Restoration Plan for the Silver Springs and River
DRAFT

Prepared For

Florida Department of Environmental Protection
Ground Water and Springs Protection Section
2600 Blair Stone Road
Tallahassee, Florida 32399-2400

Prepared By

Normandeau Associates, Inc.
102 NE 10th Avenue
Gainesville, FL 32601
352-372-4747
www.normandeau.com

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Thank you to Dr. Matt Cohen and Dr. Andrea Albertin at the University of Florida for their invaluable support, input, and guidance throughout the development of the draft Restoration Plan and for their commitment to understanding our springs systems through scientific research.

The Silver Springs Basin Working Group has been fortunate to have many passionate and hard-working people dedicated to protecting and restoring Silver Springs and River over many decades. It is through their support that many successes have been made. And it is through their vision that we hope to restore and protect the Silver Springs and River.

Thanks to everyone for a job well done.

Pete

Peter Colverson
Normandeau Associates
102 NE 10th Avenue
Gainesville, FL 32601
352-372-4747 ext. 7017
pcolverson@normandeau.com
www.normandeau.com

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Acronyms and Abbreviations

AWT	advanced wastewater treatment
BMAP	basin management action plan
BMPs	best management practices
cfs	cubic feet per second
CR	county road
DO	dissolved oxygen
FDACS	Florida Department of Agriculture and Consumer Services
FDEP	Florida Department of Environmental Protection
FDOF	Florida Division of Forestry
FGS	Florida Geological Survey
FORS	Friends of Rainbow Springs State Park
FOWA	Florida Onsite Wastewater Association
FWC	Fish and Wildlife Conservation Commission
gpcd	gallons per capita per day
MCAVA	Marion County Aquifer Vulnerability Assessment
MCPR	Marion County Parks and Recreation
MFL	minimum flow and level
mg/L	milligram per liter
mgd	million gallons per day
MSWCD	Marion Soil and Water Conservation District
N	nitrogen
OSDS	onsite sewage disposal system
P	phosphorous
ppm	parts per million
RIB	rapid infiltration basin
RSBWG	Rainbow Springs Basin Working Group
RSSP	Rainbow Springs State Park
SAV	submerged aquatic vegetation
SJRWMD	St. Johns River Water Management District
SPZ	springs protection zones
sq mi	square mile
SRSP	Silver River State Park
SSBWG	Silver Springs Basin Working Group
STA	stormwater treatment area
SWFWMD	Southwest Florida Water Management District
SWIM	Surface Water Improvement and Management
TDS	total dissolved solids
TMDL	total maximum daily load
USGS	U.S. Geological Survey
WAM	Watershed Assessment Model
WRAMS	Water Resources Assessment and Management Study
WRWSA	Withlacoochee Regional Water Supply Authority
WWTP	wastewater treatment plants
µg/L	microgram per liter

1 Executive Summary

2 Background

2.1 Overview of Silver Springs and the Silver River

Silver Springs is a first-magnitude springs group (mean annual discharge > 100 cubic feet per second (cfs)) located in central Marion County (**Figure 2-1**) that gives rise to the Silver River. Collectively, it is the largest freshwater spring in Florida, with an average discharge of 766 cfs or 495 million gallons per day (mgd) (Osburn et al. 2002). There are 30 known springs and 61 known vents in the upper 1,200 m of the Silver River (Butt et al. 2008), with eight main, named springs in the river (**Figure 2-2**). The three main vents that together comprise the head springs are known as the Main or Mammoth Spring, Blue Grotto, and The Abyss. The Silver River flows approximately 7 miles until it joins the lower Ocklawaha River. Silver Springs has been a renowned tourist attraction since the 1800s, with tourists being transported upriver in steamboats. Today an amusement park, Silver Springs Nature Park, (the Attraction) surrounds the upper portions of the river and offers glass-bottom boat rides, river nature tours, and animal exhibits. The Attraction is actually owned by the state of Florida and managed by Palace Entertainment of California on a lease. The land downstream of the Attraction on both shores of the river is owned by the state of Florida and operated by the Florida Park Service as the Silver River State Park.

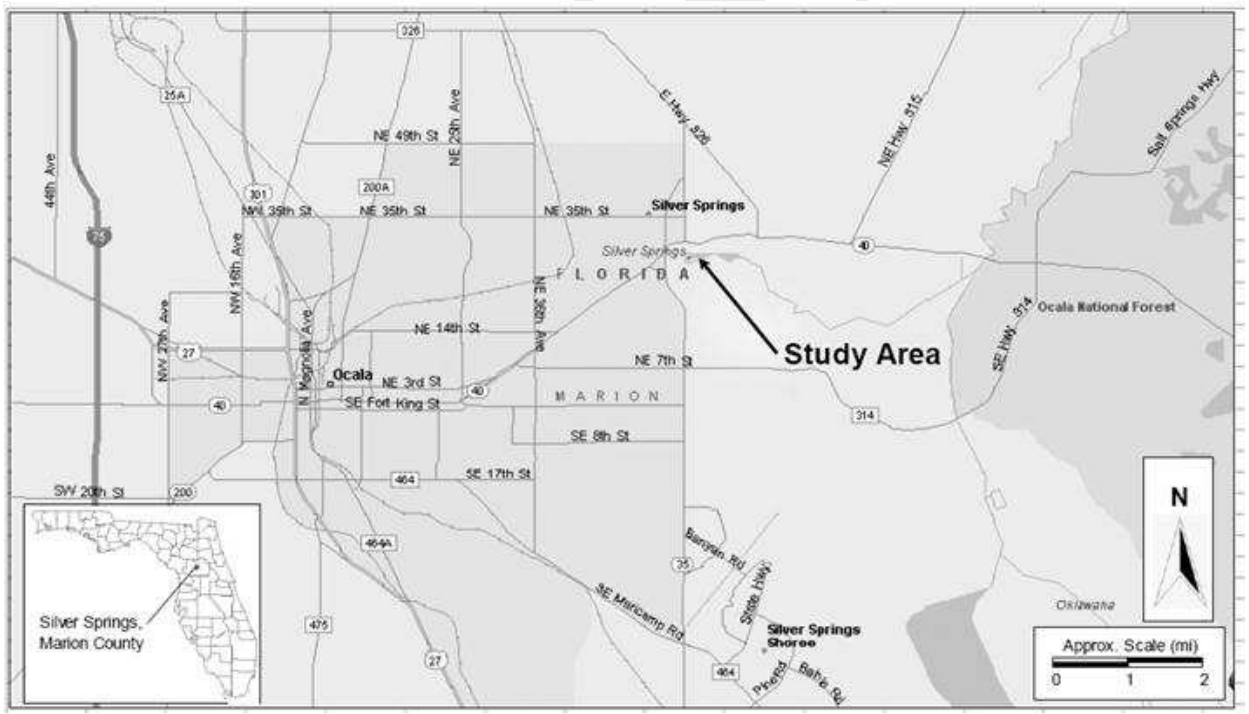

Figure 2-1. Location of Silver Springs, Marion County.
Source: Munch et al. 2006

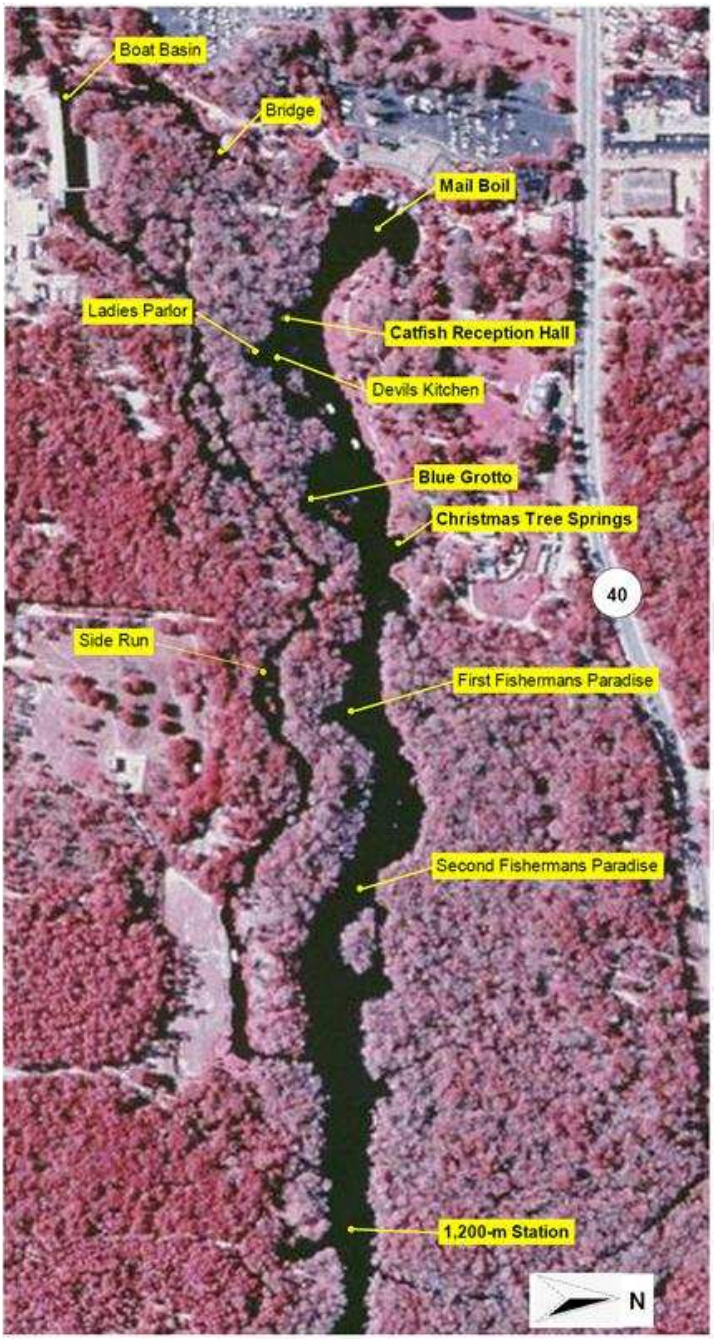

Figure 2-2. The largest named springs in the upper reaches of the Silver Springs run.
Source: Munch et al. 2006

The area that contributes groundwater to Silver Springs has been delineated by various researchers whose estimates of the size of the springs basin vary from 700 to 1,200 square miles. A version of the springs basin map that has been used to guide Silver Springs Basin Working Group (SSBWG) activities is shown as **Figure 4-2**. Silver Springs is situated in the center of its springs basin which is mostly agricultural land but contains the cities of Ocala, Belleview, Reddick, and the northern sections of The Villages.

In addition to its significance due to the high rate of flow, Silver Springs has remarkable historical significance, both from a scientific standpoint and in its importance as an early transportation center and magnet for visitors from all over the United States and even the world. Steamboats brought tourists up the Ocklawaha River to Silver Springs as early as 1860, and many early travelers wrote with eloquence about the magnificence of the Silver River and the springs at its source. In the late 1870s, Phillip Morell, a lifetime resident of Silver Springs, built a glass-bottom rowboat and sold rides above the springs. The appeal of Silver Springs after that time is intimately related to the glass-bottom boats and their ability to show a fascinated public what lies underwater. For more information, see the Silver Springs Nature Park (the Attraction) historical timeline at http://www.silversprings.com/heritage.html.

Silver Springs continues to appeal to visitors despite the advent of new Florida theme parks, which still have nothing to compare with the view from the glass-bottom boats. The famous clarity of the water is a long-term, stable economic asset to Marion County. Flow and water quality data have been collected at Silver Springs for the longest time period of any Florida spring. The fact that a long-term record exists has attracted scientific study to Silver Springs, most notably with Howard T. Odum's landmark publication in 1957 of "Trophic structure and productivity of Silver Springs, Florida," one of the most detailed studies of an aquatic ecosystem ever completed. A retrospective study by several authors (Munch et al. 2006) to see how Odum's findings have changed since 1957 was completed in 2006 and released as a publication through the St. Johns River Water Management District in 2007.

3 Planning Process

3.1 Description of Working Groups

Between July 2010 and June 2011, the Silver Springs Basin Working Group (SSBWG) focused on developing a draft Restoration Plan for the Silver Springs and River.

The draft Restoration Plan has been developed through discussion, cooperation, and consensus among a broad range of stakeholders. A stakeholder is self-described as an individual who cares about the future of the Silver Springs and River. The SSBWG stakeholder list has 211 individuals on it including representation of a broad range of agencies, organizations, and citizens. The list is updated regularly, especially after each quarterly meeting, based on referrals and also based upon requests from stakeholders to be added. Stakeholders participated in the planning process through, four quarterly meetings, several planning meetings, individual meetings, phone calls, and email communications. Email updates were sent to stakeholders periodically to announce news of interest, to summarize the status of the planning process, and to alert stakeholders about upcoming meetings, events, issues, news articles, and funding opportunities that relate to the Silver Springs and the springs basin.

Stakeholders that have participated in the process include:

- Florida Department of Environmental Protection (Office of Greenways and Trails, Ocklawaha and Rainbow River Aquatic Preserve, Silver Springs State Park)
- Florida Fish and Wildlife Conservation Commission (FWC)
- Florida Division of Forestry (FDOF)
- Florida Geological Survey (FGS)

- St. Johns River Water Management District (SJRWMD)
- Withlacoochee Regional Planning Council
- University of Florida, School of Forestry and Conservation
- Marion County (Engineer, Extension, Health, Parks and Recreation)
- City of Ocala (Water and Sewer Department)
- Florida Onsite Wastewater Association (FOWA)
- Marion Soil and Water Conservation District (MSWCD)
- Suwannee St. Johns Sierra Club
- Florida Audubon Society and the Ocklawaha Valley Audubon Chapter
- Smart Growth Coalition
- Wetland Solutions, Inc.
- Aquapure, Inc.
- TerraPointe Services
- Awareness Adventures
- Ocala Boat Club
- Ray & Associates
- Assorted citizens

The planning process began with a joint meeting with the Rainbow Springs Basin Working Group (RSBWG) to decide upon the priorities and sideboards for both planning processes. Out of this meeting came the primary categories for goal setting as follows:

- Biodiversity
- Education and Outreach
- Land Use and Development
- Recreation (particularly important for Rainbow)
- Water Quality
- Water Quantity (Spring Flow)

3.2 Meeting Summaries

Over the course of the year, four quarterly working group meetings were held as well as numerous planning and stakeholder meetings that were both in-person and over the phone (**Table 3-1**).

Table 3-1. Working Group Meetings August 2010 – June 2011

Month	Type of Meeting	Description
August	Quarterly	First Stakeholder Quarterly Meeting – Jointly held with RSBWG
September	Planning	Meeting with Marion County Staff (County Engineer, Growth Management, Utilities)
September	Planning	Meeting with City of Ocala (Director of Water and Sewer)
September	Planning	Meeting with SJRWMD staff from several departments
November	Quarterly	Second Quarterly Meeting – working session on developing the Vision

Month	Type of Meeting	Description
December	Planning	Meeting with Coordinating Group for the Working Group to discuss strategies
December	Planning	Meeting with Agricultural Stakeholders to discuss agricultural land users, nitrate loading and BMPs
Nov - Jan	Planning	Preparatory and follow up phone discussions with meeting participants for the agricultural stakeholders planning meeting
February	Quarterly	Third Quarterly Meeting for Goal Setting
Feb -March	Planning	Meetings (phone calls) with stakeholders organized into goal setting groups to discuss progress towards development of goals and actions
March	Planning	Meeting with three golf courses superintendents to discuss golf course management (meeting was in Dunnellon but purpose was to begin dialogue with course superintendents)
Feb-March	Planning	Numerous calls to various people associated with golf course and turf grass management
March	Planning	Meeting with Ocala Marion Chamber of Commerce Director to discuss economic value of the springs
May	Quarterly	Fourth Quarterly Meeting to continue Goal Setting
April - June	Planning	Numerous meetings (phone calls) with stakeholders organized into goal setting groups to discuss progress towards development of goals and actions
May	Planning/ relationship building	Attended Field Day on golf course management at the UF turf grass research facility in Citra

3.3 Plan Refinement and Implementation

At this time, it is uncertain what the future holds for the Silver Springs Basin Working Group. Funding for coordination of the group has been cancelled for 2011-12. The planning process was to continue into year 2 and also restoration actions were to be encouraged.

In an effort to determine how the SSBWG can be more effective, Dr. Martha Monroe of the University of Florida implemented a stakeholder survey. The survey has been distributed via email to the stakeholders, and results will eventually be shared with the coordinator. An additional survey of the public during 2011-12 is planned to determine attitudes about springs protection. This should inform educational efforts.

During 2011-12 it will be important for all stakeholders to unite around the Restoration Plan's goals and to refine the actions and the responsibility for each action. Without leadership and coordination, this effort will be difficult. A mechanism to maintain the SSBWG's coordination function would therefore be advantageous. It should be noted that both a Total Maximum Daily Load (TMDL) and a Minimum Flows and Levels (MFLs) process will be implemented in the

upcoming months and years and both will require public input. Following the TMDL will be a Basin Management Action Plan (BMAP) process, also needing public input. The existing SSBWG infrastructure (coordinator, stakeholder contact list, local knowledge of the players, meeting structure, etc.) could all play a supporting role to the TMDL and MFLs processes. Both processes represent significant aspects of the restoration effort and are supported by goals in the Restoration Plan. A shared funding mechanism among the Florida Department of Environmental Protection (FDEP), the appropriate water management districts, plus county and city governments could maintain the basic elements of the SSBWG and allow the agencies to move smoothly into the public input process for their regulatory processes.

With this in mind, the following goal for the SSBWG for Fiscal Year 2012 is offered.

Goal 1. Coordinate restoration efforts (centered on the TMDL and MFLs processes) with all stakeholders to avoid duplication and consolidate and share resources effectively.

Actions

1. Maintain a stakeholder email list with representatives from all key agencies and organizations.
2. Provide mechanisms for sharing information and collaboration among stakeholders.
3. Help identify unifying messages and approaches when possible.
4. Facilitate decision making on restoration actions to implement goals within the Restoration Plan based on priorities, capacities, and costs.
5. Plan ways to implement actions and monitor success.
6. List restoration actions and strategies for tracking potential changes in the system.

4 Physical Description

The Silver Springs have an average discharge of 766 cfs or 495 mgd (Osburn et al. 2002). There are 30 known springs and 61 known vents in the upper 1,200 m of the Silver River (Butt et al. 2008), with eight main, named springs in the river (see **Figure 2-2**). The head springs, also known as the Main Spring boil, is comprised of three separate named vents, Main Spring, Blue Grotto, and The Abyss. The Silver River flows approximately 7 miles until it joins the lower Ocklawaha River.

