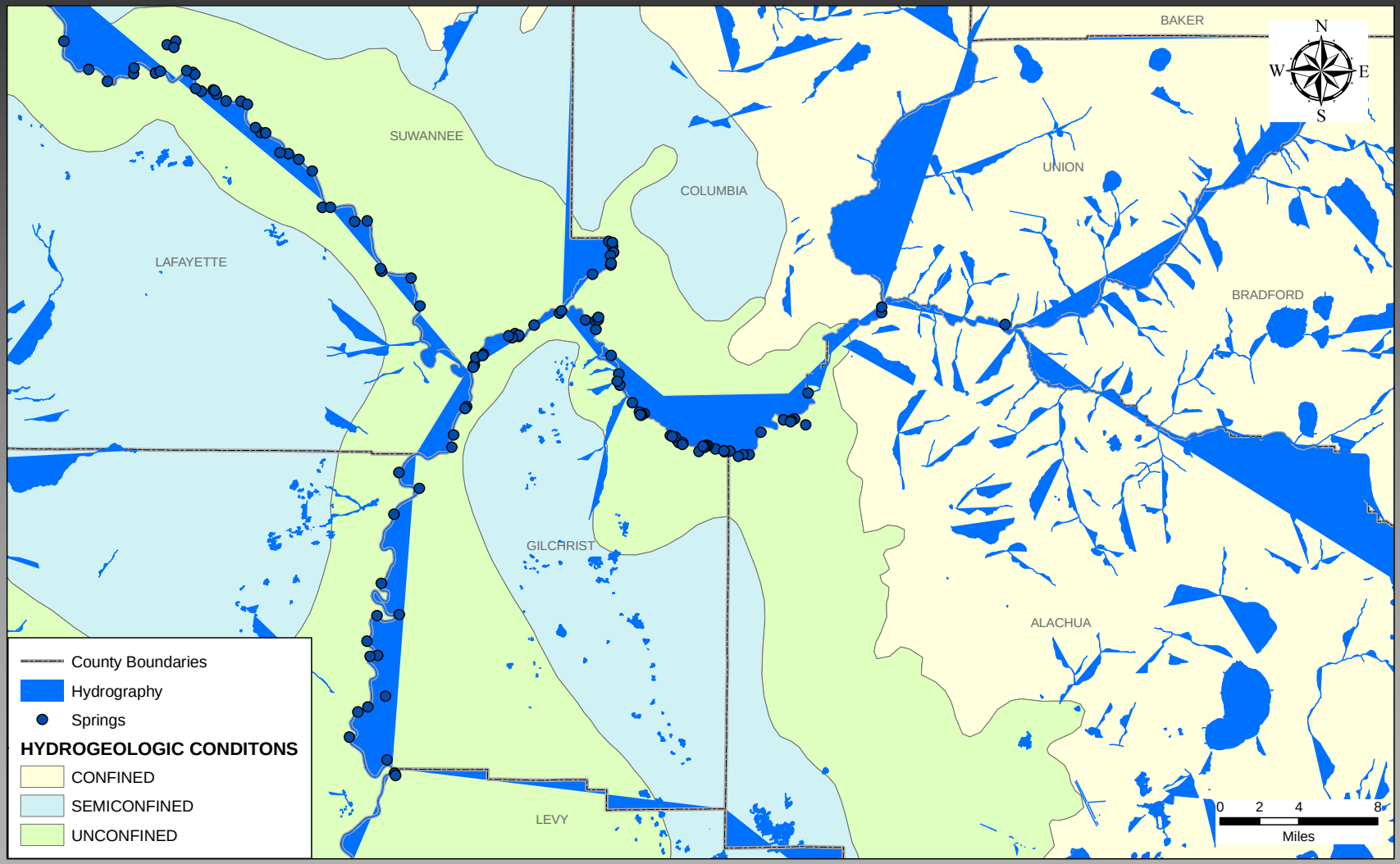
Spring Clusters



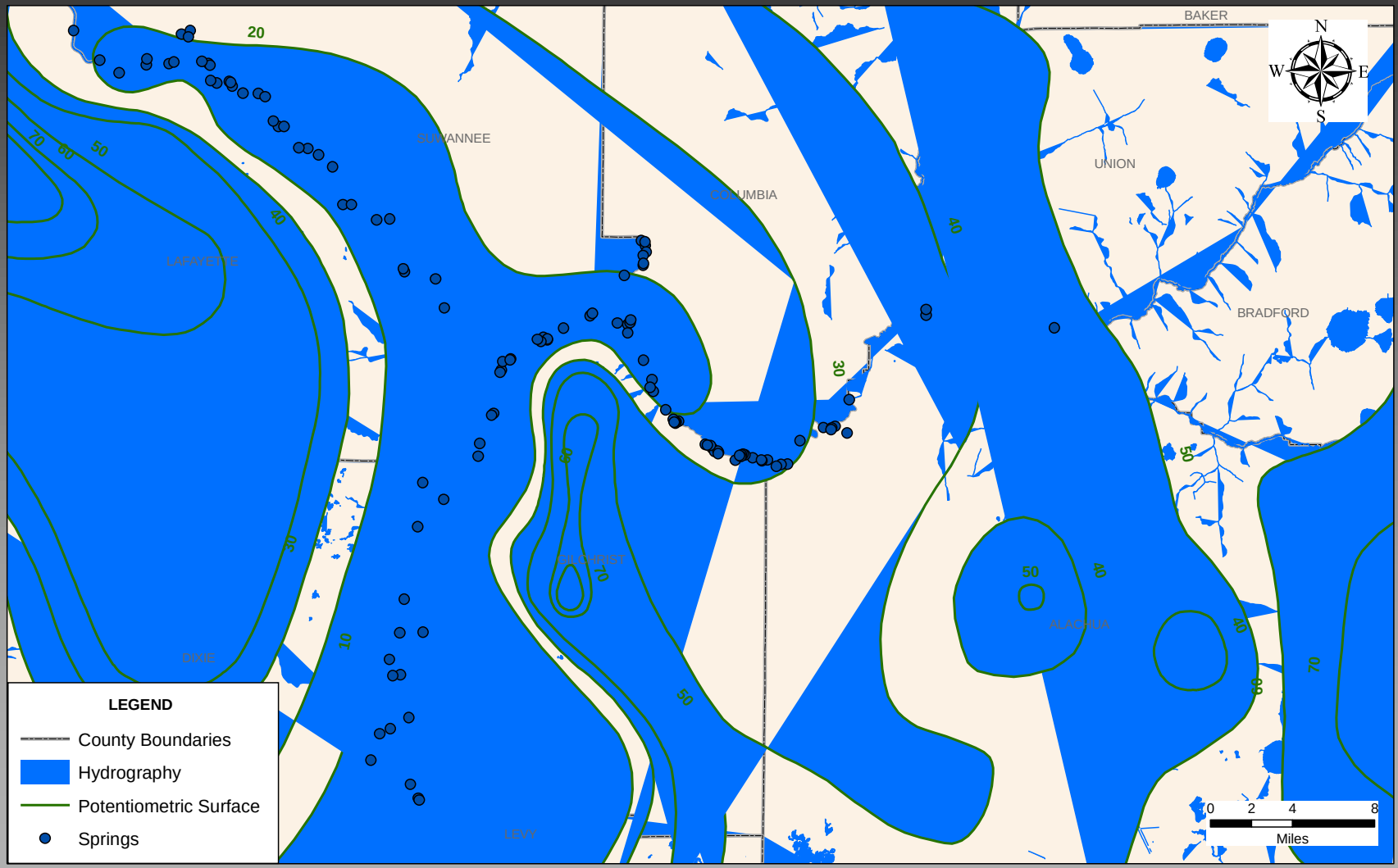
Physiographic Provinces



Aquifer Confinement



2000 Potentiometric Surface



Why Index Period of 2000?

