Priority Focus Area for Madison Blue Spring

Division of Environmental Assessment and Restoration

Florida Department of Environmental Protection

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More Information

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Introduction

Under the Florida Springs and Aquifer Protection Act, the Florida Department of Environmental Protection (DEP) is required to delineate priority focus areas (PFAs) for all Outstanding Florida Springs identified as impaired. According to the Florida Springs and Aquifer Protection Act, adopted by the Florida Legislature in 2016 (Chapter 373, Part VIII, Florida Statutes [F.S.]):

> " 'Priority focus area' means the area or areas of a basin where the Floridan Aquifer is generally most vulnerable to pollutant inputs where there is a known connectivity between groundwater pathways and an Outstanding Florida Spring, as determined by the department [DEP] in consultation with the appropriate water management districts, and delineated in a basin management action plan. Using the best data available from water management districts and other credible sources, the department, in coordination with the water management districts, shall delineate priority focus areas for each Outstanding Florida Spring or group of springs that contains one or more Outstanding Florida Springs and is identified as impaired in accordance with s. 373.807. In delineating priority focus areas, the department shall consider groundwater travel time to the spring, hydrogeology, nutrient load, and any other factors that may lead to degradation of an Outstanding Florida Spring. The delineation of priority focus areas must be completed by July 1, 2018, shall use understood and identifiable boundaries such as roads or political jurisdictions for ease of implementation, and is effective upon incorporation in a basin management action plan."

Factors to consider in establishing these geographically bounded areas include the following:

- Groundwater travel time to the spring, which could be based on empirical data from tracer studies and/or predicted travel time from modeling, if such data or studies are available.

- Hydrogeology, which includes the spring's groundwater contributing area (or springshed), the amount of confining material protecting the Floridan aquifer, the aquifer recharge characteristics, the capacity for the aquifer to transmit water, and other characteristics that help determine the aquifer vulnerability and the likelihood of adverse water quality impacts to springs.

- Nutrient load to the spring, which includes the actual measured load in the water discharging from the spring as well as the potential nutrient load based on land uses in specific regions that would most probably influence water quality in the spring.

- Other factors, including soil characteristics that are favorable for pollutant leaching to the aquifer in the springshed and the presence or absence of pollutant sources in the area.

- Identifiable boundaries, including roads, natural boundaries, and political jurisdictions.

Steps in Delineating the PFA for Madison Blue Spring and Related Springs

The PFA delineated for Madison Blue Spring also includes related springs downstream along the Withlacoochee River. It was developed using geographic information system (GIS) tools, spring-specific data, and published information to help identify the portion of the springs' contributing area that is most important from both water quality restoration and protection perspectives. The steps listed below were taken to develop a draft PFA for review and input by stakeholders. The consideration of mapped characteristics that express high vulnerability, a high potential for pollutant mobility, and likely pollutant sources provides the best assurance that the PFA includes the areas of greatest concern for water quality restoration and protection.

Step 1. Establish the springshed for the priority spring(s). SDII Global Corporation created a springshed boundary for Madison Blue Spring for the Suwannee River Water Management District (SRWMD) in 2004.[1] In 2016 DEP and the SRWMD expanded the springshed boundary to include the contributing area for spring vents downriver that were confirmed by cave exploration and dye trace work to share a common conduit system with Madison Blue Spring. **Figure 1** shows the Madison Blue Springshed, the Madison Blue/Pott/Tanner combined springshed, and the PFA boundary. The map also shows the groundwater elevation contour map for the Floridan aquifer for May 2010. Groundwater flow gradients were part of the basis for the springshed delineation.

Step 2. Identify regions in the contributing area where the greatest recharge occurs. Several GIS coverages developed by the U.S. Geological Survey (USGS), the water management districts (WMDs), and others delineate areas of high, medium, and low recharge to the Floridan aquifer system as well as areas of aquifer discharge. The PFA delineation considers areas with the highest recharge to the aquifer, which could occur as diffuse infiltration through permeable geological material as well as focused recharge to sinkholes that breach confining layers. Pollutant sources in high-recharge areas have the greatest potential to cause adverse impacts to groundwater and springs because water is impeded the least as it infiltrates to the aquifer from the surface. In high-recharge areas, recharge is 10 inches per year (in/yr) or greater.

1 SDII Global Corporation. September 13, 2014. *Delineation of spring protection areas at five, first-magnitude springs in north-central Florida.* Prepared for the SRWMD under Project No. 3008033.

Unfortunately, available WMD or USGS recharge coverages do not include most of the Madison Blue Springs area. However, another GIS coverage, developed by the Florida Natural Areas Inventory (FNAI) for state land acquisition priority ranking, identifies areas of potential recharge important for natural systems and human use, based on features that contribute to aquifer vulnerability and springshed protection zones near public water supply wells.2 In this coverage, higher priority areas are those with the greatest recharge to the Floridan aquifer. **Figure 2** shows the FNAI recharge coverage.

[2] FNAI. December 2000. *Florida Forever conservation needs assessment summary report to the Florida Forever Advisory Council.*