4.1 The Silver Springs Basin

The size of the Silver Springs basin (the recharge area for the springs group) is approximately 1,200 mi^2, although the boundaries of the springs basin vary depending on groundwater levels (Phelps 2004). It includes parts of Marion, Alachua, Putnam, Lake, and Sumter counties, but the majority is located in Marion County (760 mi^2 or 63%) (Phelps 2004). The basin is delineated using water-level contours representing average potentiometric surface conditions of the Upper Floridan Aquifer (**Figure 4-1**). The geographic extent of the springs basin, with 2, 10, and 100 year capture zones marked, is shown in **Figure 4-2**.

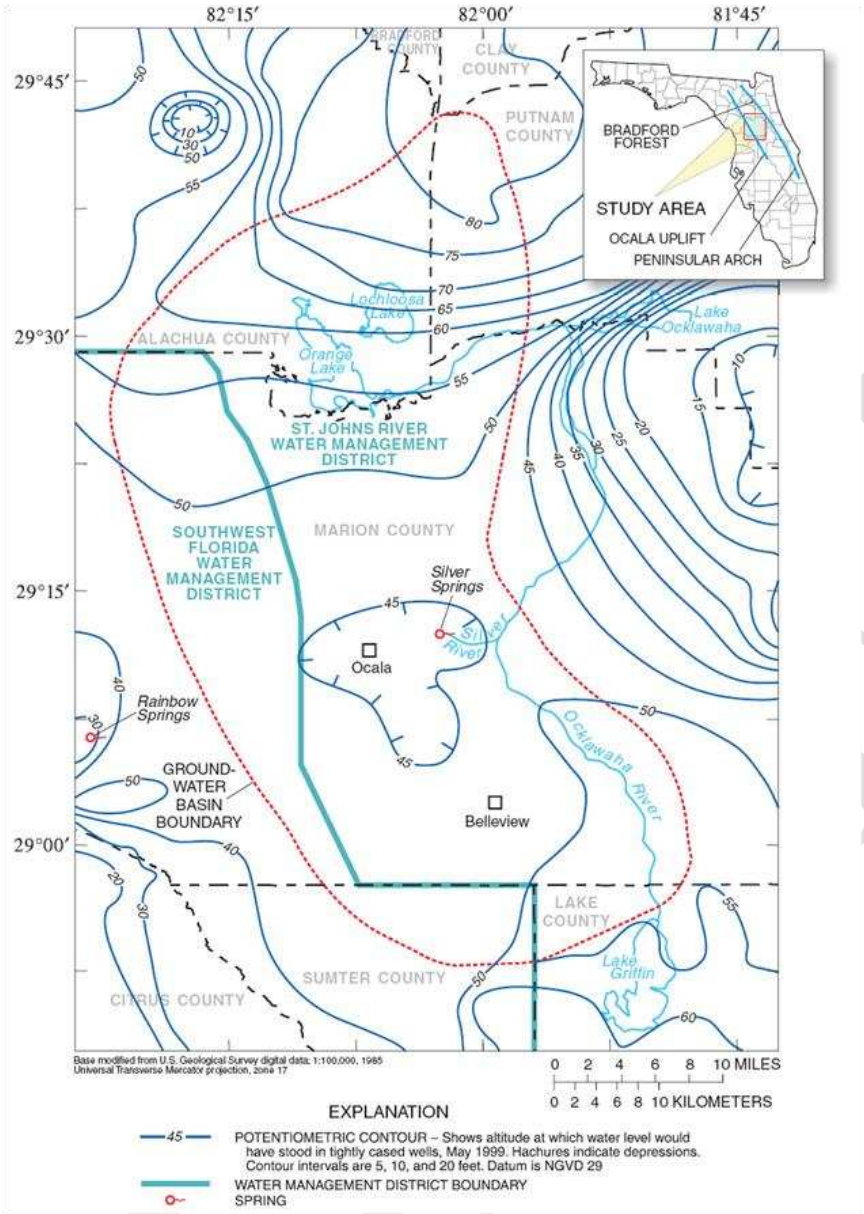

Figure 4-1. Extent of the Silver Springs Basin.
Source: Phelps 2004

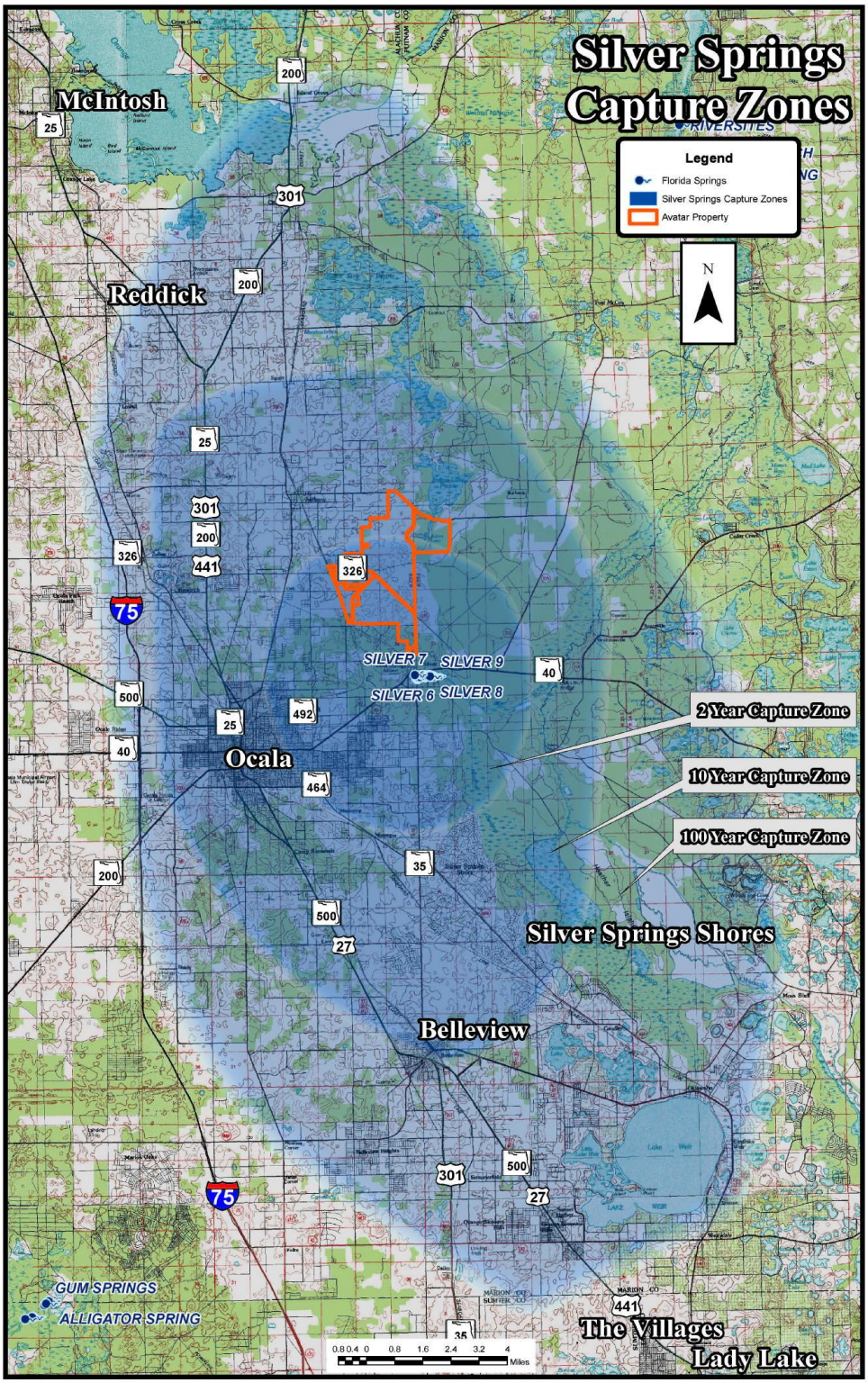

Figure 4-2. Generlized map of Silver Springs basin with capture zones for 2, 10, and 100 years.
Source: Louis Ley, FDEP and David Toth, SJRWMD

4.1.1 Aquifer recharge characteristics and vulnerability

Limestone is at or near the land surface in large portions of the Silver Springs basin, resulting in rapid recharge of the aquifer (Phelps 2004). The Upper Floridan Aquifer is approximately 1,800 ft thick in the Silver Springs basin, and water discharging from the springs comes predominantly from the Ocala Limestone, the upper stratum of the aquifer in this area (**Figure 4-3**) (Knowles 1996). A middle confining unit of the aquifer present in the Rainbow Springs basin is absent, so the upper and lower aquifer systems are connected in the Silver Springs basin (Knowles 1996). The Marion County Aquifer Vulnerability Assessment (MCAVA) (Baker and Cichon 2007) indicates that a majority of the Silver Springs basin is classified as being "more vulnerable" to contamination from overlying land uses (**Figure 4-4**) (Harrington et al. 2010). Age dating of water from Silver Springs indicates that a large portion of the water discharging from the springs is relatively young. Using two methods to date the water (SF6 and 3H/3Hetrit), Phelps et al. (2004) estimated that water discharging from The Abyss spring was approximately 10-years old in 2000-2001 and followed a relatively simple flow path. Water discharging from the Main Spring boil (Mammoth 1 and 2) and from Blue Grotto was less than 30-years old, and their respective flow paths were more complex. The SJRWMD has conducted a dye trace study to improve the characterization of the karst pathways within the spring basin. This study is being concluded in the summer of 2011.

Data from the dye trace study to be inserted here when available.

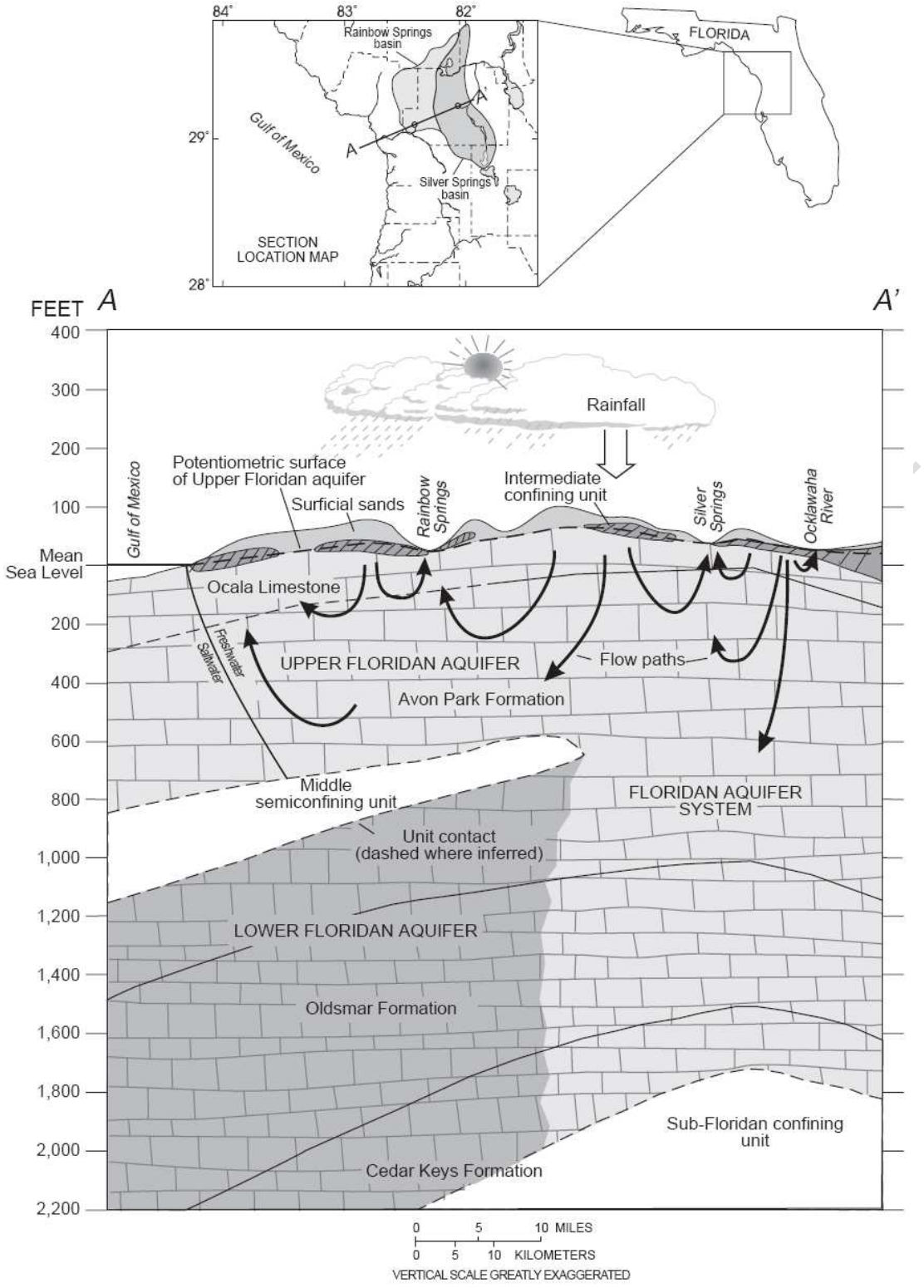

Figure 4-3. Generalized hydrologic section A to A' of the Floridan Aquifer in the Rainbow and Silver Springs basins.
Source: Knowles 1996

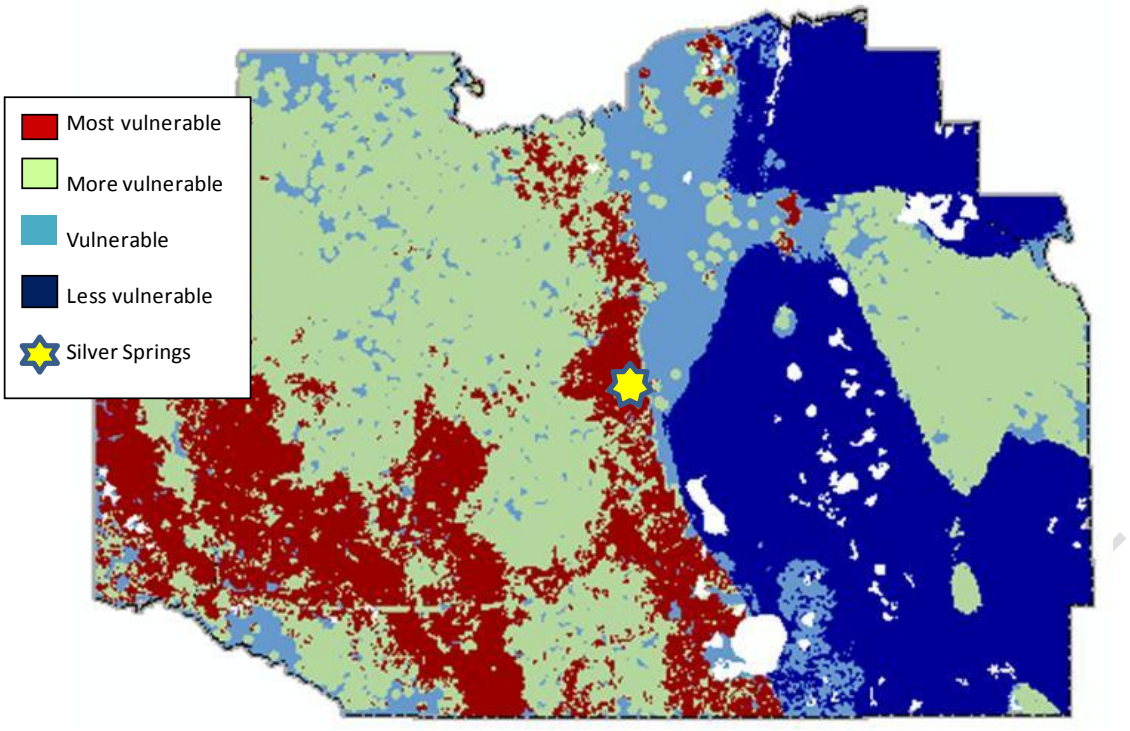

Figure 4-4. Marion County Aquifer Vulnerability Assessment (MCAVA).
Source: Baker and Cichon 2007

4.1.2 Land use in the Silver Springs basin

Figure 4-5 shows agricultural land uses of pastures and rangeland form the majority of the western section of the springs basin with forests more common in the east and north. There is also a significant urban category immediately west of the springs with the City of Ocala. Significant urban growth has also occurred south of Ocala around the City of Belleview and further south near The Villages which is centered in Lake County.

As shown in **Figure 4-6**, land use in the Silver Springs basin has changed drastically since 1949, from being largely natural forest to more urban/agriculture in 2005 (Munch et al. 2006). Based on the two-year capture zone for the Silver Springs basin (a much reduced area of the basin), between 1949 and 2005, forested and vegetated areas decreased from 68% to 31%, while urban areas increased from 3% to 37%. The area covered by pine plantations also increased significantly, with changes from 1.5% of the basin in 1949 to 13% in 2005 (Munch et al. 2006).