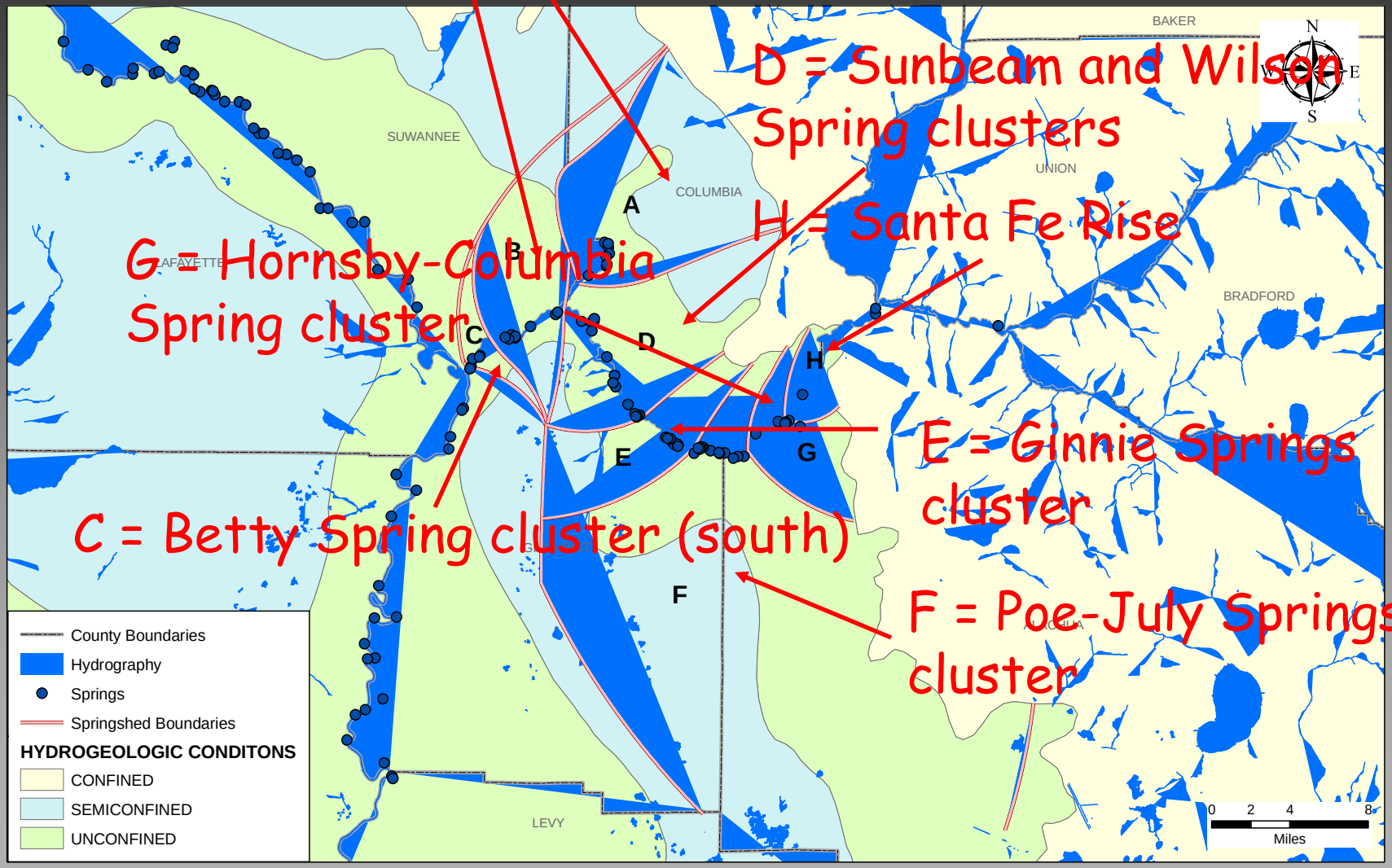
- The District's groundwater flow model was calibrated to conditions in 2000 (Schneider and others, 2008),
- 2000 was a dry year, so the potentiometric surface should have maximum relief and enhance ability to identify springsheds, and
- Potentiometric data were relatively abundant.

Springshed Delineation from Potentiometric Surface Data

- Well density is low in many critical areas
- Available data contoured at 1-foot interval
- Contour map reconciled with known geology and USGS 2000 potentiometric surface

Results

B = Betty Spring cluster (north)

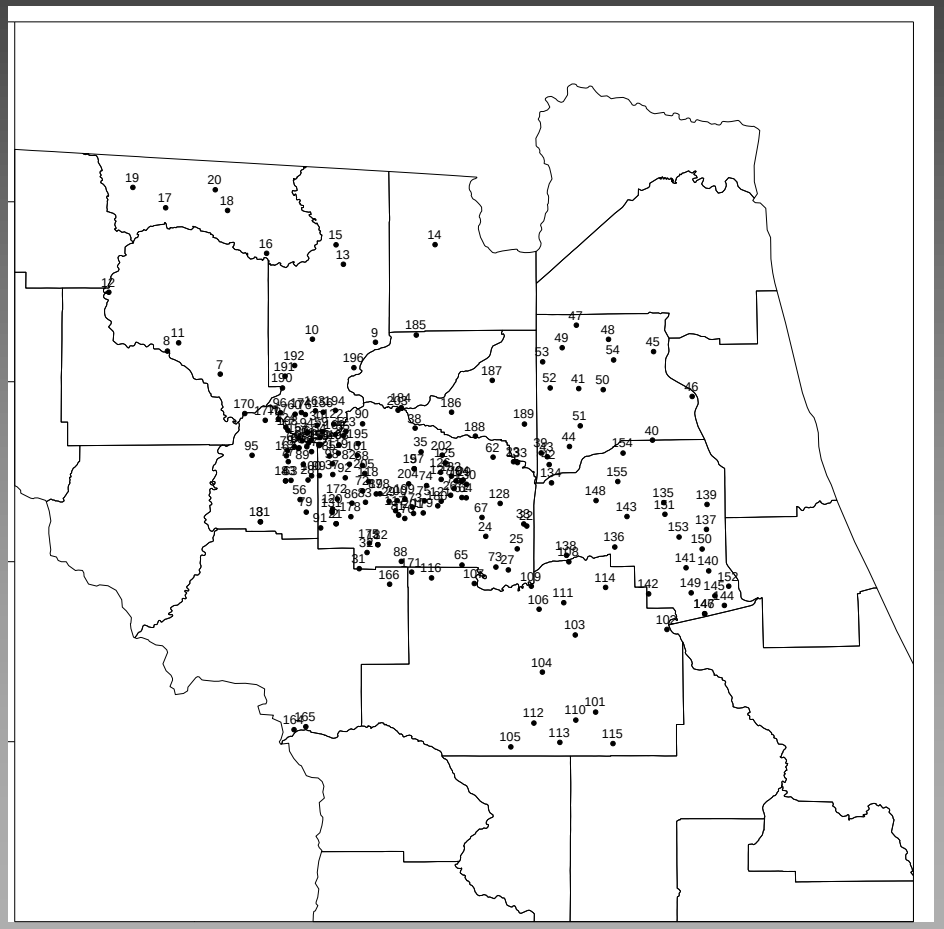


Phase I Delineation Evaluation

- Individual springsheds could not be identified because of
  - Low monitoring well density
  - High hydraulic conductivities and/or conduit flow results in relatively flat potentiometric surfaces near springs
- Springsheds could be identified for spring clusters

