

Silver Springs Group

Springshed Delineation and Dye Trace Studies

St. Johns River Water Management District

<http://floridaswater.com/springs/marion/silver.html>



Silver Springs Springshed

- Includes all the surface and subsurface flow and drainage that contribute water to discharge at the spring vents in the Silver Springs Group (SSG)



Silver Springs Springshed

- UFA in the springshed is a karst aquifer
 - Geologic terrain or landscape with distinctive characteristics of relief and drainage due to dissolution of rock by the circulation of natural waters, developing preferential flow paths
 - Network of fractures and conduits embedded in and interacting with a limestone matrix

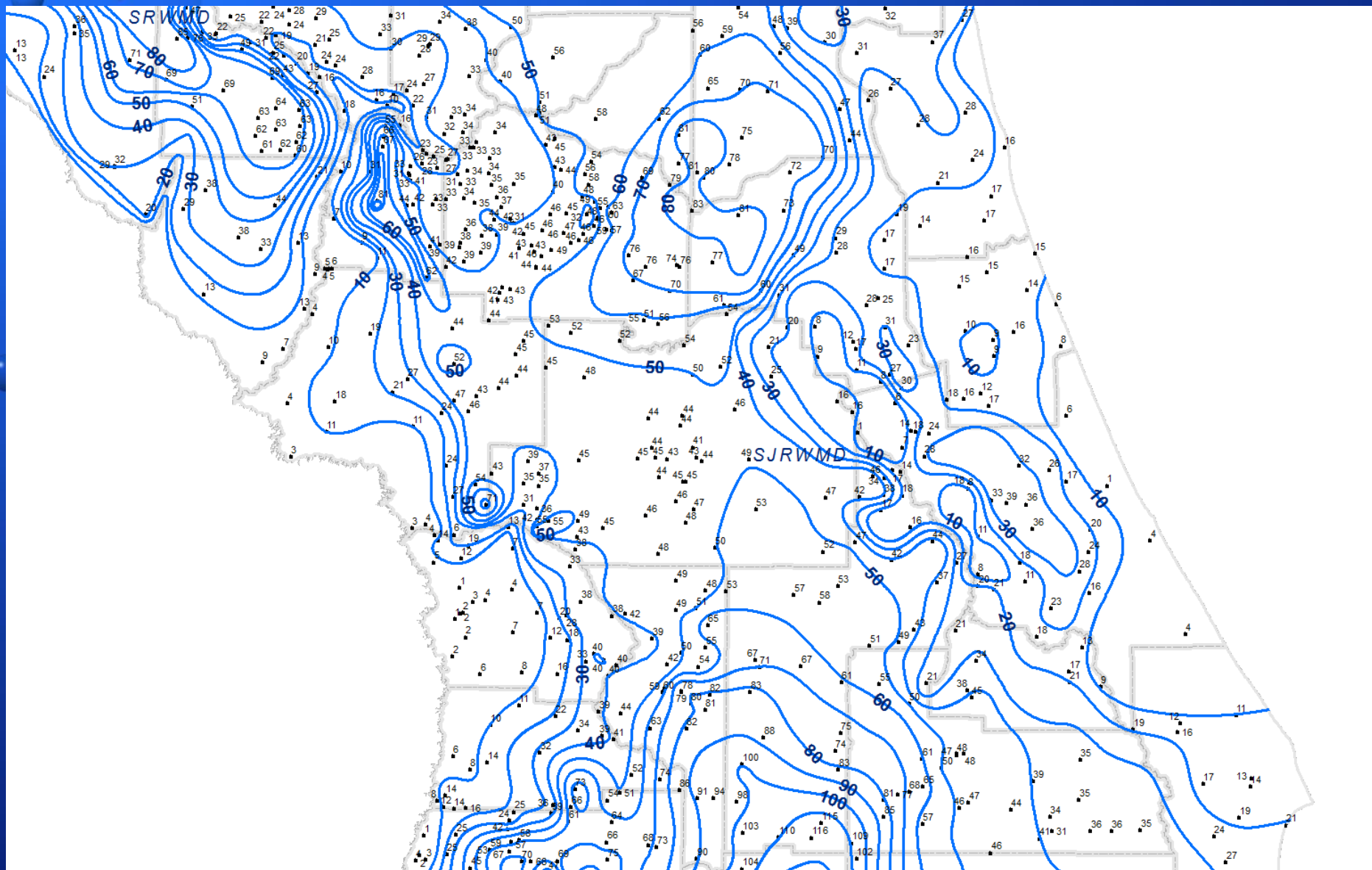


Springshed delineation methods

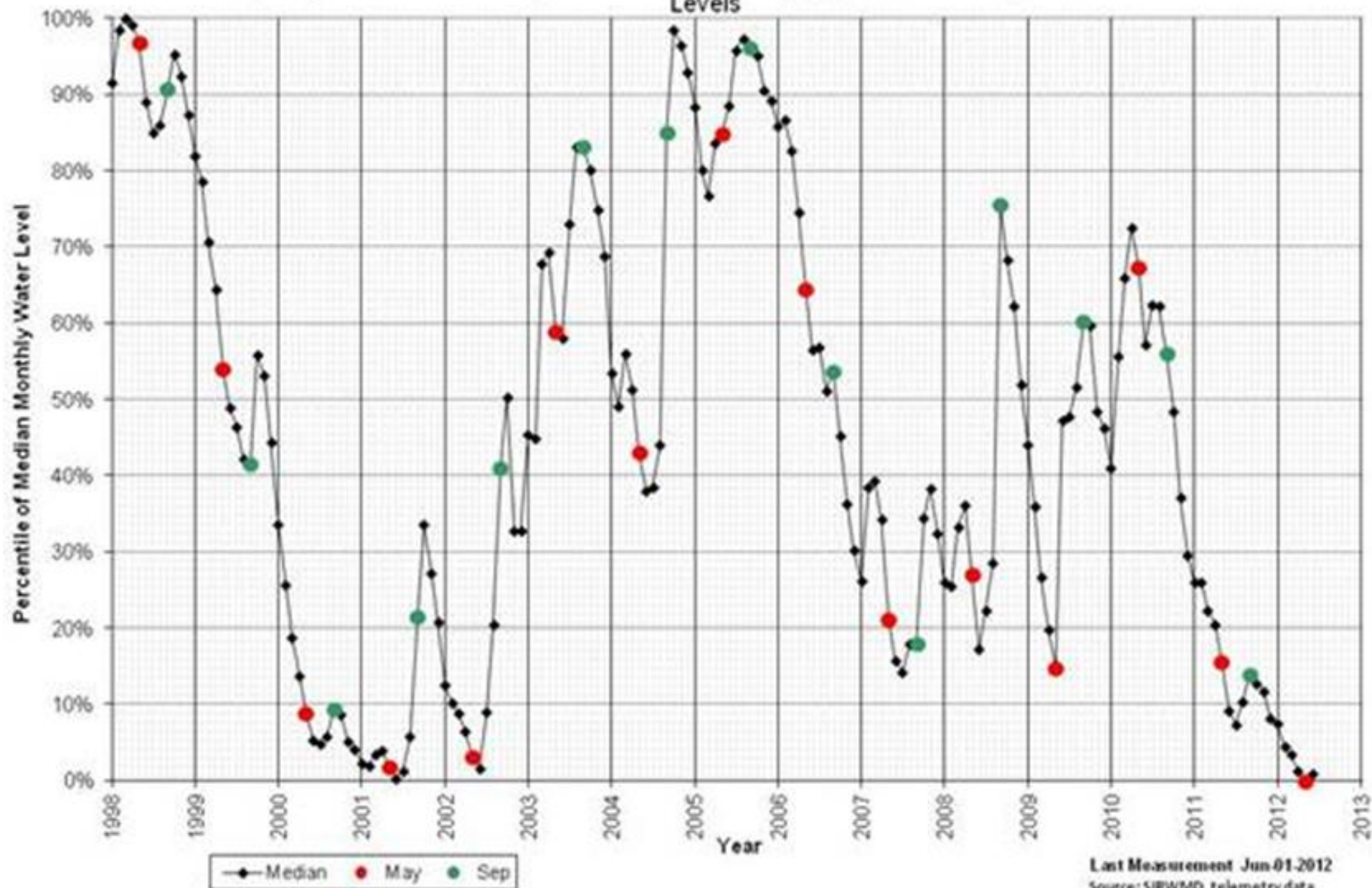
- Evaluation of UFA water level data
- ArchHydro flow direction generator
- MODPATH particle tracking