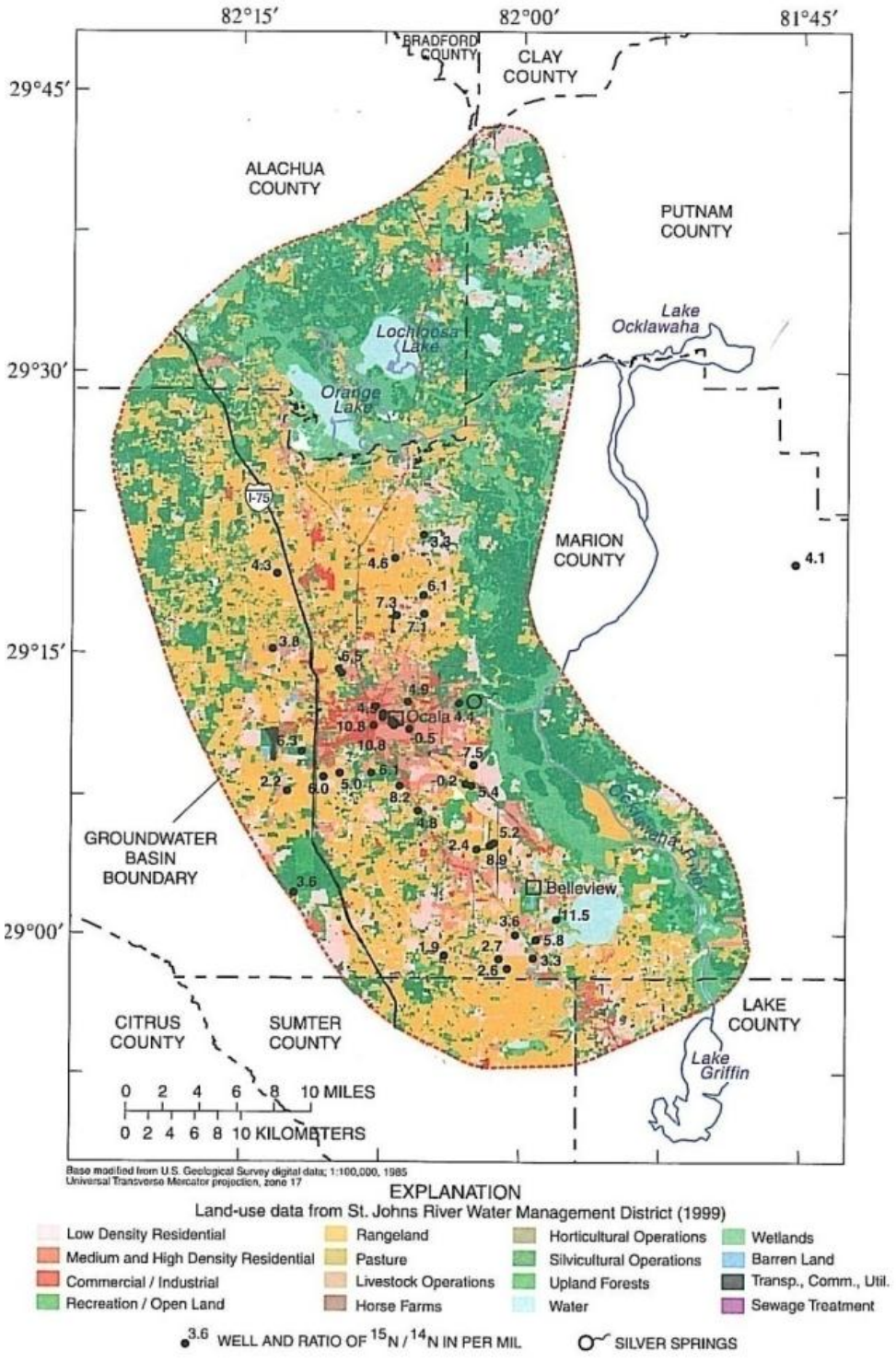

Figure 20. Areal distribution of $^{15}N/^{14}N$ for ground-water samples.

Figure 4-5. Land uses in the Silver Springs Basin.
Source: Phelps 2004

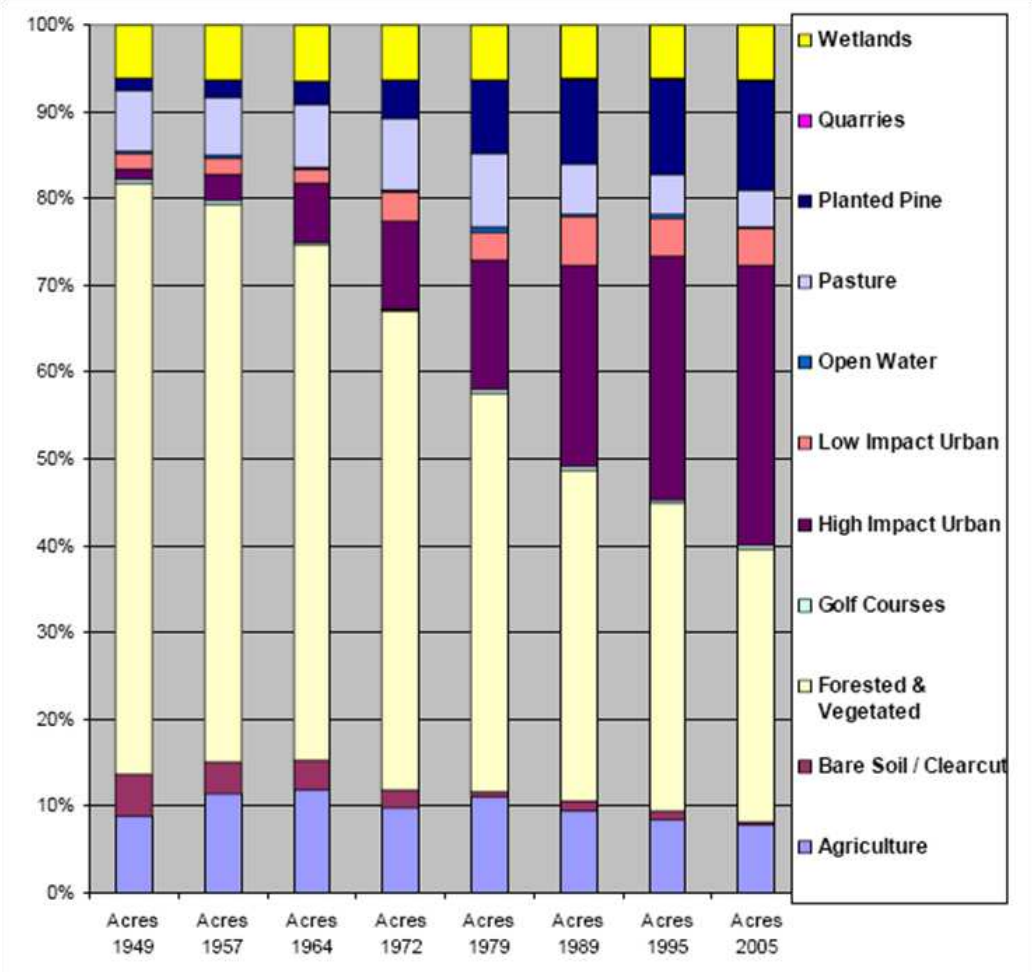

Figure 4-6. Land use change in the Silver Springs Basin two-year capture zone in percent of total area.
Source: Munch et al. 2006

4.2 Water Quality

4.2.1 Nitrate concentrations and sources of N in the Silver Springs basin

Long-term records indicate that Nitrate-N concentrations in the Silver Springs Main Spring boil (Mammoth 1 and 2) have greatly increased since 1974, from approximately 0.55 mg/L to 1.35 mg/L in 2010 (**Figure 4-7).** Median nitrate concentrations taken by FDEP between 2001 and 2006 at three springs in the upper run were highest in Blue Grotto (1.5 mg/L), followed by 1.4 mg/L in the Catfish Reception Hall and lowest in the Main Spring (1.1 mg/L). Nitrate-N concentrations in 56 wells sampled throughout the Silver Springs basin in 2000-2001 varied from <0.02 to as high as 12 mg/L (**Figure 4-8**) (Phelps 2004). Agricultural areas had the highest mean concentrations (1.7 mg/L), while rangeland and forests (combined land-use category) had the lowest mean concentrations (0.09 mg/L). The FDEP Springs Initiative Monitoring Network (begun in 2001) reported that of 328 wells sampled in the basin from 2001 to 2006, 66% had

nitrate concentrations higher than 1.0 mg/L, and 28 wells had concentrations higher than 10 mg/L, with one as high as 31 mg/L (Harrington et al. 2010).

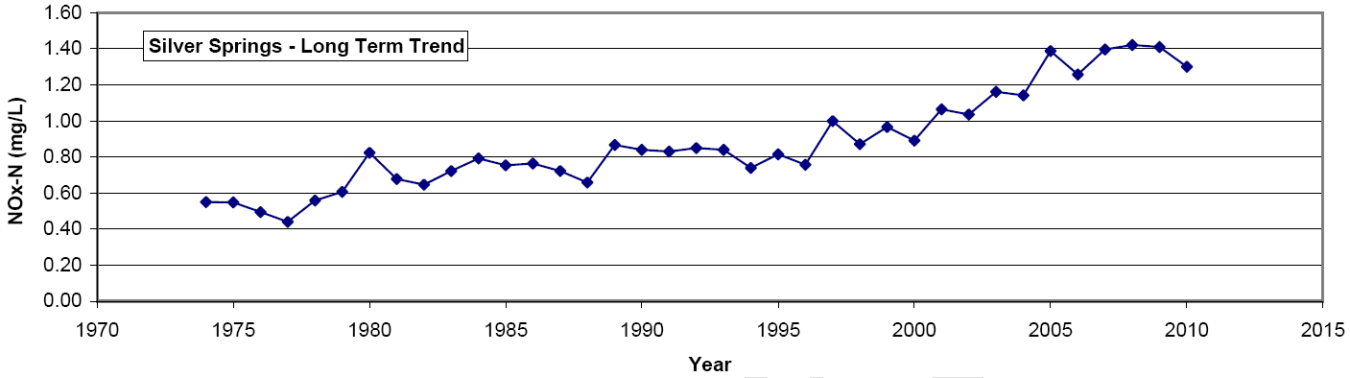

Figure 4-7. Nitrate concentrations at Silver Springs from 1974 to 2010.
Source: Wetland Solutions, Inc. 2010

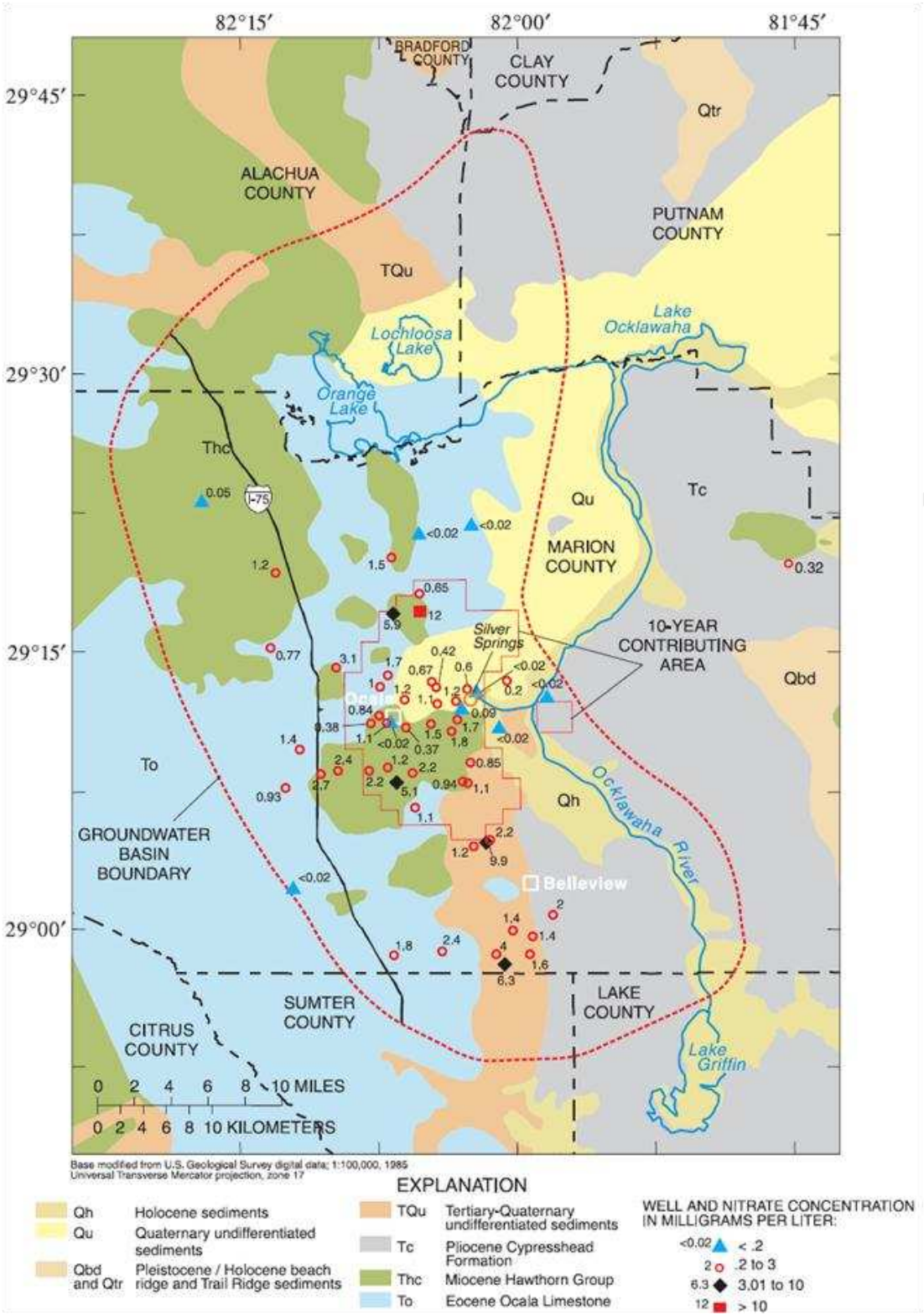

Figure 4-8. Nitrate-N concentrations (mg/L) of wells in the Silver Springs basin, in 2000-2001.
Source: Phelps 2004

As recharge occurs relatively quickly in most areas of the Silver Springs basin, nutrients applied to the land surface can reach the Floridan Aquifer rapidly. Principal sources of nitrogen in the basin identified by Phelps (2004) included atmospheric deposition, inorganic fertilizers applied to agricultural and urban areas, and animal livestock and human waste. Livestock taken into account included beef and dairy cattle, calves, hogs, sheep, horses, and chickens. Estimated nitrogen loading rates for Marion County from 1940 to 2000, of both land applications and quantities reaching the Floridan Aquifer, are shown in **Figure 4-9** (Phelps 2004). Livestock waste and commercial fertilizer (in terms of sales) make up the greatest estimated N load applied to land surfaces as well as to groundwater if 30% infiltration is assumed for livestock-generated N. However, if 10% infiltration to the aquifer is assumed, the contribution of commercial fertilizers is assumed to be higher. Phelps (2004) indicated that this variability in percent infiltration is due to different handling methods applied to livestock.

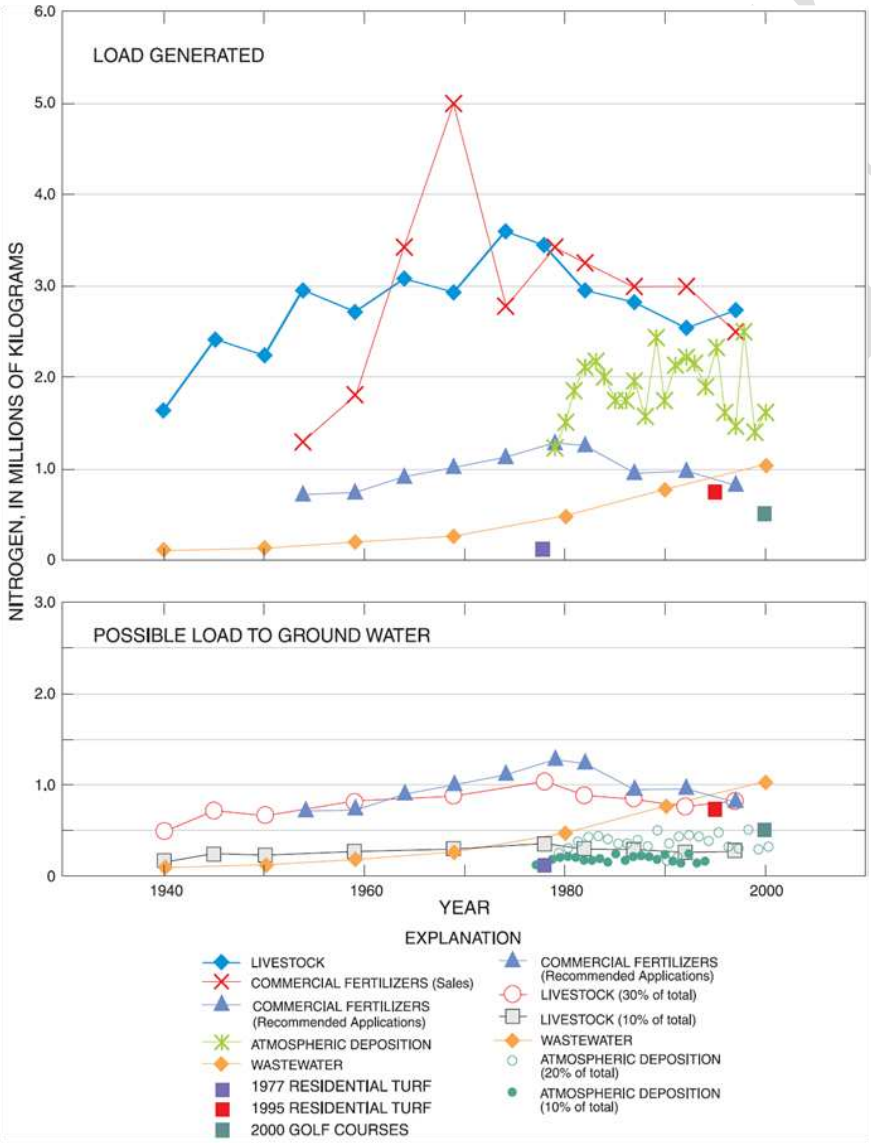

Figure 4-9. Estimated annual nitrogen inputs for Marion County from 1940 to 2000.
Source: Phelps 2004

Stable isotopes of nitrogen ($\delta^{15}N$) can provide information about possible sources in groundwater. Values of $\delta^{15}N$ less than 6‰ are generally indicative of inorganic fertilizers, while values greater than 9 ‰ are often attributed to organic N from human or animal waste (Katz et al. 1999). Values in between are often considered as coming from mixed organic and inorganic sources. Values of $\delta^{15}N$ ranged from –0.5 ‰ to 11.5 ‰ in wells throughout the Silver Springs basin. In agricultural areas, the median $\delta^{15}N$ value was 4.8 ‰, while in urban areas the median value was 5.4 ‰. Phelps sampled $\delta^{15}N$ in the Main Spring boil on four occasions and found variable values, from 3.7 to 8.7 ‰ indicating a change in N sources, from inorganic fertilizer to mixed inorganic and organic sources on separate occasions in the water discharging from the springs. Albertin (2009) sampled the Main Spring boil in 2005, 2006, and 2008 and found values ranging from 6.8 to 7.6 ‰.

4.2.2 Orthophosphate concentrations

Orthophosphate and total phosphorus concentrations have remained relatively stable in the Main Spring boil from 1967 to 2004 (Phelps 2004). Both orthophosphate and total phosphorus concentrations measured during this time period ranged from 0.02 to 0.07 mg/L. The FDEP Springs Initiative Monitoring Network reported the following median values from 2001 to 2006 of orthophosphate at three of springs in the upper reach of the Silver River: 0.044 mg/L at Silver Main Spring boil, 0.042 mg/L at Catfish Reception Hall, and 0.039 mg/L at Blue Grotto (Harrington et al. 2010).