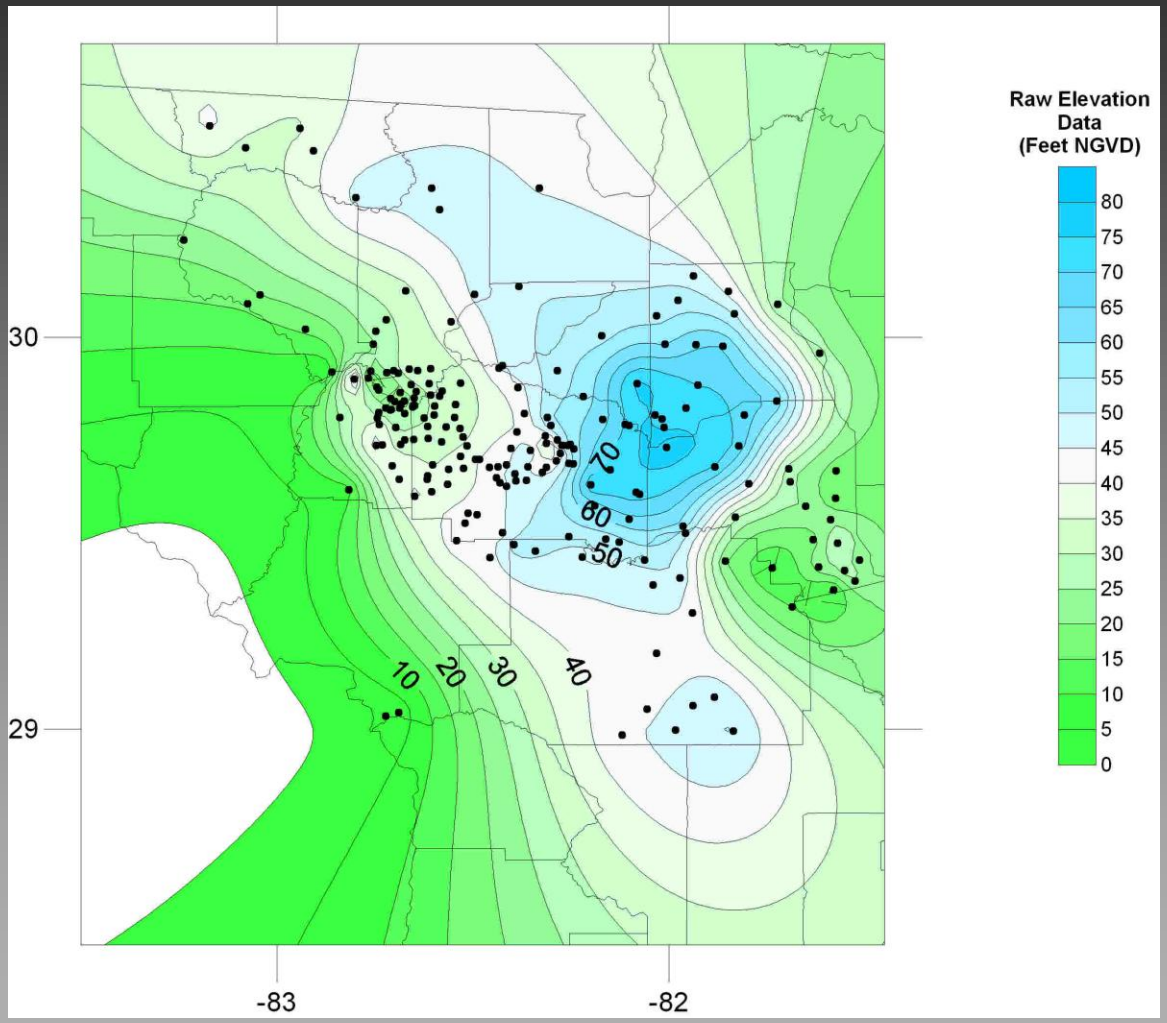
Phase II, High-Resolution Springshed Delineation

- Mix of domestic wells, monitoring wells and piezometers
- Includes
  - Alachua County network,
  - SRWMD WARN data,
  - Danone/Coca-Cola wells



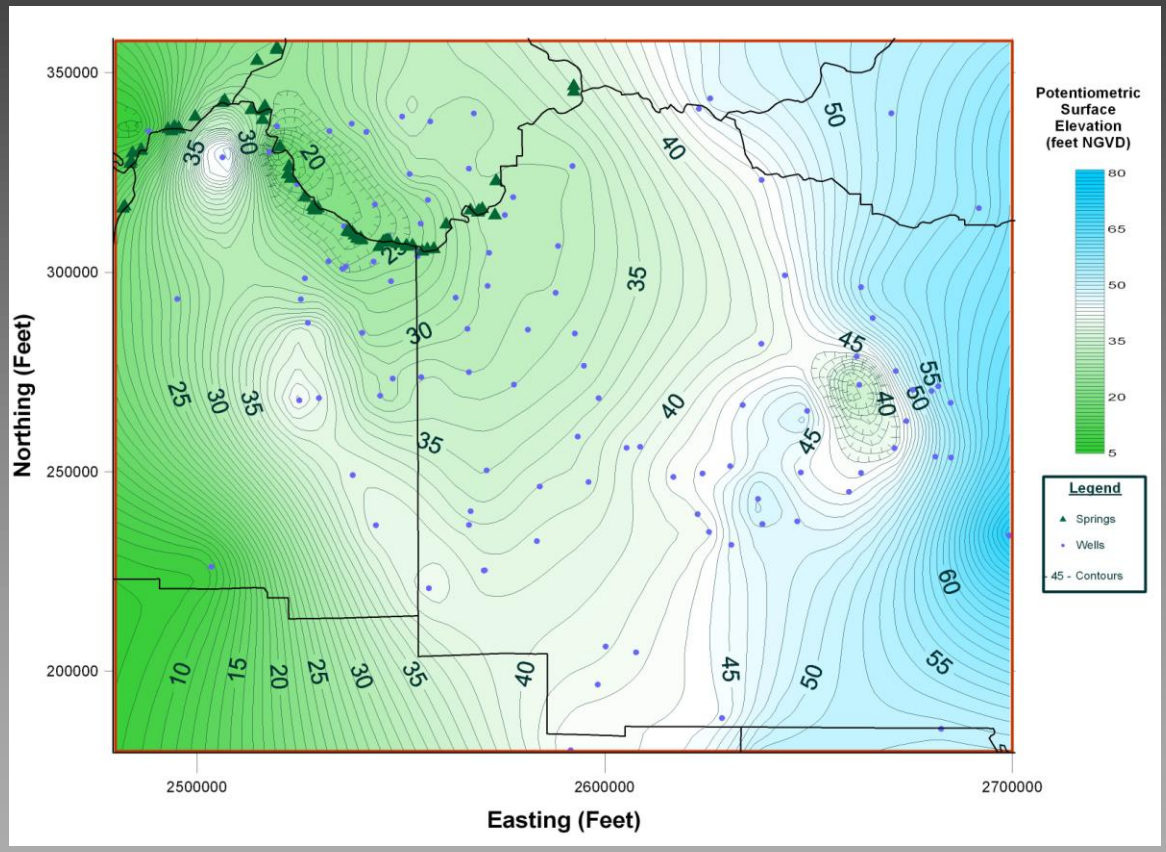
Regional Potentiometric Surface

- Distal wells provide boundary conditions
- Reproduces potentials in Newberry Plain well



