A Groundwater Model for the Santa Fe River Springsheds (DRAFT)

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Comparison of Calculated Groundwater Velocities

Woodville Karst Plain, North Florida

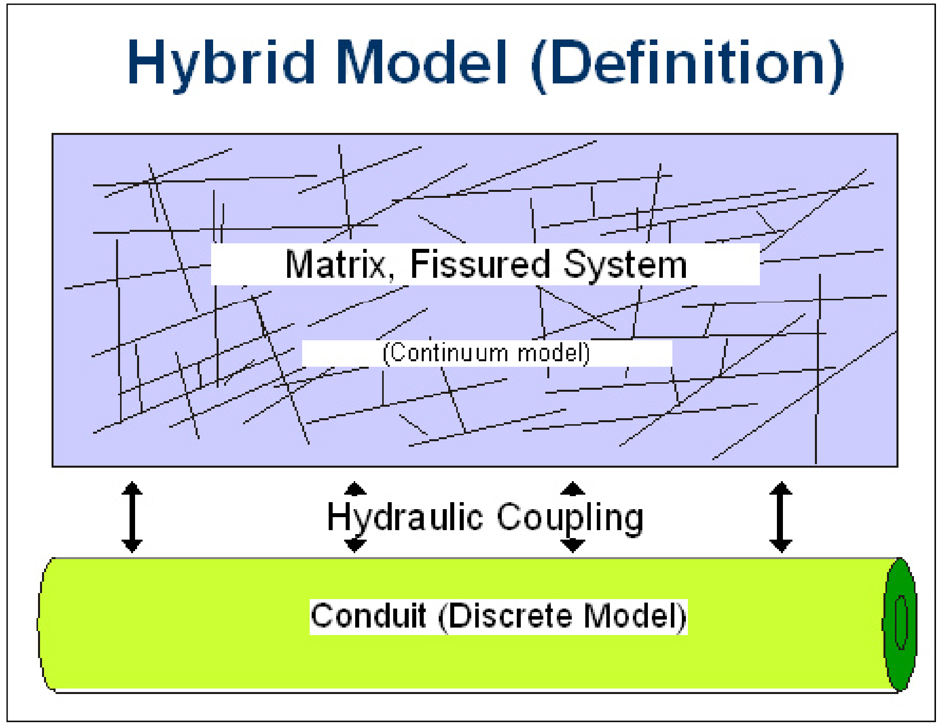
Method	Velocity (m/day)	Assumptions	Source
Tracing	252-2,337 m/day	none	5
Pumping Test Transmissivities	0.03-0.23 m/day	Calculated Gradient Aquifer b = 100m	1
Model Derived Transmissivities	0.03 – 1.17 m/day	Calculated Gradient Aquifer b = 100m	3
Geochemical age dates	7.5 – 15 m/day	Age ~20-40 years 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 Unpublished data and report on stable isotopic age dating of waters in the Woodville Karst Plain, Florida for the Florida Geological Survey, Tallahassee, FL.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.
5. Kincaid, T.R. and Werner, C.L., 2008. Conduit Flow Paths and Conduit/Matrix Interactions Defined by Quantitative Groundwater Tracing in the Floridan Aquifer, in Lynn Yuhr, Calvin Alexander, and Barry Beck editors, *Sinkholes and the Engineering and Environmental Impacts of Karst: Proceedings of the 11th Multidisciplinary Conference on Sinkholes and the Engineering and Environmental Impacts of Karst*, American Society of Civil Engineers.