Throughout the Silver Springs basin (56 wells), orthophosphate concentrations ranged from 0.01 to 0.089 mg/L (0.03 mg/L median value), while total phosphorus concentrations ranged from 0.02 to 2.7 mg/L (0.04 median value) (Phelps 2004). Phelps (2004) indicated that effluent from land application of wastewater could be a likely source of P to the aquifer rather than sediments from the Hawthorn Group, which often contain phosphate minerals, but Hawthorn sediments are relatively thin and discontinuous in the Silver Springs basin.

4.2.3 Dissolved oxygen

Measurements between 1977 and 2002 show that the mean average concentrations of dissolved oxygen (DO) in the Main Spring boil ranged from 1.3 to 6.8 mg/L (median 2.3 mg/L) and that DO generally increases as discharge increases (Phelps 2004). As part of the Springs Initiative Monitoring Network, DO measurements were taken at three springs in the upper reach of the Silver River between 2001 and 2006 (Harrington et al. 2010). Main Spring boil DO ranged from 1.18 to 2.45 mg/L (median 1.67 mg/L), Catfish Reception Hall DO ranged from 2.93 to 5.99 mg/L (median 3.57 mg/L), and Blue Grotto DO ranged from 2.77 to 6.08 mg/L (median 3.61 mg/L). Munch et al. (2006) measured DO at eight of the major springs above the 1,200 m station, and values ranged from 1.26 mg/L at Christmas Tree Springs to 3.86 mg/L at Devil's Kitchen. Concentrations of DO in samples from 56 wells in the Silver Springs basin ranged from 0.1 to 8.3 mg/L in 2000-2001, with higher values generally occurring in areas where the Floridan Aquifer was unconfined (Phelps 2004).

4.2.4 Water clarity

Water clarity in the upper reaches of Silver Springs is high. Horizontal secchi disk measurements taken by Munch et al. (2006) averaged 73 m in the Main Spring boil area, and the lowest average value (28 m) was obtained at the 1,200 m station. Odum (1957) measured a secchi distance of

approximately 105 m, but details of the measurement were not given, so size of the disk, number of readings, or light conditions are unknown (Munch et al. 2006).

4.3 Springs Discharge

The estimate of mean annual discharge of Silver Springs from 1932 to 2010 (USGS station 02239500) is shown in **Figure 4-10**. Although spring flows were measured at multiple places along the spring run, complicating discharge estimation, the majority of measurements were made at the 1,200 m station, located approximately 0.75 mi downriver from the Main Spring boil (Mammoth 1 and 2) (Munch et al. 2006). Estimated discharge has fluctuated from below 500 cfs in 2001 to as high as 1,100 cfs in 1960. Discharge from the Main Spring boil accounts for approximately 50% of the river flow at the 1,200 m station (Munch et al. 2006).

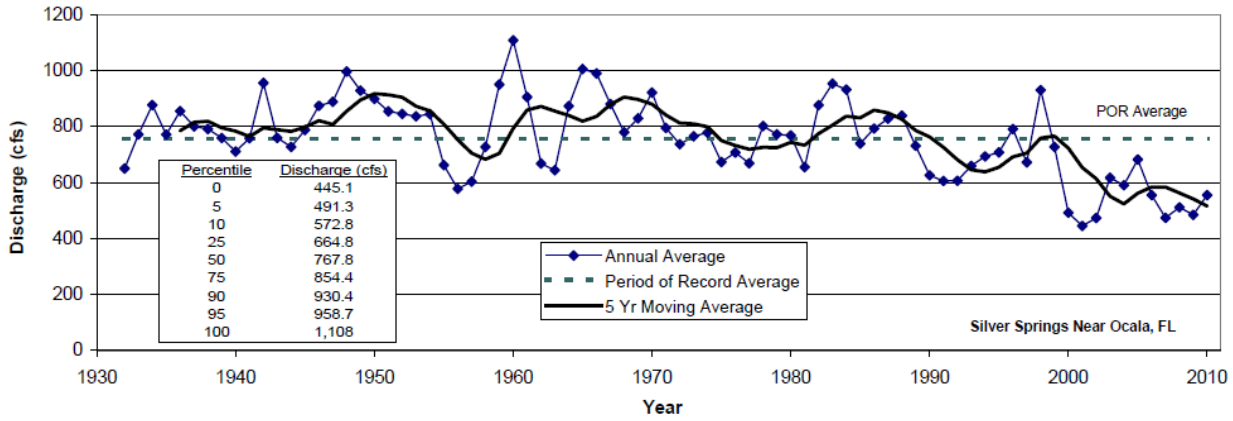

Figure 4-10. Discharge at Silver Springs from 1932 to 2010.
Source: Wetland Solutions, Inc. 2010.

4.4 Biota

4.4.1 Submerged aquatic vegetation and benthic algae

As part of the 50-year retrospective study, Quinlan et al. (2008) compared primary producer communities (submerged aquatic vegetation, epiphytes, and benthic algal mats) of Silver Springs in 2003/2004 to what was reported by Odum in 1957. As in the 1950s, submerged aquatic vegetation (SAV) in Silver Springs was dominated by *Sagittaria kurziana*. While at least 14 other species of submerged, floating, and emergent aquatic species were found in the river in 2003/2004, together they accounted for less than 5% of total macrophyte biomass (Quinlan et al. 2008). Seasonal differences in biomass were observed in 2003/2004 but not in the 1950s. Estimated biomass for SAV in the summer was almost the same in 2003/2004 (584 g dry weight/m^2) as in the 1950s (578 g dry weight/m^2). Odum did not report a difference in biomass in the winter, while Quinlan et al. (2008) found that in the winter it decreased to a mean of 426 g dry weight/m^2.

The composition of epiphytic communities sampled by Quinlan et al. (2008) (largely diatoms, filamentous green algae, and filamentous cyanobacteria) was very similar to what was reported by Odum (1957), but biomass estimates were much higher in 2003-2004 than in the 1950s. The

biggest change in 50 years in primary producers was the increase in benthic algal mat biomass (largely the cyanobacteria, *Lyngbya wollei*). Odum did not consider the mats as important components of the system in terms of biomass, while Quinlan et al. (2008) reported average algal mat biomass estimates similar to those of SAV, particularly in the summer (641 g dry weight/m^2(±247 g/m^2)).

4.4.2 Mussels and fish in the Silver River

Walsh and Williams (2003) surveyed mussel and fish species at various sites along the Silver River, from the head springs area to its confluence with the Ocklawaha River. They collected five species of native mussels, the most common by far being *Elliptio* sp. comprising 89% of the total number of specimens. One non-native species was found, the Asian clam (*Corbicula fluminea*) and represented 8.8% of the total number of samples collected.

A total of 29 species of fish from 22 genera and 15 families were also collected (Walsh and Williams 2003). The most common species, in terms of relative abundance, included the redeye chub (*Notropis harperi*) (13%), the eastern mosquitofish (*Gambusia holbrooki*) (11.5%), the sailfin molly (*Poecilia latipinna*) (10%), and the spotted sunfish (*Lepomis punctatus*) (10.1%). One non-native species was found, the vermiculated sailfin catfish (*Pterygoplichthys disjunctivus*), a South American species introduced into west central Florida. Walsh and Williams (2003) stated that this collection was the first documented occurrence of the fish in the Ocklawaha River tributary. By combining their survey with collections in the Florida Museum of Natural History and those listed by Hubbs and Allen (1943), Walsh and Williams (2003) estimated that at least 41 species have been reported for the Silver River. An additional species not listed in the Walsh and Williams (2003) study, the blue tilapia (*Tilapia aurea*) was observed in the spring run by Munch et al. (2006).

4.4.3 Other vertebrates

Five species of turtle, one of which was not identified, were seen along the Silver River in a combined four days of visual observations (Munch et al. 2006). The identified species include the following (in order of decreasing abundance): the peninsula cooter (*Pseudemys peninsularis*), the Florida red bellied cooter (*Pseudemys nelsoni*), the soft shelled turtle (*Apalone ferox*), and the common snapping turtle (*Chelhydra esrpentina*). Twelve bird species were observed during these same four days. The double crested cormorant (*Phalacrocorax auritus*) and the white ibis (*Eudocimus albus*) were the most commonly observed species. Additionally, juvenile and adult alligators (*Alligator mississippiensis*) were along the river. There is a population of Rhesus macaques (*Macaca mulatta)* living in the floodplain forests surrounding the Silver and Ocklawaha rivers. They were introduced to an island on the Silver River in the 1930s to add an exotic element to the Jungle Cruise boat ride. Excellent swimmers, the monkeys quickly colonized the woods on either shore and have been residents there ever since.

5 Economic Value

Silver Springs provides significant economic value to central Marion County. That value is directly dependent upon the physical and biological health of the system. Visitors come to the springs and river for a variety of reasons: sightseeing, boating, or riding in one of the world famous glass-bottom boats. If the springs and river became severely impacted by declining flows

or poor water quality, or some combination of the two, the impact on the local economy would likely by severe.

A recent study by Bonn (2004) of the economic impact of several springs including the Silver Springs Nature Park (the Attraction) estimated that 1 million visitors contribute over $60 million to the local economy annually, creating 1,060 full- or part-time jobs with a payroll of $12.61 million (Bonn 2004). More than 70% of the visitors came from outside of Marion County. Unlike other Marion County springs, the seasonality of visits to Silver Springs is distributed fairly evenly throughout the year, leading to a more stable contribution to the local economy than if visits were highly seasonal. The data from this study are shown in **Table 5-1**.

Table 5-1. Data from Bonn (2004) of the Economic Impact of Six Springs

Spring	Economic Impact	Wages & Salaries	Jobs	Number of Visitors (Person days)	Non-resident visitors
Silver	$61,450,000	$12,610,000	1,060.5	1,095,000	70%
Silver Glen	$348,770	$66,360	5.63	39,235	70%
Alexander	$775,520	$170,240	13.6	55,819 (Day); 21,414 (Camp)	68%
Apopka	$28,520	$5,940	0.52	5,776	70%
Bugg	$11,660	$2,420	0.21	2,888	61%
Ponce de Leon	$2,185,440	$425,600	36.11	259,000	72%
Gemini	$322,870	$68,910	6.26	57,755	64%
Green	$81,550	$16,870	1.53	14,439	64%

Source: Bonn 2004

There have been other studies to determine the economic value of certain natural resources in the state of Florida. The Florida Park Service does an annual analysis of the economic impact of all the parks in their system on the local economies where each park is located. The report for 2009/2010 revealed a cumulative $950 million impact generating $66 million in state sales taxes and supporting 18,900 jobs.

Florida State University studied the economic impacts of Ichetucknee, Volusia Blue, Wakulla, and Homosassa Springs in 2003 (**Table 5-2**). This study (Bonn and Bell 2003) measured spending on lodging, restaurants, groceries, transportation, shopping, entertainment, and admissions fees to parks. It used a formula that assumed additional expenditures by visitors beyond the studies done by the Florida Park Service. The study noted that Volusia Blue was the only park to have a decrease in attendance over a ten year period (1992-2002) despite being close to Orlando and Daytona Beach. This appeared to be related to environmental degradation suggesting that the quality of the springs affected the attendance and thus the economic impact.

Hazen and Sawyer (2008) estimated the total value provided to Volusia, Brevard, Stuart, St. Lucie, and Indian River counties by the Indian River Lagoon. The total impact calculated was $3.725 billion. The estimate included annual recreational expenditures of $1.302 billion, real estate values directly related to the proximity of the lagoon of $934 million annually, $629.7 million worth of income for jobs directly related to the lagoon restoration, $91 million worth of

expenditures for research and education, and $3.8 million in the dockside value of commercial fishing products. In addition to these "revealed preferences," there were additional "stated preferences" for a recreational use value of $762 million and a nonuse value of $3.4 million. The real estate value represents almost 22% of the total value of property in the area. The study predicted that the stated preferences would increase with an increase in the amount and diversity of wildlife in the lagoon which demonstrates a direct correlation between willingness to pay and the quality of the local environment as a contributor to quality of life.

Table 5-2. Data from Bonn and Bell (2003) of the Economic Impact of Four Springs

Spring	Economic Impact	Wages & Salaries	Jobs	Number of Visitors	Non-Resident Visitors
Ichetucknee	$22.7 million	$5.09 million	311	188,845	90%
Wakulla	$22.2 million	$4.33 million	347	180,793	70%
Homosassa	$13.6 million	$3.13 million	206	265,977	64%
Volusia Blue	$10.0 million	$2.38 million	174	337,356	65%
Average	**$17.13 million**	**$3.73 million**	**259.5**	**243,243**	**70.48%**

Source: Bonn and Bell 2003.

A study conducted at Jackson Blue Spring in Jackson County (Morgan and Huth 2011) estimated the economic benefits of cave diving. It found that at this spring $575,000 was spent annually by cave divers at a rate of $1,075 per person per year. Divers were also asked how their spending would change if access was improved and if a privately owned spring was opened for diving. Divers stated they would spend an additional $150 per person per year or about $82,000 total in new expenditures per year.

A survey conducted in the Ocala National Forest by Shrestha et. al. (2002) asked visitors questions regarding the current state of facilities, recreation opportunities, food and supplies, rentals, interpretive activities, and overnight accommodations and their willingness to pay additional expenses for improvements to park facilities. The survey estimated that visitors were willing to pay $1 million for basic facilities, $1.9 million for moderate improvements, and $2.5 million for high quality improvements.

Recommendation

A comprehensive study of the economic contribution of Silver Springs and River to central Marion County should be conducted using a similar methodology to the Hazen and Sawyer study described above. This study should be done together with a similar analysis of the value of Rainbow Springs and River. There is often considerable controversy about expenditures needed for proposed environmental improvements e.g., expenses needed to upgrade septic systems or to change farm practices over to best management practices (BMPs). A clear understanding of the economic value that Silver Springs and River create would provide an estimate of the cost of inaction, if that inaction leads to the demise of the quality of the resource and therefore the loss of the economic contribution.

6 Existing Legal Protections

Federal, state, and local protections in place for Silver Springs are shown in T**ables 6-1, 6-2**, and **6-3** below.

Table 6-1. Federal Laws and Policies that Apply to the Silver Springs and River and Silver Springs Basin

Federal Policy/Regulations	Entity	Resource Protected	Type of Protection	Permit or Approval
Rivers and Harbors Act, 1899 Sections 9 and 10	USACE	Water and Wetlands	Prohibits unauthorized construction in or over navigable waters of the U. S.	Yes
Clean Water Act, 1972 Amended 1977 Section 404 (33 CRF Parts 320-330) NPDES Permit Wastewater Stormwater (40CFR Parts 122,123,124)	USACE	Water and Wetlands	Controls discharge of dredged or fill material into waters of the US Permit requirements for wastewater treatment plants Directs States to develop Total Maximum Daily Loads(TMDLs)	Yes USACE EPA
Fish and Wildlife Coordination Act of 1956	USACE	Water and Wetlands	Requires USACE to coordinate permit applications with state and federal fish and wildlife agencies	No
Archaeological and Historical Preservation and Protections Acts, 1974 PL 74-292; 16 U. S. C. 461*et seq* PL 93-291; 16 U. S. C. 469 PL 89-665; 16 U. S. C. 470 PL 96-95 ; 16 U. S. C. 470aa-11	Dept. of Interior	Archeological and Historic	Establishes policy, programs, rules, and regulations regarding the preservation and protection of archeological and historic resources. Establishes civil and criminal penalties for unlawful excavation and removal.	Yes for excavation and removal
Endangered Species Act of 1973 PL93-205; 16 U. S. C. 1531 *et seq*	FWS/ NMFS	Species & Habitat	Protects all marine and non-marine endangered and threatened species and the critical habitat on which they depend.	Yes
Executive Order of 1979, Creation of Federal Emergency Management Agency	FEMA	Flood Plain	Provides flood insurance and provides guidance on building codes and floodplain management	No
National Environmental Protection/Policy Act (NEPA), 1970 PL 91-190; 42 U. S. C. 4321-4370d	CEQ	Land and Water	Requires federal agencies to prepare reports including an Environmental Impact Statement (EIS) for all 'major federal actions significantly affecting the quality of the human environment. An Environmental Assessment (EA) may be performed first with recommendations for either Findings of No Significant Impact (FONSI) or that an EIS is necessary.	Yes
Soil Conservation Act (16 U.S.C. 590a)	NRCS	Land and Water	Directs NRCS to prevent soil erosion through local regulations and watershed improvement projects	

Table 6-2. State of Florida and Regional Agencies Laws and Policies that Apply to the Silver Springs and River and Silver Springs Basin

State of Florida Policy/Regulations	Entity	Resource Protected	Type of Protection	Permit Approval Agency
Florida Aquatic Preserves Act, 1975 F.S. Part II Chapter 258, F.A.C. 18-20	FDEP	Water	Sets the intent of the establishment of the state's aquatic preserve system and sets guidelines for administration and management of the preserves. Addresses the need to manage cumulative impacts within and surrounding the preserve, protection of indigenous life forms from sale or commercial use and the need for resource inventories and management plans for each preserve.	FDEP
Outstanding Florida Water (OFW) F.S. , 1979 Silver designation 1988 (62-302.700 F.A.C.). (Rule 62-302.700(9), F.A.C.)	ERC & FDEP	Water	Prohibits direct and indirect pollutant discharges that would lower the existing water quality. Permits for dredging and filling have to be in the public's interest. Establishes a process for designating Outstanding Florida Waters (OFW) worthy of special protection with more protective standards.	FDEP or SJRWMD
Warren S. Henderson Wetlands Protection Act, 1984 (403. 92-. 938,FS)	FDEP & WMD	Water and Wetlands	Regulates activities in wetlands considered to be waters of the state. Note – Florida and USACE have permitting jurisdiction; Florida's rules require a hydraulic connection to surface water, USACE does not.	FDEP or WMD
Management and Storage of Surface Waters, (Ch. 40C-4, Ch. 40C-40, and Ch. 40C-41, F. A. C. , Sec 403, FS)	WMD	Water and Wetlands	Establishes standards and permit requirements for the management, consumptive use, and storage of surface waters including stormwaters and impoundments.	WMD
Surface Water Quality Standards (Rule 17-302. 400, F. A. C.)	FDEP	Water	Establishes surface water classifications for specific uses and corresponding water quality standards.	FDEP
Local Government Comprehensive Planning and Land Development Act, 1985 (Ch. 163.3161-163.3243, F. S. ; Ch. 9J-6, 9J-24, F. A. C.	FDCA	All	Directs local governments to adopt comprehensive plans and land development regulations; outlines rules and minimum criteria; and outlines elements to be included in plans. Ch. 380, F. S. establishes criteria for Developments of Regional Impact (DRI).	FDCA, RPCs, Local Government
Environmental Resource Permits Chapter 40C-41, F.A.C	WMD	All	Lays down guidelines for permit requirements in surface water management.	SJRWMD, Local Government
RPC Policy Goal 4.10 & 4.11 July 1998	EC Florida RPC	Water Resources	Best management practices (BMPs) will be practiced for control of erosion and sedimentation. The hydrological and ecological functioning of the region's river systems is protected.	DCA, RPCs, Local Government
RPC Policy Goal 4.24 July 1998	EC Florida RPC	Wetlands	Ensuring protection of rare or endangered ecosystems (identified in state, regional or local lists & inventories).	DCA, RPCs, Local Government
RPC Policy	EC	Habitat	Establishment of buffer zones encouraged to protect water quality and quantity and	DCA, RPCs,

Table 6-2. State of Florida and Regional Agencies Laws and Policies that Apply to the Silver Springs and River and Silver Springs Basin

State of Florida Policy/Regulations	Entity	Resource Protected	Type of Protection	Permit Approval Agency
Goal 4.29 &.30 July 1998	Florida RPC		to provide habitat for semi-aquatic or water dependent terrestrial wildlife. Recommendation of locating these buffer zones landward of regionally existing wetlands. It states that natural vegetative communities (native plants and animals) shall be conserved and protected to ensure their existence in the future (encouraged through comp. plans for local areas to establish adequate conservation areas, open spaces, river buffers, etc.).	Local Government
Impaired Waters Rule (Ch. 62-303 FAC)	FDEP	Water	Established a methodology for identifying Impaired Florida Waters and the calculation of TMDLs for those bodies of water.	
Springs Protection Act, July 2006	Florida Senate	All	Provides for the creation of the Florida Springs Commission, whose duty is to identify strategies that will protect, restore, and preserve Florida's springs. Lays out minimum requirements for assessment information and model plans for the springs.	

