Variability in Springsheds Delineated by Potentiometric Surfaces

A Discussion Paper to Support the Silver Springs Basin Management Action Planning Process

May 2013

Background

The goal of Silver Springs Basin Management Action Plan (BMAP) is to reduce nitrate concentrations in Silver Springs to 0.35 mg/L as specified in the Total Maximum Daily Load (TMDL) developed for the springs group. To achieve this goal management strategies and projects, both mitigating current sources of nitrate and measures for controlling future sources of nitrate, will be required from the stakeholders. Stakeholders include but are not limited to local and state government agencies, private businesses, commercial and hobby agricultural operations, and environmental interests. By Florida law the basin management action plan process is intended to involve a broad range of interested parties with the objective of encouraging the greatest amount of cooperation and consensus possible.

The actions required from the BMAP must have a sound scientific background. The Florida Watershed Restoration Act (Section 403.067, Florida Statutes) directs that the Department of Environmental Protection may develop a basin management action plan that addresses some or all of the watershed and basins tributary to the impaired water body. In order to determine who is a stakeholder and to define the area over which nitrate reduction projects and control of future nitrate sources must occur, a BMAP boundary is established through the planning process. Within the BMAP boundary focus areas for specific pollutant sources may be established. For example, the focus area for stormwater runoff may be defined as the urbanized area within the BMAP boundary.

For surface waters with TMDLs, the BMAP boundary is typically the watershed of the impaired waterbodies. The watershed is defined by surface topography, where topographic high points (hilltops and ridgelines) act as drainage divides between waterbodies. For a spring system the analogous feature is a springshed, or ground water contributing area defined by a potentiometric surface or groundwater flow model.

This discussion paper is intended to assist with deliberations on the most appropriate BMAP boundary.

Springshed Delineation Methods

A potentiometric surface is similar to a topographic surface. It represents the maximum elevation, in a well, that groundwater would rise to in a confined aquifer. Groundwater flows from potentiometric high points (analogous to hilltops and ridgelines) to low points (springs and seeps). The potentiometric surface is developed from monitoring well levels. Surfaces are typically produced twice a year in May and September corresponding to the end of dry season and end of wet season respectively. The amount and distribution of rainfall in a given year influences the size and location of the springshed. The availability and location of wells is an important limiting factor in developing the surface. For perspective, the September 2008 surface developed by the United States Geological Survey (USGS) used 41 wells in Marion County, which is 1,652 square miles, to develop the surface. Groundwater flow models typically use particle tracking computations to determine the time it would take water to flow from a model grid cell to a spring. An example of such a model is MODPATH. The result is a springshed that is referenced to a travel time such as 1000 years. It is important to understand that groundwater flow models treat the aquifer as a uniform porous material and do not account for conduit flow.

Both of these methods were discussed during the March 2013 BMAP meeting by the St Johns River Water Management District (SJRWMD). In both cases the Silver Springs springshed originates from potentiometric high points located near the Alachua-Putnam-Bradford-Clay County intersection (north) and in western Lake County (south). From the north, the springshed boundary proceeds southwest through Alachua County in western Marion County. The springshed then passes through extreme northeastern Sumter County before entering Lake County. From the southern potentiometric high, the springshed boundary proceeds northward into eastern Marion County and extreme western Putnam County.

For purposes of this paper the springshed will be referred to as follows:

- North – Those portions in Alachua and Putnam Counties
- South – Those portions in Sumter and Lake Counties.
- East – Eastern Marion County
- West – Western Marion County

The potentiometric springsheds discussed during the March SJRWMD presentation were in close agreement to the 1000-year modeled capture area, with differences mainly in the west and south. The west springshed boundary was considered to be of lesser importance because it would coincide with the Rainbow Springs boundary. Rainbow Springs is also listed as impaired with the same 0.35 mg/L TMDL and will be subject to a future BMAP process. It was proposed at the April BMAP meeting that the 1000-year capture area and the potentiometric springshed were essentially the same. However, concerns were raised; therefore further analysis has been undertaken.

Analysis

The analysis consisted of manually defining springsheds using twice yearly potentiometric data from SJRWMD and USGS. At least one year from each decade from the 1970s was used along with a surface estimated for 1936. No particular criteria were used in selecting the years, although the frequency between years selected decreased the more recent the data was:

- From 5 years in the 1980s to,
- 3-4 years in the 1990s to,
- 2 years in the 2000s.