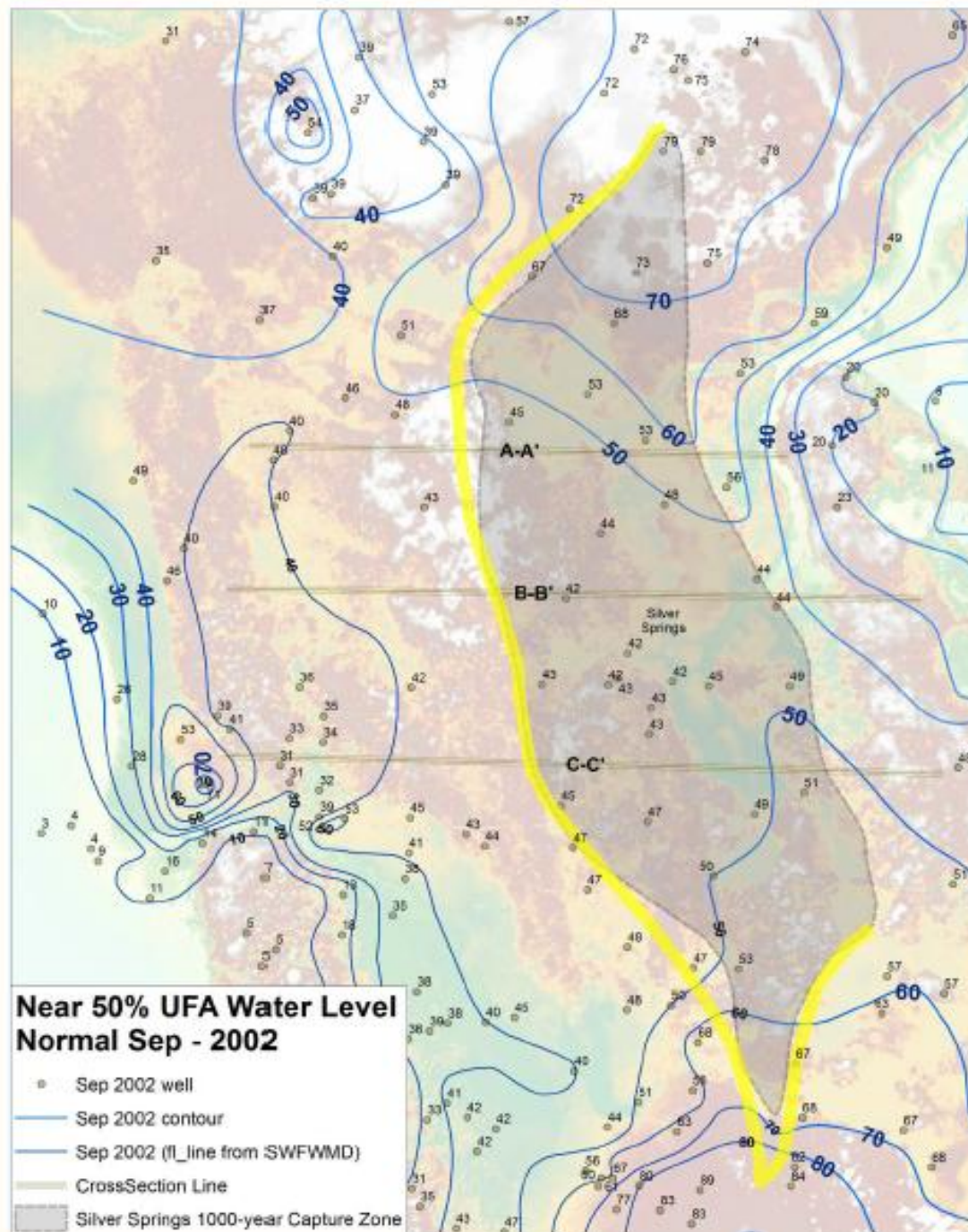
UFA Potentiometric Surface, May 2010

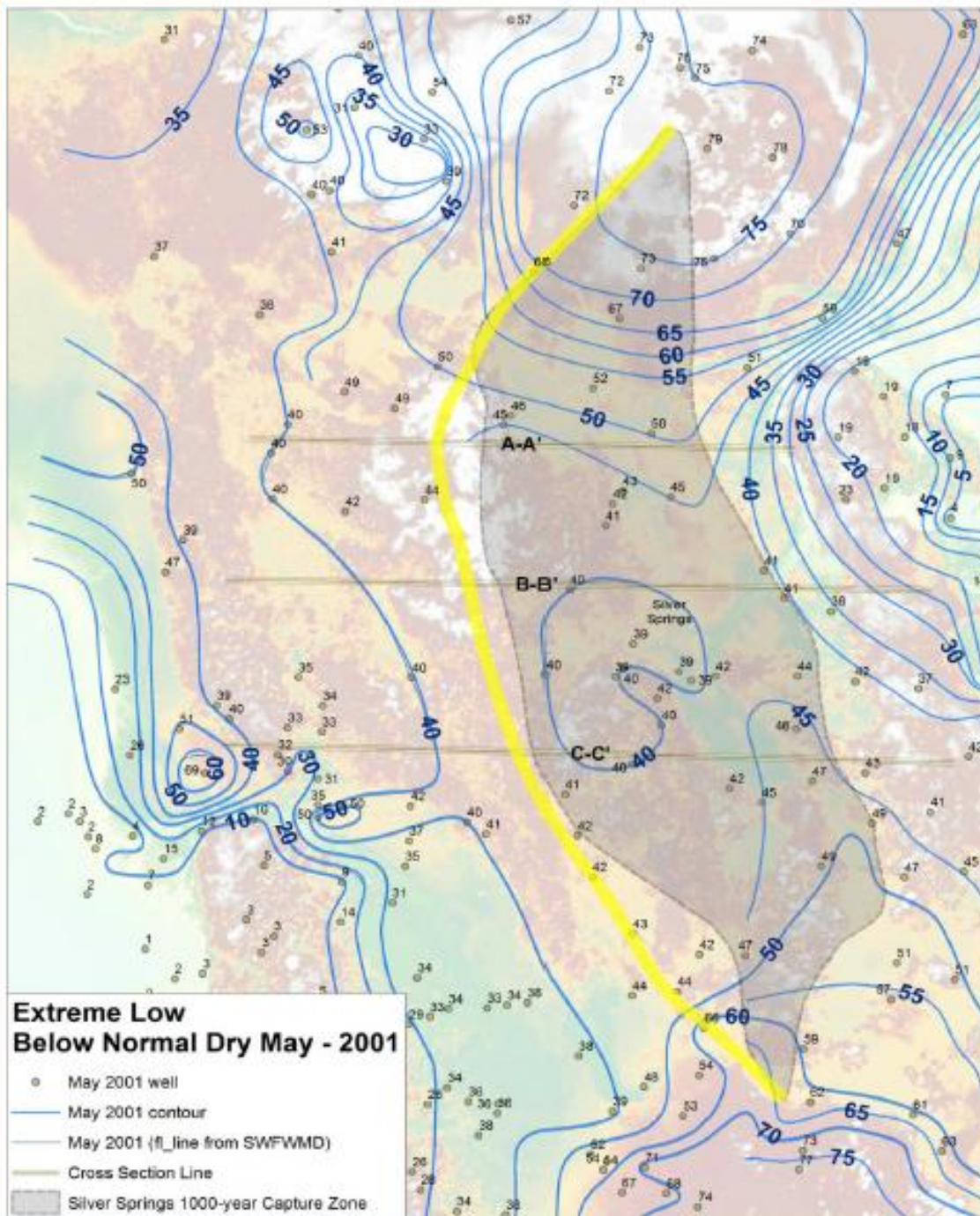


Silver Springshed UFA Monitoring Wells Median Monthly Upper Floridan Aquifer Potentiometric Levels



Last Measurement Jun-01-2012
Source: SJRWMD telemetry data
(provisional)





Delineating springshed from UFA water level data

- Springshed boundaries move short distances as a result of wet and dry climatic conditions
- No observed trend in the movement of springshed boundaries in any one direction over long periods of time