Table 6-3. Counties and Local Municipalities with Policies and Comprehensive Plan Amendments applying to the Silver Springs and River and Silver Springs Basin

Policy/Regulations	Entity	Resource Protected	Type of Protection	Permit Approval
Marion County Board of County Commissioners- Land Development Code, Amendment 14, Section 6.4- Springs Protection Ordinance	Marion Co.	All	The objective of the Springs Protection Ordinance is: "to preserve the quantity and protect the quality of the Floridan Aquifer underlying all of Marion County and to protect the environmental, recreational, and economic values of Silver Springs and Rainbow Springs in the interest of public health, safety and general welfare. This is to be accomplished by regulating land uses and activities which can adversely impact the quality and quantity of groundwater within the identified Springs Protection Zones (SPZ)." **Sec 6.4.4** Establishes boundaries for the primary and secondary SPZ. **Sec 6.4.5.A** Lists prohibited activities within the Primary SPZ **Sec 6.4.5.B** Lists permitted uses with conditions, including design requirements set forth for "New and expanding golf courses," "New and existing auto salvage yards within the Secondary SPZ," "New and expanding uses which store and/or stock fertilizers, pesticides, and pool and spa chemicals," "Hazardous Materials and Waste Facilities," "Construction and Demolition Debris (C&DD) Disposal Facilities," "Mining Operations," and "Heavy Industrial and Commercial Uses" **Sec 6.4.5.C** Provides detailed restrictions on agricultural uses within the SPZ,	

Table 6-3. Counties and Local Municipalities with Policies and Comprehensive Plan Amendments applying to the Silver Springs and River and Silver Springs Basin

Policy/Regulations	Entity	Resource Protected	Type of Protection	Permit Approval
Section 8.2.10 Landscape Standards and Tree Preservation			including the prohibition of Concentrated Animal Feeding Operations, restrictions on manure handling within the SPZ, required use of fertilizer BMPs, and so forth. **Sec 6.4.6.B** Provides design standards for general purposes, very detailed standards (7 pages worth) for "domestic wastewater management," and detailed standards (2-3 pages) for "water supply management," "natural groundwater recharge protection," "stormwater runoff management," and "karst feature protection." **Sec's 8.2.10.d-i** Require permitting for certain tree removals, set minimum standards for tree replacement requirements (and maintenance standards for those replacement trees), require protection for trees not cleared for removal during development, and lay down regulations for inspections and enforcement of adhering to these standards **Sec 8.2.10.k** Provides regulations concerning the maintenance of native vegetation, landscaping with native vegetation, and regulations on the minimum amount of land that must be landscaped in non-residential, new residential, or mixed use development. It also provides guidelines for buffering practices, irrigation design standards, and other protections. **Sec 8.2.10.i** Sets limitations on amount of coverage allowable for high and low volume irrigation.	
Marion County Code of Ordinances Ch. 5, Boats, Docks and Waterways: Article I. Ch. 5, Boats, Docks and Waterways: Article IV. Ch. 5.5, Building and Building Regulations Ch. 16, Solid Wastes Ch. 17, Special Assessments: Article IV.	Marion Co.	Water, habitat Water, habitat Water Water	**Sec. 5.2** disallows scuba diving in the headwaters of Silver River to a point 3,000 yards down river from the headwaters. **Sec 5.53** prevents the use of any motorcraft in a designated Environmentally Sensitive Area Provides regulations for building/ construction **Sec 5.5-33** lays down guidelines for permitting, including stormwater drainage regulations Provides regulations for solid waste management **Sec 17-111** establishes a stormwater management program **Sec 17-112** establishes a stormwater management services fund. Services and facilities for stormwater management will be provided through stormwater assessments	

Table 6-3. Counties and Local Municipalities with Policies and Comprehensive Plan Amendments applying to the Silver Springs and River and Silver Springs Basin

Policy/Regulations	Entity	Resource Protected	Type of Protection	Permit Approval
Ch. 19, Water and Sewers: Article II.		Water	**Objectives:** "To prevent the introduction of pollutants into the publicly owned treatment works that will interfere with its operations; To prevent the pass through of pollutants into the publicly owned treatment works and subsequently into receiving waters; To protect both personnel who may be affected by wastewater and sludge in the course of their employment, and the general public; To promote reuse and recycling of industrial wastewater and sludge; To provide for fees for the equitable distribution of the cost of operation, maintenance, and improvement of the publicly owned treatment works; and To enable the county to comply with its national pollutant discharge elimination system permit conditions, sludge use and disposal requirements and any other federal or state laws to which the publicly owned treatment works is subject."	
Article IV.		Water	**Objectives:** "to implement procedures that promote water conservation through the more efficient use of landscape irrigation." **Sec 19-223** Sets a schedule for when irrigation is allowed. Exceptions to this schedule are provided in section 19-224	
Article V.		Water	**Objectives:** "This article regulates the proper use of fertilizers by any applicator; requires proper training of commercial and institutional fertilizer applicators; establishes training and licensing requirements; specifies allowable fertilizer application rates and methods, fertilizer-free zones, low maintenance zones, and exemptions. This article requires the use of best management practices which provide specific management guidelines to minimize negative secondary and cumulative environmental effects associated with the misuse of fertilizers." **Sec. 19.249** disallows the application of fertilizer to turf grass within 75 feet for the ordinary high water line of Silver Springs and Silver Run.	
Marion County Land Development Code: Article 5, Zoning	Marion Co.		**Sec 5.3** provides zoning classifications for the unincorporated area of Marion County, helping regulate the flowing: "the location, height, bulk and size of buildings and other structures; the percentage of the lot, tract, or parcel which may be occupied; the size of lots, tracts or parcels, courts and green spaces; the density and distribution of population; the location and uses of land, buildings and structures for trade, industry, residential, recreation, public activities or other purposes."	
Article 6, Overlay Zones		All	**Sec 6.2** establishes Environmentally Sensitive Overlay Zones (ESOZ) to protect native habitats, vegetation, wetlands, and other sensitive areas. It lays out regulations that developers must abide by.	

Table 6-3. Counties and Local Municipalities with Policies and Comprehensive Plan Amendments applying to the Silver Springs and River and Silver Springs Basin

Policy/Regulations	Entity	Resource Protected	Type of Protection	Permit Approval
Article 12, Wellhead Protection		Water	**Sec. 12.4** establishes Wellfield Protection Areas to protect potable water quality. **Sec. 12.7** defines hazardous substances or materials	
Marion County Comprehensive Plan	Marion Co.	Water	**Sec. 1.11** Requires the existence of a buffer zone around new development when adjacent to existing incompatible land uses **Sec. 1.22** Land Development Regulations will contain standards protecting springs and springsheds. Some restricted/prohibited practices are listed. **Sec. 4.2** Listing of developmental design standards designed to protect recharge/ springs areas. Addresses impervious surface coverage, stormwater collection, hazardous materials, and so forth. **Sec. 4.5c** "Resource extraction which will exacerbate or result in an adverse effect on springs and environmentally sensitive areas which cannot be restored shall be prohibited." **Sec. 4.5d** Springs and other environmentally sensitive areas will be protected from mining activities in surrounding areas and by buffer zones surrounding them. **Sec. 4.9j** "Establish a Springs Protection Zone (SPZ), that includes the Primary and Secondary Zone, that are additional, but distinct parts of the ESOZ." **Sec. 13.0** Discusses implementation of a Transfer of Development Rights program designed to protect natural resources including springs/high recharge areas.	
Code of Ordinances (Ord. No. 2008-12, § 1, 1-12-2009)	City of Dunnellon		**Sec. 97** Promotes environmentally sensitive and efficient uses of agricultural land, lists functions of the conservation subdivision of the code of ordinances (chapter 97).	
Unified Land Development Code	Alachua Co.		**Sec. 406.41** states that no alteration shall occur in, on or over a surface water (includes springs), wetland, or buffer area, and that no alteration shall occur adjacent to a connected surface water that changes the water regime in a way that prevents hydroperiod or function maintenance. **Sec. 406.43** sets guidelines for water resource buffers, including minimum and average buffer distances for different protected water resources. **Article 8**, entitled "Springs" is currently reserved and unavailable as it is being rewritten (accurate as of 2/7/2011) **Sec. 406.58** defines high aquifer recharge areas, and section **406.59** lays down standards and restrictions that apply to both stormwater and hazardous materials. **Sec. 406.61** provides a delineation of wellfield protection zones and section **406.62** lays out restrictions for each classification of protection zone. **Sec. 406.70** states that all new wastewater treatment plants in high aquifer recharge areas or in semiconfined or unconfined areas must provide advanced treatment that includes nutrient removal prior to discharge. Existing plants in high aquifer recharge	

Table 6-3. Counties and Local Municipalities with Policies and Comprehensive Plan Amendments applying to the Silver Springs and River and Silver Springs Basin

Policy/Regulations	Entity	Resource Protected	Type of Protection	Permit Approval
Unified Land Development Code	Alachua Co.		areas must be upgraded to these same standards. Also provides regulations on surface water/ wetland discharge, deep well injection processes, spray irrigation, the use of infiltration basins and absorption fields, and land application of biosolids. **Sec. 406.90** protects important geological features including sinkholes, caves, springs, springsheds, and so forth. Includes onsite protection, buffering standards, habitat function maintenance, use of BMPs, and mitigation of adverse impacts. **Sec. 406.91** provides special requirements for sinkholes, including management strategies for protection and restoration. **406.92** provides protection for karst features, including requirements of a 3-ft distance between stormwater basins and limestone bedrock, studying water bodies to determine aquifer connectivity, subsurface channel analysis and regulations, and the stipulation that no septic systems are permitted in the subsurface channel area. **Sec. 406.101** prohibits discharge of waste or stormwater into conservation management areas with some listed exceptions. **Sec. 406.113** minimizes adverse environmental impacts of storm and waste water by maximizing treatment processes and siting septic tanks and drainfields in places that will have the smallest impact on natural and historical resources.	
Comprehensive Plan, Conservation and Open Space Element	Alachua Co.		**Policy 3.5.3** states that LDRs will address surface and groundwater quality **Policy 3.6.8.2** sets minimum and average buffer widths for surface waters and wetlands of varying sizes **Policy 4.2.5** states that development will retain the natural character of important shallow groundwater tables. **Policy 4.2.8** states that stormwater outfall and irrigation connections must be designed to prevent erosion and sedimentation **Policy 4.3.1.3** LDRs will have provisions that minimize adverse impacts of mining on surface and ground water quantity and quality **Policy 4.3.4** groundwater quality will not be significantly impacted through mining extractions. **Policy 4.4.4** pretreatment of stormwater and wastewater will be required prior to any	

Table 6-3. Counties and Local Municipalities with Policies and Comprehensive Plan Amendments applying to the Silver Springs and River and Silver Springs Basin

Policy/Regulations	Entity	Resource Protected	Type of Protection	Permit Approval
Comprehensive Plan, Conservation and Open Space Element	Alachua Co.		discharge to any karst features. **Policy 4.4.5** provides for the protection of groundwater in watersheds with sinks or open pits that act as aquifer connections and are subject to harmful deposition of atmospheric and non-point source surface pollution. **Policy 4.4.6** provides for management of sinkholes and sinkhole-prone areas that will protect water quality, hydrologic integrity, and ecological value. **Policy 4.5.1** provides for the establishment of a wellhead protection program. **Policy 4.5.2** lays down standards that apply to public wells until wellfield protection areas are established, including a 200-ft zone with no new development allowed and uses that are prohibited in the vicinity of public wells. **Policy 4.5.4** suggests a possible tax reduction for property owners who agree to use their property only for genuine high-water recharge purposes as defined in the Florida Statutes. **Policies 4.5.5-7** protect groundwater in high aquifer recharge areas through suggesting restrictions on development, stormwater practices, hazardous materials, septic tanks, treatment plants, land use restrictions, and so forth. **Policy 4.5.8** requires that applicants for new development sufficiently address potential groundwater quality impacts. **Policy 4.5.10** requires evaluation of development that involves large withdrawals of ground water, and states that the county will act to utilize reuse and reclaimed water as well as conserve water. **Policy 4.5.11** prevents the transfer of water out of the county except under emergency situations. **Policy 4.5.13** establishes a groundwater monitoring program that includes springs, with minimum requirements laid out in **policy 4.5.14**. **Policies 4.5.15-16** address abandoned or existing facilities that may be contaminating groundwater resources. **Policies 4.5.17-20** provide guidelines and limitations for redevelopment and	

Table 6-3. Counties and Local Municipalities with Policies and Comprehensive Plan Amendments applying to the Silver Springs and River and Silver Springs Basin

Policy/Regulations	Entity	Resource Protected	Type of Protection	Permit Approval
			restoration of contaminated sites, as well as the disposal of wastewater treatment effluent. **Section 4.6** deals with surface water systems, including the protection of the hydrology and function of surface waters (4.6.4), buffering (4.6.5, 4.6.6, 3.6.8), maintenance of wetlands and native vegetation (4.6.7-8), controlling invasive species (4.6.9), creation of a water monitoring program (4.6.10), pollutant discharge (4.6.15), wastewater and stormwater standards/requirements (4.6.17-22), restoration of natural flows (4.6.24), and so forth. **Policy 7.4.2** sets standards for new and existing septic tanks.	
Comprehensive Plan, Future Land Use Element	Lake Co.		**Policy 1.1.6** requires connection to a public sewer system where available and provides limitations on septic tank permissions. **Policy 1.1.13** lays out regulations such as maximum impervious coverage for different land use types	
Public Facilities Element, Sanitary Sewer Sub-Element	Lake Co.		**Policy 6A** sets guidelines for wastewater treatment and disposal, including quality standards of generated wastewater and design and construction standards for wastewater management.	
Solid Waste Sub-Element			**Policy 6B-1** provides for an integrated solid waste management system, including an emphasis on recycling program implementation **Policy 6B-2** provides ways to encourage, support and provide facilities for hazardous (and hazardous-exempt) waste management and disposal.	
Stormwater Sub-Element			**Policy 6C-1** states that degrading surface and groundwater quality will be corrected, and that aquifer recharge will be enhanced with stormwater management where practical so long as water quality is not adversely affected. **Policy 6C-5** states that stormwater management systems will be regulated and designed to protect the quality and quantity of surface waters, groundwater, recharge areas, springs, and springsheds.	
Natural Groundwater Aquifer Recharge Sub-Element			**Policy 6E-1** protects the quality and quantity of surficial and Floridan aquifers, and protects and enhances the capabilities of groundwater recharge areas. **Policy 6E-2** prevents contamination of aquifer resources through limiting underground storage tank pollution	

Table 6-3. Counties and Local Municipalities with Policies and Comprehensive Plan Amendments applying to the Silver Springs and River and Silver Springs Basin

Policy/Regulations	Entity	Resource Protected	Type of Protection	Permit Approval
Conservation Element			**Policy 7-1** provides details for an environmental resource management plan, which includes the identification of groundwater contamination problem areas, creation of surface water quality and restoration plans, groundwater management plans, and other protections for surface and ground water resources. **Policy 7-2** protects high groundwater recharge areas. Requires hydrological reports for development sites within these areas, and lays out restrictions such as impervious surface coverage, land use strategies, landscape irrigation reduction, protection from saline intrusion, and so forth (7-2.2). Prohibits land uses that are known threats to groundwater availability or quality (7-2.9), and restricts the use of potable water for landscape irrigation (7-2.10). Provides restrictions on withdrawals where saltwater intrusion is a possibility (7-2.12). Injection wells are prohibited (7-2.13), surface waters with hydrological connection to the aquifer will be highly regulated (7-2.14), and wastewater as well as septic tank use will be regulated as well (7-2.15-16). Wellfields will be surrounded by a 200-ft zone of exclusion (7-2.18). **Policy 7-3** aims protect surface water quantity and quality by reducing levels of pollution intrusion, restoring damaged hydrological processes, and avoiding excessive groundwater drawdowns. **Policy 7-4A** aims to protect and restore springsheds and associated areas such as caves, karst features, sinkholes, recharge areas, springs, and seeps. Encourages education (7-4A.4), silvicultural and agricultural BMP use (7-4A.6), use of Florida-Friendly Landscaping (7-4A.8), land use and stormwater regulations (7-4A.9-10), designation of a minimum open space coverage in springsheds (7-4A.12), implementation of existing BMPs on golf courses (7-4A.15), and so forth. **Policy 7.5** aims to prevent a net loss in wetlands functional value or extent.	
Code of Ordinances, Appendix A, Chapter VI: Resource Protection Standards	Lake Co.		**Policy 6.09.02** provides standards for the protection of groundwater aquifer and recharge areas. **Policy 6.10.01** provides very detailed standards for water quality, and prohibits the act of exceeding these standards. Also requires that high quality receiving waters only be introduced to the highest and best practical treatment available. **Policy 6.11.00** deals with waste treatment, laying out water quality testing requirements, stormwater and surface drainage requirements, operational details for pollution control structures, and regulatory requirements for waste treatment effluent	

Table 6-3. Counties and Local Municipalities with Policies and Comprehensive Plan Amendments applying to the Silver Springs and River and Silver Springs Basin

Policy/Regulations	Entity	Resource Protected	Type of Protection	Permit Approval
			disposal and agricultural waste. **Policy 6.12.01** sets connection requirements for private water and treatment systems with central water and sewage systems. **Policy 6.14** provides detailed regulations for golf course development, including environmental protection standards, water resource requirements, habitat and vegetation conservation, pollution prevention, land use and open space details, and alterations (some incentive-based) to existing courses.	
Code of Ordinances, Chapter 34: Environment Chapter 118: Trees, Landscaping and Other Vegetation	City of Ocala		**Sec. 34-94** makes it unlawful to allow any sewer or drain carrying refuse, waste material, or putrid matter of any kind to empty into any surface water or water retention area. **Sec. 118-101** sets minimum tree coverage requirements, depending on the zoning classification of the site of interest. **Sec. 118-102** sets requirements for tree preservation and maintenance.	
Comprehensive plan, Future Land Use Element Infrastructure Element, Stormwater Management Sub-Element	City of Ocala		**Policy 4.2** States that new or replacement septic systems are disallowed if sewer service is available within one-eighth mile of the development **Policy 8.1** identifies incompatible land uses and disallows these uses within 1500 ft of a city well. Also, landfills, bulk storage/ processing/ handling of toxic waste, mines, wastewater treatment, percolation ponds, and similar facilities are all disallowed in the 1-year zone of influence. **Policy 8.3** promotes xeriscaping and the use of native vegetation in landscaping. **Policy 8.4** provides for the elimination or filtering of drainage wells. **Policy 8.7** provides for the protection of groundwater resources, floodplains, and other environmentally sensitive areas during the development review process. **Policy 2.3** provides for the control of point sources of groundwater pollution through restrictions in the amount and location of heavy industrial land uses that may cause harm to groundwater quality. **Policy 2.5** provides for the maintenance of sinkhole repair programs. **Policy 2.6** requires 20 ft vegetated buffer areas around sinkholes that are environmentally sensitive areas.	