Two surfaces were developed for each year used (except 1936) corresponding to the May and September potentiometric surfaces. The springsheds were independently hand delineated from the corresponding potentiometric surface by one person in a GIS environment with only County boundaries and municipalities visible. Thus subjectivity in interpreting the boundary between users is controlled as is the influence of features on the land surface. **Figure 1** shows the manually delineated springshed boundaries with the 1000-year capture boundary and a maximum extent boundary prepared by the Florida Springs Institute (FSI) combining modeled and potentiometric boundaries (including the approximate boundary from the 2004 USGS report by Phelps).

The potentiometric surfaces delineated for this exercise were clustered over a 2 to 5 mile wide area, although individual surfaces occasionally produced anomalous results (e.g. September of 2008). The exception was the southern portion of the springshed where no clustering was apparent, particularly for the location of the southern potentiometric high point. No long term trend in the movement of the springshed boundary was apparent.

The 1000-year capture area generally agreed with the outer edge of potentiometric boundary cluster in the north and east. However, all but two potentiometric boundaries place the springshed boundary farther west than the 1000-year capture area. Similarly the 1000-year capture area placed the southern potentiometric high in a location farther north than most of the delineated surfaces.

The FSI maximum extents also generally agreed with the outer edge of the potentiometric boundary cluster and placed the southern potentiometric high somewhat father to the south. However, the FSI boundary deviated from the other boundaries in southwestern Marion and western Putnam Counties. In these locations it appeared that the FSI maximum extent was controlled by the approximate boundary from the 2004 USGS report.

Discussion

Defining the Silver Springs springshed based on potentiometric surface or on a modeled boundary has proven to be technically complicated. Both approaches would be defendable scientifically although they would likely produce different results.

Similarly, regardless of delineation method it must be acknowledged that the Silver Springs springshed is very dynamic and will flex based on rainfall and other conditions. The total springshed area and its location are dependent on which year's potentiometric data or model results are combined. While any given year of potentiometric data would be defendable as a valid springshed, another year would produce an equally defendable result. This would present a scenario where a nitrate source could be located in our out of the springshed in any given year. This scenario presents obvious complications on whether sources near the edges of the springshed are complying with the activities required under the BMAP or should even be included under the Silver Springs BMAP; the exception being in western Marion County where the Rainbow and Silver Springs springsheds will be seamless.

A springshed should also include the surface watersheds contributing to groundwater that ultimately reaches Silver Springs. Most of the lakes in the springshed area contribute only small amounts of water to the aquifer via leakance. The exception is Orange Lake where an active sinkhole has been shown through dye tracer studies to be connected to conduits that rapidly convey water. Similarly, Silver River should be included.

Additional consideration should be given to the practical limitations of this boundary. It was noted at the April 2013 BMAP meeting that the springshed boundary defined by the 1000 year capture zone would split parcels of land under one land use complicating the implementation of best management practices. Upon closer review it was also noted that both the 1000 year capture zone and the FSI springshed delineations split surface water features, most notably Lake Santa Fe in the north.

A suggested approach , as a result of this analysis, would be that the BMAP area be defined not just by ground water movement but also by recognizable landmarks, by the proximity of other BMAP areas, and the proximity of other spring clusters (as shown in Figure 2). Consideration is also given to the time and resource constraints faced by local governments and community interests when they are asked to participate in implementation of multiple BMAPs. In effect this becomes a delineation of the area that will be managed through the Silver Springs BMAP and not a complete representation of the area contributing ground water to Silver Springs. The proposed Silver Springs BMAP boundary will be bordered on the west by the anticipated Rainbow Springs BMAP area, to the north by the Orange Creek BMAP area, and to the south by the Upper Ocklawaha BMAP area. Some overlap at the boundaries between BMAP areas is justifiable, because of surface water connections to ground water.

Based on the approach suggested above, the proposed BMAP management area would be bounded to the west by Interstate 75, to the north by State Road 26, and to the south by State Road 44. The western boundary at Interstate 75 eliminates the overlap with the anticipated Rainbow Springs BMAP. The northern boundary at SR 26 eliminates the slicing of Lake Santa Fe, but still brings the boundary close to a potentiometric high point for the Floridan aquifer. The southern boundary largely follows State Road 44 and reduces the amount of overlap with the Upper Ocklawaha Basin. It does not include the Lake Harris drainage area and a cluster of springs that discharge to Lake Harris. Those springs' nutrient load is included in the nutrient budget for Lake Harris that supports the Lake Harris total maximum daily load.