Local Potentiometric Surface

- Focus on Newberry Plain area
- Note cone-of-depression near Gainesville



Geostatistical Analysis

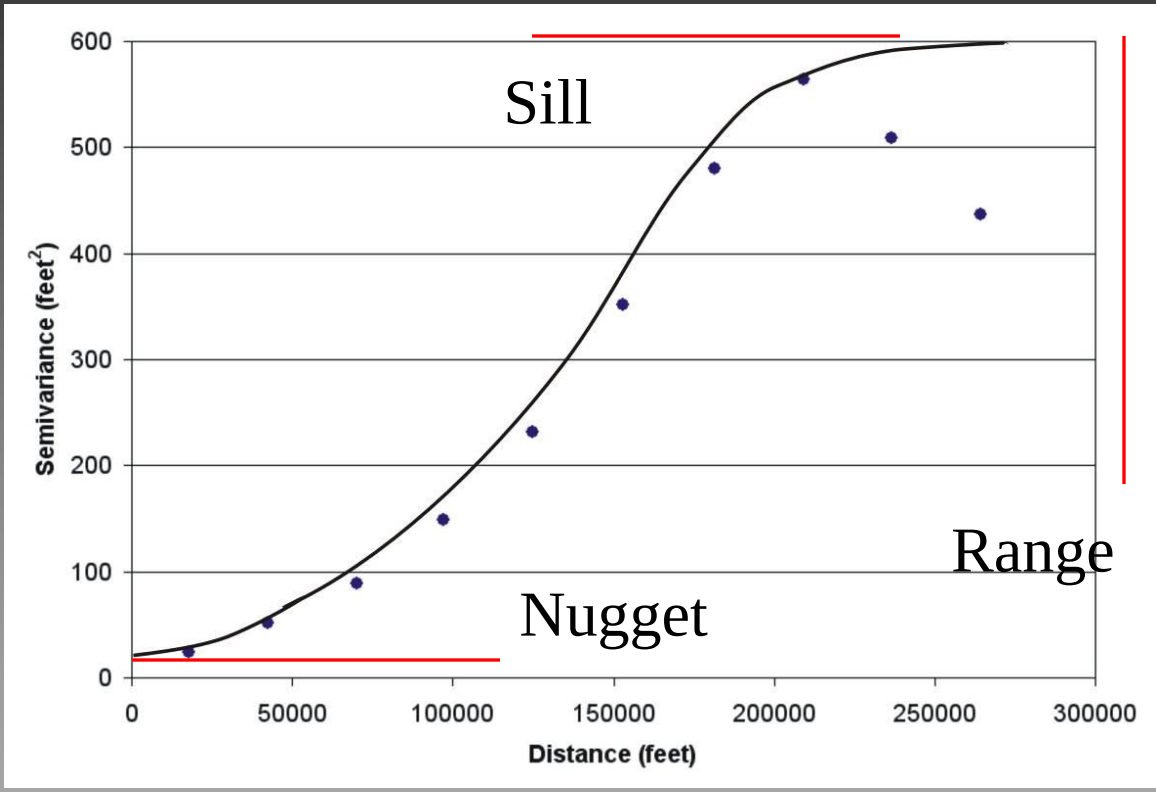
- Used to evaluate monitoring network in terms of
  - Spacing of sampling points
  - Need for additional sampling points
  - Level of uncertainty associated with contour maps (I.e., potentiometric surface maps)
  - Identification of anomalous data points

Geostatistical Analysis

- Two steps
  - Structural analysis
    - "Rules" of contouring
    - Detection of local variability
    - Uncertainty related to distance between sampling points
  - Kriging
    - Map showing property distribution
    - Map showing uncertainty distribution
    - Map that identifies "outliers"

Variogram

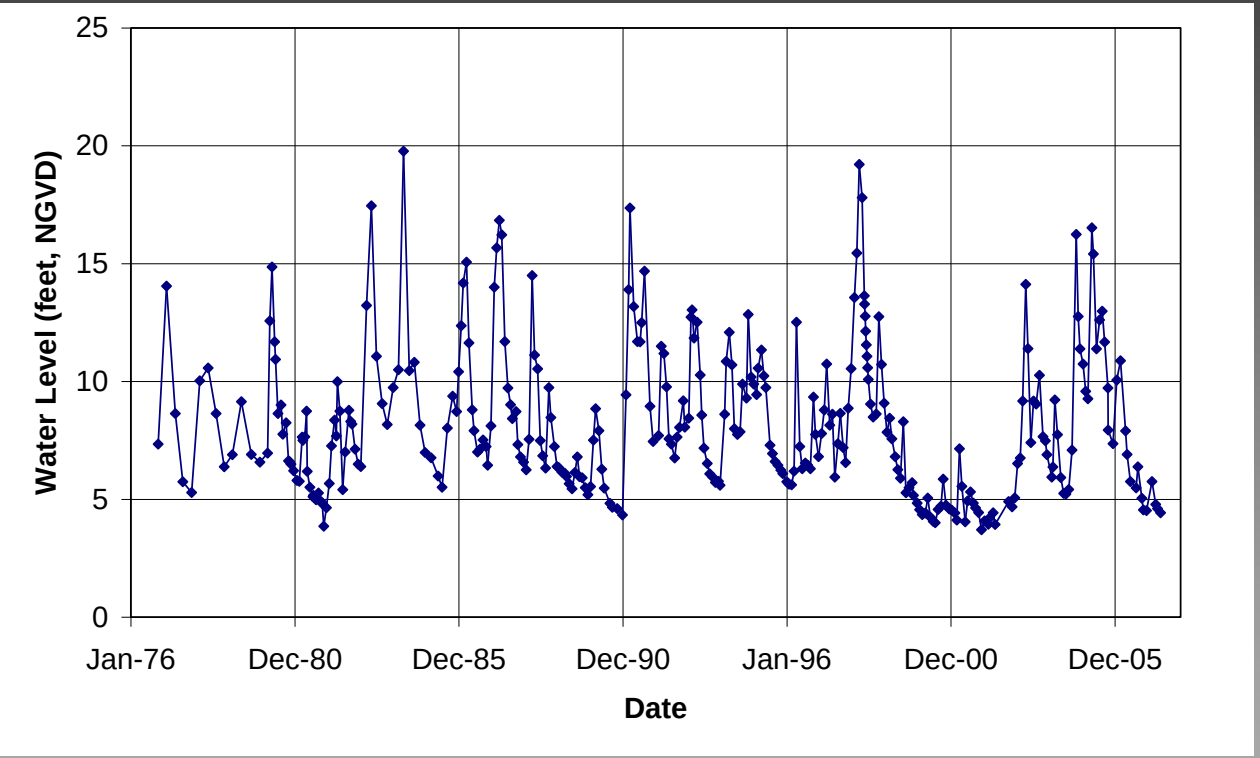
- Reflects model developed to characterize variability between sample pairs as a function of sample point spacing