Table 6-3. Counties and Local Municipalities with Policies and Comprehensive Plan Amendments applying to the Silver Springs and River and Silver Springs Basin

Policy/Regulations	Entity	Resource Protected	Type of Protection	Permit Approval
Conservation Element	City of Ocala		**Policy 2.7** requires that stormwater runoff be treated in accordance with standards set in policy 2.2 of this sub-element. **Policies 3.1-2** require that water retention areas and stormwater collection and conveyance facilities are constructed with the capacity to deal with a 10 year, 24-hour storm event. **Policy 3.3** requires that stormwater discharge facilities must not degrade the water quality of the receiving water body below minimum standards elaborated in this section. **Objective 1** provides for the inventory and classification of natural resources that include sinkholes, wetlands and floodplains as properties are annexed to the city. **Policy 3.2** sustains the disposal of reclaimed water for irrigation and other acceptable uses at or above 90% of the volume generated. **Policy 3.3** recommends an inverted block rate structure for potable water consumption charges to be established based on studies commissioned by the Water and Sewer Department. **Policy 3.4** promotes enforcement of the adopted Southern Building Code as a means to conserve water. **Policy 3.5** controls point sources of groundwater pollution by restricting land uses that will significantly diminish groundwater quality and quantity. **Policy 3.6** prohibits potentially polluting land uses within 1500 ft of city public wellfields. **Policy 5.1** promotes development and enforcement of land development regulations that preserve natural resources such as floodplains and wetlands. **Policy 5.3** requires the use of BMPs to reduce soil erosion during development. **Policies 5.4-5** prohibits development within the 10- or 100- year floodplains without provisions that provide flood storage equal to or greater than the volume displaced by the development.	

Table 6-3. Counties and Local Municipalities with Policies and Comprehensive Plan Amendments applying to the Silver Springs and River and Silver Springs Basin

Policy/Regulations	Entity	Resource Protected	Type of Protection	Permit Approval
			Policy 5.6 designates certain sinkholes as environmentally sensitive areas. **Policy 7.1.1** prohibits "development activity impacts to wetlands prior to wetland evaluation and classification" **Policy 7.1.2** requires that the developer inventories, analyzes, and evaluates on-site wetlands and will assess their significance in terms of maintaining the health of the site's watershed. **Policy 7.1.3** requires that the developer must establish easements to protect wetlands.	
Code of Ordinances, Article V: Individual Sewage and Disposal Systems	Putnam Co.	Water Quality	**Sec. 18-138** waste and effluent from individual on-site sewage disposal systems cannot be directly discharged onto the ground surface or into ditches, drainage structures or public waters.	

7 Causes of Impairment and Threats

The Silver River was declared impaired by FDEP in 2009 on the basis of high nitrate readings leading to an imbalance of flora and fauna caused by algal smothering (particularly the blue-green algae *Lyngbya wollei*) of SAV within the spring pool and upper spring run. Nitrate readings in Silver Springs now are regularly at or above 1.2 mg/L. This represents a significant change since the original ecological study done by Odum in the 1950s and represents an approximately 24 fold increase over background levels of 0.05 mg/L.

Nitrate readings above 0.4 mg/L have been observed to cause toxic effects on macroinvertebrates. Nitrates are a byproduct of many human activities including fertilization (e.g., agriculture, golf courses, lawns) and human and animal waste disposal practices.

Threats to The Silver River

In addition to the reasons why the Silver River has been declared impaired, there are threats that need to be addressed if the river is to tbe fully restored.

Decreased flow: Flow to Silver Springs has decreased by approximately 20-35% over the last three to four decades. This decrease is due to a variety of causes including decreased recharge due to lower than average rainfall in the last decade, increased human consumption of water, and possibly a migration of groundwater towards Rainbow Springs. There is a lot of uncertainty surrounding the data that supports this issue (according to several senior staff at SJRWMD).

Exotic Flora and Fauna: *Hydrilla verticillata* is common in the lower spring, possibly exacerbated by high nitrate concentrations. The armored catfish is common in the Silver River and their burrows undermine bank stability along its entire length.

Modified fish and mammal populations: The construction of the Rodman Dam limited the movement back and forth of several fish species (channel catfish and mullet in particular) as well as manatees. The fish populations observed at Silver Springs today are significantly different than those seen there in the 1950s by Odum during his famous studies.

Vision for a Restored Silver Springs and River

A Vision for Silver Springs and the Silver Springs Basin

Silver Springs is once again silver. The Main Spring basin glows like a jewel in the warm Florida sun. A globally significant artesian spring, Silver Springs is a "must see" destination for any visitor interested in experiencing "Natural Florida." Silver Springs and the Silver River form a healthy, sustainable, and diversified ecosystem. Recreational access is excellent and sustainable, low-impact tourism opportunities allow large numbers of visitors to enjoy the resources. The springs and river play an important role in the area's healthy and diverse economy. There is a deep connection and sense of ownership expressed by the community, allowing Silver Springs to be managed in a way that includes a diverse group of stakeholders interested in maintaining its integrity. Plans, policies, regulatory decisions, and land acquisition projects now protect important recharge areas and limit point and non-point source pollution. Educational initiatives are responsible for basin-wide reductions of impairments including decreased nutrients and increased water conservation.

By 2020, the following have been achieved:

- Nitrate concentrations low enough to support a viable, self-sustaining community of historically native fish, wildlife, and vegetation
- Water flows at a minimum of 90% of the historic levels based on officially recorded information
- Reconnection of Silver Springs to the St. Johns River so that fish and wildlife populations can move freely and contribute to a healthy ecosystem

8 Goals and Actions

Goals with some action steps for implementation are presented below in six categories: Biodiversity, Education and Outreach, Land Use and Development, Recreation, Water Quality and Water Quantity (Spring Flow).

8.1 Biodiversity

Silver River has a rich biodiversity both within the stream and along the riparian corridor. The entire course of the river is within the northern section of the Silver River State Park. It includes the river channel, an intact riparian community and floodplain swamp, together with associated upland habitats dominated by hardwood forest.

The in-stream environment has a rich growth of native SAV dominated by strapleaf sagitaria, (*Sagittaria kurziana)* with coontail (*Ceratophyllum demersum)* and fanwort (*Cabomba caroliniana)* being the most common less dominant macrophytes. There is a dense algal biomat present in the majority of the head springs area and spring run that is dominated by *Lyngbya wolleii* with at least four other filamentous species present as well as numerous species of diatoms. There is likely more algal biomass today than there was in prior decades based on observations of earlier studies (Quinlan et al. 2008). Many of these species, most commonly the diatoms, also form an epiphytic community on the leaf surfaces of the SAV.

Macroinvertebrate fauna is diverse with various species of fly larvae dominating. There is a diverse fish population with 41 species represented according to a survey by Walsh and Williams in 2003, including one new exotic species, the vermiculated sailfin catfish (*Pterygoplichys disjunctivus*) introduced from South America. Species richness for birds, fish, and reptiles was studied and found to be similar to the richness observed by Odum in the 1950s. However there were some significant differences at the level of individual species. Odum reported the presence of musk turtles (*Sternotherus odoratus* and *S. minor)*, channel catfish (*Ictalurus punctatus),* and striped mullet (*Mugil cephalus)*, all of which were either absent or significantly reduced in number in the 2003 study. Fish biomass overall was reported to be reduced by 96% since the 1950s with a significant reduction in the two species listed above representing a major reason for the decline.

The river supports a diverse bird population, both aquatic feeders (swimmers, divers, and waders) and forest birds living in the forested floodplain habitat along both shores. Otters are present. Manatees are not often seen although they are reported by staff from the Office of Greenways and Trails to periodically move through the locks at the Rodman Dam, and they have been seen upstream from the Reservoir in the Ocklawaha River.

Threats to the biodiversity of the Silver River include increased numbers of invasive exotic plants such as *Hydrilla* and *Lyngbya,* continued declines in water quality causing the river to become less habitable by species intolerant of pollution, and continued separation of the Silver River from the St. Johns River.

Goals

1. Restore the diversity and quantity of native flora and fauna in the Silver River system.
2. Reduce and control invasive exotic flora and fauna in the Silver River system.

Goals with Suggested Actions

1. Restore the diversity and quantity of native flora and fauna in the Silver River system.
    - Conduct flora inventory and calculate species diversity index.
    - Conduct faunal inventory and calculate species diversity index.
    - Implement use of zoning in the river to protect biodiversity.
    - Identify species in need of specific management actions and develop strategies to address them.

2. Reduce and control invasive exotic flora and fauna in the Silver River system.
    - Inventory location and extent of invasive exotic species.
    - Develop invasive exotic treatment plan for Silver River.
    - Develop invasive exotic education and enforcement program targeting river access locations.
    - Research potential solutions to remove or control Lyngbya.
    - Research potential solutions to remove or control Rhesus macaque.

8.2 Education and Outreach

Education programs to inform citizens about issues associated with the protection of groundwater and springs are widely thought to be an important element of springs protection. It is generally assumed that people do not intentionally use too much water or fertilizer and that they usually do not realize their actions might cause damage. Many people assume their own actions are too insignificant to make a difference. It is hoped that education will fill these gaps and provide people with the necessary information that will guide their future behavior. The extent to which this is true is in some dispute. See discussion of social marketing below.

Education programs that target water conservation and fertilizer reduction in Silver Springs basin are available from the SJRWMD, Marion County, some nonprofit groups, and a variety of one-time events such as Earth Day festivals. SJRWMD centers its education program on its website with downloadable materials under the logo *Water Less* to educate about water conservation during drought conditions. These materials, updated in April 2011, are primarily designed for use by local water authorities, both public and private, and include the following: a printable postcard, a pre-printed newspaper advertisement, a ready to print billboard, a means to directly link any website to the SJRWMD's *Water Less* site, a print-ready poster showing days when watering is allowed, and public service announcements. Additionally, SJRWMD provides more general educational materials on its website including the *Water Conservation Guide*, a Home Use Survey for households to calculate their daily average use, brochures including *Efficient Irrigation Systems, Watering Restrictions* (including a watering restrictions door hanger), and the *Water Conservation Activity Book.* There are also numerous pages on the SJRWMD's website devoted to issues related to water conservation.

Marion County offers several programs associated with stormwater in an attempt to decrease pollutants washing down storm drains. *Ten Things You Can Do* is a document on the Stormwater Division website that provides guidance for Florida Friendly plantings, minimizing fertilizer and irrigation, other water saving tips, used motor oil disposal, septic tank maintenance, and grass clipping management. *Be Wise When You Fertilize* is a public service announcement designed to encourage people to use less fertilizer and was created after the Fertilizer Ordinance was passed in 2009. The Marion County Extension program offers numerous educational programs to foster the protection of groundwater and springs. The Clean Farms Program informs equine farm owners one-on- one about manure management and proper care and fertilization of pastures using BMPs. The Florida Master Gardener Program trains people to become educators about low input gardening techniques. The Sustainability Program, a new Marion County Extension program, informs about a variety of sustainability issues and received funding from the Protect Florida Springs Tag Grant Program, in partnership with the springs working groups, to develop a groundwater awareness and springs protection module during the next fiscal year.

The Marion County Springs Festival, coordinated by a consortium of organizations sponsors a springs festival in September of each year with a mix of educational and entertainment events. The festival included an Earth Day event at Silver River State Park in 2011. The Silver Springs Basin Working Group has included numerous speakers in its quarterly meetings and has produced a poster that raises awareness about the springs basin and the need for careful stewardship of water resources (assistance received from SJRWMD and the Protect Florida

Springs Tag Grant Program). A small committee of working group members is coordinating distribution of the posters and the working group coordinator has given several presentations to civic groups.

Research on a variety of education programs from many areas has led some educators to conclude that traditional education programs often are unsuccessful in changing behavior (McKenzie-Mohr and Smith 1999). Most people apparently do not change behavior simply because they know that what they are doing will cause damage. It appears that other factors such as convenience may be more important. This has led to the development of a relatively new form of education called social marketing. It is based on the successes of marketing firms to get people to change their purchasing behavior when shopping for products. The method was adapted to health education programs and was widely credited with being a major factor in causing the rate of smoking to drop among the American population. Social marketing programs involve traditional educational techniques but are designed specifically to change behavior rather than simply to inform.

Goals

1. Educate stakeholder groups on ways to improve the water quality in the Silver Springs basin.
2. Conduct an aggressive public education program on the benefits of water conservation to the Silver River.
3. Develop a set of easy to interpret graphics (graphs, figures, images) that clearly depict water quality and quantity data for use in education programs
4. Develop materials that interpret and explain TMDLs and MFLs in a way that can be readily understood by the public. Provide this information for Silver River in ways that prevent misinterpretation.
5. Erect signs within the Silver Springs basin that raise the awareness of the geographic location of the springs basin.

Goals with Suggested Actions

1. Educate stakeholder groups on ways to improve the water quality in the Silver Springs basin.
    - Inventory existing education programs to identify possible overlaps and new programs needed.
    - Assess audiences for different aspects of the education program and develop appropriate messages specific to each group.
    - Maintain existing educational efforts: Clean Farms, teacher trainings, etc.
    - Create a specific curriculum for the Silver Springs basin for schools.
    - Create neighborhood programs promoting landscape BMPs, specifically for fertilizer use.
    - Coordinate a forum for decision-makers on the economic impacts of poor water quality vs. improved water quality.

2. Conduct an aggressive public education program on the benefits of water conservation in the Silver River.
    - Build this goal into the actions listed above for water quality where appropriate.

3. Develop a set of easy to interpret graphics (graphs, figures, images) that clearly depict water quality and quantity data for use in education programs.
   - Assess graphics already produced and determine most appropriate format.
   - Develop graphics and make available to educational entities.
   - Regularly update statistics.

4. Develop materials that interpret and explain TMDLs and MFLs in a way that can be readily understood by the public. Provide this information for the Silver River in ways that prevent misinterpretation.
   - Assess any educational material already developed.
   - Develop new materials and make especially relevant to the Silver Springs basin.
   - Determine groups and individuals that can effectively deliver these materials.
   - Implement programs with the new materials.

5. Erect signs within the Silver Springs basin that raise the awareness of the geographic location of the springs basin.
   - Assess the number of signs already erected and location of these signs.
   - Assess locations that do not currently have signs.
   - Create and erect new signs as needed.
   - Maintain signs at each location and replace as needed.

8.3 Land Use and Development

Land use in the Silver Springs basin is composed mostly of agricultural and urban land uses (see **Figure 4-5 and Figure 9-1**). Cow calf operations and equine facilities make up the majority of the agricultural land use classification. There is also some acreage devoted to raising row crops and some small areas have nurseries. The City of Ocala forms the majority of the urban land and is located directly west of the springs. The City of Belleview, south of Ocala, forms the other significant urban area close to the springs. Land use changes from rural to urban have been continuous as Ocala has grown as seen in **Figure 4-6** which shows land use changes in the two-year capture zone. In 1945, forested and vegetated lands made up about 65% of the area with all urban uses forming less than 5%. By 2005, forested and vegetated lands had decreased to 30% of the basin (less than one-half of its original extent), and both low and high impact urban land had increased to about 35%, an increase of 700%. Interestingly, during the same time period, the percentage of agricultural land in this area did not change significantly.