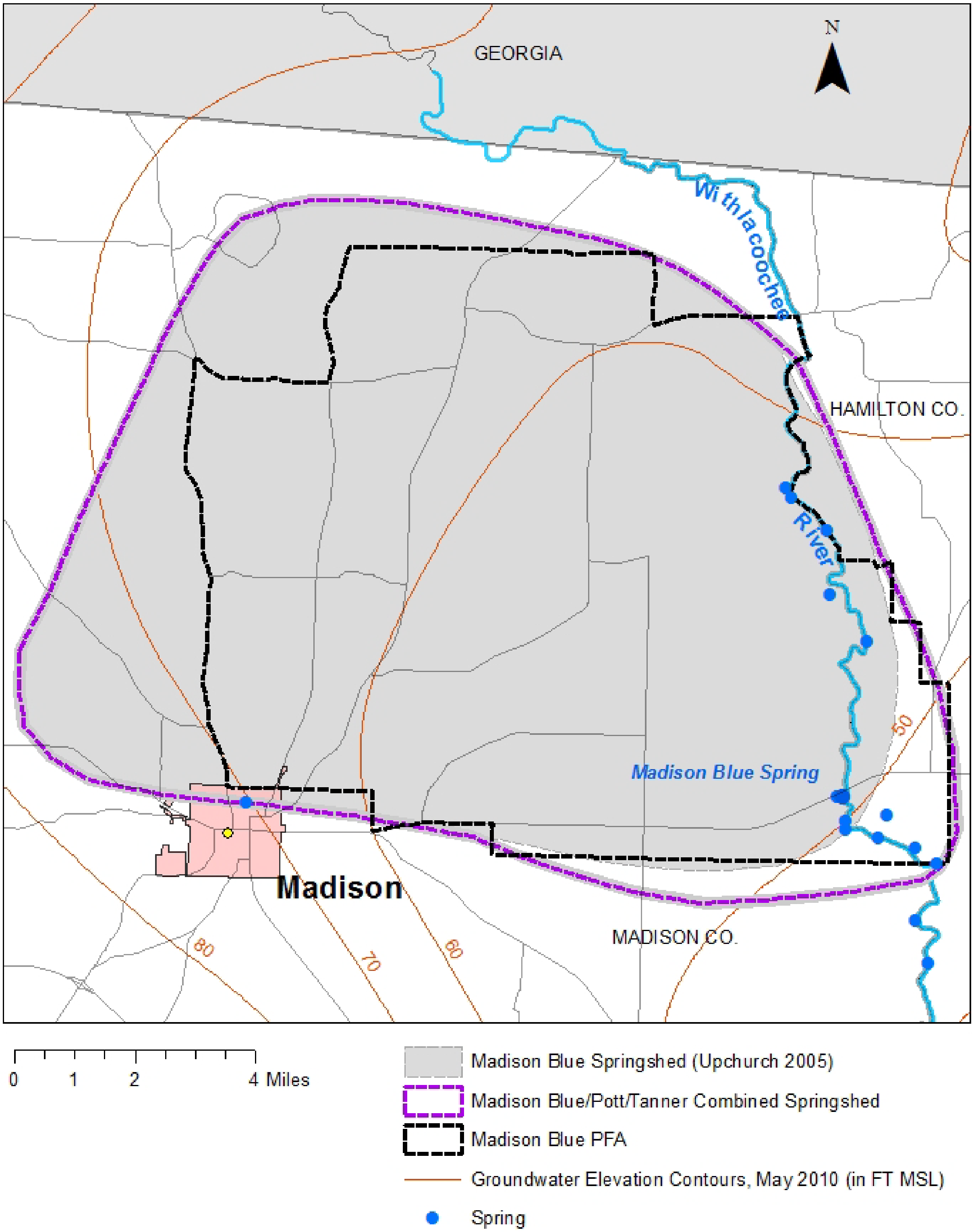

Figure 1. Madison Blue Springshed, Madison Blue/Pott/Tanner combined springshed, and PFA boundary

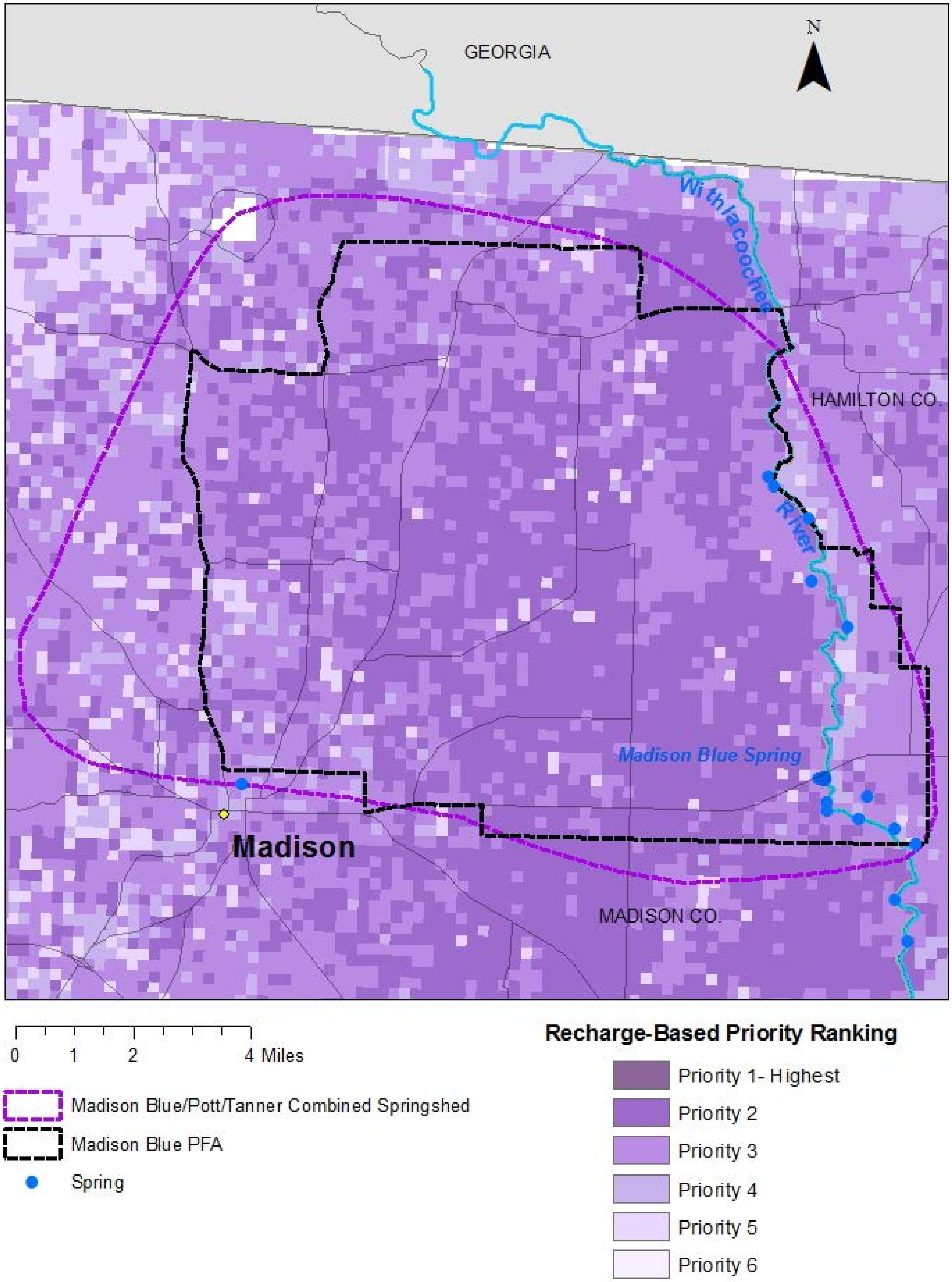

Figure 2. Florida state lands recharge-based prioritization coverage and PFA boundary

Step 3. Identify regions in the springshed where the Floridan aquifer is most vulnerable. The Florida Geological Survey (FGS) developed the Florida Aquifer Vulnerability Assessment (FAVA) model to provide spatial coverage of aquifer vulnerability ranges across an area of interest.[3] According to the statewide FAVA model for the Floridan aquifer system, the entire springshed is in the "more vulnerable" category (**Figure 3**).

