Understanding Florida's Karst

Results & Lessons Learned from the Woodville Karst Plain Research

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DEPARTMENT OF ENVIRONMENTAL PROTECTION FLORIDA

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Groundwater Flow Velocities

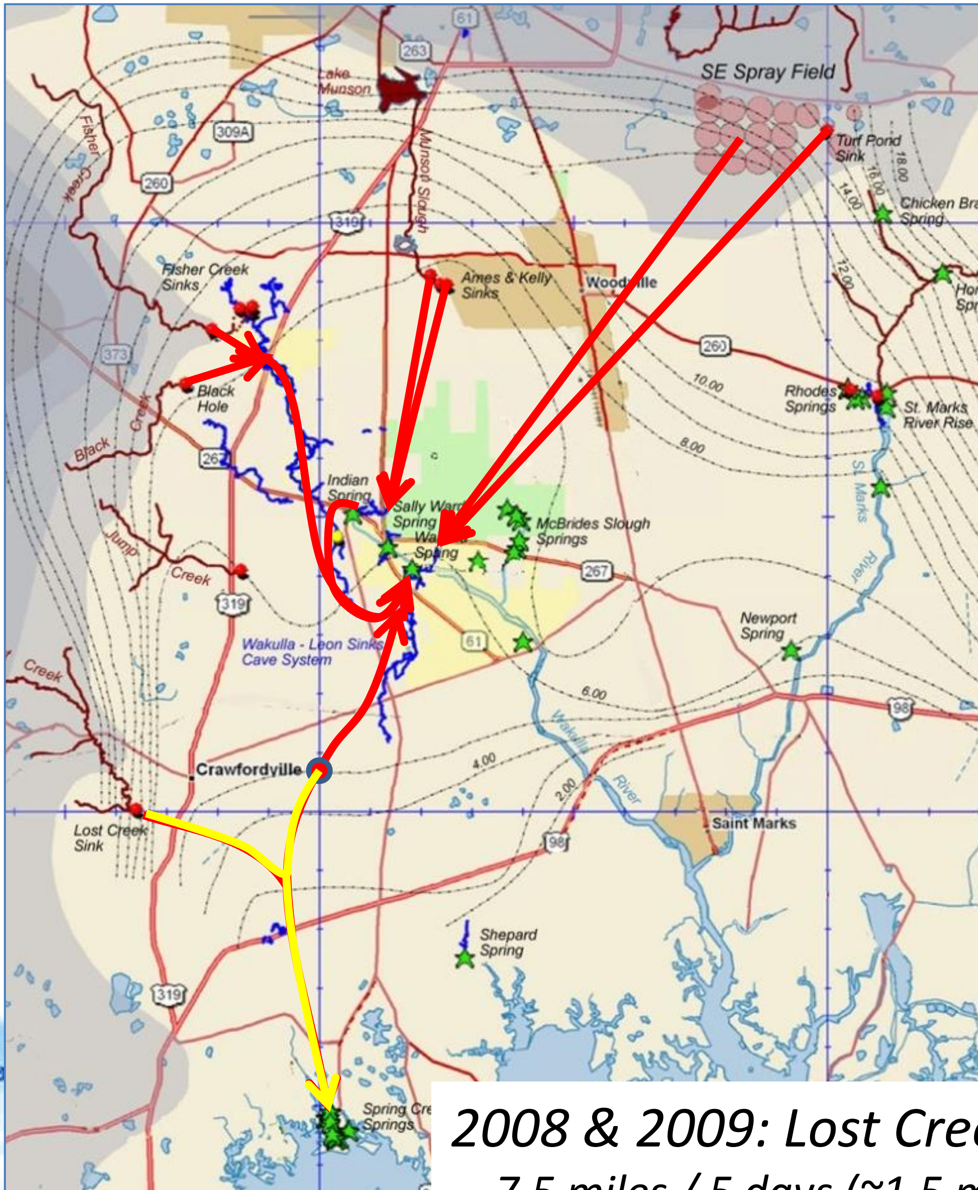
Problem: severely underestimate reality

Method	Velocity (m/day)	Assumptions	Source
Pumping Test Transmissivities	0.1-0.75 ft/day	Calculated Gradient Aquifer b = 100m	1
Model Derived Transmissivities	0.1 – 3.9 ft/day	Calculated Gradient Aquifer b = 100m	3
Geochemical age dates	25 – 50 ft/day	Age ~20-40 years 100% of Recharge derived from top of basin (~110 km to north)	2, 4

1. Bush, P.W., and Johnston, R.H., 1988. Ground-water hydraulics, regional flow, and ground-water development of the Floridan aquifer system in Florida and parts of Georgia, South Carolina and Alabama: U.S. Geological Survey Professional Paper 1403-C, 80 p.
2. Chanton, J. 2002. Unpublished data and report on stable isotopic age dating of waters in the Woodville Karst Plain, Florida for the Florida Geological Survey, Tallahassee, FL.
3. Davis, H. 1996. Hydrogeologic Investigation and Simulation of Ground-Water Flow in the Upper Floridan Aquifer of North-Central Florida and Delineation of Contributing Areas for Selected City of Tallahassee, Florida, Water Supply Wells: USGS Water-Resources Investigation Report 95-4296.
4. Katz, B.G., Chelette, A.R., and Pratt, T.R., 2004. Use of chemical and isotopic tracers to assess nitrate contamination and ground water age, Woodville Karst Plain, USA: Journal of Hydrology, v. 289, no. 1 /4, p. 36-61.

e.g. Sprayfield – Wakulla: ~10 miles, 56 days, ~830 ft/day

Groundwater Tracing



2002: Fisher Creek – Emerald Sink
1.7 miles / 1.7 days (3,770 ft/day)

2003: Black Creek – Emerald Sink
1.6 miles / 1.6 days (2,670 ft/day)

2004: Emerald Sink – Wakulla Spring
10.3 miles / 7.1 days (7,650 ft/day)

2005: Kelly Sink – Indian Spring
5.2 miles / 13.5 days (2,040 ft/day)

2005: Ames Sink – Indian Spring
5.2 miles / 17.2 days (1,600 ft/day)

2005: Indian Spring – Wakulla Spring
5.5 miles / 5.9 days (4,890 ft/day)