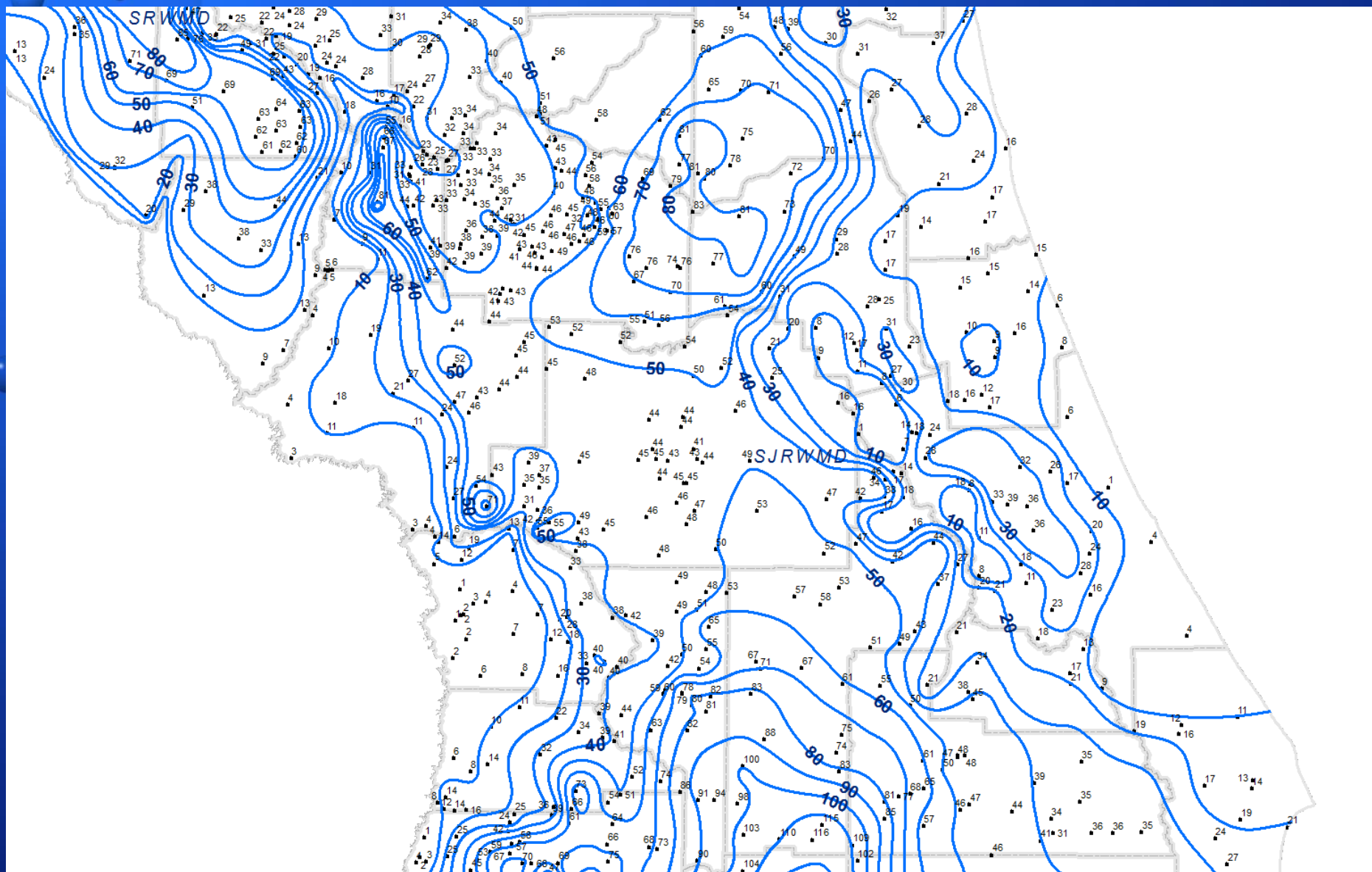


ArcHydro Flow Direction Generator

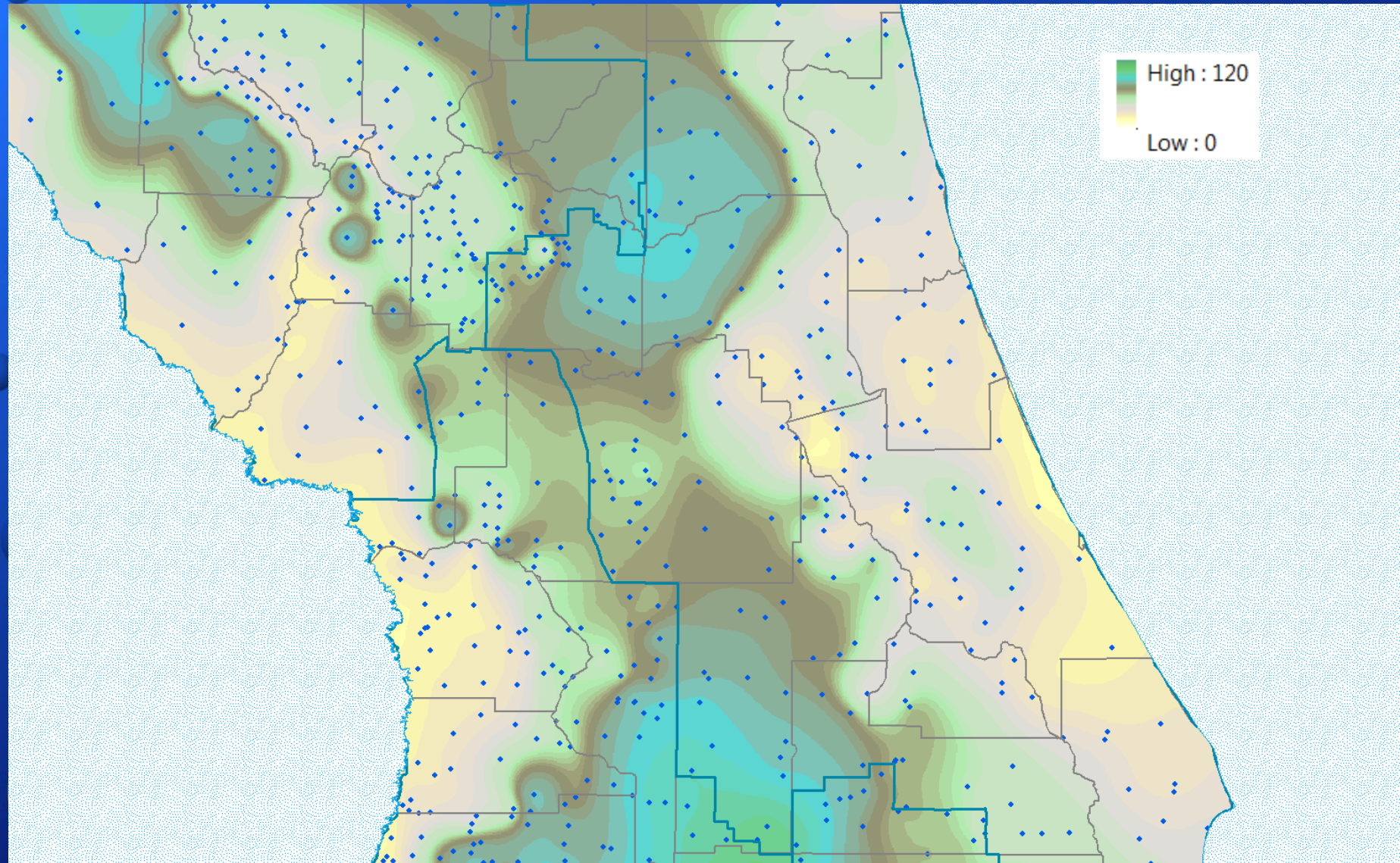
- Using May 2010 UFA potentiometric surface grid estimation, a new graphics layer is created showing flow direction arrows
- The direction and angle of the flow direction arrows are based on the value of each grid cell and the surrounding cell values