The eastern boundary is more complicated and follows several local roads and the Ocklawaha River. The BMAP area boundary would follow County Road 21, in Putnam County, and County Road 315, in Marion County, south to NE 105th Street. The boundary would follow the centerline of NE 195th Street, NE 130th Avenue and NE 98th Street to the terminus of NE 98th Street where it crosses the Ocklawaha River in the straight line to the terminus of NE 144th Terrace. The Boundary line then would follow the centerline of NE 144th Terrace; proceed in a straight line to NE 147th Avenue Road, the centerline of which would be followed to County Road 314. The boundary would follow the centerlines of County Road 314 to NE 46th Street, then to NE 145 Avenue Road to State Road 40, then east to County Road 314A. The boundary would follow the centerlines of County Road 314A to SE 95th Street Road to SE 182nd Avenue Road then south to County Road 42 then west to the Ocklawaha River. The boundary will follow the River south to Lake Griffin, passing north of the lake on local roads.

As proposed, the BMAP area is 988 square miles. In comparison, the maximum extent springshed developed by FSI is 1,363 Square mile with most of the difference being west of I-75 in an area expected to be included in the Rainbow Springs BMAP area. An additional 219 square miles could be included as part of the Rainbow Springs BMAP bringing the total area of springshed covered by a springs BMAP to about 1,207 square miles.