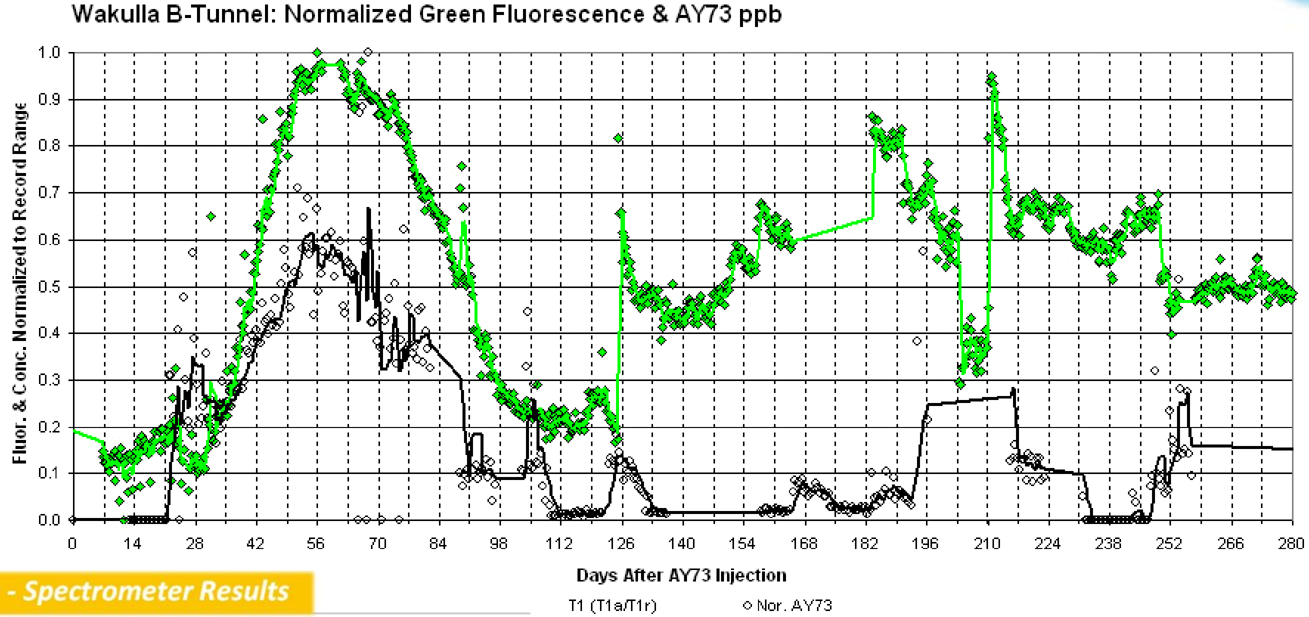
2006: Wells – Wakulla Spring
10.4 miles / 66.5 days (830 ft/day)
10.4 miles / 56 days (980 ft/day)

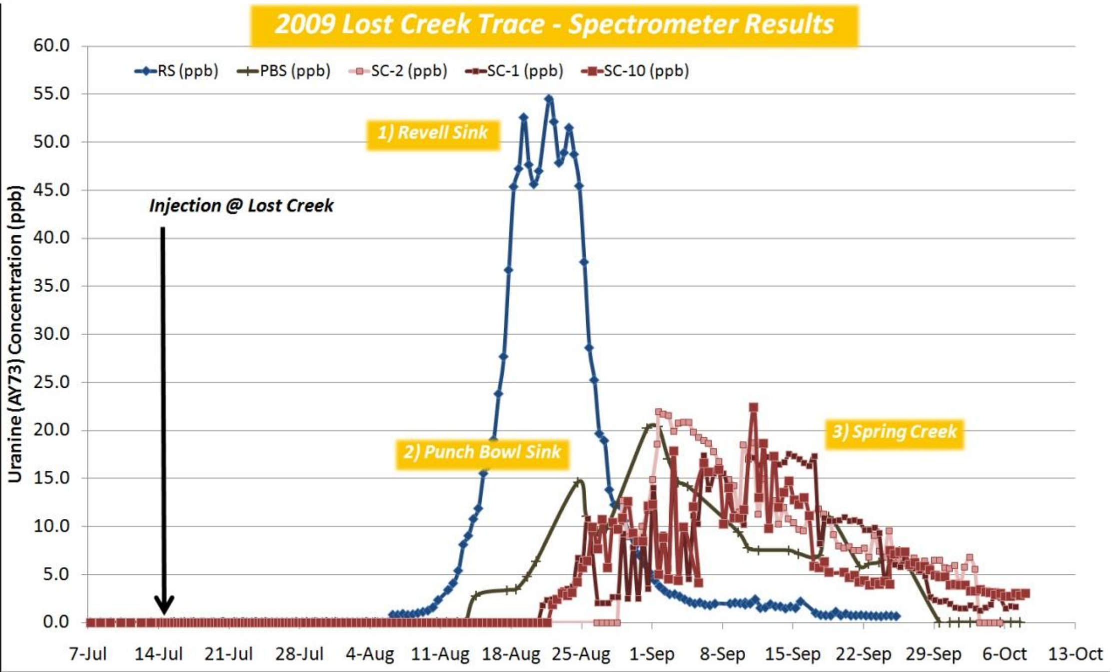
2006: Turf Pond – Wakulla Spring
10.9 miles / 56 days (1,030 ft/day)

2008 & 2009: Lost Creek – Spring Creek & Wakulla Spring
7.5 miles / 5 days (~1.5 miles/day) – 7.75 miles / 47 days (~870 ft/day)

Groundwater Tracing

Groundwater Tracing





Groundwater Tracing – Lessons Learned

- Slowest measured “real” groundwater velocity was ~830 feet / day from the Sprayfield wells to Wakulla – B-Tunnel.
  - 1,100 times faster than fastest pump-test derived velocity.
  - 213 times faster than fastest model derived velocity.
  - 17 times faster than fastest age-dating derived velocity.
- Fastest measured “real” groundwater velocity was ~7,650 feet/day (~1.4 miles/day) from Emerald Sink to Wakulla Spring.
  - 10,200 times faster than fastest pump-test derived velocity.
  - 1,960 times faster than fastest model derived velocity.
  - 150 times faster than fastest age-dating derived velocity.
- Super fast groundwater velocities are not just applicable to swallet recharge but also to matrix flow.

Groundwater Tracing – Lessons Learned

- Swallet water levels exert control on matrix groundwater flow velocities
  - When swallets are full, they pressurize the conduits.
  - Pressure in conduits stalls matrix flow and can even drive water from the conduits into the matrix.
  - Water can reside in matrix for long periods if conduits remain full.