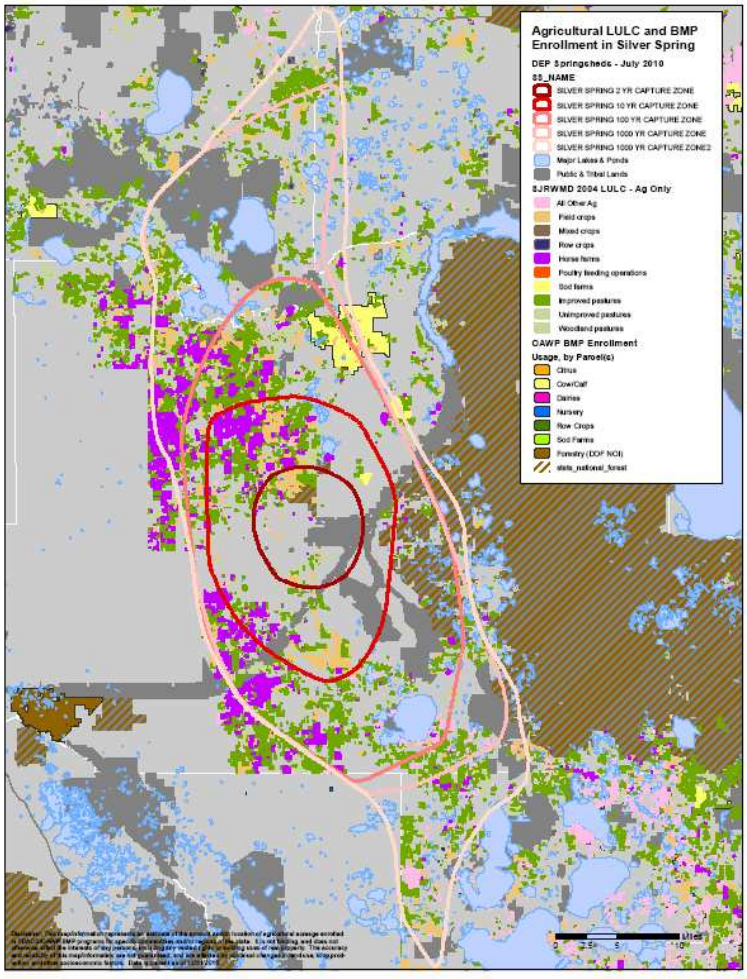

Figure 8-1. Agricultural land uses in the Silver Springs basin, 2010.
Source: Carol Johnson FDACS

In 2009, the population of Marion County was estimated to be 328,547 (61% urban, 39% rural) by the US Census Bureau. City Data.com estimated the City of Ocala's population to be 52,488 in 2006 (about 16% of the total county US Census Bureau estimation), and Belleview's population to be 4,316 for 2007. Both cities, Ocala in particular, have large areas of unincorporated land around their borders that are developed as suburbs. The county's population was projected by the Florida Statistical Abstract, to steadily rise to 651,400 by 2055 (high estimate) with a median estimate of just under 500,000 and a low estimate very close to 350,000. If the high estimate comes true, many land use changes will occur by mid-century.

Marion County has in place a Springs Protection Ordinance that specifies guidelines for development and disallows various types of development in a primary protection zone (**Figure 9-2**). The objective of the Springs Protection Ordinance is as follows:

> *…to preserve the quantity and protect the quality of the Floridan Aquifer underlying all of Marion County and to protect the environmental, recreational, and economic values of Silver Springs and Rainbow Springs in the interest of public health, safety and general welfare. This is to be accomplished by regulating land uses and activities which can adversely impact the quality and quantity of groundwater within the identified Springs Protection Zones (SPZ).* From the preamble.

The ordinance provides guidelines for stormwater and wastewater treatment to a more stringent standard than on properties outside the SPZ. It also provides specific guidelines for the protection of karst features and for areas of high groundwater recharge potential. Initially the county specified secondary protection zones with less stringent requirements but later amended this to include the whole county, outside of a primary zone) as a secondary protection zone. A county Landscape Ordinance protects native landscaping and provides for certain tree removal projects to be permitted. This assists with protection of aquifer recharge and the protection of stormwater runoff. The Marion County Comprehensive Plan includes language that supports establishing a Transfer of Development Rights program to protect sensitive areas of high groundwater recharge. This has not been implemented in the Land Development Codes.

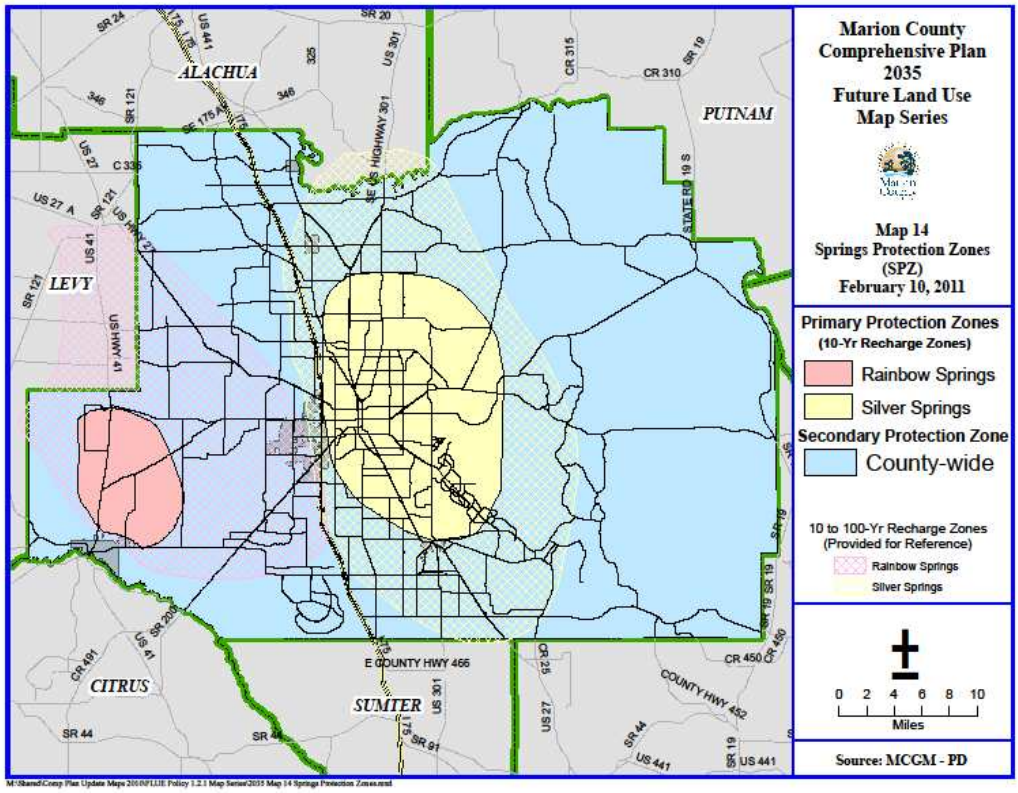

Figure 8-2. Marion County springs protection zones.
Source: Marion County

Marion County has determined the vulnerability of the Floridan Aquifer to pollution from surface runoff. The Aquifer Vulnerability Assessment shows that the entire Silver Springs basin is either "vulnerable" or "most vulnerable" (see **Figure 4-4**).

Goals (Note: The Land Use and Development Goals and Actions for Silver Springs and Rainbow Springs Restoration were combined.)

1. Using all available information (zoning/including Marion and Levy County Aquifer Vulnerability Assessments, location of major karst features, and the as yet unpublished karst flow way study by SJRWMD), identify significant groundwater recharge areas, karst sensitive areas, and areas important for springs protection. Consider adding these areas to the Primary Protection Zone for either Silver or Rainbow Springs.
2. Ensure the development and maintenance of vegetated buffers along all swales and waterbodies.
3. Develop incentives for landowner protection of aquifer recharge areas including less than perpetual easements, density bonuses for clustering and payment for ecosystem services – incentives that work in alignment with the financial structure of the landowner.
4. By 2020, retrofit existing stormwater systems and drainage ways to reduce nutrient runoff and minimize impacts on aquifer recharge. Convert to biological stormwater treatment areas (STAs) where practical and applicable.
5. By 2105, ensure all new STAs built within the Rainbow and Silver Springs basins are biological STAs.

6. Promote use of existing programs and develop new programs where needed to provide public recognition to managers of large facilities such as golf courses, housing developments, or farms that have demonstrated nutrient reduction and habitat conservation programs.
7. Fully implement the existing Marion County Springs Protection Ordinance to protect groundwater quality through the regulation of land use activities in the primary and secondary protection zones.
8. By 2020, ensure that all new developments use water saving fixtures (toilets, faucets, and sprinkler systems) at the highest level of efficiency available.
9. Upgrade existing wastewater treatment facilities to advanced wastewater treatment (AWT) and require new wastewater treatment facilities in the Rainbow and Silver Springs basins to operate at an AWT standard and provide reuse water to nearby facilities. Require golf courses in the springs basin to use reuse water from wastewater treatment facilities when available.
10. Implement regulations by 2020 to ensure all high density developments within the springs basins are hooked up to a sewage treatment systems, preferably an AWT system.
11. By 2013, identify parcels in the Rainbow and Silver Springs basins contiguous to public lands or with natural resource significance to groundwater recharge and springs protection for potential acquisition or for conservation by other means including conservation easements, mitigation, donation, or payment for ecosystem services.
12. Develop and implement a policy in transitional areas (areas that might move from a more rural use to a more urban use) that provides incentives for conservation and water quality protection to private landowners.
13. By 2020, ensure all jurisdictions within the Rainbow and Silver Springs basins offer density bonuses for cluster development as well as for "purple pipe" systems and gray water systems.
14. By 2016, decommission all existing stormwater drainage wells within the Silver Springs basin. Water should be diverted to reuse systems for irrigation projects.

Goals with Suggested Actions

1. Using all available information (zoning/including Marion and Levy County Aquifer Vulnerability Assessments, location of major karst features, SJRWMD karst flowway study), identify significant groundwater recharge areas and areas important for springs protection. Consider adding these areas to the Primary Protection Zone for either Silver or Rainbow Springs.
    - Pay particular attention to areas prone to sinkhole formation.
    - Design all STAs carefully to ensure collapse is avoided.
    - Prohibit any untreated stormwater runoff from reaching sinkholes and other direct connections to the Floridan Aquifer.
    - Ensure all STAs are regularly inspected to avoid failure of systems.
    - Ensure all appropriate regulatory mechanisms are in place such as a karst sensitive rule to protect against inappropriate development in karst sensitive areas.

8. By 2020 ensure that all new developments use water saving fixtures (toilets, faucets and sprinkler systems) at the highest level of efficiency available.
    - Marion and Levy counties and the cities of Belleview, Dunnellon, Ocala, and Williston should add language to their comprehensive plans and land development codes if not already included.

10. Implement regulations by 2020 to ensure all developments within the springs basin are hooked up to a sewage treatment system, preferably an AWT system.
    - Marion and Levy counties and the cities of Belleview, Dunnellon, Ocala, and Williston should add language to their comprehensive plans and land development codes if not already there.

13. By 2020, ensure all jurisdictions within the Rainbow and Silver Springs basin offer density bonuses for cluster development as well as for "purple pipe" systems and gray water systems.
    - Marion and Levy Counties and the Cities of Belleview, Dunnellon, Ocala and Williston should add language to their comprehensive plans and Land Development Codes if not already included.

14. By 2016, decommission all existing stormwater drainage wells within the Silver Springs basin. Water should be diverted to reuse systems for irrigation projects.
    - City of Ocala should continue its current program of conversion of stormwater drainage wells to treatment systems and accomplish all conversions by 2016.

8.4 Recreation

The Silver River is very popular for boating. On a busy weekend, many motorized water craft can be found on the river, most of which access the river via Ray's Wayside County Park off SR 40. Boats can also enter the park from the Ocklawaha River. Once in the Silver River, visitors are entering Silver River State Park (SRSP). There is no entry fee charged, and enforcement of park rules is limited to nonexistent unless a law enforcement officer is present. Fishing is not allowed, and the entire river is a no wake zone. People engage in boating, swimming at their own risk, wildlife viewing, and being towed behind a boat on a float. Canoes and kayaks are available for rent at SRSP with the access point about a mile down from the head springs. There are no access limitations to the head springs area.

Silver River State Park provided the following statistics for the number of boats using the river: 38,578 of motorized and non-motorized boats (average of three people per boat = 115,734 people) between July 1, 2010 and April 30 2011. This is based on periodic sampling, and then a percentage value is used as a multiplier. Of the total number of boats, canoe rentals at the SRSP produced 5,299 person hours on the river for the same time period. (SRSP does not keep data on the number of canoes rented, only the amount of time they are out on the river.)

Marion County Parks and Recreation reported $54,839 in revenue at Ray's Wayside County Park earned year to date for Fiscal Year 2009-10.

The Silver Springs Nature Park (the Attraction) provides visitors with the opportunity to view the head springs area and the upper section of the river in a glass-bottom boat. The boat operators act as tour guides, pointing out items of interest and explaining some aspects of the history of the area. However, there is limited to no environmental education provided, and no information is included on hydrogeology of springs, water quality, or spring flow. The Attraction does offer a program for high school age students called Using Limited Natural Resources which provides information on the Floridan Aquifer and the pressure being placed on groundwater supplies by development.

The number of visitors to Silver Springs Nature Park was not available. The management refused to provide statistics claiming privacy.

In the winter of 2010-11, Marion County proposed taking over the lease for the Attraction from Palace Entertainment. The current lease with the state of Florida expires in 2029. The county's concept is to open the Attraction to local vendors and concessionaries and make an attempt to revitalize the area for the benefit of the local economy. There are also several pollution issues associated with poor management of stormwater runoff from the small zoo that the county has pledged to correct. This proposal has not moved forward as of the writing of this plan.

Goals

1. Create programs and/or initiatives to educate adult citizens through recreational activities to understand the hydrogeology of Silver Springs and River.
2. Promote other recreational activities among youth.
3. Support and expand the Marion County education program where students (3^{rd}-7^{th} grade) visit the Silver River Museum and Environmental Education Center.

4. Develop a conference center at the Attraction.
5. Set up volunteer opportunities for a variety of tasks associated with management of the Attraction, the springs, and Silver River.
6. Establish Silver River as part of a Blueway recreational facility connected to other canoe and kayak routes in central Florida.

Goals with Some Suggested Actions

1. Create programs and/or initiatives to educate adult citizens through recreational activities to understand the hydrogeology of Silver Springs and River.
   - Develop Senior Day at the springs.
   - Create public service announcements to promote recreational activities.

2. Promote other recreational activities among youth.
   - Improve recreational curriculum for promoting healthy interactions.
   - Allocate money for recreational programs.
   - Incorporate environmental education about water conservation and avoiding use of fertilizers into recreational programs.
   - Market achievements of boy/cub scouts: merit badges for recreation on and around the springs.
   - Set aside special promotions at the Silver River State Park.

3. Support and expand the Marion County education program where students (3^{rd}-7^{th} grade) visit the Silver River Museum and Environmental Education Center.

4. Develop a conference center at the Attraction.

5. Set up volunteer opportunities for a variety of tasks associated with management of the Attraction, the springs, and Silver River.

6. Establish Silver River as part of a Blueway recreational facility connected to other canoe and kayak routes in central Florida.

8.5 Water Quality

The earliest reading of nitrate from Silver Springs was taken in 1907 and was below 0.1 mg/L (**Figure 9-3**). Zero point zero five mg/L is generally considered to the "background" nitrate level in the Floridan Aquifer (cited in numerous reports and personal communications with scientists). Subsequent to that time, nitrate has increased to its present average level that fluctuates between 1.0 and 1.3 mg/L. This represents an increase of at least 13 fold and is likely closer to a 20-fold increase in about 100 years. The graph in **Figure 9-3** indicates an acceleration of increase in the last 40 years which, if the trend continues, might cause a more serious rise in coming years. Silver Springs today has an almost continuous mat of filamentous algae covering the bottom. This was not present when Odum completed his studies in the 1950s. Nitrate may well contribute to the development and maintenance of the algal mat. However, algal growth in springs has come under considerable scrutiny in recent years, and it is now known that there is no direct correlation between nitrate concentration and volume of algae present.

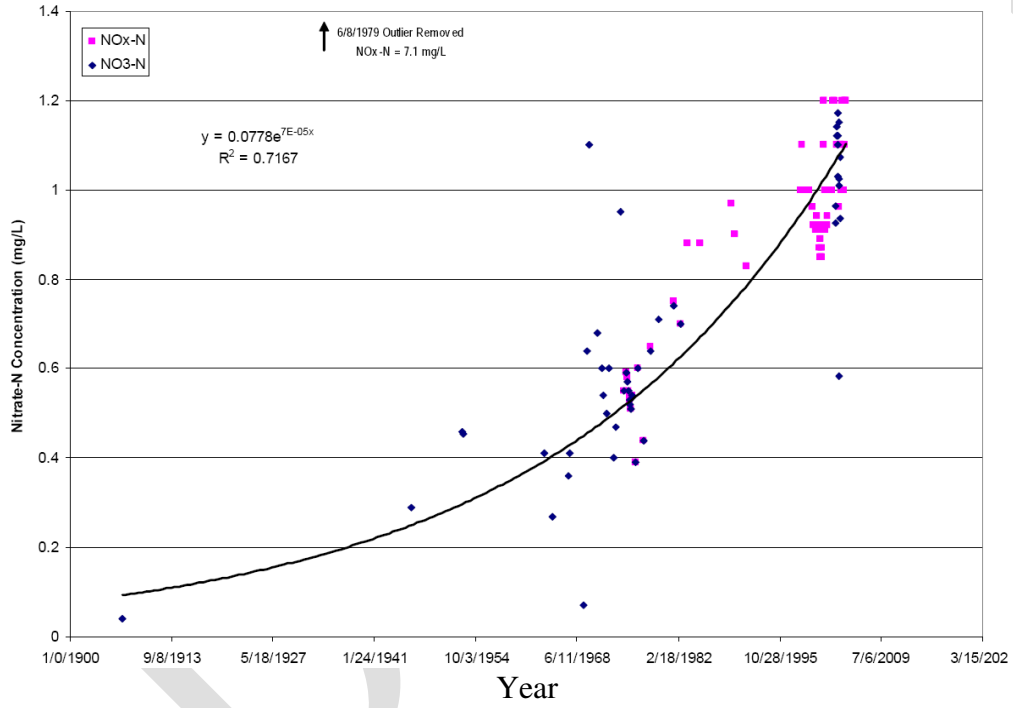

Figure 8-3. Nitrate concentrations at Silver Springs from 1907 to 2007.
Data Source: Wetland Solutions, Inc. 2010

Nitrogen is an important nutrient needed by all living organisms and is readily metabolized into different forms (ammonia, nitrate, nitrate and atmospheric gas). It is constantly cycled through living organisms and is a primary constituent of liquid waste from all animals, including humans. It is also an important constituent of all fertilizers to promote plant growth. Studies indicate that the nitrate dissolved in the waters of the Silver River is from a mix of inorganic and organic sources. The primary inorganic source is fertilizer that is applied by farmers, landscape professionals, homeowners, and golf course managers. Available data do not allow a detailed analysis of exactly which land uses cause the majority of the inorganic fertilizer problem.

Organic sources include animal and human waste. The organic nitrate is most likely derived from a mix of animal waste from both horses and cows together with thousands of septic tanks in the Silver Springs basin as well as wastewater treatment plants. The Marion County Aquifer Vulnerability Assessment shows the aquifer to be either "vulnerable" or "more vulnerable" throughout most of the Silver Springs basin (see **Figure 4-4**). Any nitrate that leaves the "root zone" (the upper layers of soil that roots penetrate) and moves down towards the aquifer will change little until it emerges from a spring and once again becomes biologically active. It is therefore necessary to examine land uses in the springs basin to derive estimates of the sources of nitrogen. **Figure 9-1** highlights agricultural land uses in the Silver Springs basin and indicates that horse farms and improved pastures are the most common agricultural category. **Figure 4-4** includes development (from prior to 2004) in addition to a more generic categorization of the agricultural land uses.