As a further refinement, the vulnerability of the aquifer to local points of recharge through sinkholes and linear karst features was evaluated by using the statewide Digital Elevation Model (DEM), which is based on the light imaging, detection, and ranging (LIDAR) remote sensing method. In this area, most closed topographic depressions form as solution or collapse sinkholes, and water flowing into these features can more rapidly reach the aquifer and erode and enlarge conduits in the limestone, and can be expressed in linear arrays across the landscape. Dry or intermittent stream traces, shown in the coverage, can have associated subterranean conduit networks. Some sink features, called "swallets," provide a direct conduit for surface water discharge into the aquifer. Swallets are sinkholes that capture stream flow. In 2007, the FGS completed a project to map all known swallets in the state and produced a GIS layer that includes their locations. **Figure 4** shows the DEM map (2009) with outlines of closed depressions and swallets in the Madison Blue Spring region.

Step 4. Consider nitrogen load. Nitrate-nitrogen is the major nutrient of concern in Florida's spring systems because of its extensive use and presence on the land surface, its mobility, and its availability for uptake by aquatic flora when it is discharged from springs. Excess concentrations of nitrate-nitrogen in the spring water have contributed to biological impairment in Madison Blue Spring. Groundwater from the Floridan aquifer system comprises the source of flow from the spring. This groundwater comes mainly from local precipitation that recharges the aquifer in the springshed area. The nitrate originates from atmospheric deposition and anthropogenic sources in the springshed. A recent nitrate concentration of 1.39 milligrams per liter (mg/L) was measured on January 17, 2017, by a nitrate sensor installed at the USGS real-time monitoring station at Madison Blue Spring.[4] This concentration is almost 4 times higher than Florida's numeric nitrate criterion for spring vents (0.35 mg/L).

The nitrogen load from the spring vent depends on concentration and flow. Using the January 1, 2017, mean flow value of 85 cubic feet per second measured at the USGS station and the nitrate concentration on the same date, the nitrogen load from the Madison Blue Spring vent was 636 pounds per day. Using this daily calculation, 0.23 million pounds of nitrogen (as nitrate) would discharge per year.

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[3] Arthur, J.D., H.A.R. Wood, A.E. Baker, J.R. Cichon, and G.L. Raines. 2007. Development and implementation of a Bayesian-based aquifer vulnerability assessment in Florida. *Natural Resources Research* 16(2): 93–107. For additional information, see the DEP FAVA website.

[4] SRWMD Water Data Portal.