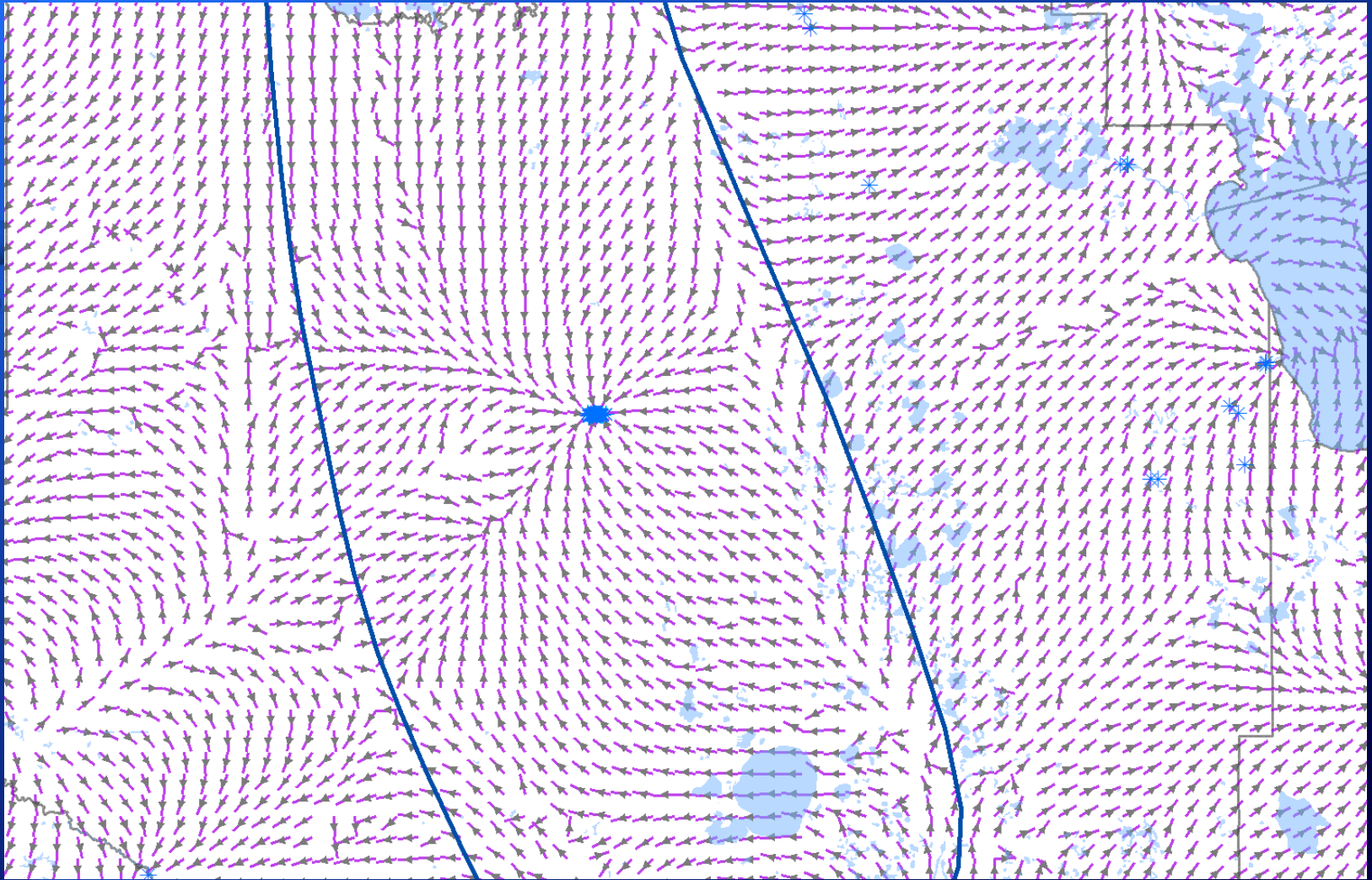
UFA Potentiometric Surface, May 2010



UFA Potentiometric Surface, May 2010



Flowlines for May 2010 UFA Potentiometric Surface

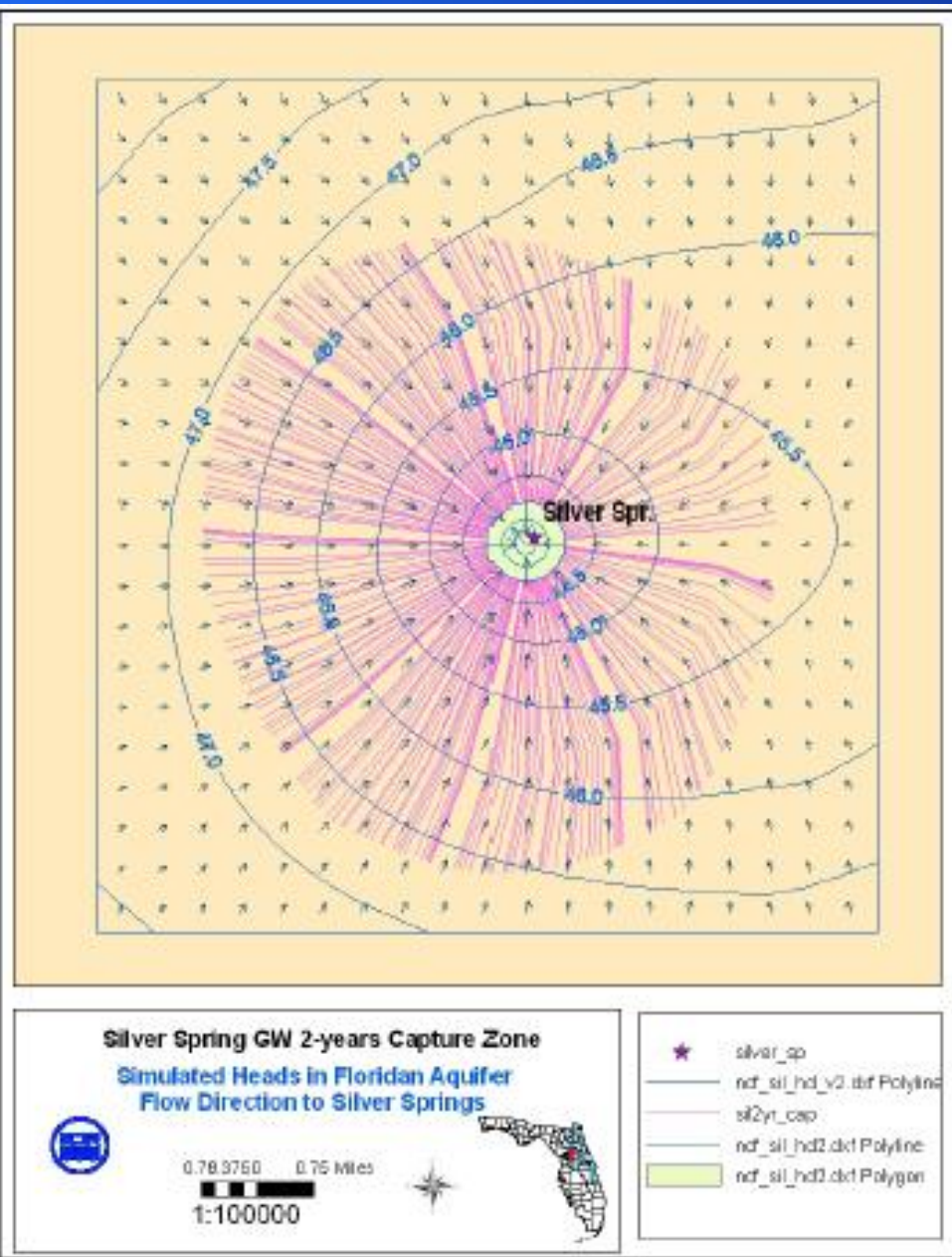


MODPATH Particle Tracking

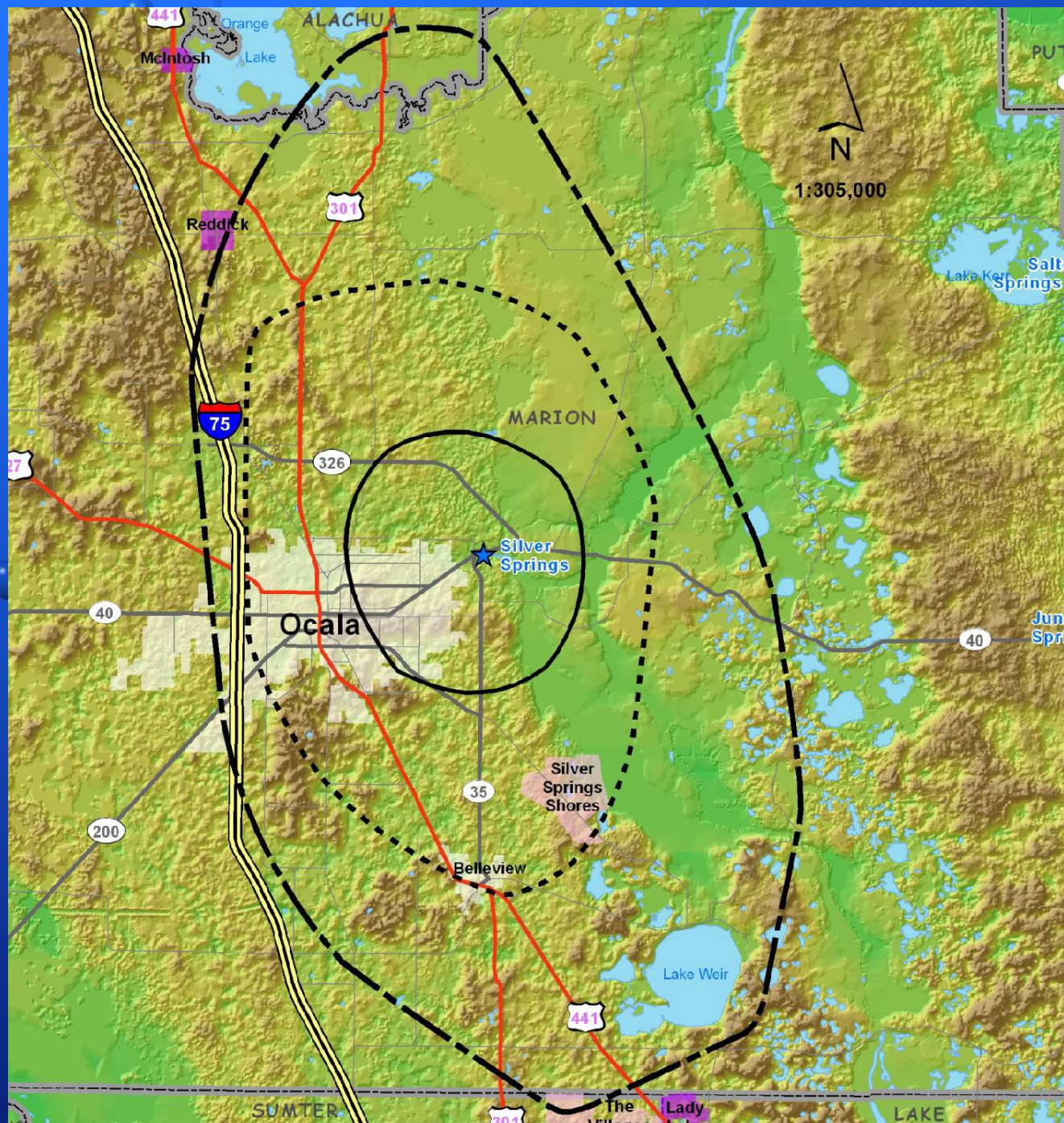
- The head distributions and hydrogeologic parameters from the NCF MODFLOW regional groundwater flow model were applied to the MODPATH particle tracking software
- Method traces the flowpaths of groundwater from SSG backward to areas of the 2, 10, 100, and 1000-year travel times, mapping the geographic extent for each travel time
- 1000-year area corresponds to historically mapped SSG springshed



Example of 2-year Travel Time



Silver Springs Basin



★ Springs

2-year Springshed Boundary

10-year Springshed Boundary

100-year Springshed Boundary

Lakes and Streams

2000 Census Boundaries

City

Town

Census Designated Place

County Boundary

DEM Elevation (Feet)

High : 200

Low : 5

Silver Springs Springshed

- ★ Springs
- 10-year Capture Zone (1999)
- - - 100-year Capture Zone (1999)
- ▭ Springshed Boundary
- ▭ Lakes and Streams

2000 Census Boundaries

- ▭ City
- ▭ Town
- ▭ Census Designated Place
- ▭ County Boundary

DEM Elevation (NGVD29, Feet)



Silver Springs Group Dye Trace Studies



St. Johns River Water Management District

**Silver Springs Nutrient Pathway
Characterization Project**

SJ2012-SP3

<http://floridaswater.com/technicalreports/spubs1.html>



This project is funded by the Florida Department of Environmental Protection using funds provided by the U. S. Environmental Protection Agency from the American Reinvestment and Recovery Act of 2009 (ARRA).