Conduit System Metering

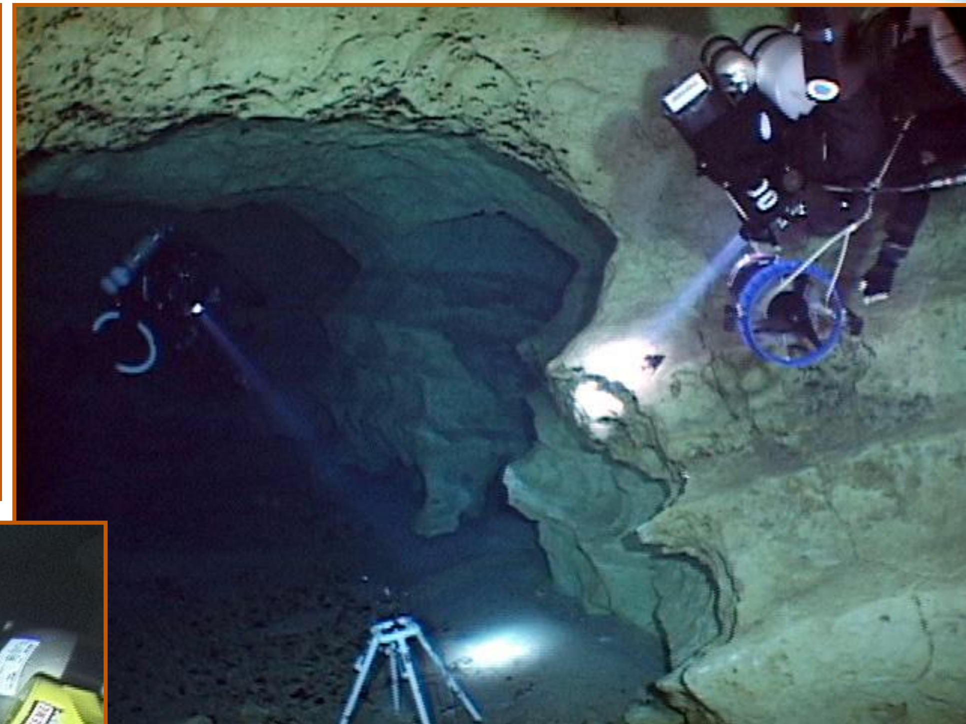
Flow, Temperature, Conductivity

- Wakulla – Vent *(2003 – 2009)*
- Wakulla – B-Tunnel *(2003 – Present)*
- Wakulla – C-Tunnel *(2003 – Present)*
- Wakulla – D-Tunnel *(2004 – 2009)*
- Wakulla – K-Tunnel *(2007 – Present)*
- Wakulla – A-Tunnel *(2004 – Present)*
- Spring Creek – #1 *(2009 – Present)*
- Spring Creek – #10 *(2009 – Present)*
- Revell Sink *(2010 – Present)*
- *Turner Sink* *(2003 – 2004)*
- *Indian* *(2005)*

Water Level *(2008 – Present)*

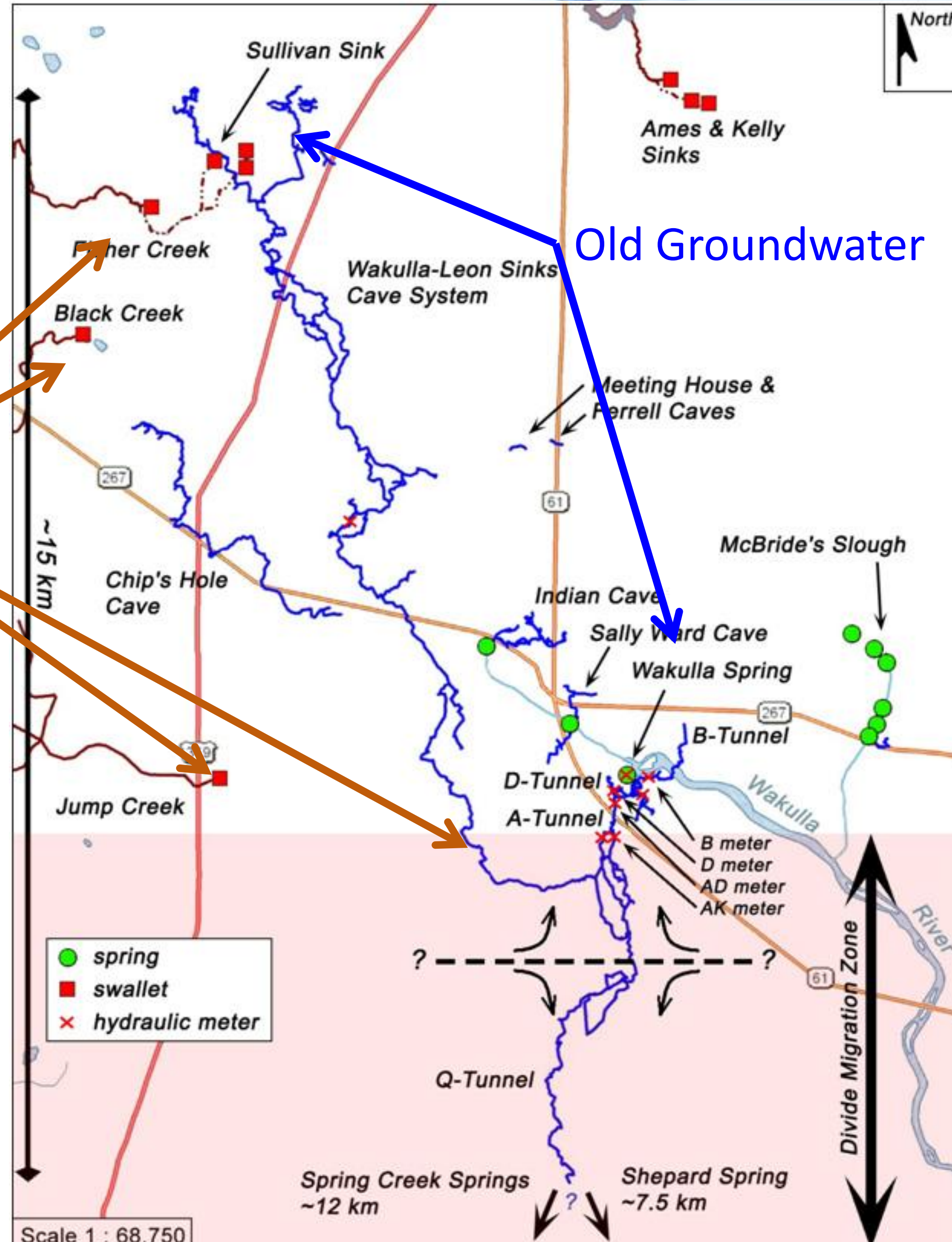
- Sullivan Sink
- Wakulla Boat Dock
- St. Marks River Rise
- Tobacco Sink
- Punch Bowl Sink
- *Shell Point Piezometers*
- *Sullivan Wells*