Nugget = 15 ft.²
Range =350,000 ft.
Sill =800 ft.²

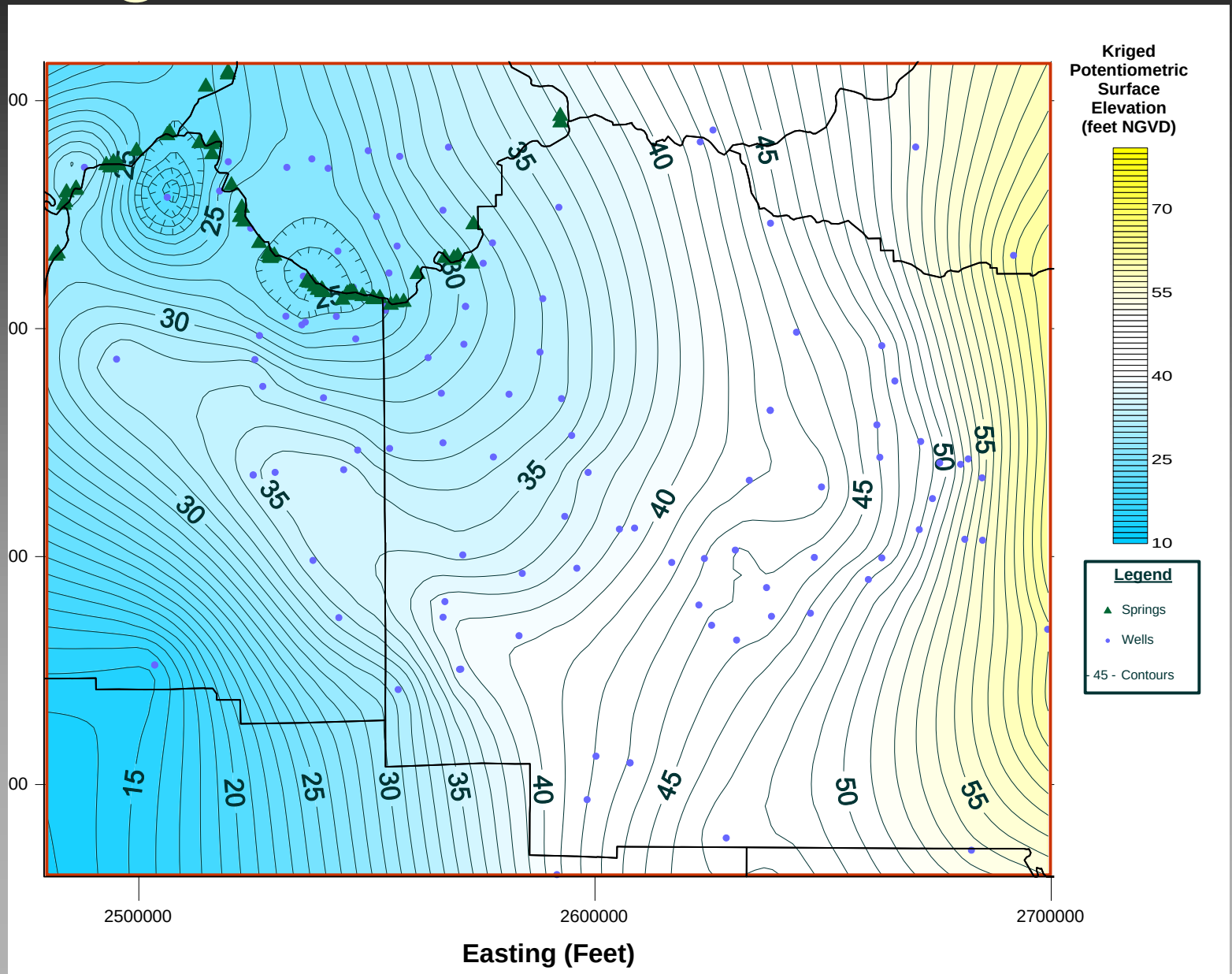
Nugget Effect

- Caused by local variability
  - Short term
  - Transient
  - Caused, in part, by sampling over a month period