Objectives

- Identify dominant groundwater pathways and travel times between specific locations and the Silver Springs Group (SSG)
- Identify potential sources of groundwater nutrient contamination that appear to be directly connected to the SSG discharge vents



Study Components

- Identify potential nutrient sources
- Review hydrogeologic data for probable flow paths (potentiometric surface maps, hydrologic cross sections, well data, karst features)
- Identify potential injection and collection sites.
- Site access and permits
- Site characterization – surface geophysics
- Dye injection and sampling Phase I and II
- Sample analysis and interpretation
- Final report

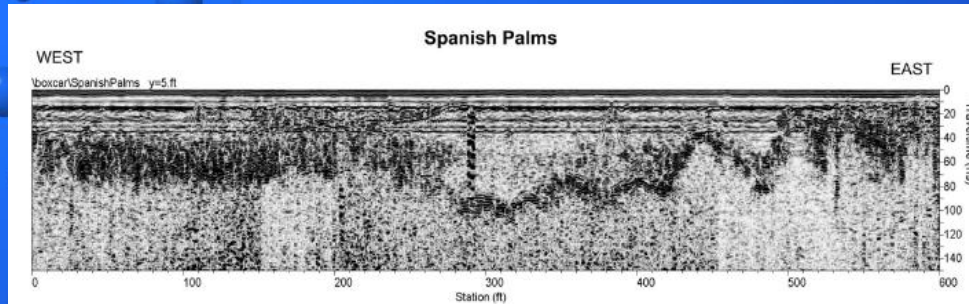


Surface Geophysics

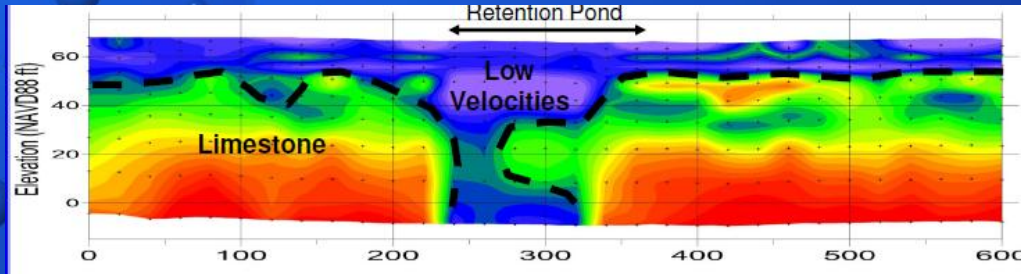
- Equipment that is operated on land surface, providing information about the subsurface
- DC Resistivity, Multi-channel Analysis of Surface Waves (seismic reflection), Ground Penetrating Radar, and Microgravity
- Reconnaissance profiles instead of detailed investigation – need many more profiles to map conduit system



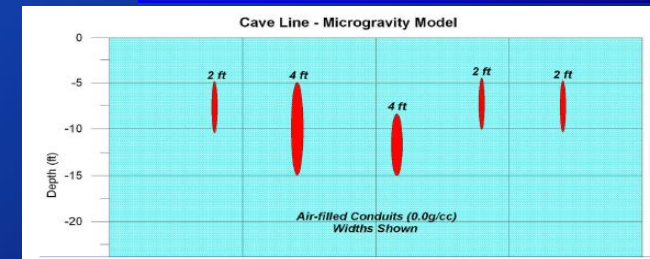
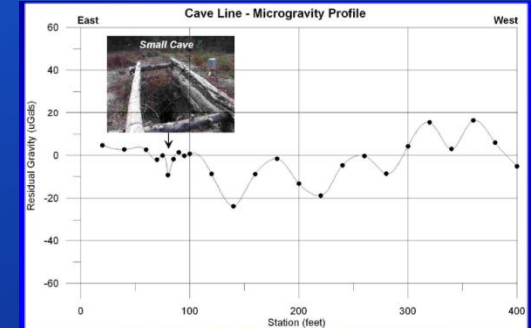
Example geophysical profiles



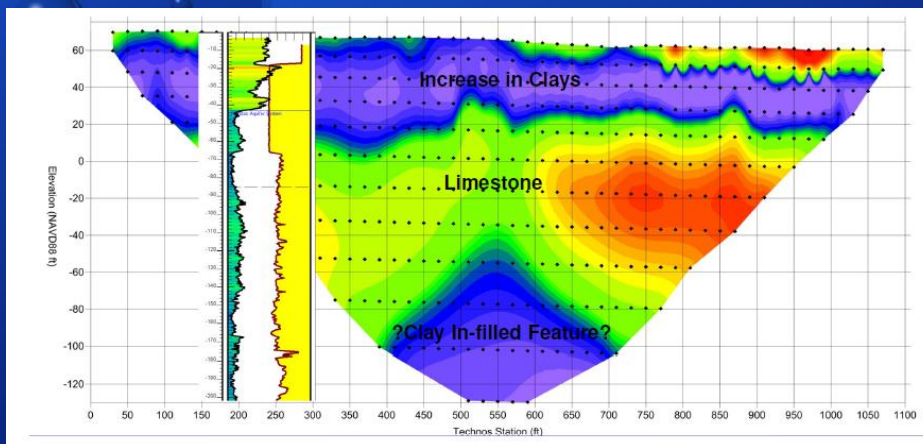
Ground Penetrating Radar



MASW (multi-surface wave seismic reflection)



Microgravity



DC Resistivity with
natural gamma
geophysical log

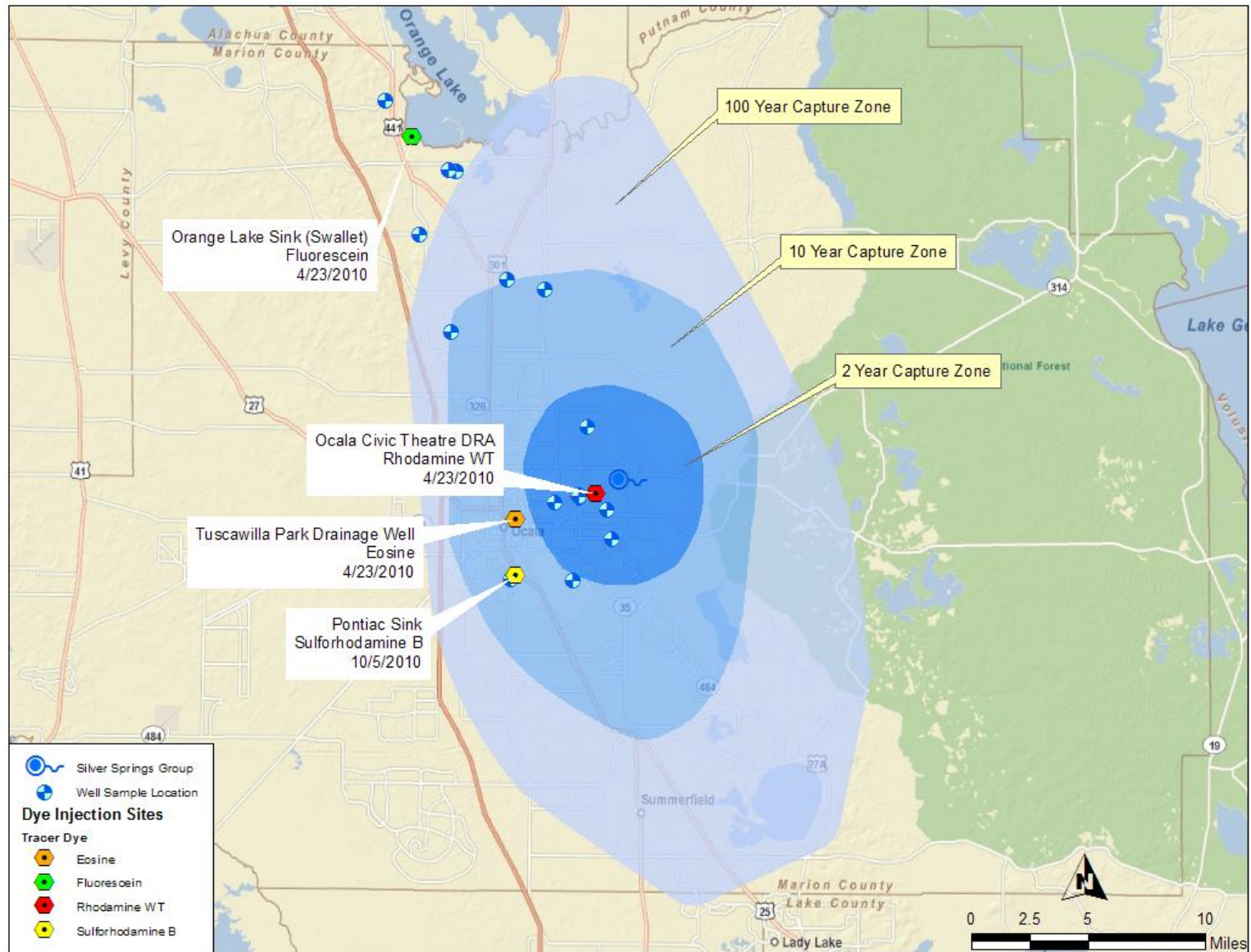
Qualitative Dye Tracers

- Initial Release (Group 1) April 23, 2010:
Fluorescein: Orange Lake Sink (aka Heagy Burry Sink)
Rhodamine WT: Ocala Civic Theatre DRA
Eosine: Tuscawilla Park storm water drainage well
- Second Release (Group 2) October 5, 2010
Sulforhodamine B: Pontiac Sink in SW Ocala



Dye Introduction & Well Sample Locations

(Sites chosen based on natural karst features, water source to flush dye through the system, and relation to UFA potentiometric flow lines)