Conduit System Metering



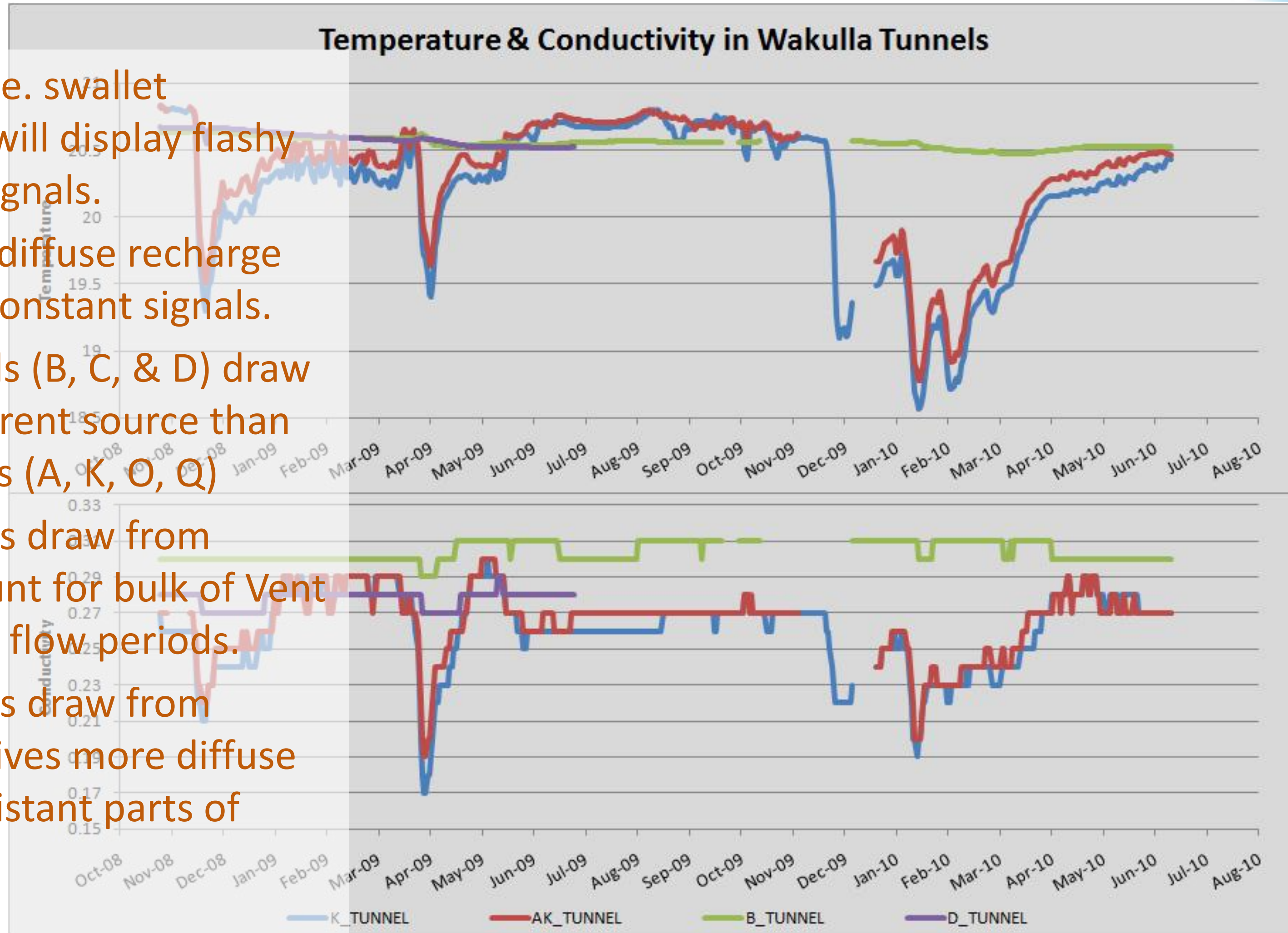
Wakulla Sources

Swallet Water



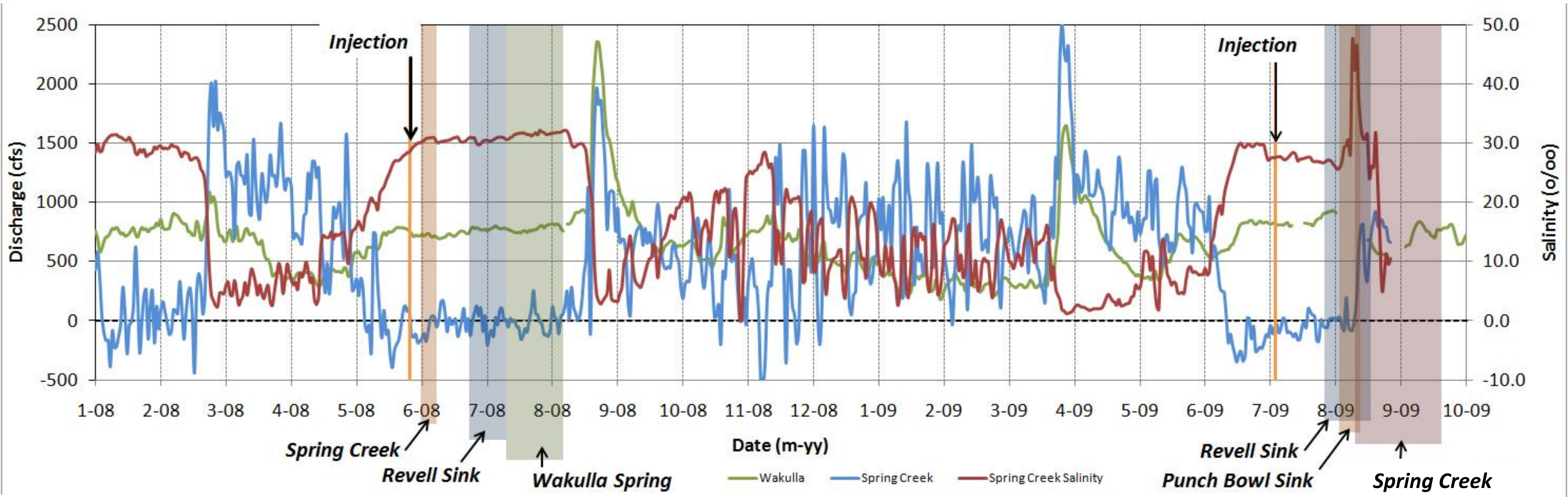
Conduit System Metering

- “Young water” i.e. swallet recharge water will display flashy temp. & cond. signals.
- “Old water” i.e. diffuse recharge will have more constant signals.
- Northern Tunnels (B, C, & D) draw water from different source than southern tunnels (A, K, O, Q)
- Southern tunnels draw from swallets & account for bulk of Vent flow during high flow periods.
- Northern tunnels draw from matrix that receives more diffuse recharge from distant parts of springshed.