Model Design: Technical Approach

Model was constructed with FEFLOW™

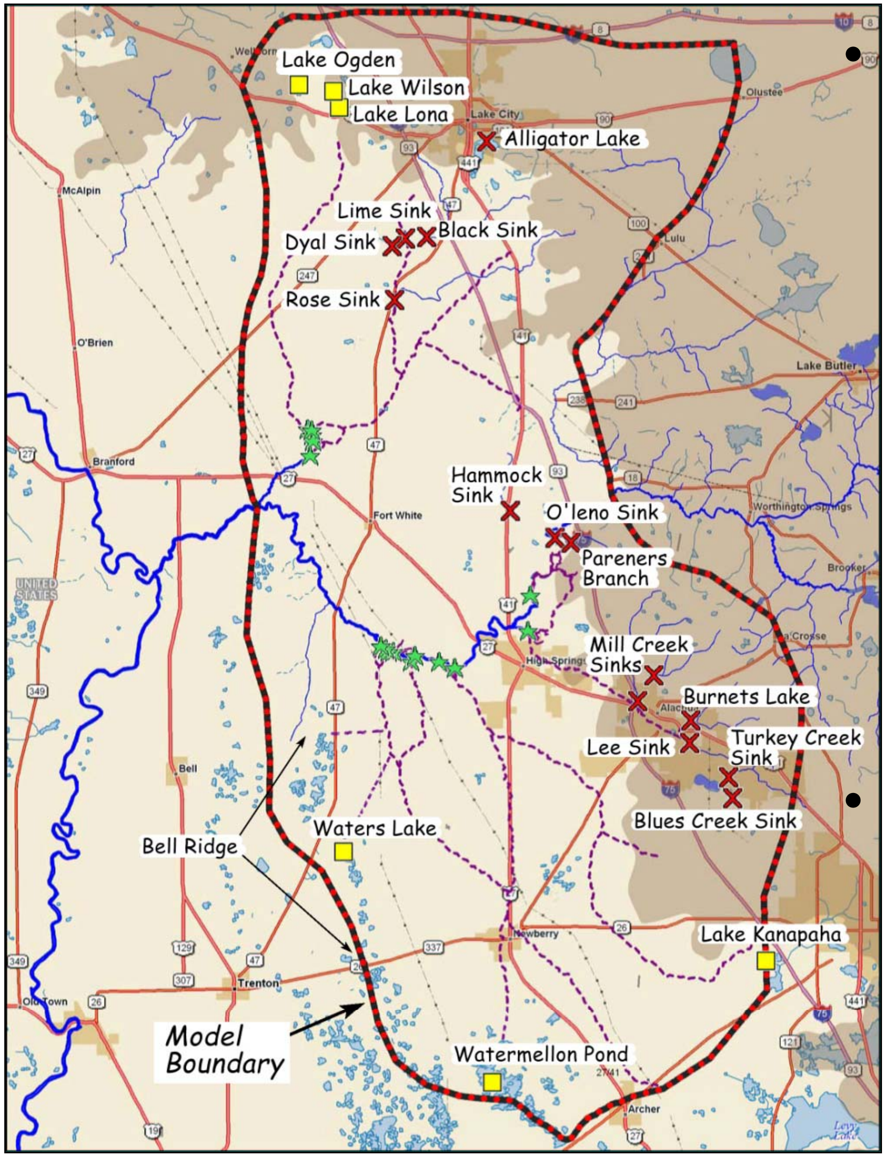
- FEFOW™ (finite element design)
- Commonly used by national laboratories & research institutions.
- Allows us to simulate combination of conduit flow and matrix flow.
- Porous media equations for matrix.
- Pipe flow equations for conduits.