Spring Sampling



Charcoal packet installed in spring vent by divers



Well Sampling

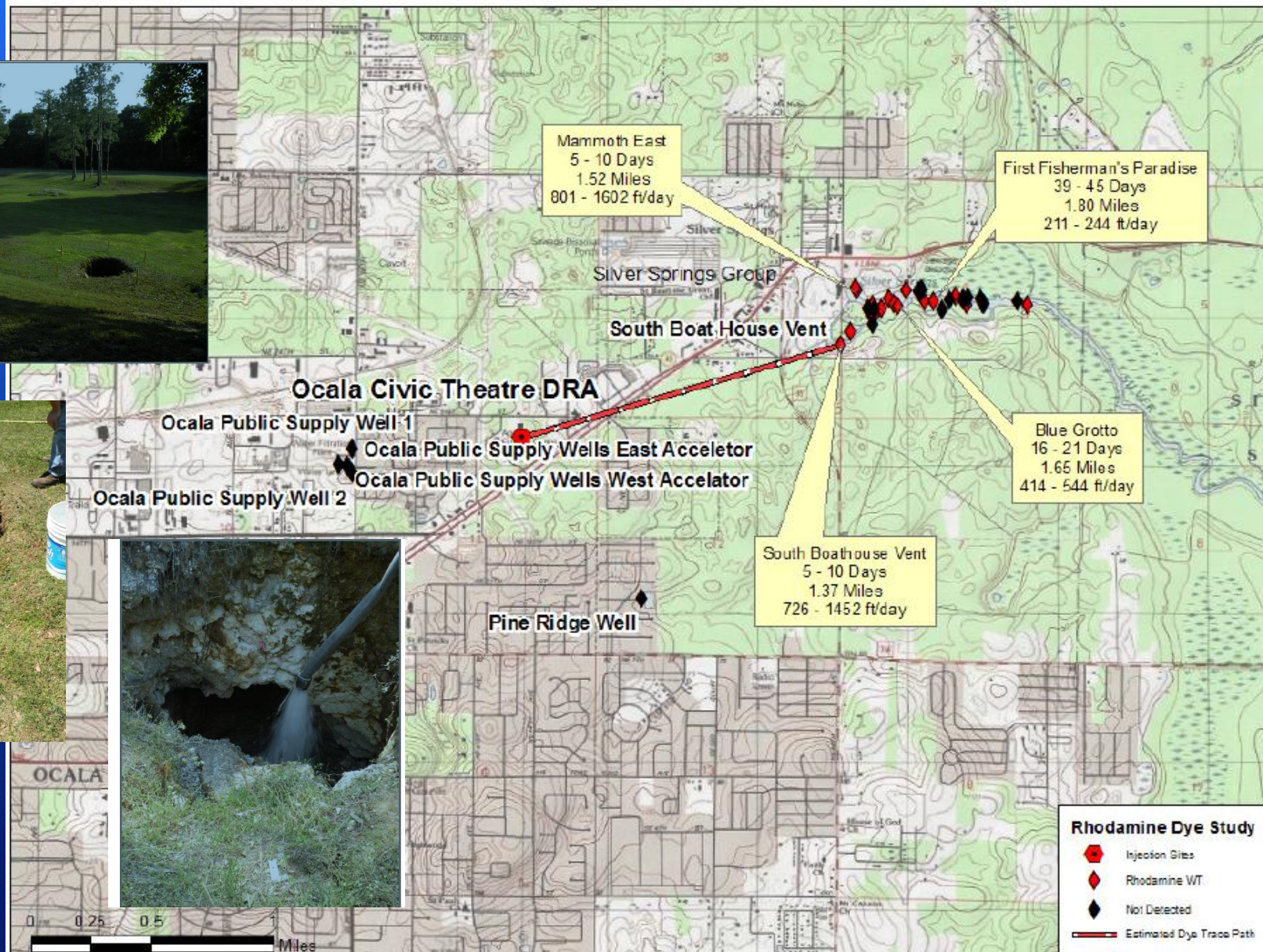


Charcoal dye sampler

Charcoal collectors inline with untreated water that flows when pump is turned on

Background samples collected to confirm no existing sources before the test (antifreeze, food dyes, etc)

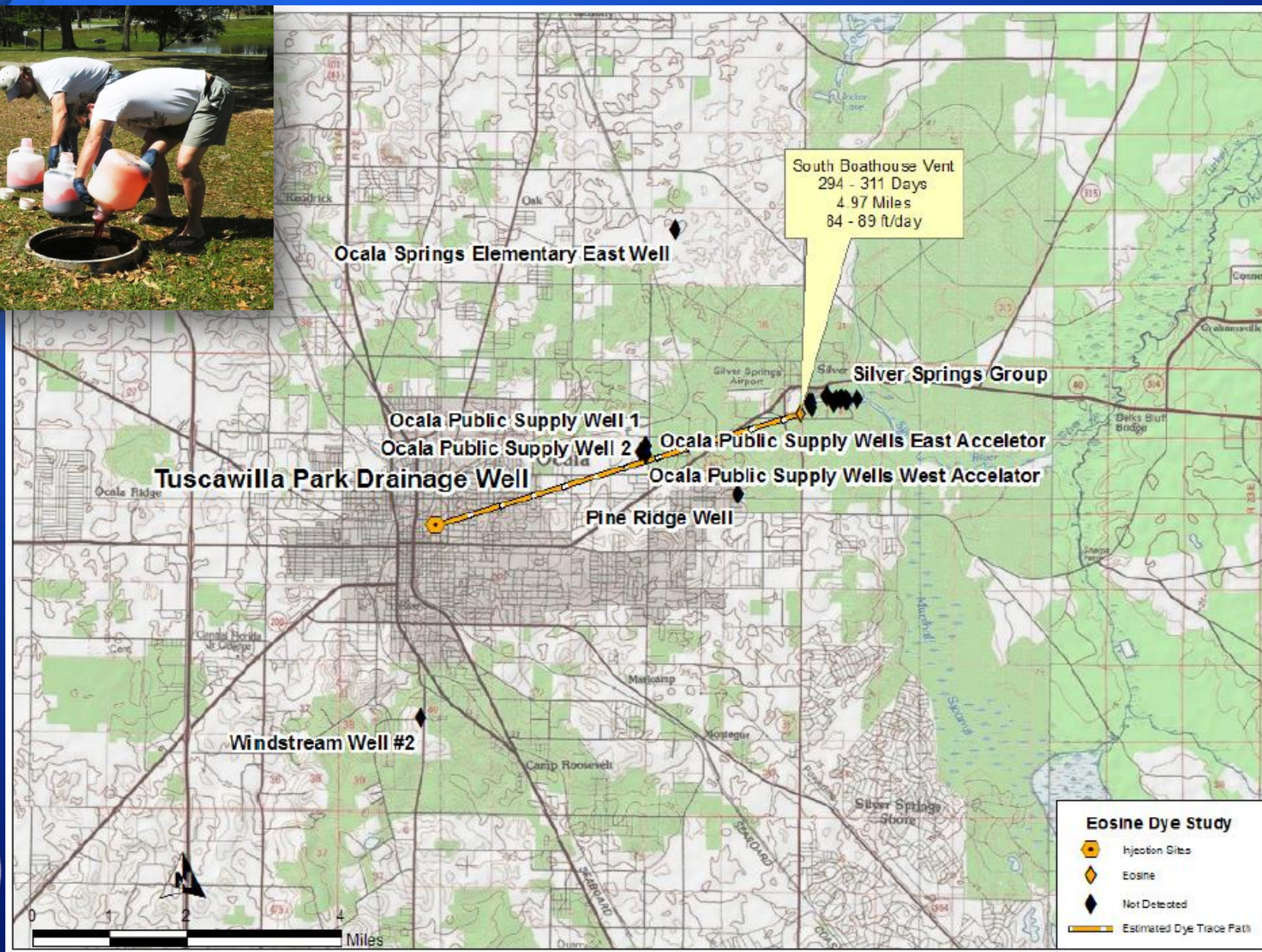
Ocala Civic Center Straight Line Dye Trace Path - Rhodamine WT



Tuscawilla Park Stormwater Drainage Well NE 9 - April 23, 2010

- 15-in well located 5.1 miles from the SSG (cased 66 ft, TD 214 ft bls; top of FAS 44 ft bls)
- Video log suggests most flow is in lower 20 ft of open-hole interval (Avon Park Fm)
- Continually receives water from Tuscawilla Lake (a DRA)
- 30 pounds of eosine dye was directly poured into the well