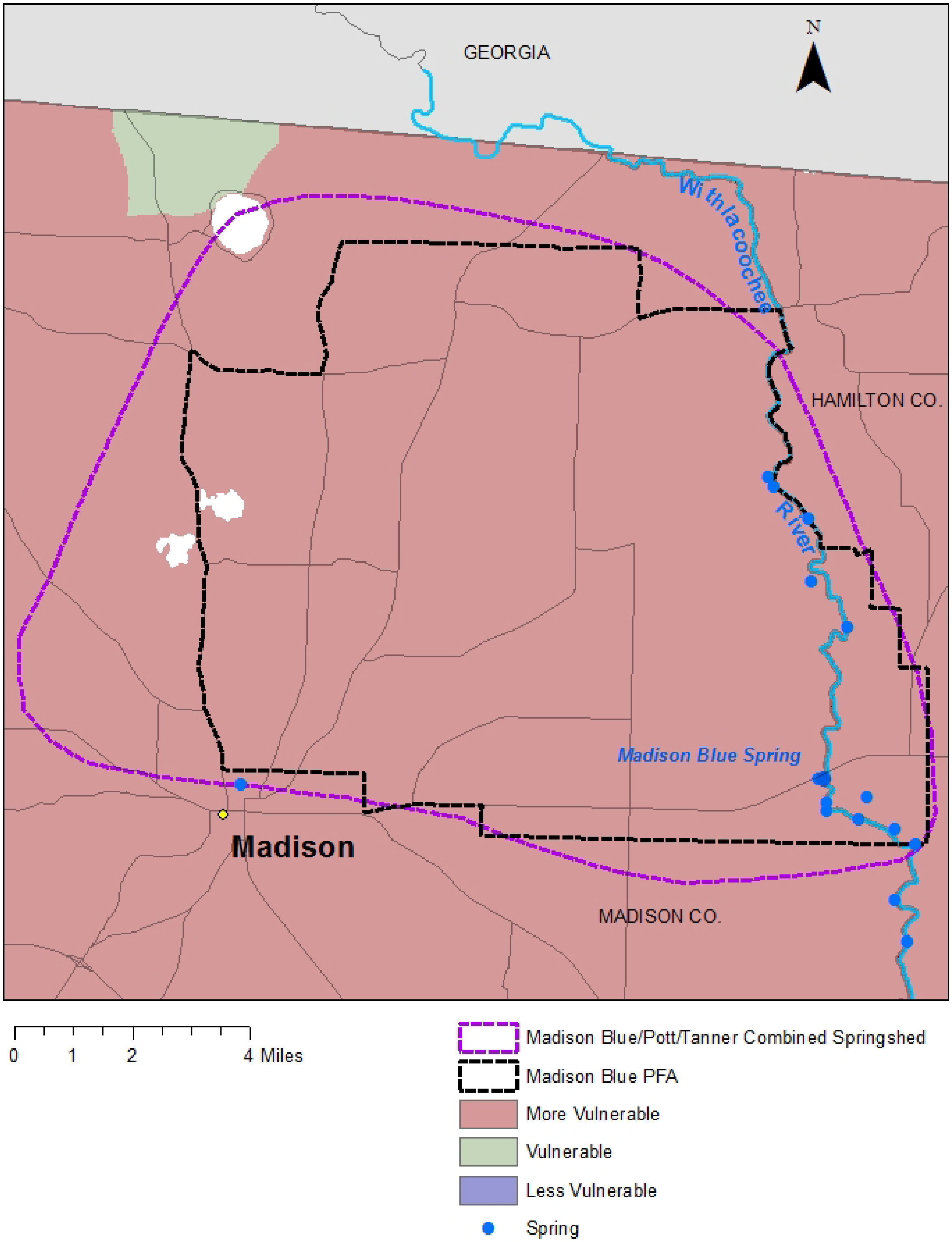

Figure 3. Floridan aquifer vulnerability based on the statewide FAVA model

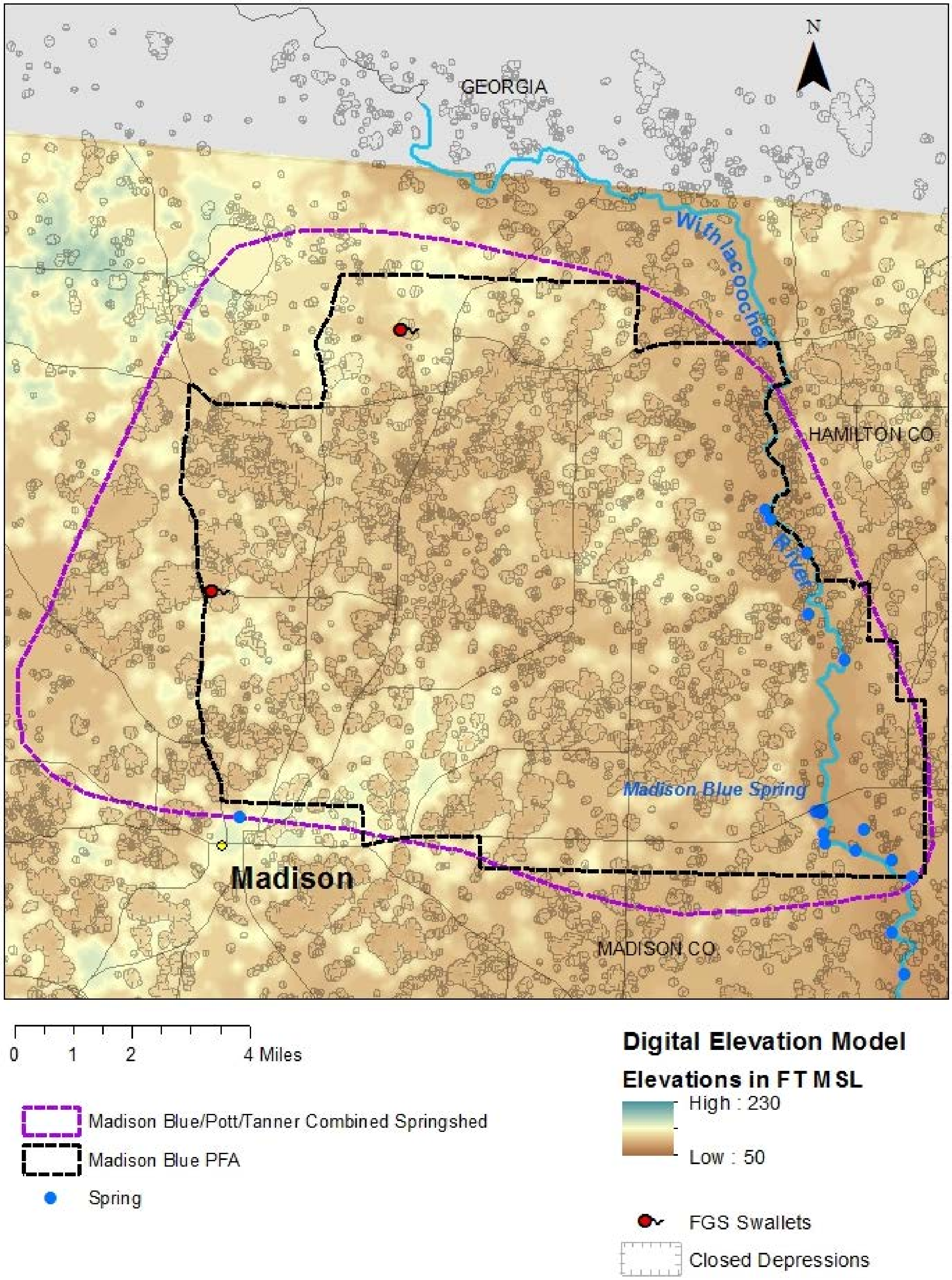

Figure 4. DEM projection with closed depressions and swallets in the combined springshed

DEP is developing a nitrogen source inventory for the contributing area of Madison Blue and related springs to serve as a tool for developing remediation strategies and projects for reducing nitrogen loads to the springs. Typical sources of nitrogen in spring contributing areas include inorganic fertilizer; livestock waste; onsite treatment and disposal systems (OSTDS), or septic systems; treated domestic wastewater; and atmospheric deposition. According to the draft inventory, the main source of nitrogen loading to groundwater in the Madison Blue Springshed is agricultural fertilizer.

Step 5. Consider groundwater travel time in creating PFA boundaries. To the extent possible, PFAs should include parts of contributing areas that have demonstrated or anticipated short travel times to the springs. Springs occur in areas of karst terrain where surface and subsurface erosion of the limestone can result in the development of complex networks of solution channels and conduits in the aquifer material. In these areas, groundwater can move rapidly from points where water enters the aquifer to the spring vents. One study documented the transport of dye from an injection point just downstream from the Madison Blue Spring vent to Pot Spring, located along the Withlacoochee River 0.8 miles to the southeast, within 24 hours. The tracer reached Tanner Spring farther downstream (2 miles to the southeast) in less than 96 hours.[5]

The Madison Blue Spring/Pott/Tanner combined springshed includes areas of dynamic flow potential where infiltrating water has caused the dissolution and creation of sinkholes, pipes, and conduits in the limestone matrix and areas where the limestone may be semi-confined by layers of lower permeability material that inhibit the erosion of the limestone by percolating water. Where karst features are less prevalent, groundwater movement occurs in intergranular pore spaces in the limestone and is slower. However, in areas where conduit development has been extensive, the rate of groundwater movement can be very rapid.

Considering that the development of karst solution features is common throughout much of the springshed, it is safe to assume that groundwater transport to the springs is very rapid from many points in the springshed and that recharge areas are shared. The development of these features is prevalent along the Withlacoochee River and may be more extensive in areas of locally greater recharge.