Modeling Strategy

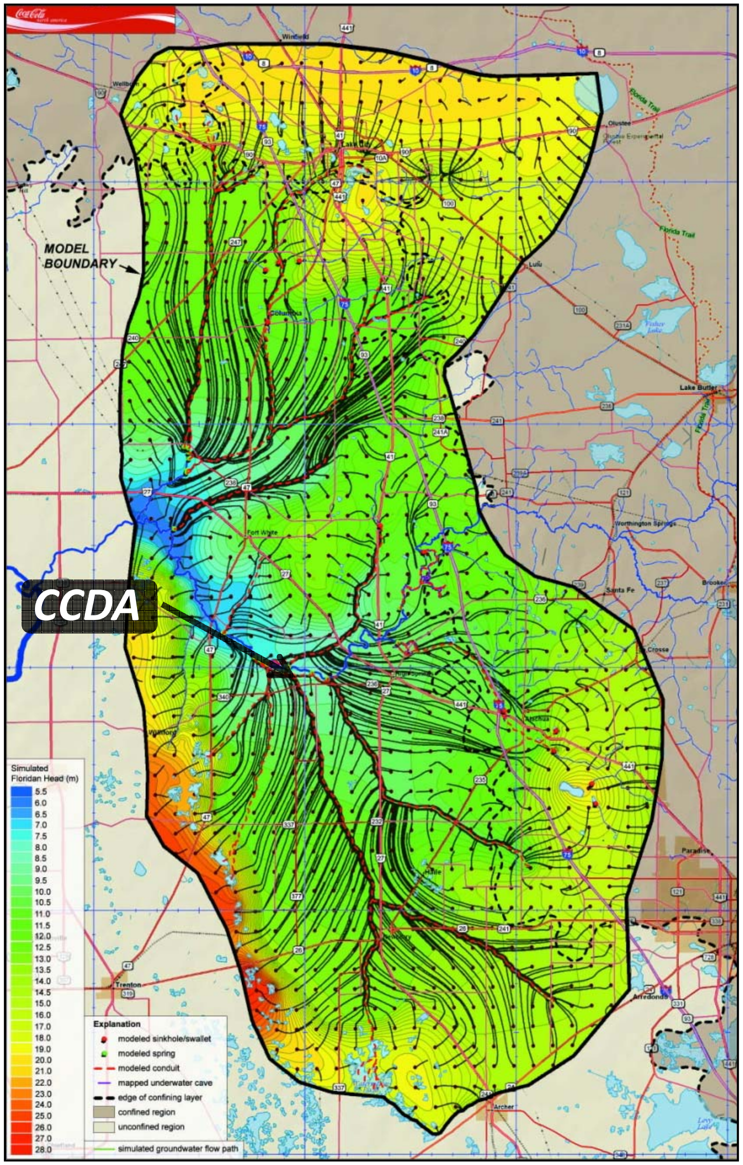
- 3D structure (surficial, intermediate confining layer, & Floridan)
- Define conduit locations from cave maps, tracer tests, and groundwater levels (high & low water conditions)
- Define conduit capacities from levels & flows at high water conditions
- Steady-state (designed to simulate average conditions)
- Calibrate model to both high water & low water conditions