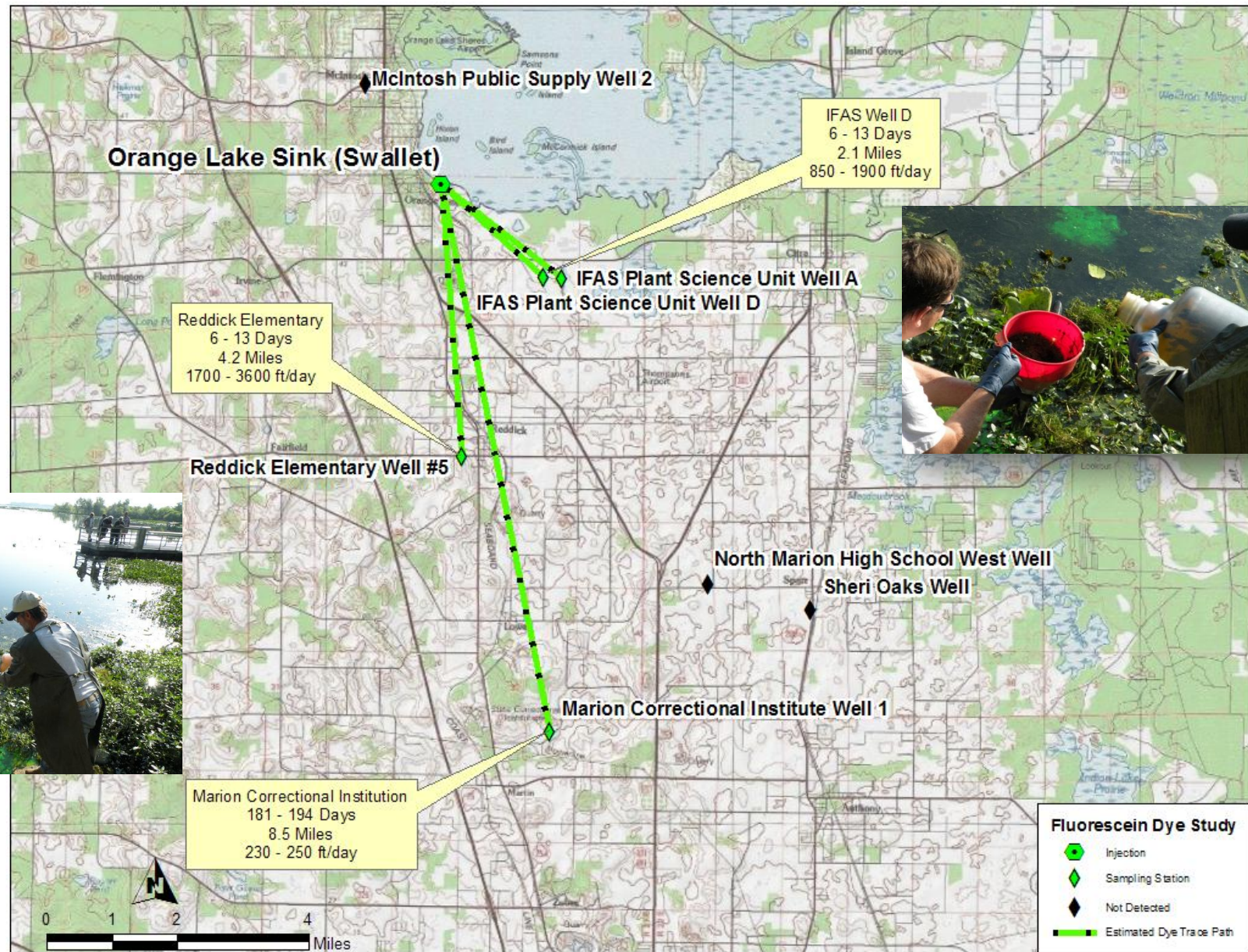


Orange Lake - April 23, 2010

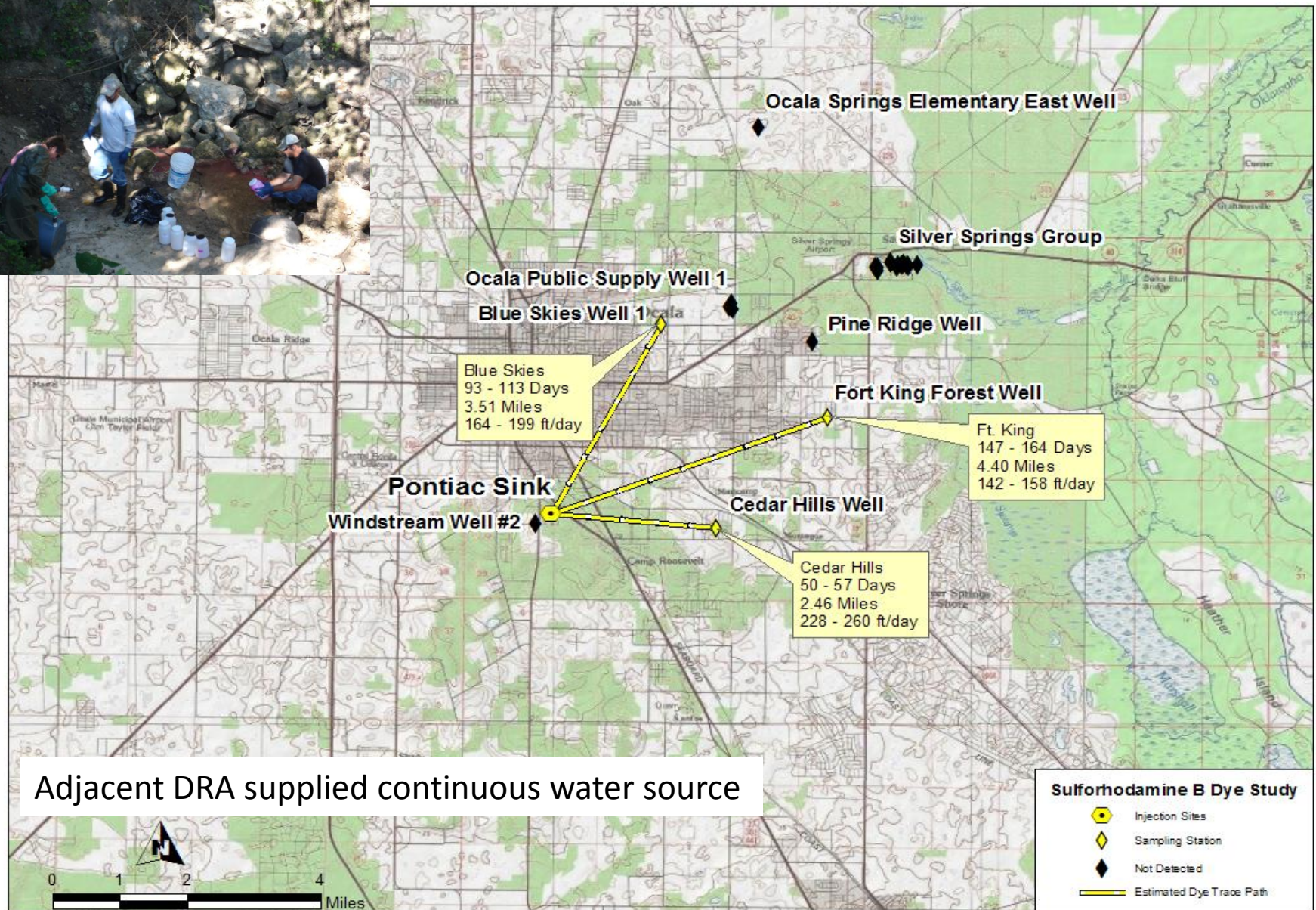
- Located 17 miles north of SSG
- 30 pounds of fluorescein introduced into Heagy Burry Sink
- Estimated drainage from Orange Lake into Floridan aquifer:
 - Nov 1992 about 24.3 mgd or 37.7 cfs (Haller and Hoyer, 1992)
 - Dec 2009 about 15.5 mgd or 24 cfs (Project team site recon)