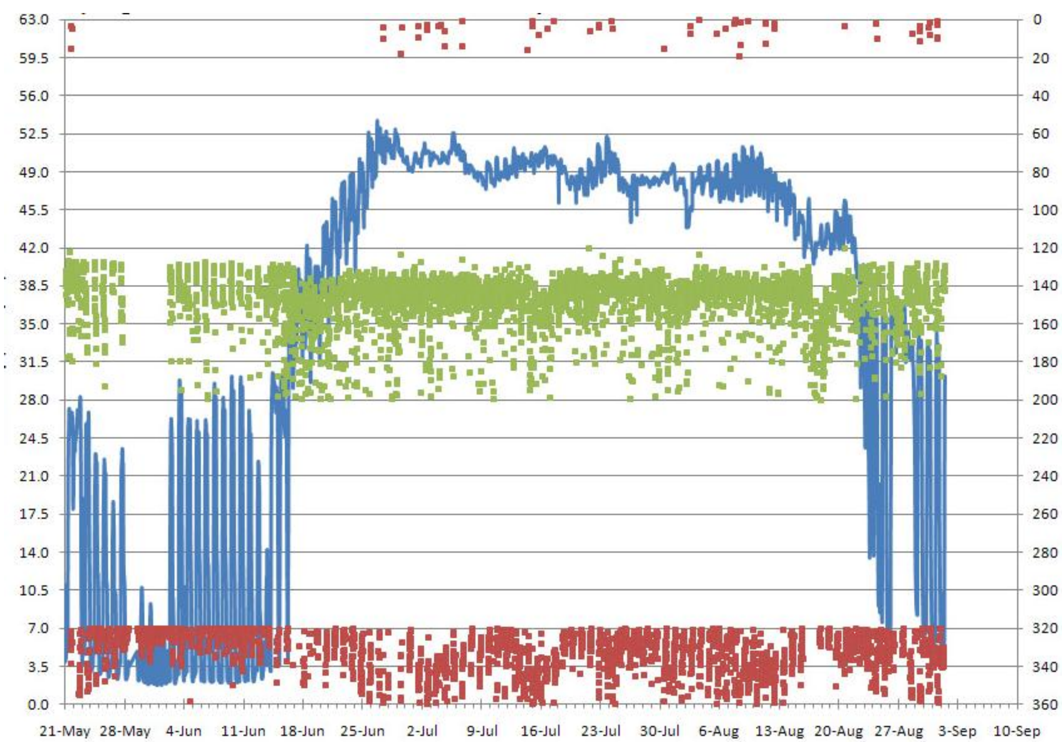


Spring Creek Metering

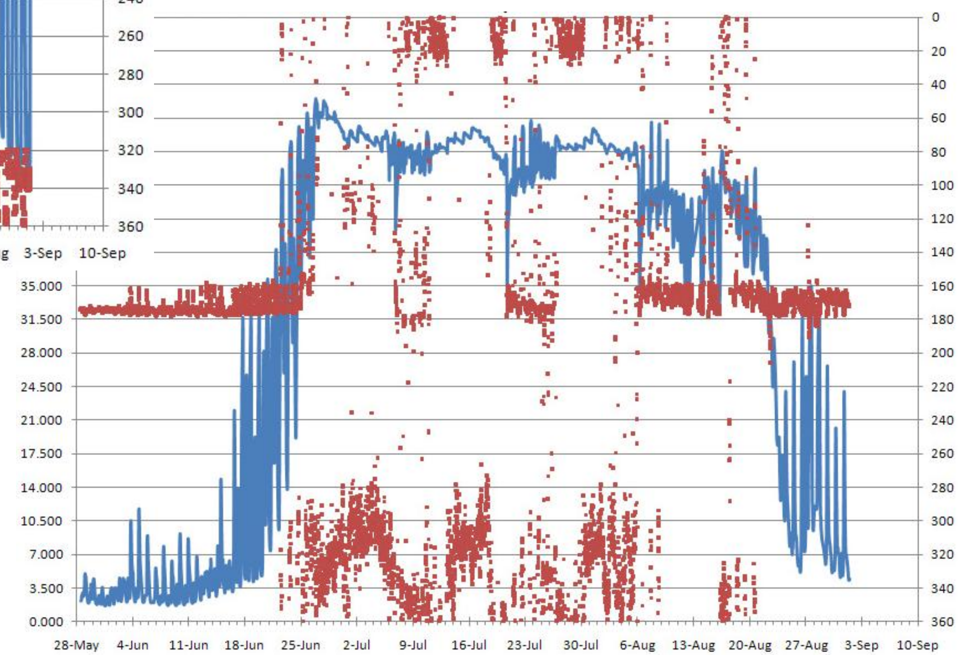
- Composite Spring Creek flow & salinity (USGS).
- Summers 2007-2010: Spring Creek stops flowing / salinities rise to sea water levels.
- When Spring Creek stops flowing, Wakulla Spring flow increases
- When Spring Creek is flowing, Lost Creek water flows rapidly to Spring Creek.
- When spring Creek stops flowing, Lost Creek water flows slowly to Wakulla Spring.