Modeling in the Santa Fe River Basin



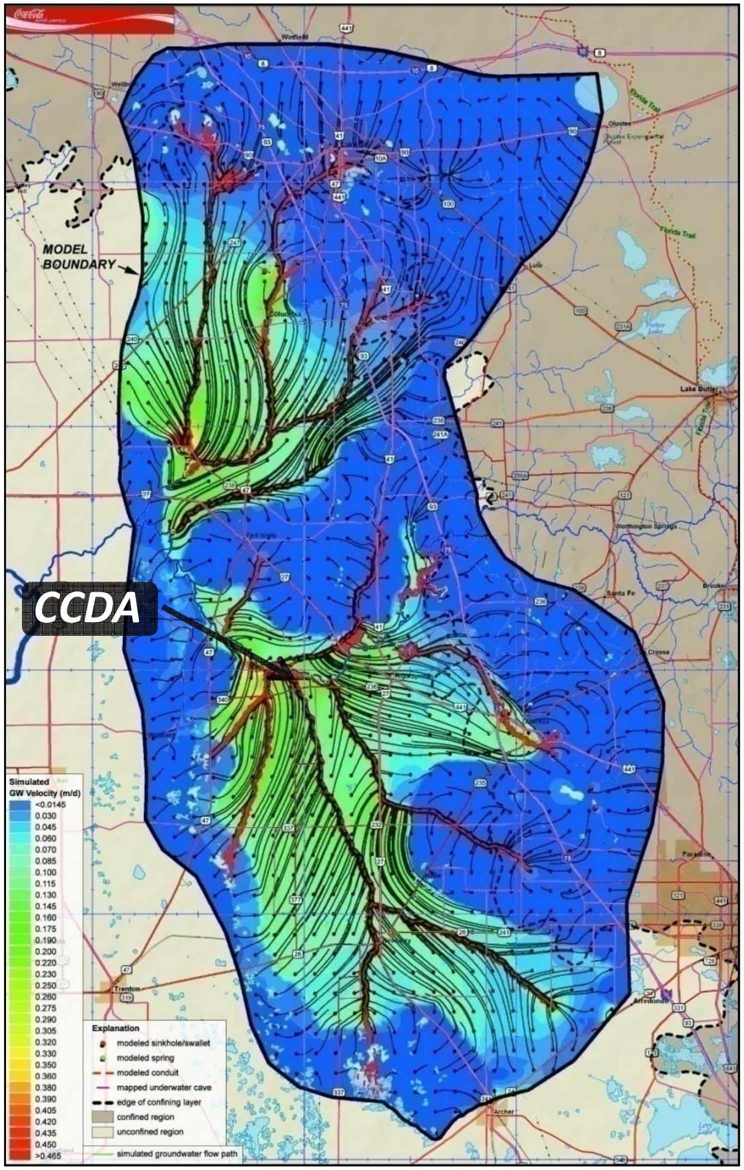
- Major Swallets (10) – Observed loss in sinkholes
  - Santa Fe Group (3)
    - O'leno Sink: 638 cfs in May 2005 Avg
  - Hornsby Group (5)
    - Mill Creek Sink: 0.9 cfs *(est)*
    - Lee Sink: 0.5 cfs *(est)*
    - Burnetts Lake: 0.45 cfs *(est)*
    - Turkey Creek Sink: 0.5 cfs *(est)*
    - Blues Creek Sink: 0.33 cfs *(meas)*
  - Blue Hole Group (5)
    - Rose Creek Sink: 110 cfs *(est)*
    - Black Sink: 25 cfs *(est)*
    - Dyal Sink: 25 cfs *(est)*
    - Lime Sink: 25 cfs *(est)*
    - Alligator Lake Sink: *(not estimated)*
- Minor Swallets (4) – Probable loosing lakes
  - Ichetucknee: *Lakes Ogden, Lona, & Wilson*
  - Ginnie & Blue: *Waters Lake, Watermellon Pond, Perched Lakes along Bell Ridge*
  - Poe: *Lake Kanapaha (Hogtown Creek)*