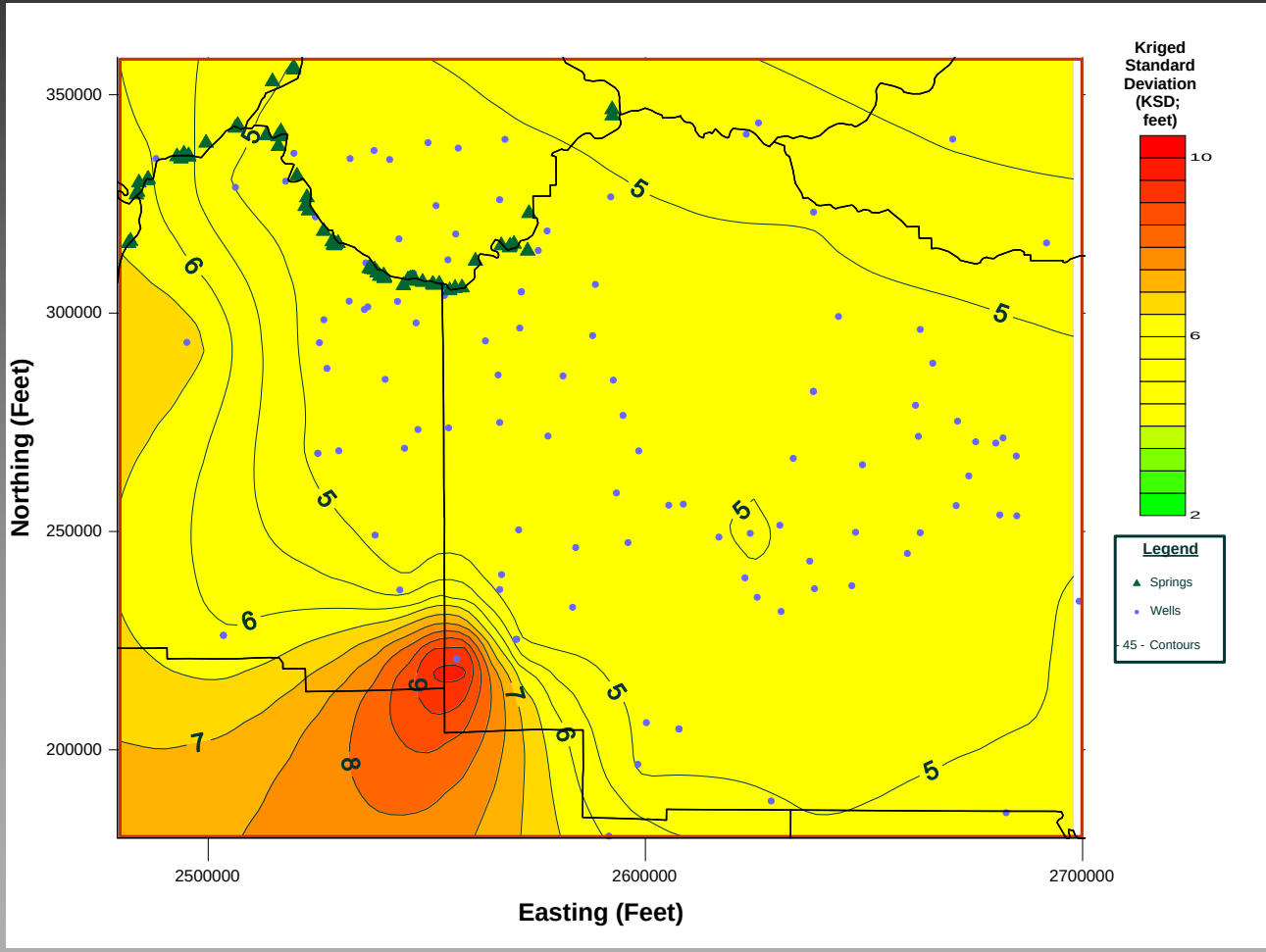
Gilchrist County Well

Kriged Potentiometric Surface



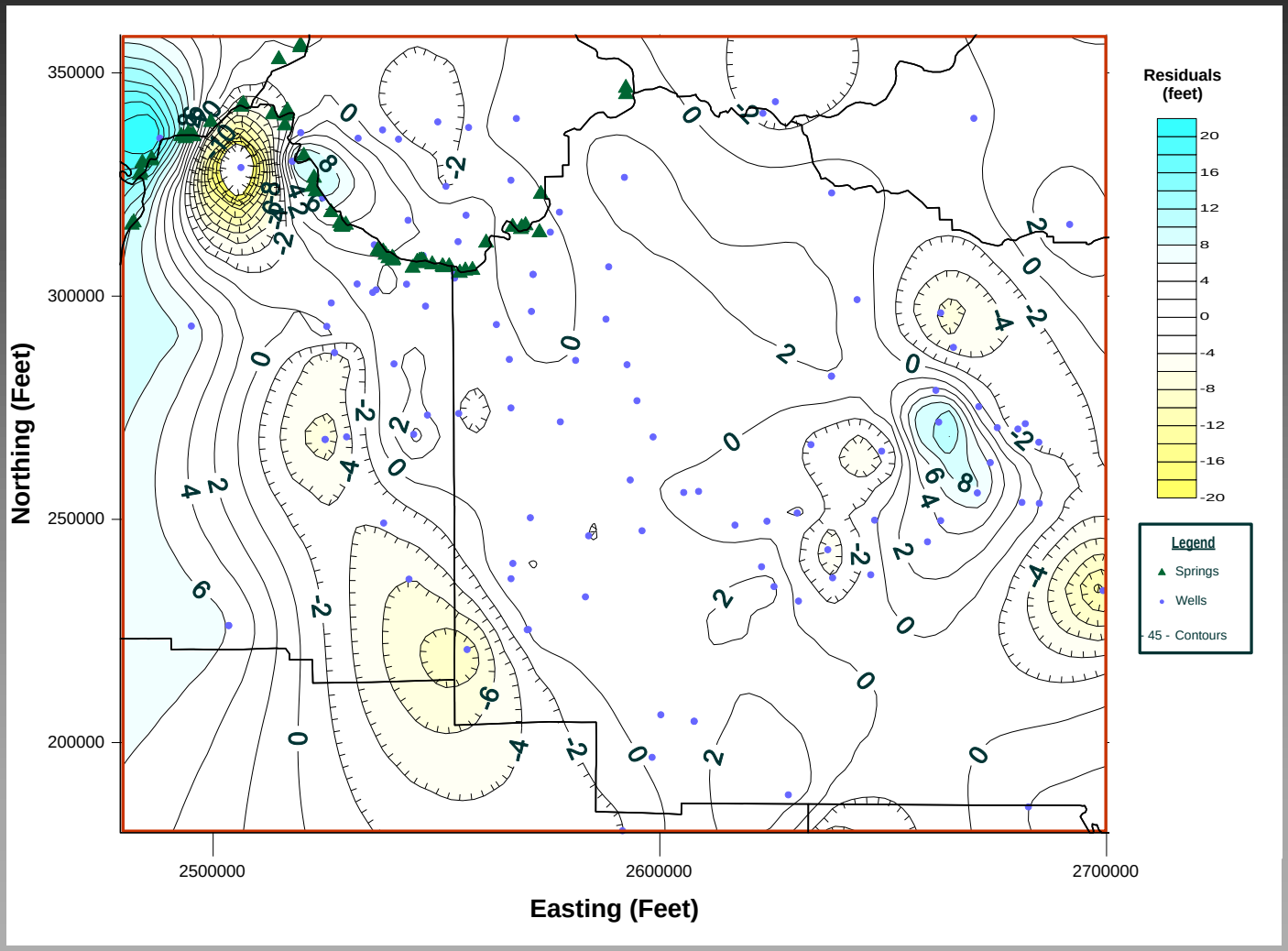
Kriged Standard Deviation

- Shows the distribution of uncertainty
- Units of feet based on K_{SD} (kriged standard deviations)



Residuals

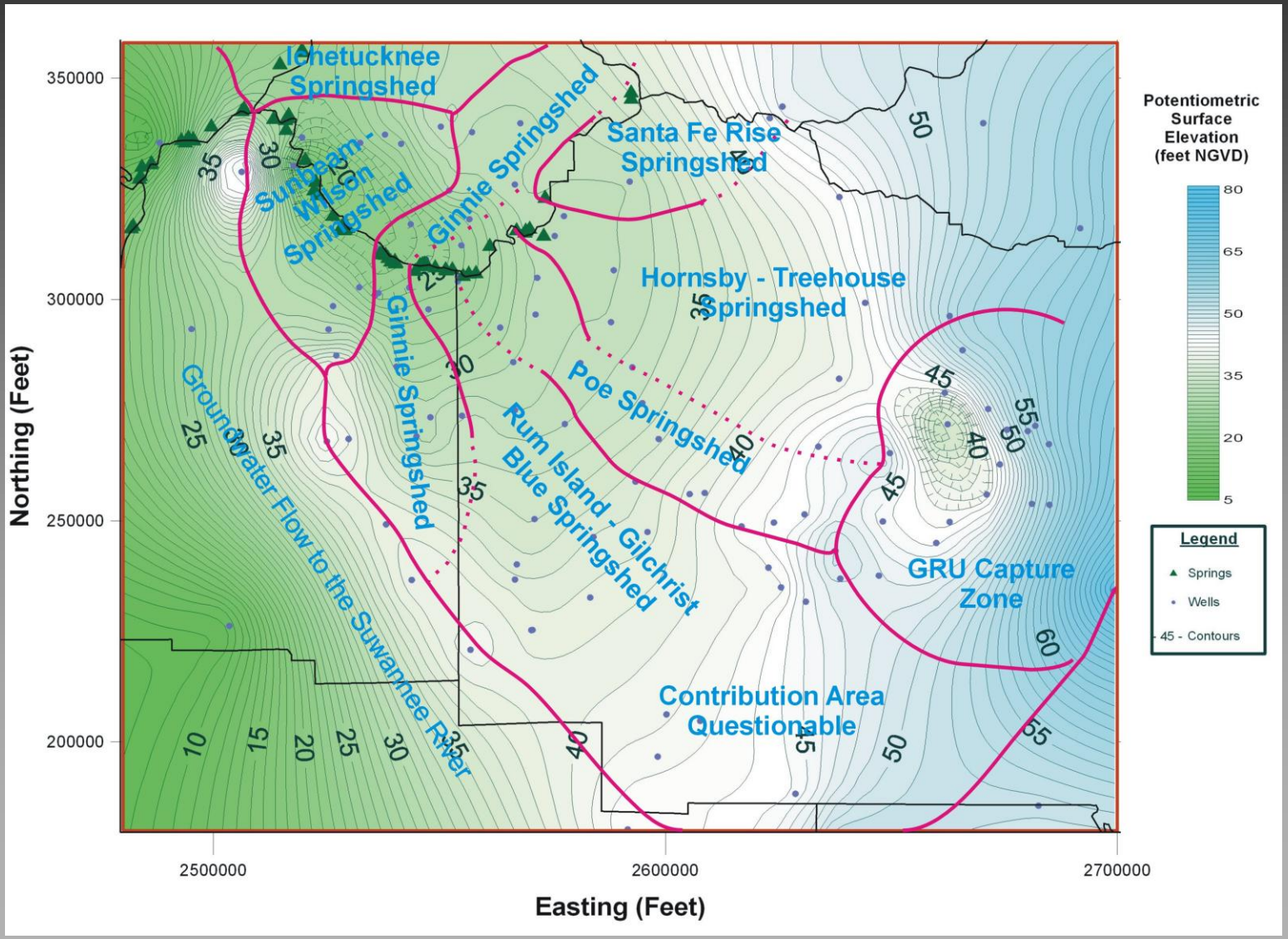
- Observed water level – kriged water level
- Helps identify outliers