Step 6. Identify regions in the contributing area where soil conditions are most favorable for nitrogen to leach from surface sources. Nitrogen has been identified as the target nutrient for spring restoration. Research has shown that nitrogen removal in the soil zone through denitrification and its tendency to leach are related to soil drainage class.[6] Denitrification is

[5] SDII Global Corporation. March 30, 2005. *Ground water chemistry and origin of water discharging from Manatee and Fanning Spring, Troy Spring, Madison Blue Spring.* Prepared for the SRWMD.

[6] Otis, R.J. 2007. *Estimates of nitrogen loadings to groundwater from onsite wastewater treatment systems in the Wekiva Study Area, Task 2 report, Wekiva Onsite Nitrogen Contribution Study.* Prepared by Otis Environmental Consultants for the Florida Department of Health (FDOH).

lowest and nitrogen leaching is highest in areas with soils that are excessively drained, somewhat excessively drained, or well drained. Leaching may occur in areas with moderately well-drained soils and nitrogen leaching is least likely to occur in areas where soils are poorly drained, somewhat poorly drained, or very poorly drained because of the greater potential for denitrification where drainage is poor. The portions of the contributing area where soil conditions are more favorable for nitrogen leaching can be mapped using the U.S. Department of Agriculture Natural Resources Conservation Service Soil Survey Geographic (SSURGO) Database for Florida.[7] These excessively to well-drained soils tend to occur in areas where aquifer recharge is highest and vulnerability is greatest.

Figure 5 shows the area where soil conditions are most favorable for nitrogen leaching. This includes soils in the excessively drained, somewhat excessively drained, and well-drained SSURGO drainage classes. The figure also shows areas of moderately well-drained soils where nitrogen leaching could be significant. The mapped areas of higher soil drainage are often the same as the areas of higher groundwater recharge shown in **Figure 2**.

Step 7. Identify regions in the contributing area to exclude or include based on land use and the potential for pollutant sources to occur. Conservation lands, wetlands, and undeveloped open land protected from development may be excluded from the PFA if there is no expectation that they would include pollutant sources affecting springs in the foreseeable future and they are under protection. The conservation lands in the Madison Blue/Pott/Tanner Springshed include part of the Withlacoochee State Forest, located along the Withlacoochee River corridor. Portions of this forest in the Madison Blue Springshed are included in the PFA as a protection measure. The PFA boundary also includes Madison Blue Spring State Park, which contains the Madison Blue Spring vent. **Figure 6** shows the location of conservation lands from the FNAI Conservation Lands (Managed Areas) GIS layer.

The springshed includes a large aggregate area in agricultural land uses (31 % of the springshed area) and scattered areas of urban land use north of the City of Madison (7 % of the springshed). The PFA delineation includes areas with significant potential for nitrogen leaching to groundwater based on the nitrogen sources found there. Agricultural lands can include fertilizer use and livestock that may contribute significant nitrogen inputs. Urban lands can include areas with higher densities of OSTDS, domestic wastewater application sites, and areas of urban fertilizer use, all of which can be sources of nitrogen to the aquifer and springs. **Figure 7** shows the locations of mapped agricultural and urban lands (based on the 2013–14 SRWMD land use–land cover GIS coverage).

Hofstra, N. and A.F. Bouwman. 2005. Denitrification in agricultural soils: Summarizing published data and estimating global annual rates. *Nutrient Cycling in Agroecosystems* 72: 267–278.

[7] The SSURGO Database is a digital soil survey developed by the National Cooperative Soil Survey. The dataset includes georeferenced digital map data and computerized attribute data. Metadata can be found online.

OSTDS are potentially significant sources of nutrients to be considered when delineating the PFA. **Figure 8** shows the locations of OSTDS in the area. Their locations are based on GIS coverage developed as part of the FDOH Florida Water Management Inventory Project.

DEP-regulated wastewater facilities can also be significant nutrient sources. **Figure 8** shows the locations of existing domestic facilities with design flows greater than or equal to 0.1 million gallons per day (mgd) because they also have the potential to contribute nitrogen to groundwater. There are currently no DEP-permitted wastewater facilities in the Madison Blue Springshed, based on information obtained from the DEP Wastewater Facility Regulation (WAFR) Database.

Step 8. Create PFA boundaries that correspond with understood and identifiable boundaries. For stakeholders to implement restoration and protection actions in a PFA, the boundaries must be clearly defined and associated with features easily recognizable on a map. For that reason, the PFA boundary conforms to easily recognizable natural features, roads, political boundaries, and major survey boundaries.