Orange Lake Heagy Burry Park Straight Line Dye Trace Path - Fluorescein

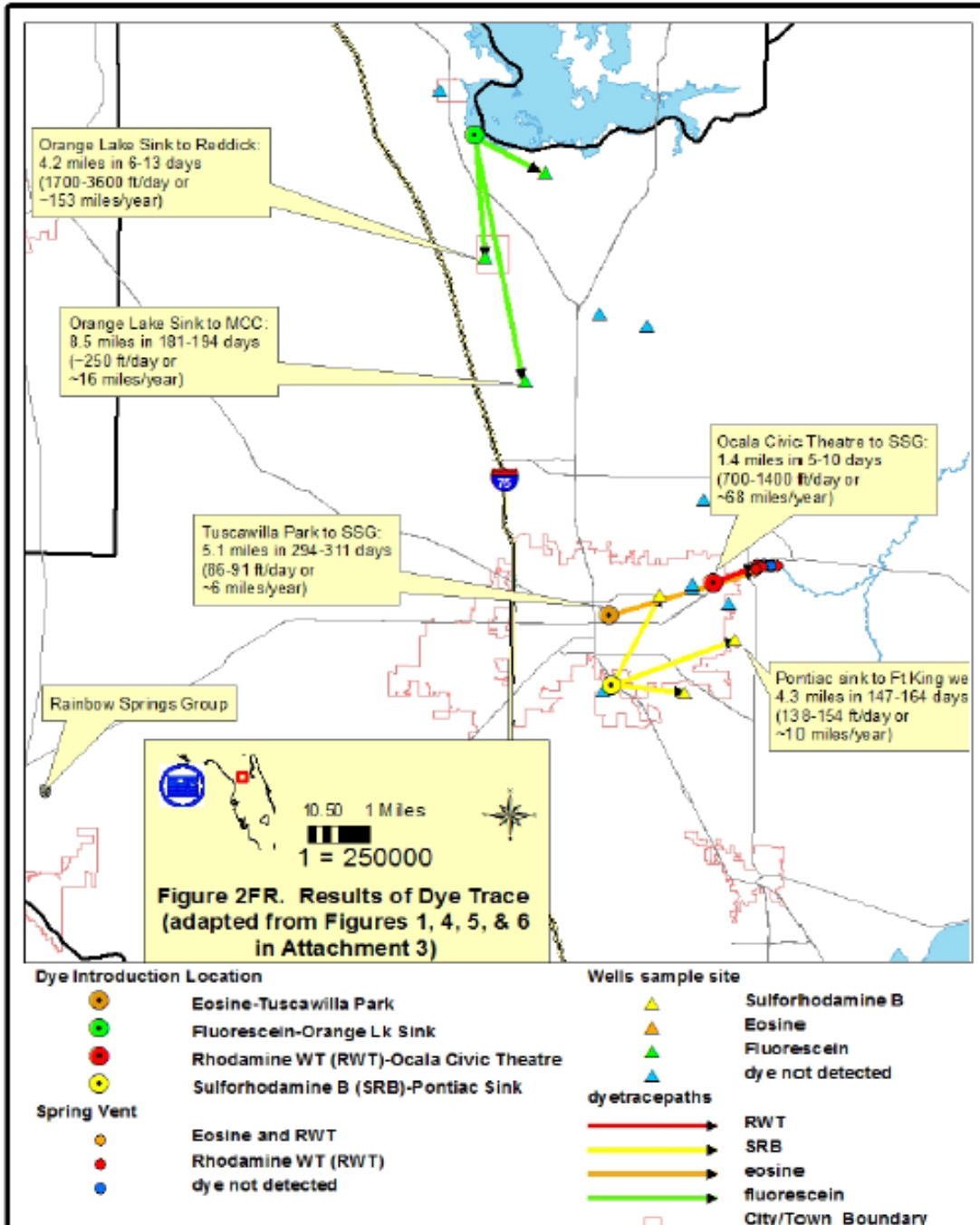


Pontiac Sink Straight Line Dye Trace Path - Sulforhodamine

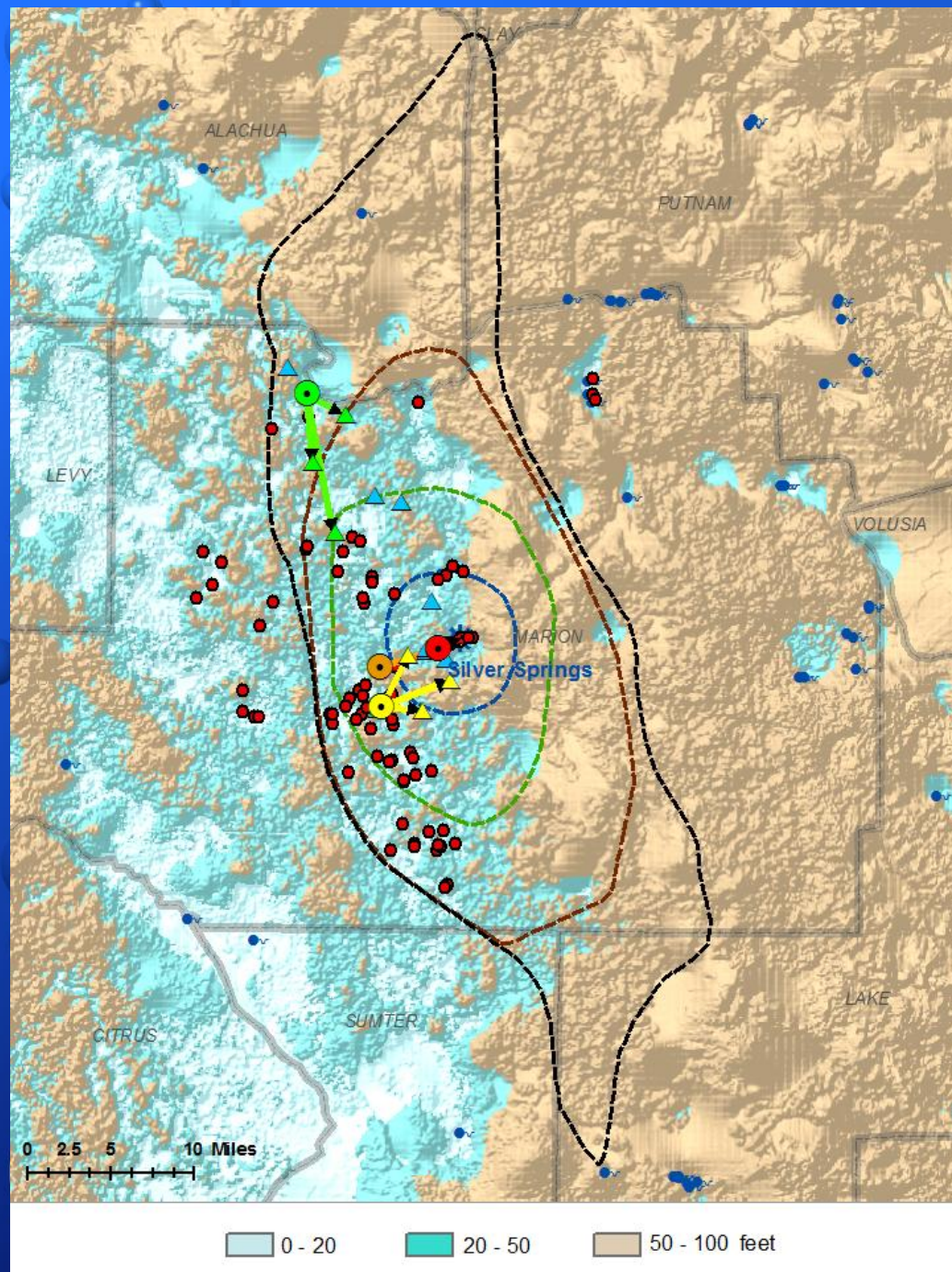


Summary Velocities

- Orange Lake to Marion Correctional Institute
~ 16 miles/year
- Tuscawilla to SSG
~ 6 miles/year.
- Pontiac Sink to Ft. King
~ 10 miles/year.
- Ocala Civic Center to SSG
~ 68 miles/year



Thickness of Sediments Overlying Upper Floridan Aquifer with Cave Locations and Capture Zones



Summary

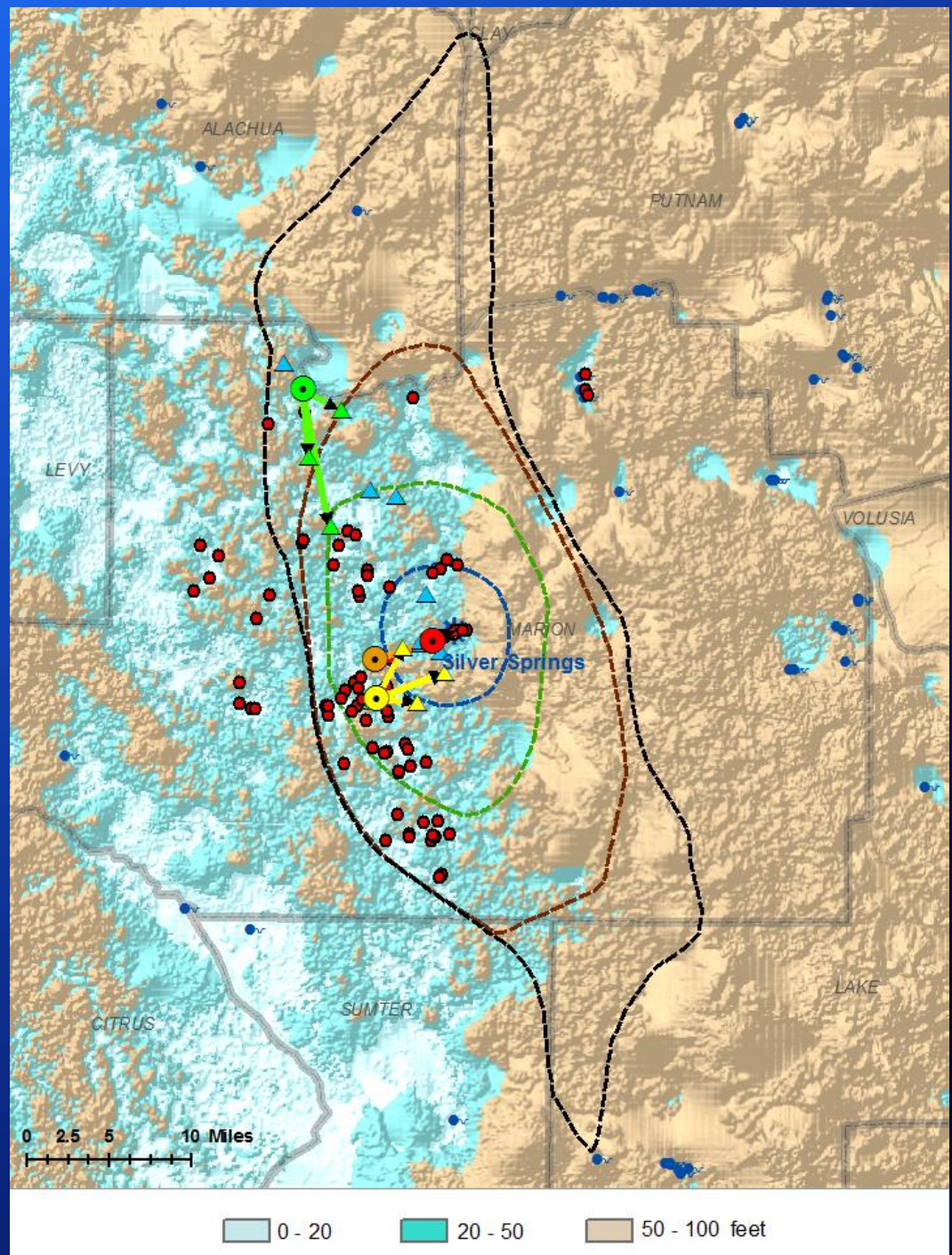
- Mapping methods demonstrate that springshed delineation is similar for the three methods
- Springshed boundary moves a short distance as a result of wet and dry climatic conditions, but is generally stable in areal extent
- Dye tracer tests indicate that there is lateral and vertical anisotropy in groundwater flow
- Comparison of the dye tracer and particle tracking suggest that a large part of the 2-year capture zone is dominated by conduit flow



Summary

- Dye tracer results imply conduit flow has significantly higher velocities than indicated by the more conservative modeled particle tracking capture zones
 - Groundwater contributing flow to the SSG from distant locations would therefore be seen more quickly
- Other areas may be dominated by matrix flow – duration of dye study limited ability to estimate velocities through matrix flow







Steamboat Okeehumkee that traveled on the Silver River in the 1800s (Florida Archives)