Spring Creek Metering

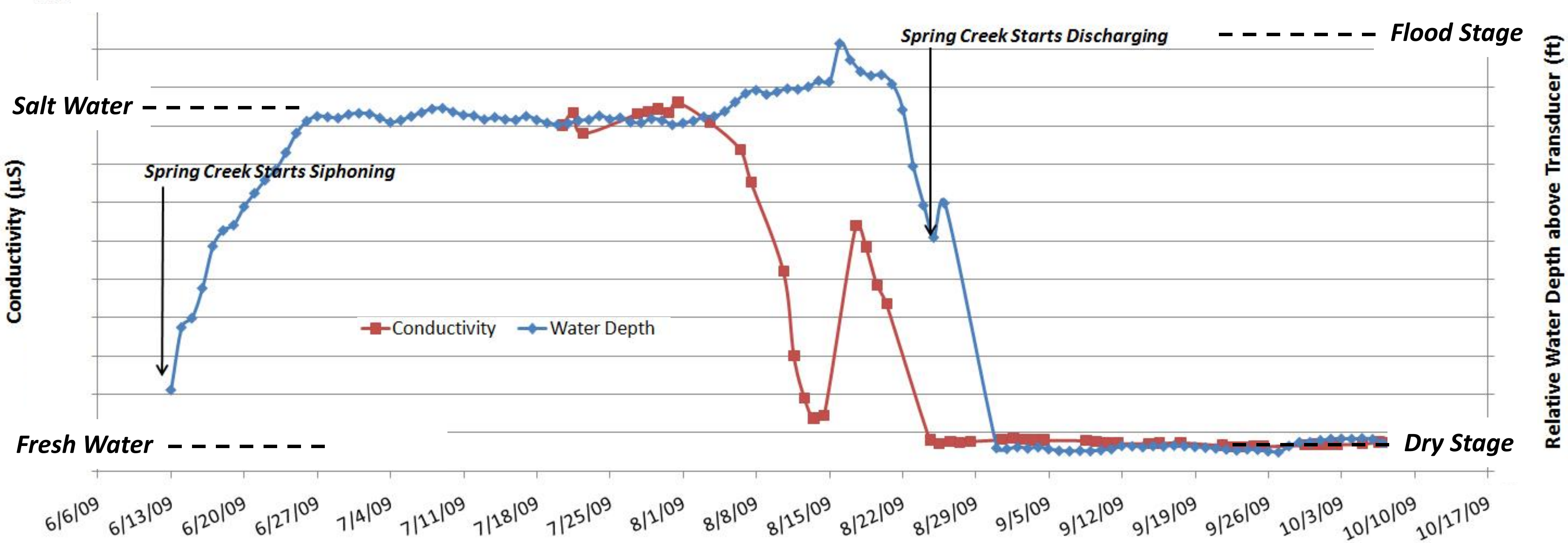


- Conduit meters record short flow reversals followed by long period of tidal cycling.
- #1 (deeper cave) reverses first
- # 10 (shallower cave) reverses for longer period than #1.



Conduit System Monitoring

- 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.

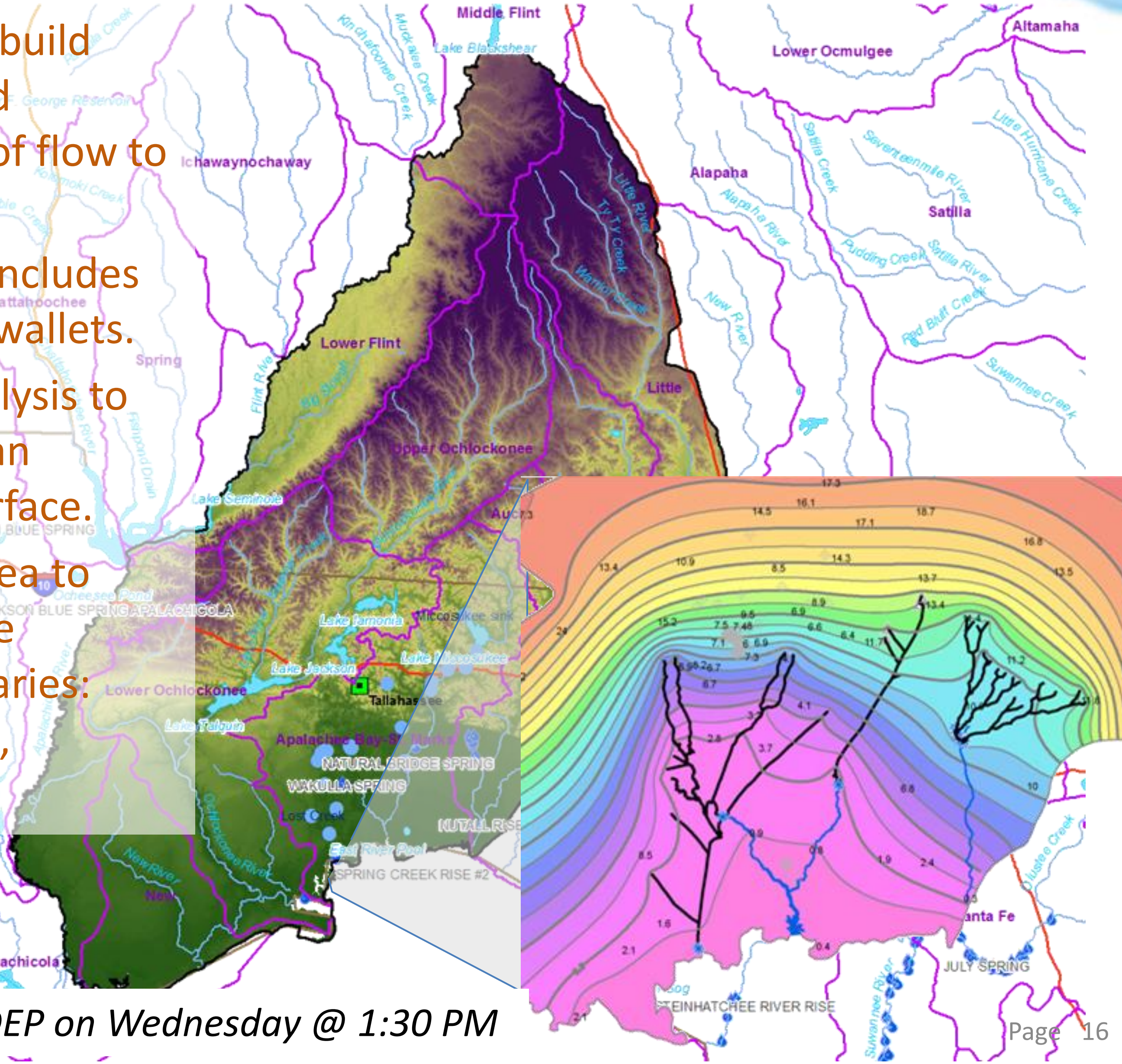


Metering – Lessons Learned

- Wakulla discharges two types of water
  - Relatively old clear water that originates as diffuse recharge in the distant part of the springshed (baseflow ~70-80 MGD)
  - Very young dark colored water that originates as stream flow into swallets (everything >~80 MGD)
- Wakulla & Spring Creek springsheds are linked
  - Cannot understand Wakulla without an understanding of Spring Creek.
  - Poor summer water quality at Wakulla is likely a result of Spring Creek shut offs which cause water that would normally flow to Spring Creek to flow to Wakulla instead.
- Continuous measurements of basic parameter data provide important information about aquifer behavior that cannot be gleaned from quarterly monitoring or snapshots of groundwater age.