Network Evaluation

- Network is good within the Newberry Plain and vicinity
- There is no need for additional wells in the Newberry Plain area
- There is an uncertainty (the nugget) when contouring between wells of up to ±10 feet because of local variability

High-Resolution Springshed Delineation



Springshed Evaluation

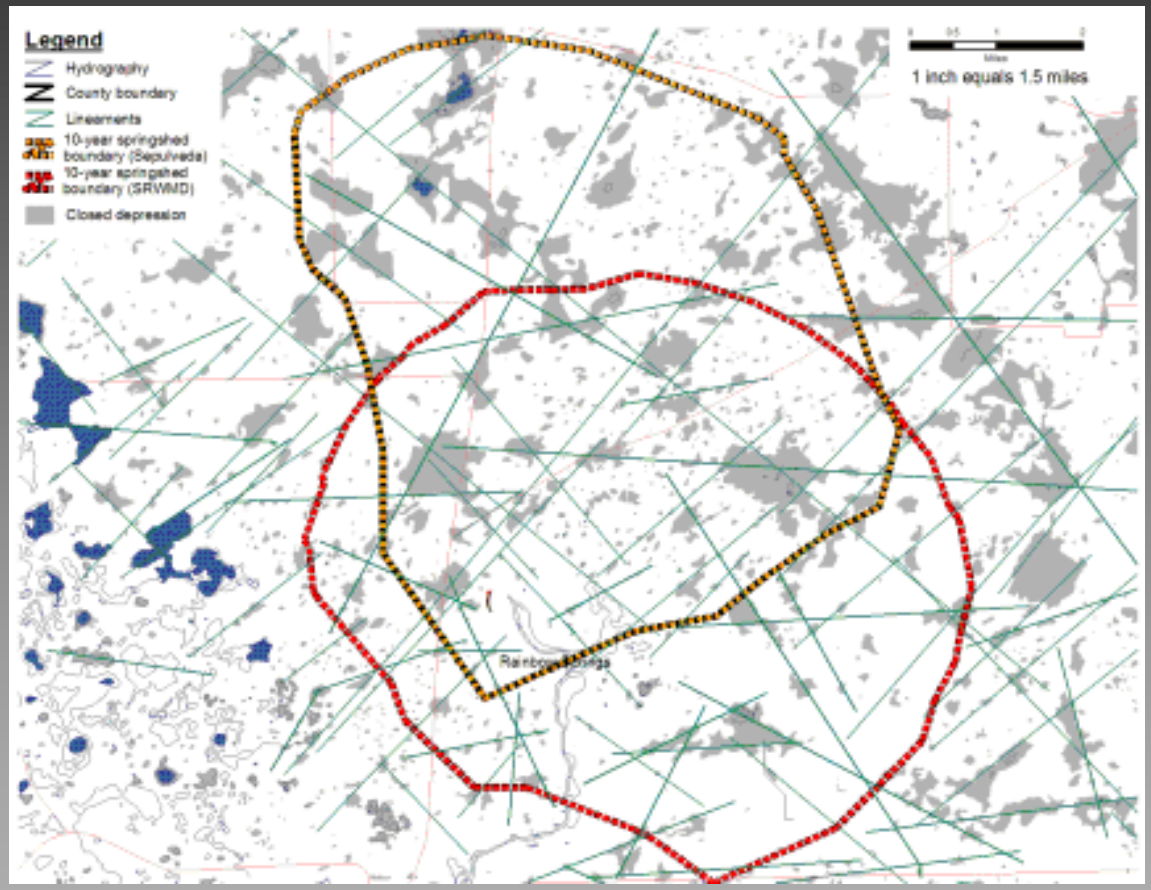
- High-resolution monitoring allows for resolution of springsheds with much more confidence than with the typical regional potentiometric surface map
- Confidence in springsheds of major spring clusters ranges from moderate to high
- There is still a problem with where the water in the southern part of the Newberry Plain discharges

Modeling Capture Zones

- Identify spring contribution areas through groundwater flow modeling
  - USGS Megamodel by Sepúlveda (2002)
  - Suwannee River WMD Model by Schneider and others (2008)
- 5, 10, 100 year capture zones attempted
- Utilized inverse particle tracking to model capture zones

Why Use Two Models?

- Models rarely agree
- Conservative to include results of all models
- Models differ in features and construction

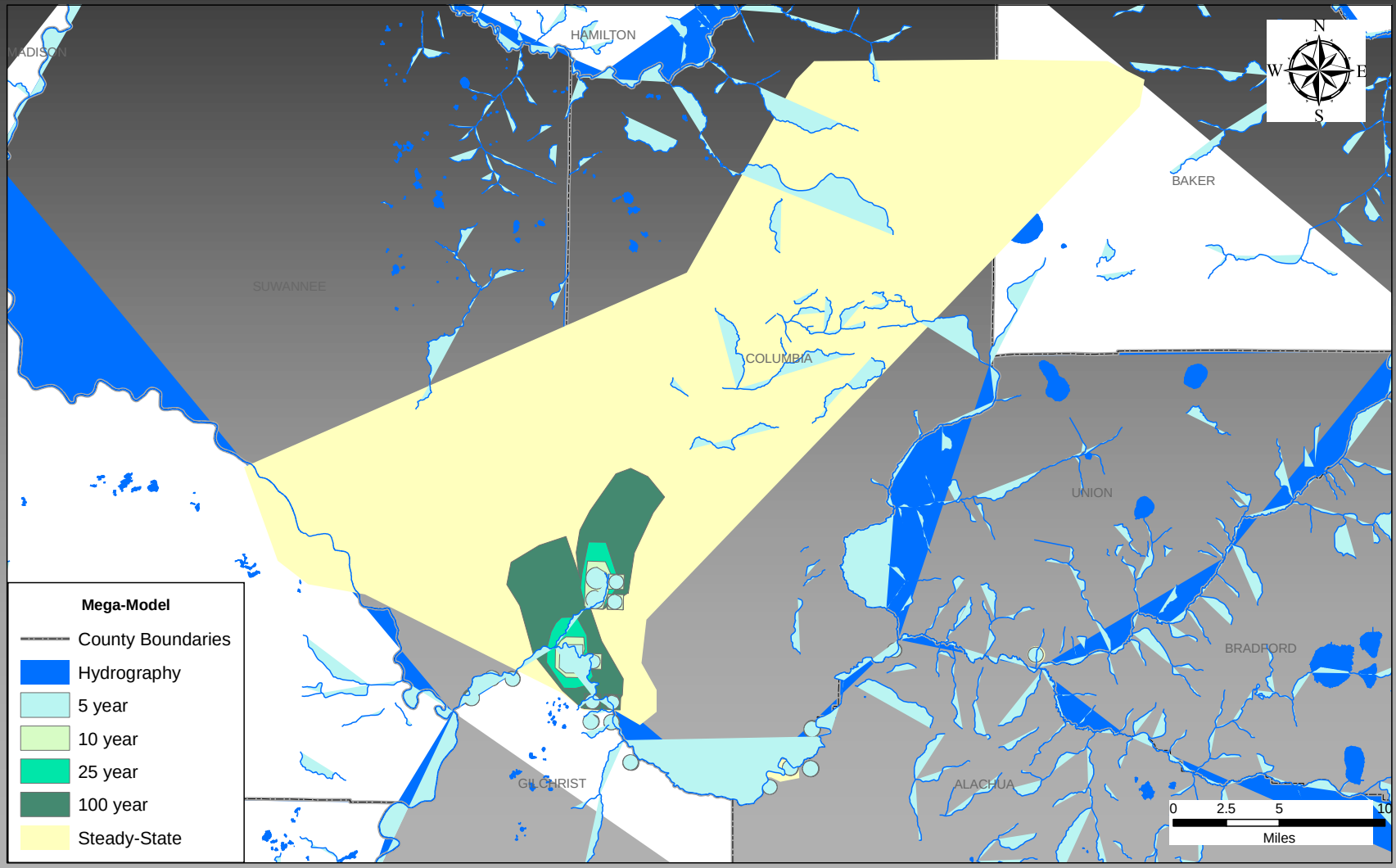


Rainbow Springs 10-year travel times

USGS Megamodel

- Regional model
- 3-D model
- 5,000 x 5,000 ft. cells
- Layers
  - 1, Surficial Aquifer, is a constant head boundary
  - 2, Intermediate Aquifer System
  - 3, upper Floridan Aquifer
- Does not account for most springs
- Cannot deal with conduit flow

