Florida Aquifer Vulnerability Assessment

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Technical Advisory Committee (TAC)

- DEP/Florida Geological Survey
- DEP/DWRM
- The Five Water Management Districts
- Department of Community Affairs
- US Geological Survey
- SDII Global Corporation, Hazlett-Kincaid, Inc.
• Orange County Comp. Policy Plan: “Primary protection zones…” based on WAVA
• DEP OIP – basis for Comp. Plan Amendment reviews
• DOH proposed rule language re: OWTS and protection zones
• Chapter 373.0395 F.S. “ground-water recharge areas”
• Chapter 163.3177(6)(c) F.S. “Comprehensive plans… high recharge areas…”
• Environmental resource permitting – “Sensitive Karst Areas (SKA)”
• Stormwater rule
• Source Water Assessment and Protection (SWAP) and Safe Water Drinking Act: “critical aquifer protection areas”
NORTHERN HIGHLANDS

75 TO 300' ABOVE SEA LEVEL (ASL)

UPLAND LAKE WITH WETLANDS

STEEPEHEAD RAVINE, SPRING & STREAM

GULF COASTAL LOWLANDS (0 TO 75' ASL)

KARST PLAIN

SCARP

ANCIENT SAND DUNE

MODERN SAND DUNE

BARRIER ISLANDS

TIDAL MARESHES

ESTUARY

REPRESENTATIVE PLANTS

1. Pines
2. Hardwoods: oak, maple, hickory, magnolia
3. Palms
4. Scrub Oak
5. Saw Palmetto
6. Cypress
7. Grasses: wetlands, marshes and dunes

ASL - ABOVE SEA LEVEL
Florida Aquifer Vulnerability Assessment (FAVA):

**Purpose:** To predict the intrinsic relative vulnerability of Florida’s aquifer systems (FAS, SAS & IAS) to contamination from land surface

**Objective:** To provide a scientifically defensible water-resource management and protection tool that will facilitate planning of human activities and help minimize potential adverse impacts on ground-water quality
DRASTIC Origins…
USEPA and National Water Well Association

- Designed to allow for the relative characterization of aquifer vulnerability
- Output is called the DRASTIC Index, which is made up of 7 layers that have weighted scores
  - D = Depth to water
  - R = net Recharge
  - A = Aquifer media
  - S = Soil media
  - T = Topography
  - I = Impact of vadose zone
  - C = hydraulic Conductivity of aquifer being mapped

Mid-1990s - DEP Aquifer
Vulnerability subcommittee of the Recharge Protection Committee
Beyond DRASTIC

The DRASTIC mapping methodology did not adequately take into account some of the unique factors influencing aquifer vulnerability in Florida:

- Does not account for karst features
- DRASTIC over-emphasizes slope
- Maps are difficult to update
- DRASTIC index score intervals do not readily allow for continuous data
Selecting a model

Statistical, empirical, simulation, index, hybrid???

Travel Time = \((T_s/K_s + T_{eg}/K_{eg} + T_{cu}/K_{cu}) \times K_f\)

where:
- \(T_s\) is soil thickness
- \(T_{eg}\) is environmental geology thickness
- \(T_{cu}\) is conf. unit thickness
- \(K_s\) is soil hydraulic conductivity
- \(K_{eg}\) is est. vadose hydraulic conductivity
- \(K_{cu}\) is conf. unit hydraulic conductivity
- \(K_f\) is the karst factor

- Travel time
- Fuzzy Logic
- Weights of Evidence (WofE)

Pilot studies TAC review
WofE: Bayesian probabilistic, data-driven model; ArcSDM

- Components:
  - Evidential Theme (data layer)
    - “Confinement” thickness
    - Soil permeability
  - Training points (known occurrence)
    - Wells with WQ data indicative of vulnerability
  - Response Theme (output map)
    - Model output of relative vulnerability
Evidential themes considered

- Karst
- Depth to water table
- Soil properties
- Confinement thickness
- Head difference
- Other hydrogeology coverages
Proximity to Karst Features

- Closed hachured contour lines (CTDs) from USGS 1:24,000 quadrangles were attributed as depressions and extracted
- Hachured features were buffered, 6 intervals each, 400 m wide to allow model to address proximity
- Data filtered to remove anthropogenic features, dunes, etc.
Training Points as Predictors

- Point coverage (locations) where a “known” occurrence is present. Example: gold mines
- Occurrences (as in FAVA) are recharge indicators such as high DO, total N, etc.
- The set of point locations is used to calculate the weights for each data layer, one weight per class, using overlap relationships between points and the various classes
Training Points

- Training set (point theme) consists of wells within the FDEP background water quality network (n>2,600)