Model Results: Groundwater Levels



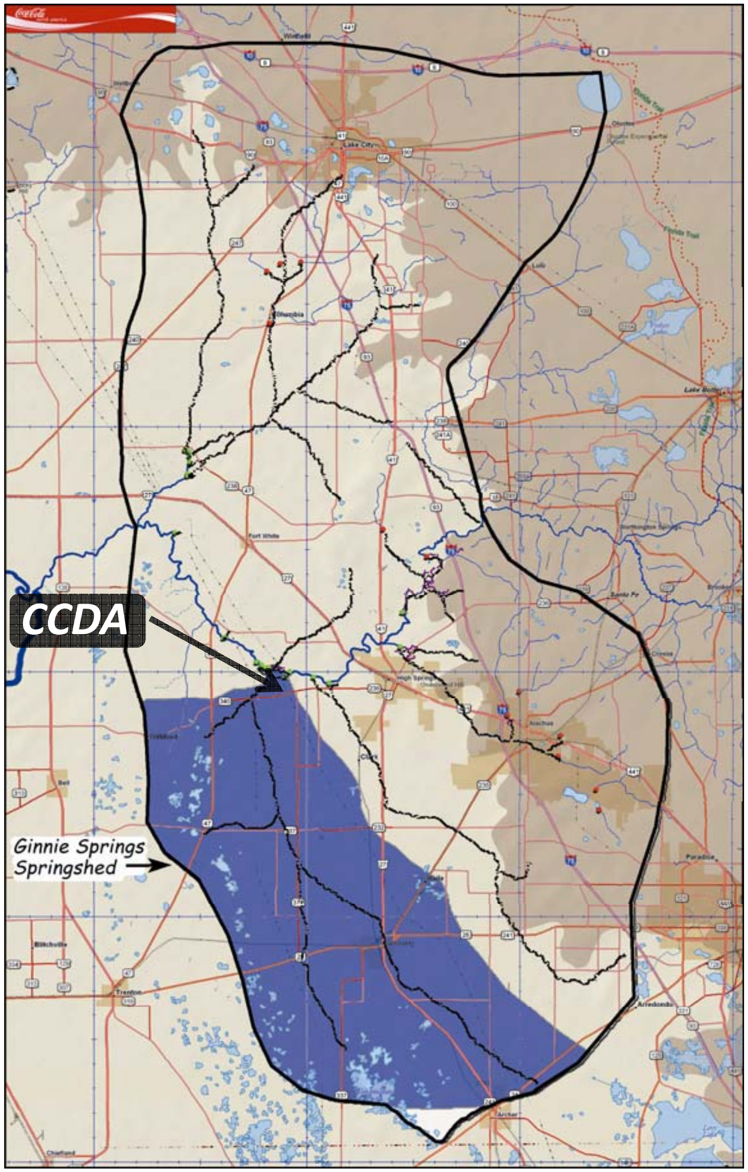
- Flow is from red to blue areas.
- Calibrated to high and low water levels
  - Acceptable criteria: +/- 5% of total change in levels at any observation well (+/- 3 ft)
  - Achieved for 170/185 low-water wells
  - Achieved for 135/147 high-water wells
- Calibrated to high & low spring discharges
  - Acceptable criteria: +/- 10 % of reported or estimated flow
  - Achieved for all springs
- Calibrated to tracer-defined groundwater velocities
  - Acceptable criteria: <= 1,320 ft/day
  - Achieved for all flow paths
- Significantly better calibration than any other existing models

Model Results: Velocities



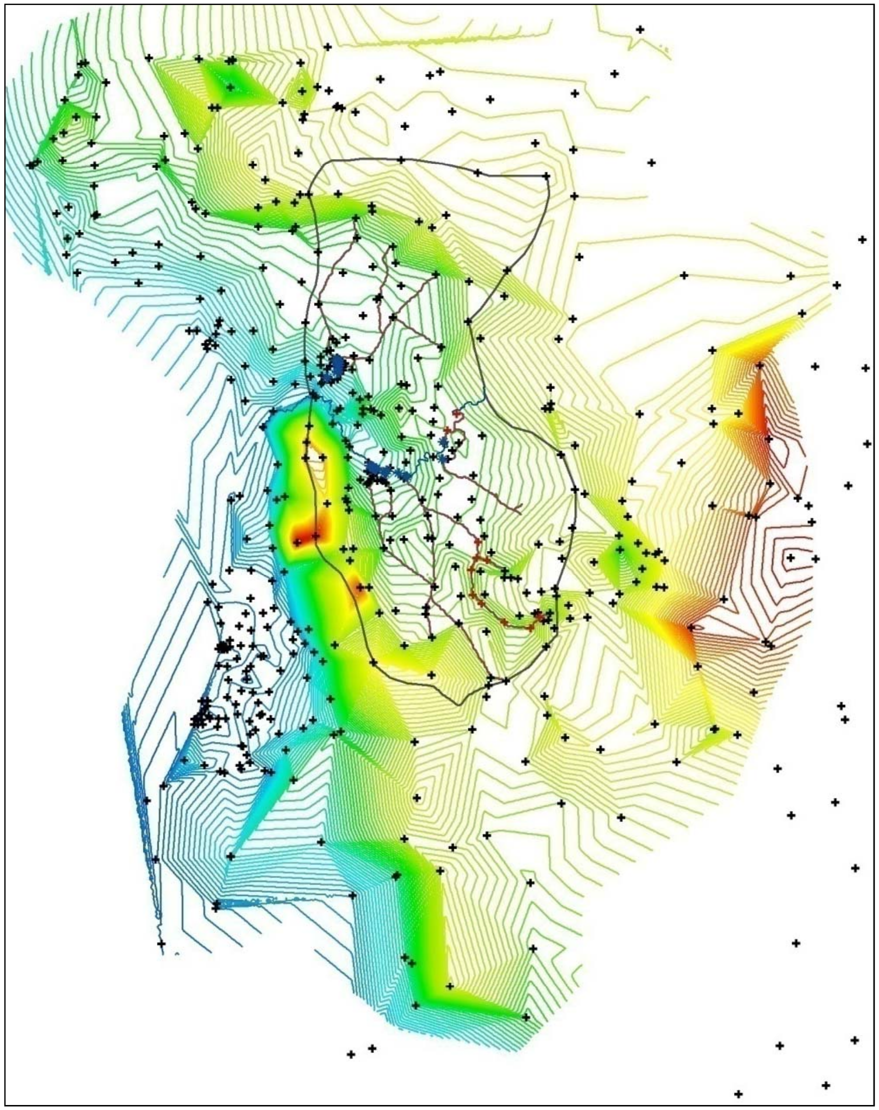
- Red, yellow and green areas have highest groundwater velocities.
- Velocity ranges
  - Conduits: <= 400 ft/day
  - Matrix: ~ $5X10^{-5}$ ft/day - $2.4X10^{-2}$ft/day
- Conduit velocities compare favorably to tracer test results.
- Flow in matrix is primarily toward closest conduits.
- Rapid flow through conduits to springs.
- Areas closer to conduits are of higher concern than areas more distant from conduits regardless of proximity to well or springs.