Building Better Predictive Models

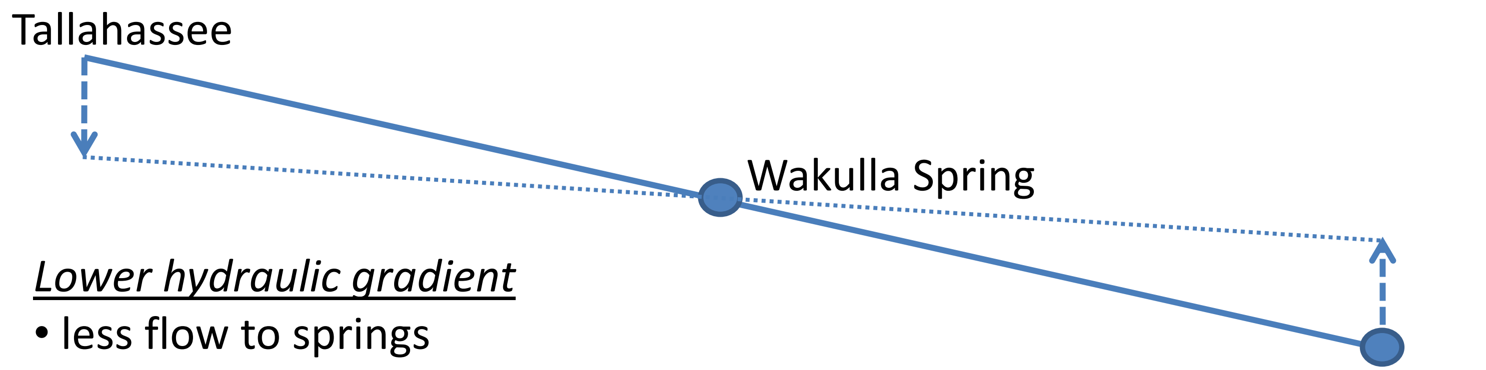
- Leveraged data to build new numerical and statistical models of flow to Wakulla.
- Numerical model includes caves, springs, & swallets.
- Historical data analysis to understand Floridan potentiometric surface.
- Addresses large area to accurately simulate springshed boundaries: Wakulla, St. Marks, Wacissa.



Detailed discussion at FLDEP on Wednesday @ 1:30 PM

What Have We Learned?

- Groundwater flow is fast
- Flow from most of Tallahassee region flows to Wakulla Spring.
- Spring Creek reversals are likely due to reduction in total flow to Wakulla + Spring Creek.
- Loss of the old groundwater component of flow to Wakulla is the most pressing issue confronting the spring.