- Water quality data is used to define the training set and obtained from the FDEP/GWIS database
Response Theme

- An output map that displays the probability that a unit area contains a point
- Calculated by estimating the combined weights of the data layers
- Output theme is displayed in classes of relative vulnerability (one area is more vulnerable than another) or favorability
  - In the following example total dissolved N was used as the training point theme; concentration per aquifer at 75th percentile; upper fence to remove anomalies. Model output is a total dissolved N vulnerability map.
FAVA Conceptual Model with Training Points
Validation and sensitivity

- PrP = 0.0013
- Max PsP = 0.00371
- 2.85X or 185%
- “Less vulnerable”
- “Vulnerable”
- “More vulnerable”

Confinement thickness

Soil Permeability

CTD’s

Head Difference
Intrinsic vulnerability "overlays"

- Drainage wells
- Mining
- Drawdown
- Recent sinkhole activity
- Swallets; stream to sink
- Catchment basins
- Conduit maps
Application

• FAVA is a statewide snapshot based on best available data at the time of generation
• It’s a tool in the toolbox
• Use as guide for additional local study; for example, in predicted highly vulnerable areas, require greater amount of local geologic and geotechnical study prior to implementation of certain land-uses
  – Not intended to replace site-specific data
  – Not appropriate to assess contamination of surface waters or ground-water discharge areas, such as seeps or springs.
Vulnerability assessment applications

- GW Protection, inc. wellhead and source-water
- Springs or springshed protection zones
- Land conservation programs (recharge ranking)
- Land-use planning/growth management
  - Restrictions
  - Additional geologic data requirements
  - Risk management
  - Stormwater pond design
  - Best Management Practice (BMP) implementation
  - Degree of required sewage treatment (i.e., basic septic, performance-based septic, on-site treatment and disposal)
  - Percent impervious surfaces
  - Intensity/density of residential development
- Environmental risk assessments
- Animal carcass disposal (“foot and mouth,” avian flu)
Vulnerability versus protection zones

- Proximity to a spring, and natural and manmade interconnected surface and subsurface features
- Groundwater flow gradient
- Facility discharge volume
- Dilution/dispersion
- Groundwater quality data demonstrating denitrification
- Site-specific geological conditions
- New research/studies including dye tracing tests
- Groundwater flow modeling
Current activities

- **Evidential theme refinement**
  - Soils, CTDs, Confinement thickness
- **County specific models:**
  - Citrus, Levy and Wakulla
- **Subdivide the SAS:**
  - Biscayne, Sand and Gravel, other
- **Outreach**
Outreach

- Florida Local Environmental Resource Agencies, July 2007
- American Institute of Professional Geologists - Florida Section, July 2007, Pensacola, Florida
- Florida Association of Professional Geologists, August 2005, Tallahassee, Florida
- University of Florida, Department of Geology Seminar, November 2005, Gainesville, Florida
- Florida Environmental Health Association Annual Meeting, August 2005, Jacksonville Beach, Florida
- American Water Works Association, January 2005, Palm Beach Gardens, Florida
- Florida Department of Environmental Protection, October 2004, Daytona Beach, Florida
- Florida Springs Task Force, January 2003, Ocala, Florida
- National Cave and Karst Management Symposium, November 2003, Gainesville, Florida
- Wekiva River Basin Workgroup, September 2003, Orlando, Florida
- Florida Department of Environmental Protection, May 2003, Tallahassee, Florida
County or Springshed Vulnerability Maps

Important data at the local level:

• Types of sinkholes
  - water-filled?
  - penetrate confinement?
  - connected to cave system?

• Cave/conduit maps

• Detailed potentiometric surface maps

• Lineaments – linear surface features (i.e., stream segments, alignment of sinkholes)

• More detailed confinement layer map

• Land use (?)
Conceptual Model

Calculated using linear regression equation utilizing minimum and measured water table values and land surface elevation.

Source: USGS
Relative evidence contributions and training data

- **FAS contrast**
  - ICU Thickness = 3.1
  - Karst = 1.6
  - Head Diff. = 1.8
  - Soil Perm. = 0.79

- **IAS contrast**
  - Karst/OVB = 2.8
  - Soil Perm. = 1.2

- **SAS contrast**
  - Soil Perm. = 1.3
  - Karst = 0.70
  - Depth to WT = 0.77

- **FAS**
  - 148 of 629 Training Pts
  - TD Nitrogen = 0.04 mg/L

- **IAS**
  - 98 of 130 Training Pts
  - TD Nitrogen* = 0.46 mg/L

- **SAS**
  - 92 of 390 Training Pts
  - TD Nitrogen* = 0.62 mg/L