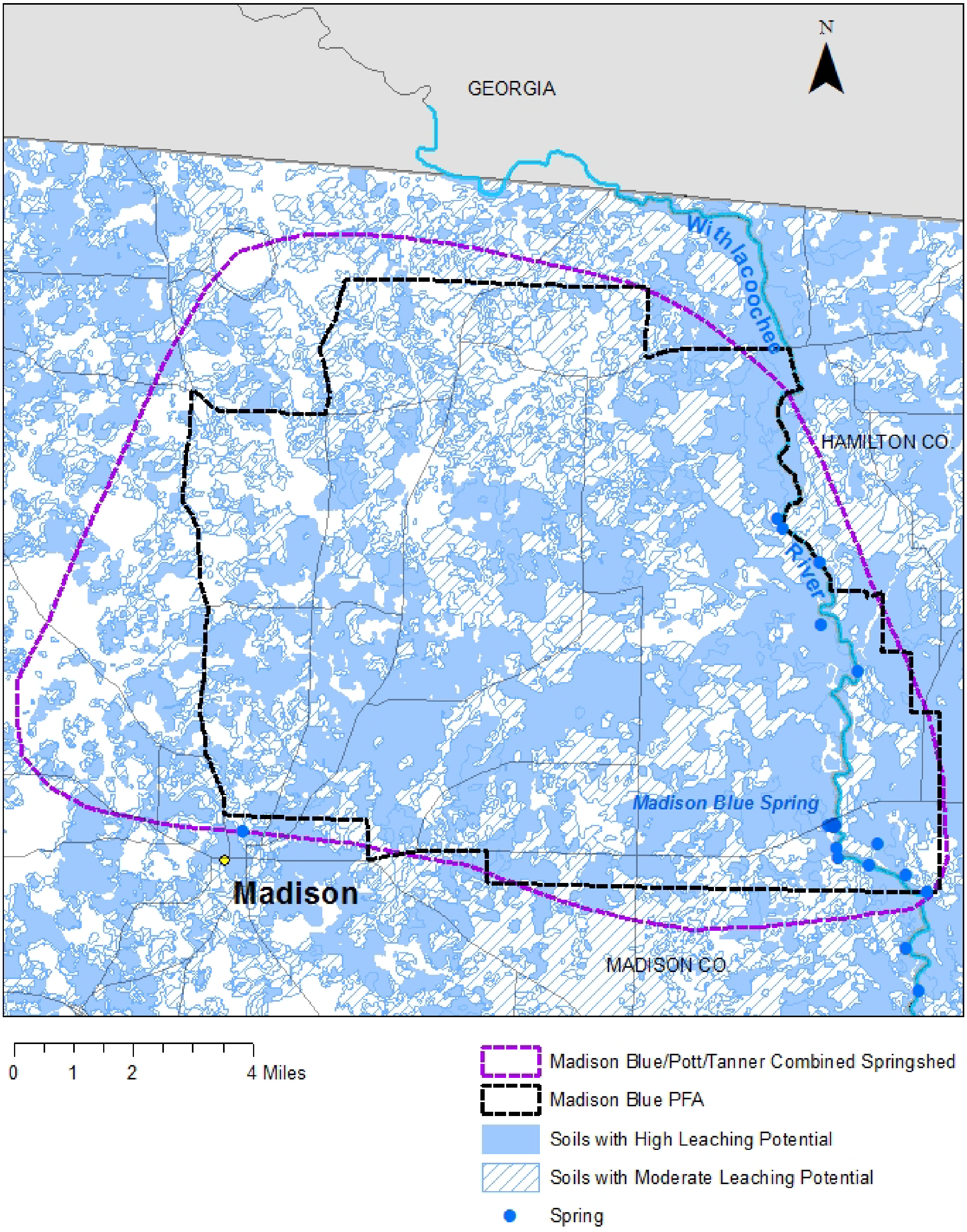

Figure 5. Areas of soils with high nitrogen leaching potential and PFA boundary

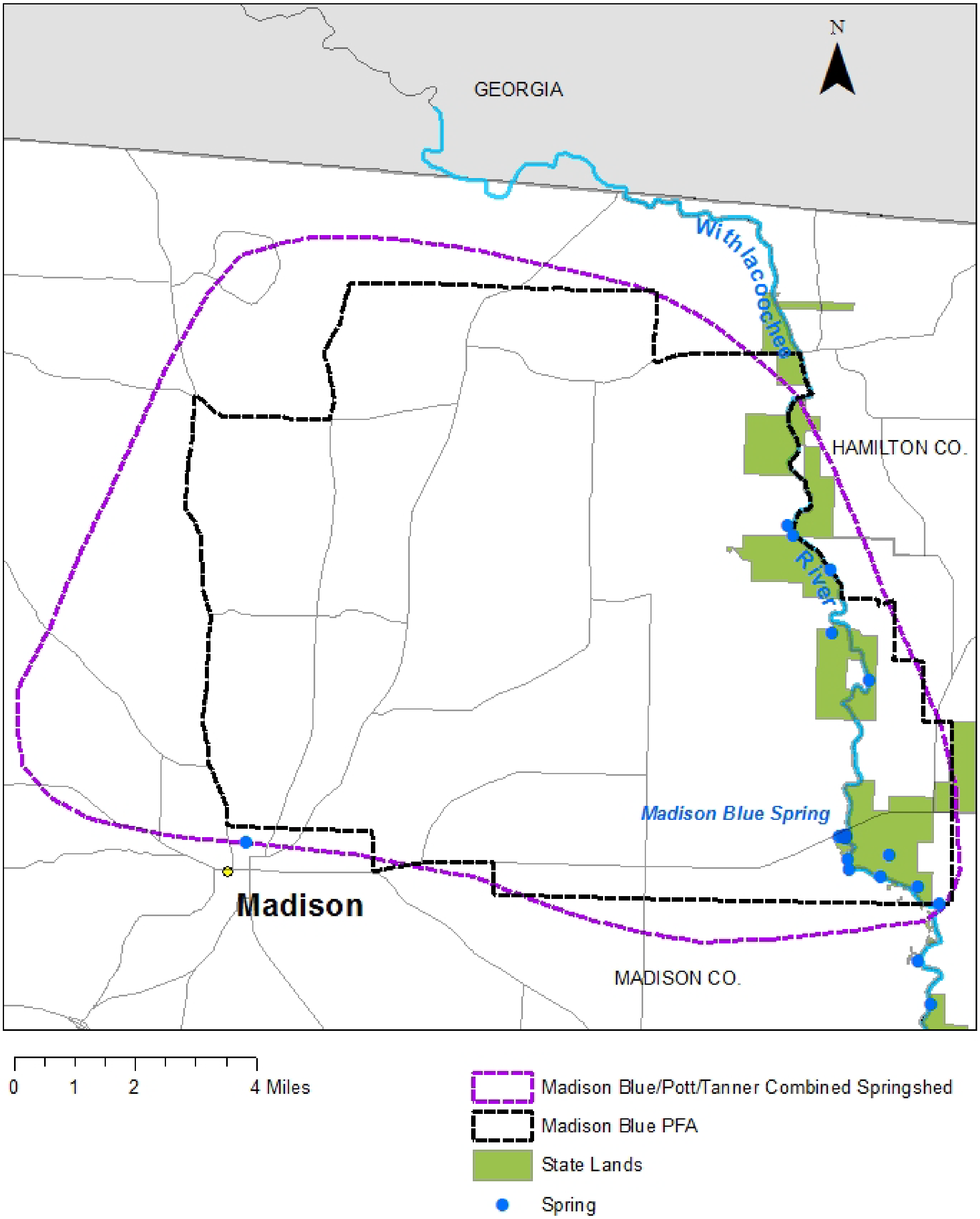

Figure 6. Conservation lands and PFA boundary

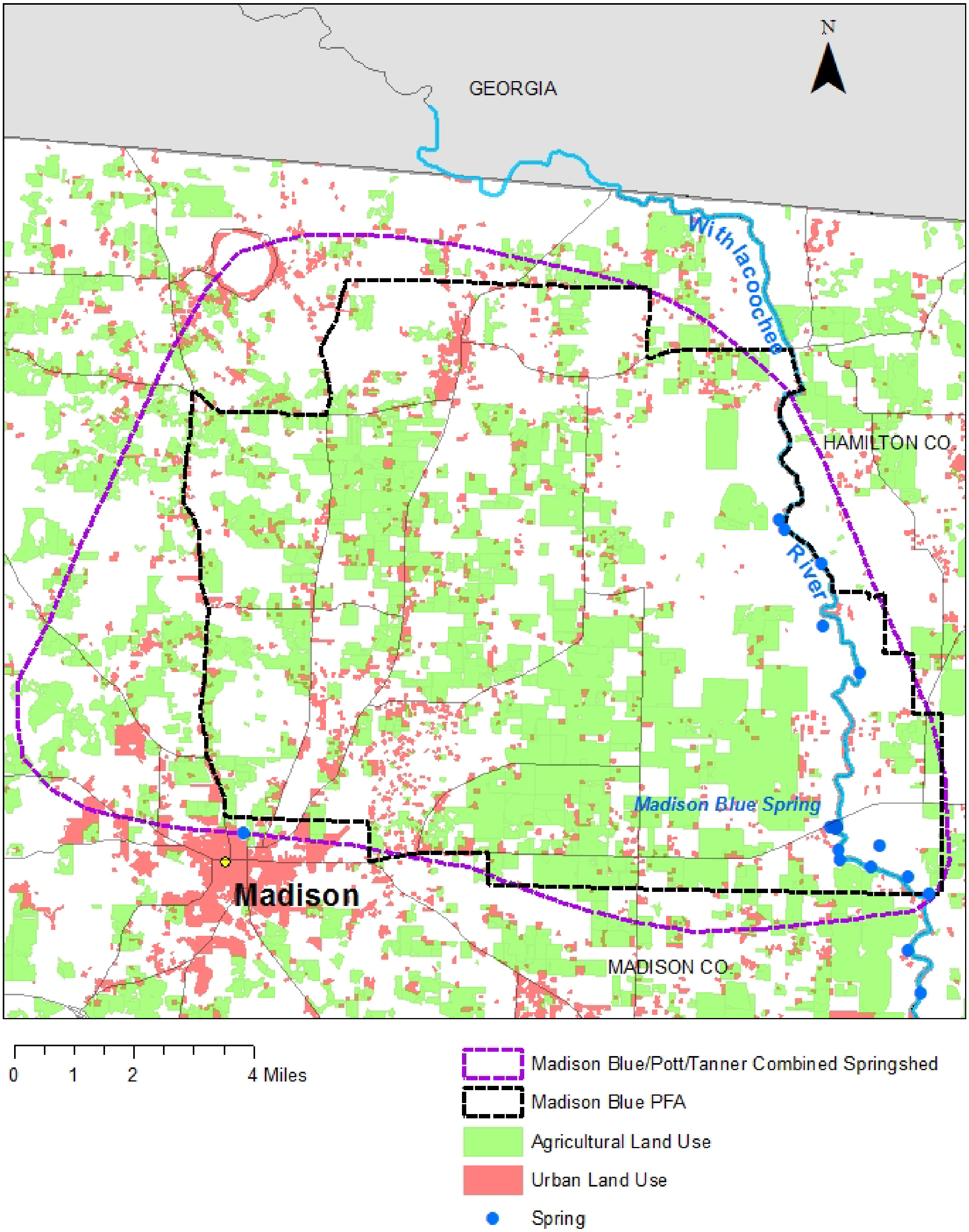

Figure 7. Agricultural and urban land use areas and PFA boundary

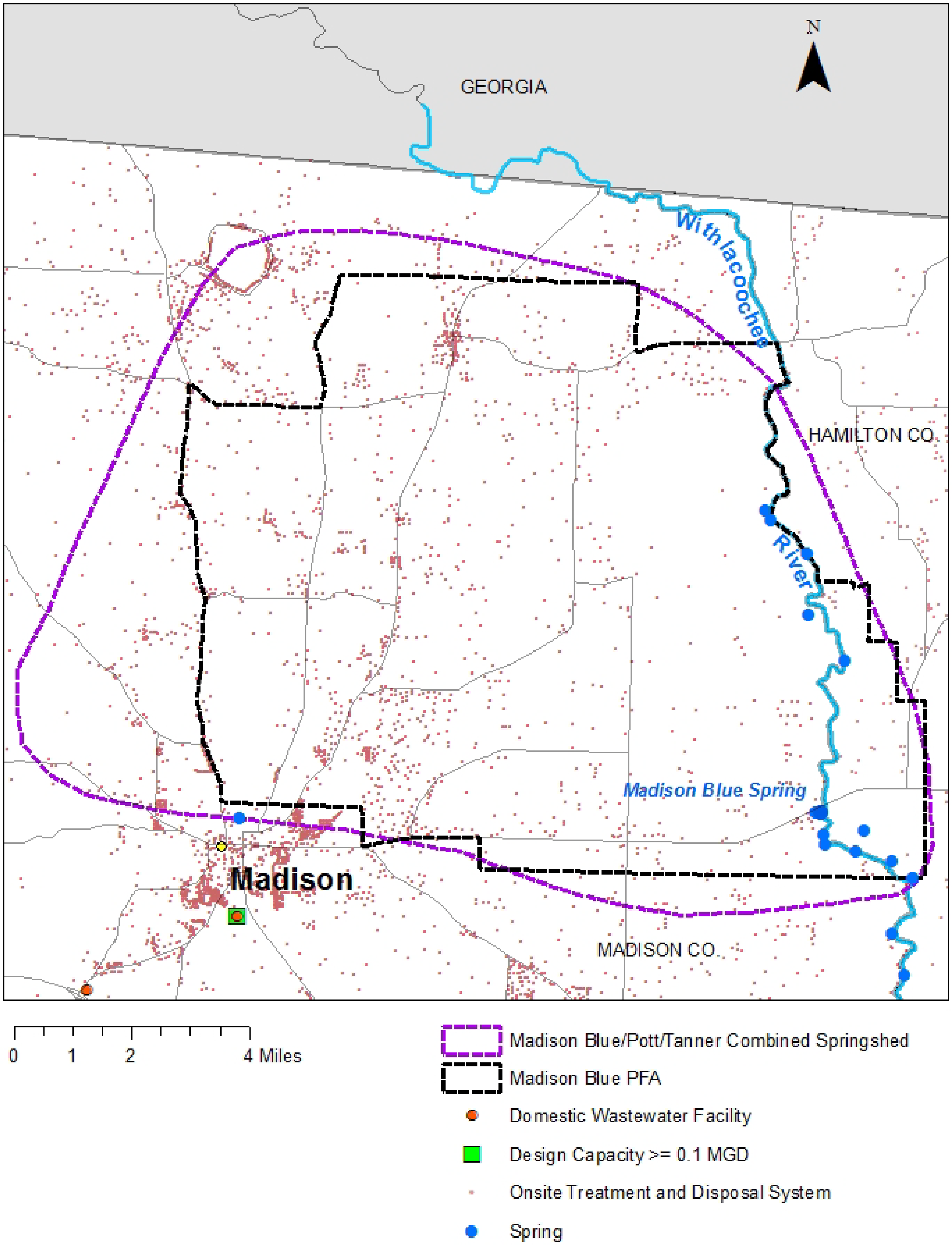

Figure 8. OSTDS, domestic WWTFs, and PFA boundary

PFA Boundary for Madison Blue Spring

The PFA boundary shown in **Figure 9** was developed by considering GIS coverages of recharge, vulnerability, soils, conservation lands, and potential contaminant nitrogen source information. The PFA includes several important springs along the Withlacoochee River (such as Madison Blue, Rossiter, Pot, Tanner, and several other named springs) that contribute flow to the system and share the same springshed. This area includes