Lower hydraulic gradient

- less flow to springs
- more salt water intrusion

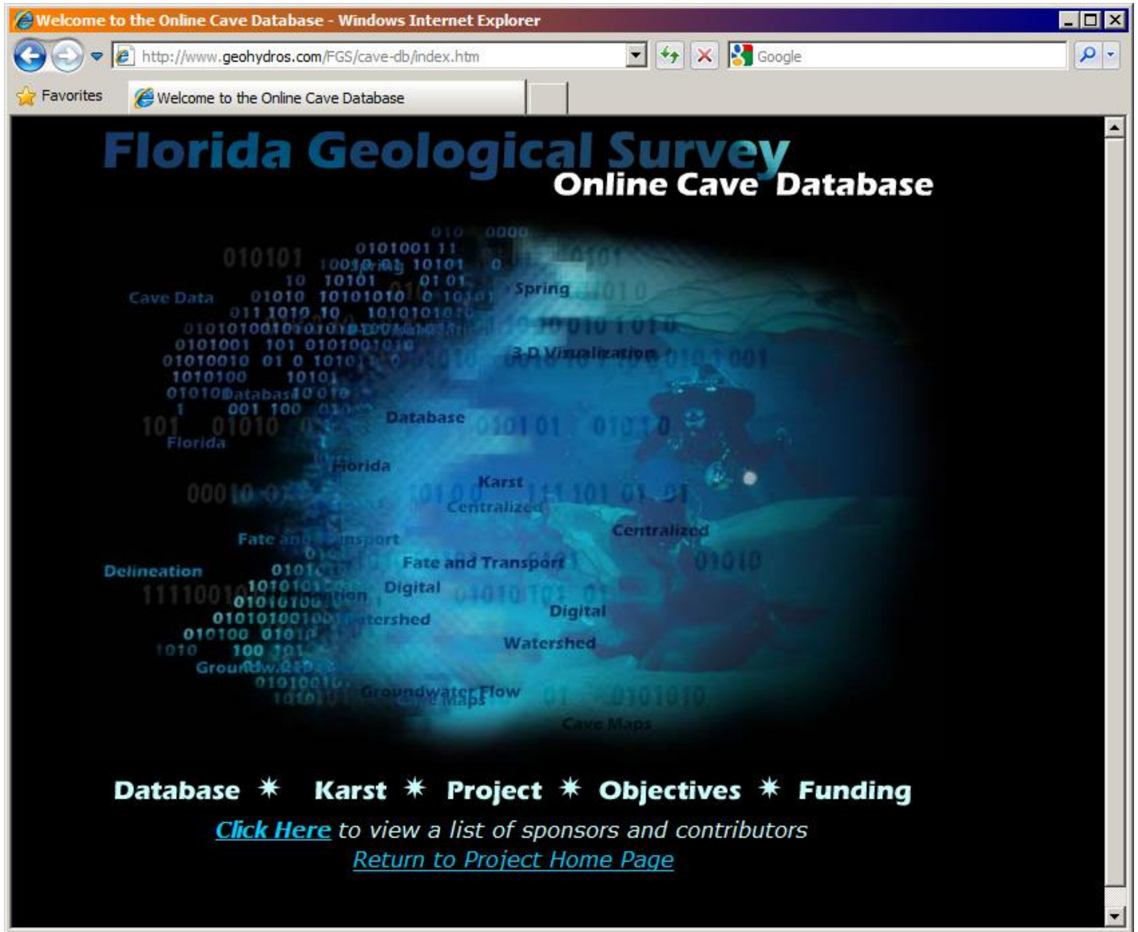
Changing water levels

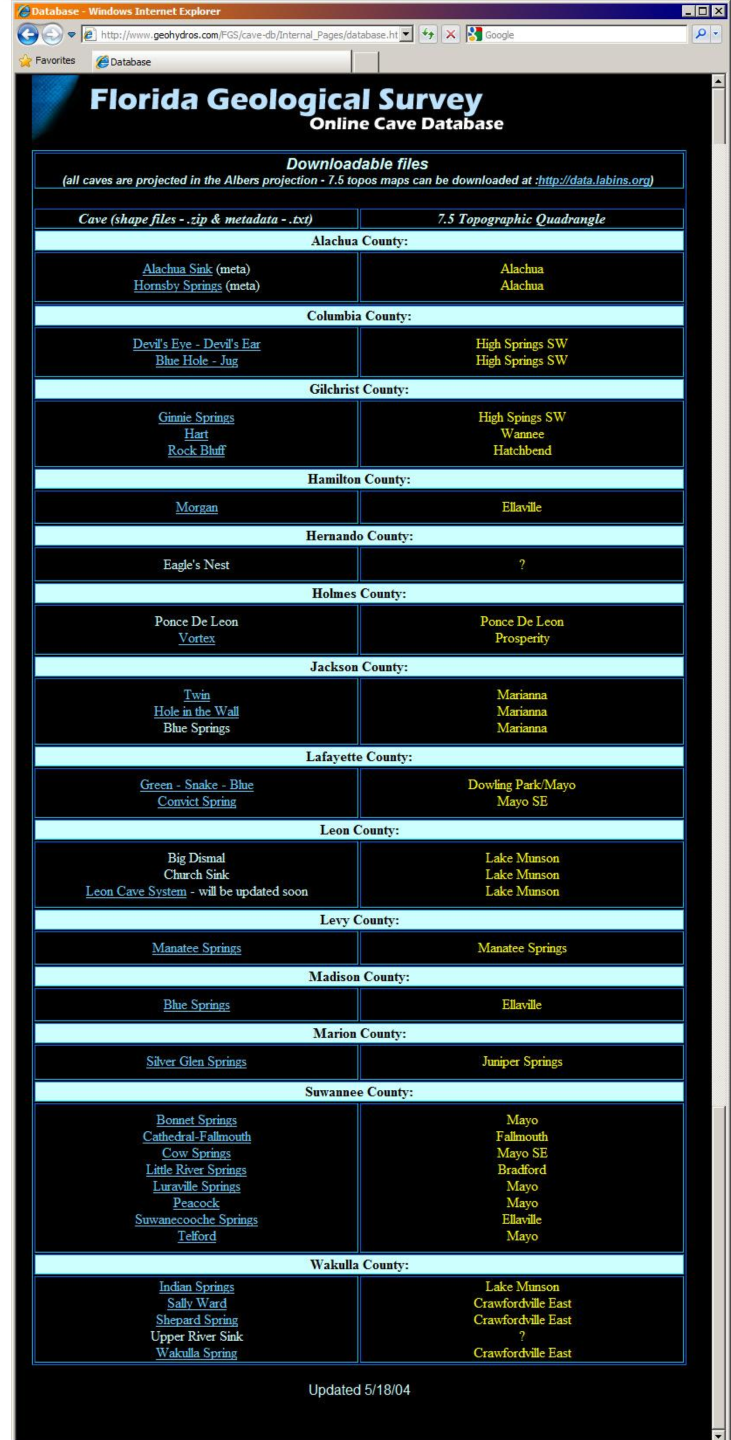
- depressed conditions in north
- deeper unsaturated zone
- elevated conditions in south
- reduced unsaturated zone

Education & Outreach

- Expand "data" to include caves
  - WKPP volunteer divers
  - Florida Cave Database
  - Workshops with NSS-CDS
- Science based guidelines & recommendations
  - Hydrogeology Consortium Workshops (2002 – 2005)
  - Recommendations for Wakulla
  - Short courses & field trips
  - *Hosted 2008 ASCE Karst Conference*
- Public Outreach
  - Exploring the Secrets of Wakulla Spring (Apr & Aug 2004)
  - Wildlife Festivals (2000 – 2010)
  - Florida's Awesome Aquifer – educational DVD
  - Florida's Karst – exhibit presentation

Florida Cave Database




Database - Windows Internet Explorer

http://www.geohydros.com/FGS/cave-db/Internal_Pages/database.ht

Florida Geological Survey
Online Cave Database

Downloadable files

(all caves are projected in the Albers projection - 7.5 topos maps can be downloaded at :http://data.labins.org)

Cave (shape files - .zip & metadata - .txt)	7.5 Topographic Quadrangle
Alachua County:	
Alachua Sink (meta) Hornsby Springs (meta)	Alachua Alachua
Columbia County:	
Devil's Eye - Devil's Ear Blue Hole - Jug	High Springs SW High Springs SW
Gilchrist County:	
Ginnie Springs Hart Rock Bluff	High Spings SW Wannee Hatchbend
Hamilton County:	
Morgan	Ellaville
Hernando County:	
Eagle's Nest	?
Holmes County:	
Ponce De Leon Vortex	Ponce De Leon Prosperity
Jackson County:	
Twin Hole in the Wall Blue Springs	Marianna Marianna Marianna
Lafayette County:	
Green - Snake - Blue Convict Spring	Dowling Park/Mayo Mayo SE
Leon County:	
Big Dismal Church Sink Leon Cave System - will be updated soon	Lake Munson Lake Munson Lake Munson
Levy County:	
Manatee Springs	Manatee Springs
Madison County:	
Blue Springs	Ellaville
Marion County:	
Silver Glen Springs	Juniper Springs
Suwannee County:	
Bonnet Springs Cathedral-Fallmouth Cow Springs Little River Springs Luraville Springs Peacock Suwanecooche Springs Telford	Mayo Fallmouth Mayo SE Bradford Mayo Mayo Ellaville Mayo
Wakulla County:	
Indian Springs Sally Ward Shepard Spring Upper River Sink Wakulla Spring	Lake Munson Crawfordville East Crawfordville East ? Crawfordville East

Updated 5/18/04

www.geohydros.com/FGS/cave-db/

Soon at: www.hydrogeologyconsortium.org

Public Outreach

Public presentations attracted media and helped inspire a sense of urgency