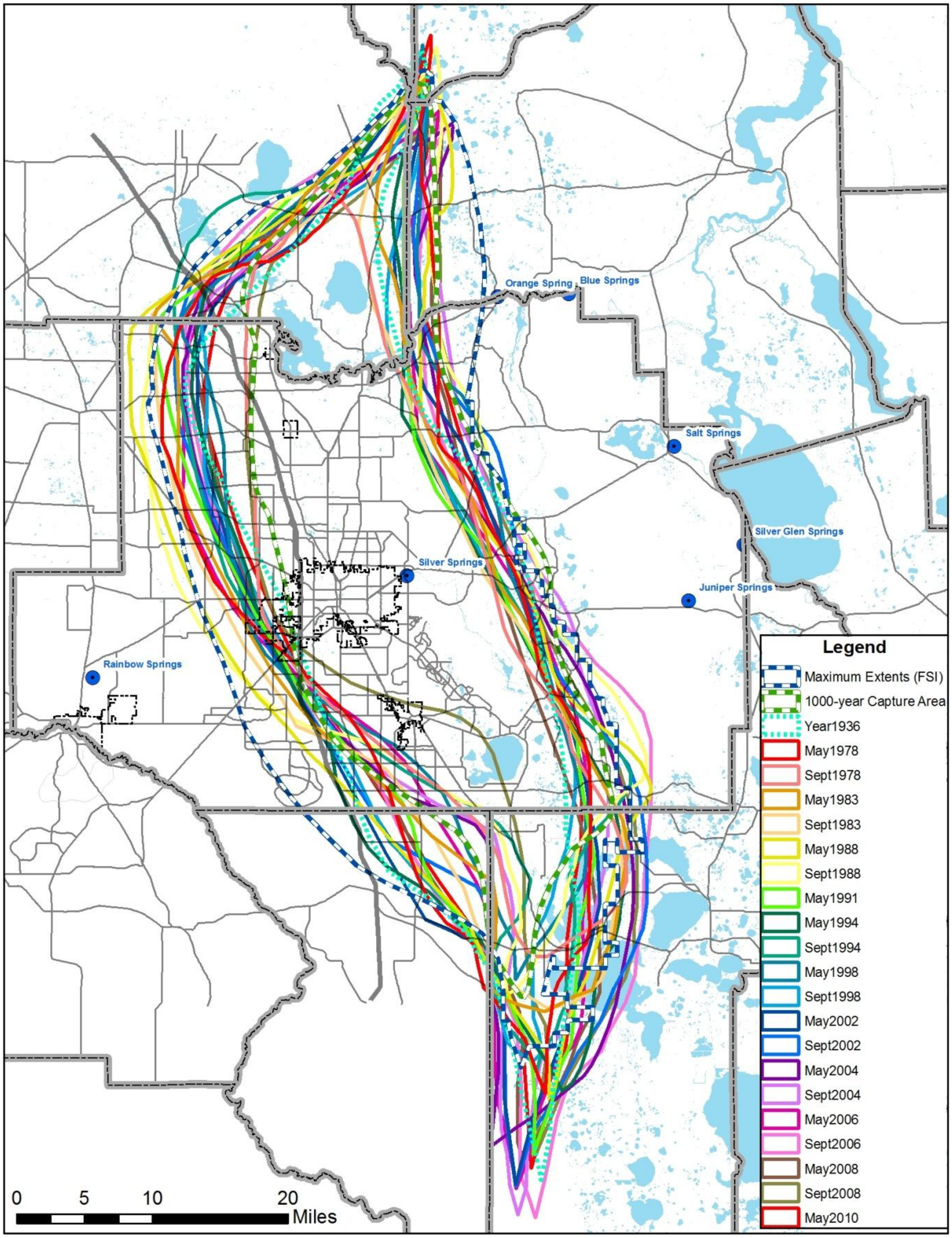

Figure 1: Springshed Boundaries From Selected Potentiometric Surfaces

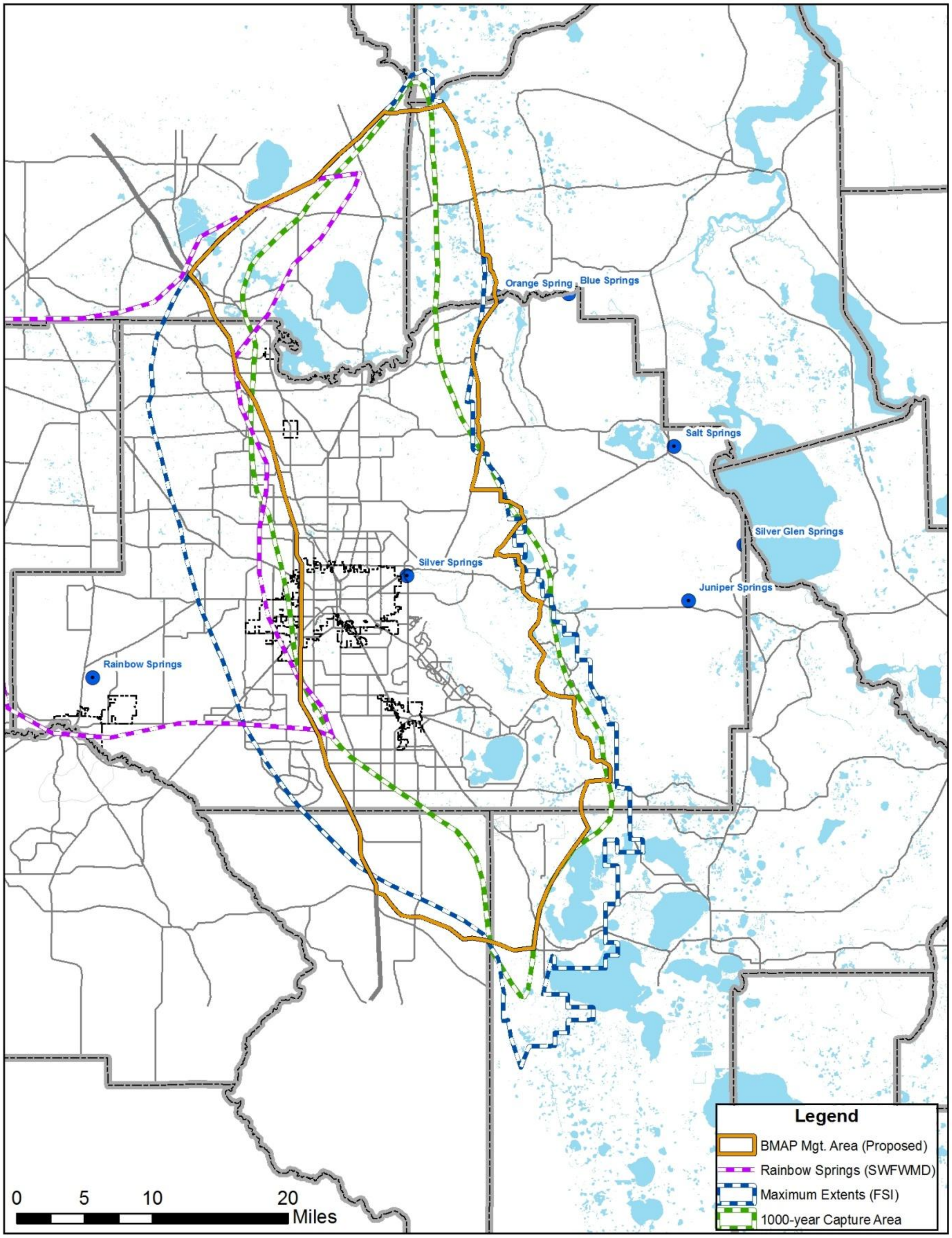

Figure 2: Proposed Silver Springs BMAP Area