Springshed Delineations



- Springsheds based on both high and low water calibrations.
  - Good estimate of area contributing to springs under average conditions.
  - May vary under extreme high or low conditions
- Ginnie springshed primarily encompasses the southwest part of the model region.
- Blue, Poe, and Lilly springsheds primarily encompass the southeast side of region.
- Both primarily south of the Santa Fe River.
- Ginnie primarily drawing water from the Bell Ridge south to Waters Lake.
- No major swallets in Ginnie springshed.
- Blue, Poe, and Lilly drawing water from Kanapaha Prairie where Hogtown Creek disappears.

Model Development Needs



- No quantitative traces forced higher reliance on wells.
- Groundwater levels available for high & low periods.
  - High period: 1998 & 2005 wet periods
    - Inside model area
      - 11 wells from 1998
      - 154 wells from 2005
      - 9 spring stage elevations
      - 7 river and lake stage elevations
  - Low Period: 2002 & 2007 droughts
    - Inside model area
      - 92 wells from 2002
      - 109 wells from 2007
      - 7 spring stage elevations
      - 6 river and lake stage elevations
    - Outside model area
      - 254 wells from 2002
      - 117 wells from 2007
- Used for calibration & conduit assignment.

Blueprint for Springshed Characterization

- Identify target springsheds to characterize (major springs).
- Design and execute multi-tracer quantitative traces.
  - use insitu fluorometers to track tracer recovery
  - back up continuous data with laboratory analyzed samples
  - use multiple tracers to characterize flow path interactions
    - *uranine / phloxine*
    - *uranine / rhodamine*
- Develop groundwater tracing database
  - require permit for tracer injections
  - compile design and results data for database from permits
- Deploy and maintain continuous hydrologic meters during tracer tests.
  - spring flows
  - groundwater levels
  - temperature / conductivity
- Follow tracer tests with springshed groundwater modeling.
  - model conduit/matrix interactions
  - calibrate to head, discharge, velocities, hydraulics
  - Develop water budget and delineate vulnerability zones from groundwater model.
  - Use model to facilitate program objectives (TMDL, etc.)

Questions / Discussion