USGS Megamodel



Megamodel Conclusions

- Could not accurately reproduce capture zones of springs not explicitly in model
  - Steady state run produced spatially and temporally unrealistic results
  - Absence of many springs and of siphons that capture river water in model a limitation
  - Constant head in Layer 1 apparently prevents accurate representation of dispersed recharge

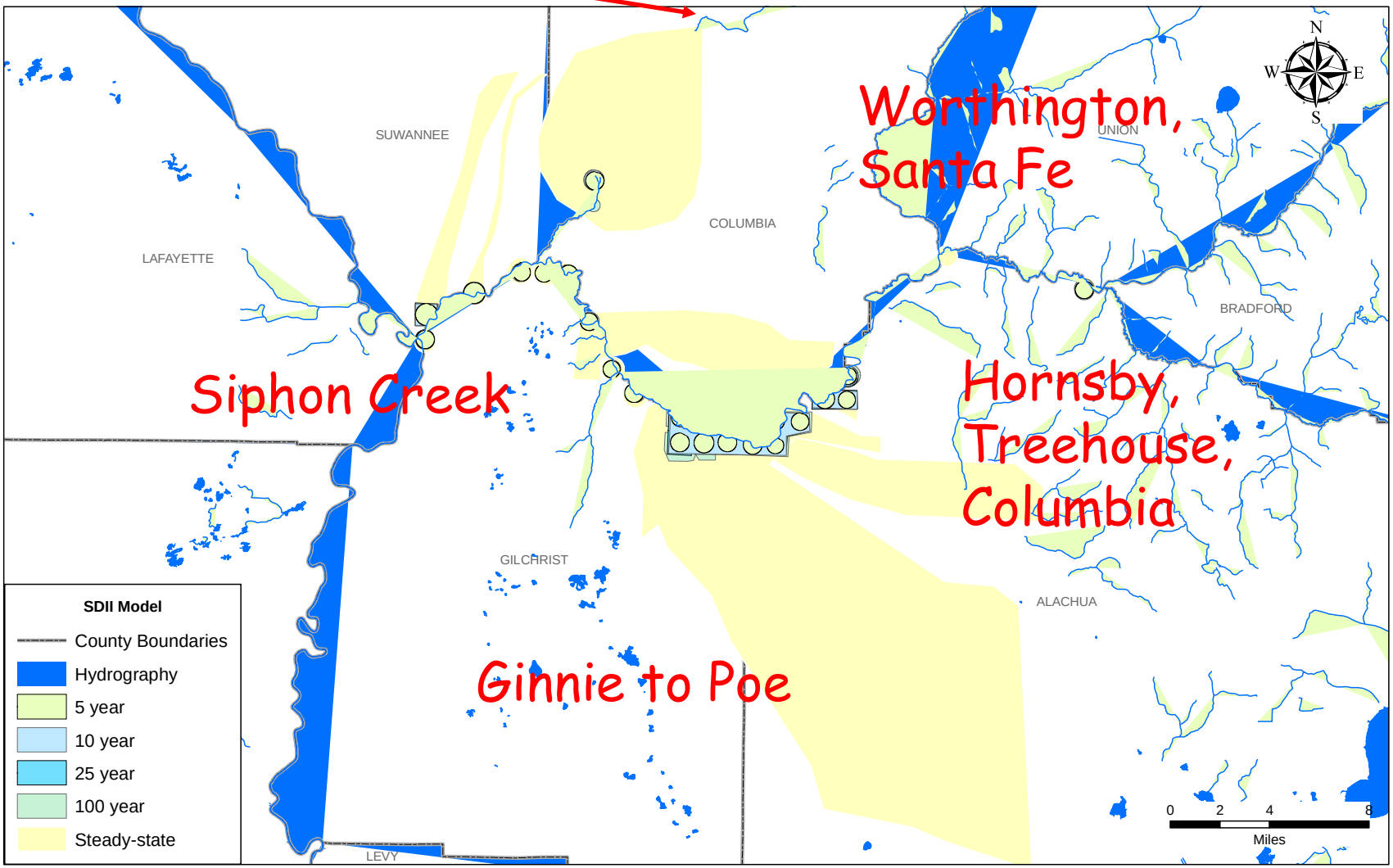
District Model

- Regional model
- 3-D model
- 5,000 x 5,000 ft. cells
- Active Layers
  - 1, Surficial Aquifer
  - 2, Intermediate Aquifer System
  - 3, upper Floridan Aquifer
  - 4, middle confining unit
  - 5, lower Floridan aquifer

District Model (cont.)

- Accounts for
  - All 1st and 2nd magnitude springs,
  - Many 3rd magnitude springs, and
  - All major siphons and swallets
- Cannot deal with conduit flow

District Model



District Model Conclusions

- Appears reasonable with respect to many springsheds in steady-state mode
- This is important because the District uses steady-state modeling to evaluate permit applications
- Model cannot accurately model capture zones based on travel time because it cannot account for conduit flow

District Model Conclusions

- Model provides insight into flow systems
  - When aquifer approximates flow through homogeneous aquifer, travel times can be approximated
  - When flow is dominated by conduit transport, the model may approximate springshed in steady-state mode but not short-term capture zones

Evaluations of Springsheds

- Springsheds from potentiometric surface and model are consistent within limitations
- Addition of swallets and siphons is critical to capture zone modeling
- Rum Island – Gilchrist Blue springshed remains large for magnitude of spring discharge
- Flow to springs is limited from Bell Ridge/Waccasassa Flats area and Northern Highlands

Evaluations of Springsheds

- Many springs are dominated by swallets that capture water from Northern Highlands
- Springs are dominated by conduit flow
- Worthington and Santa Fe Springs are not consistent with Floridan aquifer potentials

Recommendations

- It is not appropriate to set up protection zones based on model-based travel times
  - Models do not deal with conduit flow – karst flow is too complex
  - Dye tracing proves that basins are larger than model predictions and that travel times in conduits are shorter
- ***Spring protection zones should consist of all areas within the springshed and streams that discharge to swallets***

Recommendations

- Siphon-spring systems have been identified by Butt et al. (2007), do they need special protection strategies?
- The entire Newberry Plain should be considered a springshed and subject to primary protection measures
- Areas north of the river in Columbia County are as important as those areas of Alachua and Gilchrist counties in the Newberry Plain

Recommendations

- Sub-regional model
  - Needed because of growth in Lake City and Gainesville/Alachua areas
  - Allow refinement of karst system
  - Transient model
  - Integrated surfacewater/groundwater model

Recommendations

- Model being developed privately for Western Valley may better refine knowledge
- Dye tracing
  - Robinson Sinks
  - Western Valley
  - Poe Springs


Thank You, Any Questions?