high groundwater recharge/vulnerability conditions and soils that tend to leach nitrogen. It also includes potential areas of higher nitrogen loading from agriculture and urban land uses, as well as an area where groundwater travel to the springs could occur rapidly. In addition, the PFA includes areas of agricultural land use and urban development, where there is the potential for significant nitrogen contributions to the aquifer and springs.

The PFA is mainly located in Madison County, with a smaller portion along the Withlacoochee River in Hamilton County. It includes Madison Blue Spring State Park and a part of the Withlacoochee State Forest that forms a corridor along the Withlacoochee River. Conservation land boundaries, natural features, political boundaries, roads, and major survey boundaries in the area were used in the development of a readily identifiable boundary.

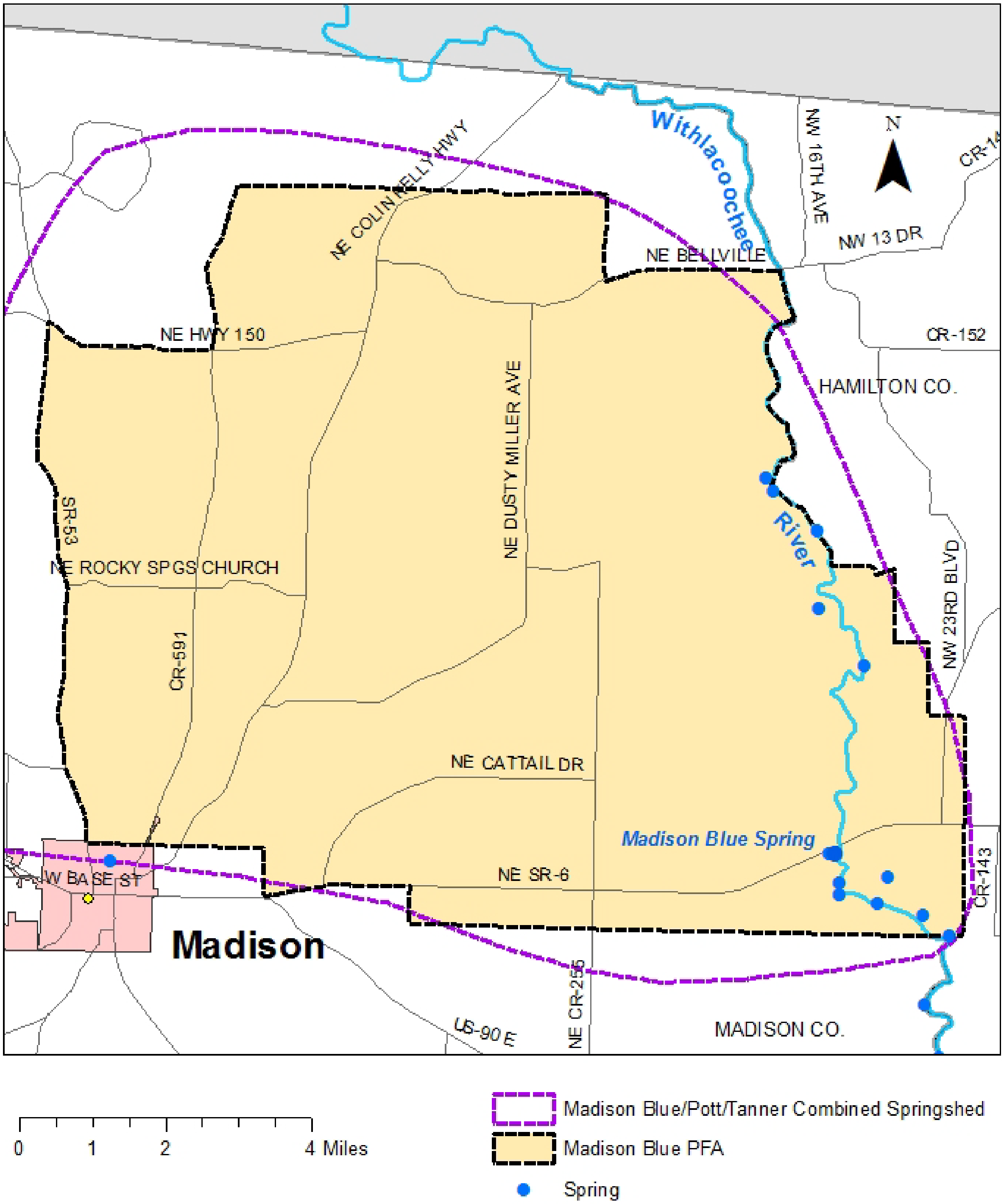

Figure 9. PFA boundary for Madison Blue Spring that also protects related downstream springs

Appendix A: Important Links

Cover Page:
DEP website – www.dep.state.fl.us

More Information:
Email address for Terry Hansen – terry.hansen@dep.state.fl.us
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Step 7:
Florida Department of Health (FDOH) Florida Water Management Inventory Project website – http://www.floridahealth.gov/environmental-health/onsite-sewage/research/flwmi/index.html

Footnotes:
DEP FAVA website – http://www.dep.state.fl.us/geology/programs/hydrogeology/fava.htm

SRWMD water data portal – http://www.srwmd.state.fl.us/index.aspx?nid=267

SSURGO Database metadata website – https://catalog.data.gov/dataset/soil-survey-geographic-ssurgo-database-for-various-soil-survey-areas-in-the-united-states-