The large uncolored space in the center of the springs basin in **Figure 9-1** represents the location of Ocala. Much of the uncolored land is urban residential, both high and low density. Most of the eastern portion of the basin is forested. There are many thousands of onsite sewage disposal systems (OSDS) (or septic systems) which do little if anything to remove nitrogen. There are also several wastewater treatment plants (WWTP) in and around Ocala (see section below for more details), which again do not normally remove much nitrate from effluent. There are 13 golf courses within the Silver Springs basin (east of I-75). Three courses within the City of Ocala use reuse water for irrigation which they acquire from City of Ocala WWTPs. A list of golf courses in Marion County is provided separately from this report.

A detailed analysis of the amount of land in each land use category will be needed in order to calculate nutrient loading rates. Nitrogen loading is calculated based on nitrate concentration and volume of water. Nitrate loading was estimated by Phelps for 2000 and the results of that estimation are shown in **Table 9-1**.

Table 8-1. Estimates of Nitrogen Loading into Silver Springs for Year 2000

Source	Tons per year	% of Total
Atmospheric deposition	4.4	26
Livestock	5.5	32
Agricultural Fertilizer	2.2	13
Human Waste	2.2	13
Residential Fertilizer	1.5	9
Golf Course Fertilizer	1.1	6

Source: Phelps 2004.

Silver Springs is listed as impaired by FDEP, primarily due to the rising nitrate and the thick mat of algae that covers the bottom of the spring pool. In order to cause a decrease in nitrate loading it will be important to calculate nitrate loading rates based on different land uses and then allocate reductions based upon those calculations within a TMDL process. A Total Maximum Daily Load (TMDL) is the maximum amount of a specific pollutant that a waterbody can receive and still remain healthy. The calculation of a TMDL provides a water quality threshold that can serve as the target for restoration of a waterbody impaired by that pollutant. A Basin Management Action Plan (BMAP) is a restoration plan that is developed by FDEP and basin

stakeholders that formalizes the activities that will be implemented by the stakeholders to reduce the pollutant loads and achieve the TMDL.

It should be noted that there is a relationship between spring flow (water quantity) and water quality. The spring flow of Silver Springs has declined (perhaps as much as 32%) and therefore leaves less water for nitrate to dissolve in thus raising the nitrate concentration. Another important factor to consider in this analysis is the age of the water emerging from the springs and therefore the age of the nitrate.

An analysis done by SJRWMD called "Kriging" took nitrate data from wells as reported by Phelps in 2004 (Phelps 2004) and averaged them. **Figure 9-4** shows the results of that analysis. Two nitrate "hotspots" are indicated: one north of Ocala and the other a more diffuse double hotspot in the southern half of the springs basin. Both areas consist primarily of agricultural land uses with some houses in the area although a sprayfield for Ocala effluent is in the southern area.

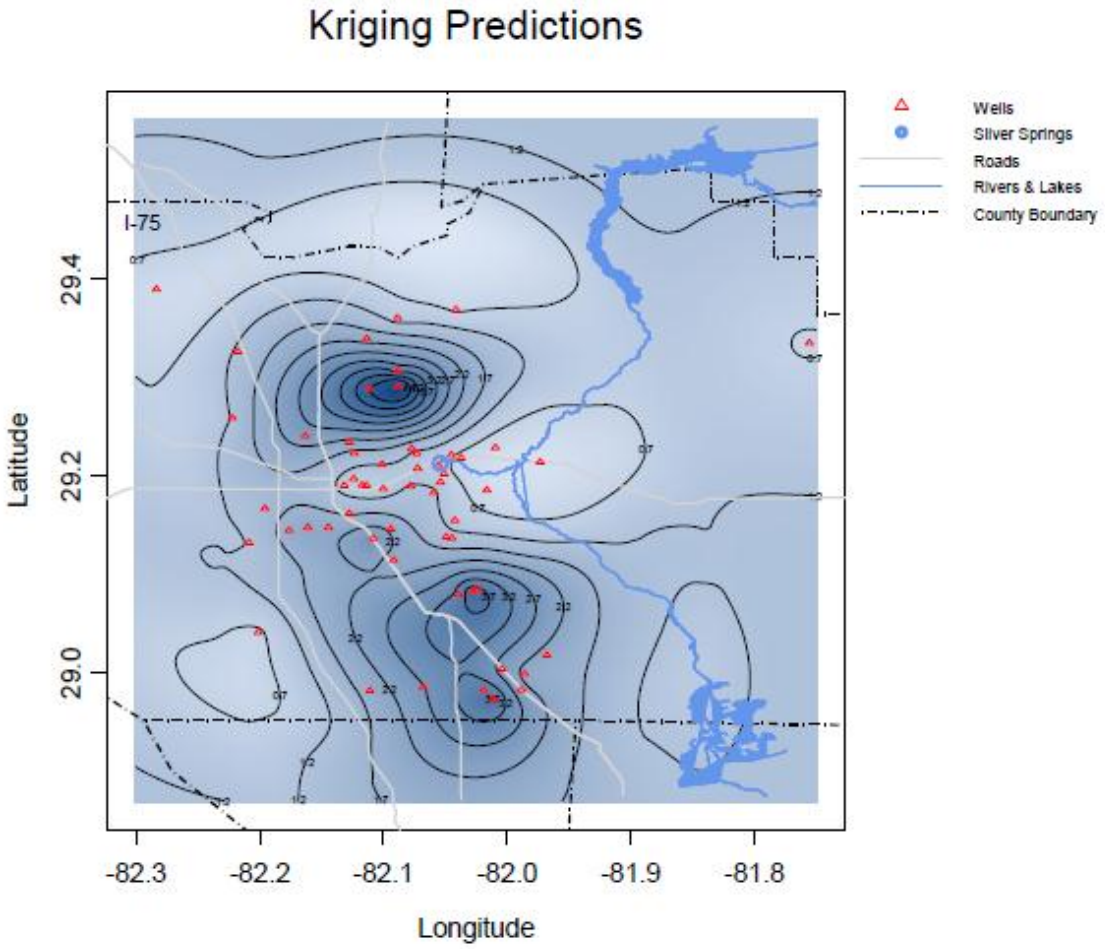

Figure 8-4. Kriging predictions of nitrate well data from available wells in the Silver Springs basin.
Source: SJRWMD

At this time, only one agricultural property owner has adopted BMPs, a large cow calf operation northeast of Silver Springs that shows as yellow in **Figure 9-1.** However, there are 50 Farms of Distinction in Marion County, a designation given by Marion Soil and Water Conservation District (see separate file titled Farms of Distinction). Thirty-two of them, comprising about 650 acres in total, are located east of I-75 and, therefore, contribute runoff to Silver Springs. Soil testing and minimal fertilizer use are common characteristics of Farms of Distinction. In addition, the Florida Department of Agriculture and Consumer Services (FDACS) has prepared a new BMP manual for Equine Operations which should be fully approved and available for distribution later in 2011.

There are 19 permitted golf courses operating in and around the City of Ocala, about one-half of which are east of I-75 and, therefore, in the Silver Springs basin (see separate file titled Marion County Golf Course Inventory). Three of these courses receive reuse water from the City of Ocala and an additional two receive reuse water from another source. All the superintendents have been exposed to the Golf Course BMP Manual with the level of adoption varying. Golf course BMPs are less formally adopted than agricultural BMPs. Golf courses represent very intensive land uses, but the total acreage of this land use is quite small compared to other uses.

Wastewater treatment plants are scattered all across the Ocala area. Those operated by Marion County are summarized below.

Marion County Wastewater Treatment Plants

Marion County Utilities Department currently operates 11 wastewater treatment facilities (WWTFs) as shown in **Table 9-2**. The county is planning to consolidate some of these facilities to eliminate old facilities, improve service to existing customers, and expand service to new customers. The total average flow capacity of WWTFs in Marion County is 5.054 mgd. The final product can be used for irrigation of golf courses, commercial or residential landscape, or crops such as grass or hay. Disinfection (part of advanced treatment) can lead to the water becoming potable based on federal and state regulations.

Plant site visits by Marion County staff in December of 2008 documented the condition of the WWTFs:

The Silver Springs Shores WWTF was new, in excellent condition, and well maintained. Its effluent quality was excellent.

The Stonecrest WWTF was in good condition and well maintained, although the facility is old. It had excellent effluent quality. A new 1.0 mgd facility is under construction at Stonecrest which will use Bardenpho® technology to lower nitrate levels

The Local Harbour WWTF will be decommissioned in the next five years, and its flow will be diverted to Stonecrest.

The Spruce Creek South WWTF is to be decommissioned and diverted to Sumter Utilities at The Villages. The facility was old and in poor condition with multiple leaks and defects. However, it was well maintained by the operating staff, and had excellent effluent quality. Many repairs have

been suggested to improve the condition of the facility, though these will not be carried out if the site is decommissioned.

The Silver Springs Regional WWTF was in excellent condition and well maintained. The effluent quality was excellent, and nitrate concentrations ranged between 0.82 to 1.7mg/L.

The Salt Springs WWTF was in good condition and well maintained. Its effluent quality was good.

The Northwest Regional WWTF was severely underloaded, and none of the flow was going to reuse.

The Oak Run WWTF was under construction to expand its capacity to 1.6 mgd. Negotiations are under way with JB Ranch, the Royal Oaks Golf Course, and the Spruce Creek Preserve Golf Course to supply a reuse demand of 1.76 mgd from the Oak Run WWTF.
(Author's Note: No explanation for how they will supply more water than their stated capacity)

The Marion Oaks WWTF will be shut down and diverted to Oak Run.

The Spruce Creek Preserve will also be shut down and diverted to Oak Run. Its site could be used as a holding pond for reuse from Oak Run.

The Summerglen WWTF will also be diverted to Oak Run, although this will not happen for several years.

As of 2006, there were 54,119 onsite sewage disposal systems (septic systems) in Marion County (Source: Marion County Utilities). There are also many smaller, privately owned WWTPs in Marion County.

Table 8-2. Marion County Utilities Department Wastewater Treatment Facilities

Wastewater Treatment Facility	Average Daily Flow Capacity	Current Flow	Re-use Permitted	Type (Primary, Secondary, Tertiary)	Notes	Up Dates
Northwest Regional	0.15 MGD	0.013 MGD	0.015 MGD to restricted Public Access Reuse (PAR); 0.2 MGD to Golden Ocala Golf Course	S		
Oak Run	1.6 MGD	.817 MGD	0.8 MGD to Rapid Infiltration Basin (RIB) system; 0.8 MGD to Oak Run Executive Golf Course	S	New plant under construction	New plant completed / Taking flow from Marion Oaks, will take Summerglen and Spruce Creek Preserve soon.
Marion Oaks	0.225 MGD	n/a	0.225 MGD to RIB system	S	Going to be shut down; wastewater will be directed to Oak Run	Off Line – flow is going to Oak Run
Spruce Creek Preserve	0.095 MGD	.062 MGD	0.095 MGD to restricted public access system	S	Eventually will be pumped to Oak Run	Working on plans to take flow to Oak Run
Summerglen	0.2 MGD	.109 MGD	0.2 MGD to Summerglen Country Club Gold Course	S	Eventually will be pumped to Oak Run	Flow to Oak Run Soon
Spruce Creek South	0.45 MGD	0.110 MGD	0.45 MGD to RIB system	S		Flow to the Little Sumter WWTP soon

Table 8-2. Marion County Utilities Department Wastewater Treatment Facilities

Wastewater Treatment Facility	Average Daily Flow Capacity	Current Flow	Re-use Permitted	Type (Primary, Secondary, Tertiary)	Notes	Up Dates
Loch Harbour	0.024 MGD	.004 MGD	0.024 MGD to RIB system	S		Flow to StoneCrest soon
Stonecrest	1.0 MGD	0.190 MGD	Al l flow to Golf Course Reuse	S		New Plant
Silver Springs Shores	1.5 MGD	1.006 MGD	1.0 MGD to PAR system; 0.5 MGD to RIB system	S		Expanding to 2.25 MGD soon, reuse to Golf Courses
Silver Springs Regional	0.45 MGD	0.126 MGD	0.45 MGD to RIB system	S		Upgrading to Reuse facility
Salt Springs	0.085 MGD	0.048 MGD	0.085 MGD to RIB system	S		Replacement Plant in design

A detailed assessment of the feasibility of retrofitting septic systems within the vicinity of Silver Springs was done for Marion County by PBS&J in 2009 and presented as (Appendix L: The Silver Springs Water Quality Report) in the 20-year Water and Wastewater Master Plan (2009). Several figures from that report are presented in Appendix B.

The study assessed land uses, flow pathways, and the number and location of septic tanks and wastewater treatment facilities. The study also determined a priority for retrofitting the systems to improved treatment status.

The following summary and conclusions were stated in The Silver Springs Water Quality Report.

Summary

The following conclusions are made as a result of this study:

- The Silver Springs area is a valuable asset in terms of recreational value.
- The Silver Springs area is a valuable asset in terms of water quality for the central Florida area.
- Pollutants have increased in the springs area over the last 50 years.
- Land use in the springs area has changed significantly in the last 50 years.
- Nitrates cause a change to the vegetation in the springs, particularly algae.
- A variety of sources contribute nitrates to the springs, including livestock, fertilizers, human wastes, and atmospheric deposition.
- Some of the sources can be controlled and mitigated through county action.
- The proliferation of septic tanks in the areas next to the springs contributes more nitrates in a pounds per year scenario than does the central treatment facility owned by the county.

Conclusions

As Marion County adopts its Water and Wastewater Master Plan for the next 20 years, projects to improve the water quality within the Silver Springs area will be recommended for implementation. Prioritization will be identified, as well as suggested funding and financing plans.

The following recommendations are made:

- Engage the county's lobbying firm (Alcalde & Fay) to utilize this report to support efforts in obtaining federal State and Tribal Assistance Grants grants to fund a portion of the report's recommendations.
- Continue to submit to the state of Florida for Community Budget Issue Request funding.
- Pursue Community Development Block Grants where appropriate, based on Median Household Income.
- Continue to consider Rural Development grant in areas of eligible Median Household Income.

Goals

1. Identify sources and loads of contaminants contributing to impairment within the springs basin.

2. Support TMDL development.
3. Address and remove impairments (focus on nitrate) through the BMAP process.
4. Monitor springs and downstream river conditions.

Goals with Suggested Actions

1. Identify sources and loads of contaminants contributing to impairment within the springs basin.
   - Document "hotspots" of surface and groundwater contamination sources. This will help identify more localized sources of surface and groundwater pollution.
   - Identify agricultural sources of nutrient loading.
   - Continue SJRWMD work to understand conduits, direct flow connections, etc.
   - Understand land use activities around the head springs area. Identify the "area of interest" in terms of the size of the "buffer" around head springs. Possibly utilize capture-zone concept used in 50-year study (e.g., 2-year or 10-year capture zone).
   - In conjunction with monitoring, identify impairments other than nitrate which may need to be addressed. This could include other nutrients such as phosphorous (P), elevated ionic concentrations in the spring water due to aquifer drawdowns, and emerging contaminants (pharmaceuticals, cosmetics, etc.).

2. Support TMDL development.
   - Identify research/data needs. Focus on the data needed to develop technically defensible TMDL.
   - Identify target nitrate concentration that will be protective either through specific analyses or by adopting existing targets developed at other springs.
   - Establish TMDL.
   - Implement TMDL through BMAP development.

3. Address and remove impairments (focus on nitrate) through the BMAP process.
   - Better stormwater management – improve quality of surface water runoff through stormwater management/retrofit.
   - Identify ways to reduce nutrient loads to groundwater from stormwater basins in karst sensitive areas.
   - Better manage stormwater runoff at Silver Springs Nature Park (the Attraction).
   - Central wastewater – hook up more homes to centralized wastewater treatment/get off onsite systems.
   - Better manage and maintain OSDS.
   - Reduce fertilizer use or use alternate formulations (slow release, etc.) – education and other efforts to make sure fertilizer is applied properly and not in excessive amounts.
   - Reuse water issues – address nutrient loads in all reuse water applications; make sure people using reclaimed are aware of its nutrient content and reduce fertilizer application accordingly.
   - Wastewater issues – make sure water applied to rapid infiltration basins (RIBs) is sufficiently treated to prevent nutrient loads to groundwater.
   - Implement appropriate agricultural BMPs to reduce nutrient impacts to surface and groundwater.

4. Monitor springs and downstream river conditions.
    - Continue/maintain existing water quality monitoring.
    - Conduct trend analyses of various measures of ionic strength (conductivity, alkalinity, TDS, sodium, chloride, sulfate, etc.). Recent work with statewide data suggests springs are getting "saltier" due to hydrologic alteration.
    - Determine if additional variables/analytics need to be monitored based on analyses of existing data.
    - Incorporate biological monitoring to support water quality data collection and better understanding of impairments.

8.6 Water Quantity (Spring Flow)

Data gathered by both the SJRWMD and the USGS (**Figure 4-10**) indicate that there has been a measurable decline in flow at Silver Springs over the previous two decades. Quantifying this decrease has been complicated due to variations in the way the flow has been measured over time and to recent indications that the groundwater divide between the Silver Springs basin and the Rainbow Springs basin may have shifted eastward sending less water towards Silver Springs (SJRWMD unpublished data presented at a SSBWG meeting).

According to the Marion County Water Resources Assessment and Management Study (WRAMS) published in 2007, Marion County residents used 196.5 gallons of water per capita per day (gpcd). This was almost double the statewide average of 105 gpcd.

Of the total use of water in the county, 69.13% was reported as potable uses (combined from public supplies and domestic self-supply (wells). Of the remainder, almost 20% was for agriculture, almost 9% for recreation, and about 2.5% for commercial, industrial, and mining uses. A total of 86.5 mgd was used in 2005, the year that these estimates were made for the report. These percentages together with estimates of the actual amounts of water used are summarized in **Table 9-3** below.

Table 8-3. Water Use Estimates by Use Category

Water Use Type	Water Use Estimate for 2005 (MGD)	% of total County Estimate
Public Supply and Domestic Self-supply	59.8	69.13%
Agriculture	17	19.65%
Recreation	7.4	7.40%
Commercial, Industrial and Mining	2.3	2.30%
Total	86.5	100%

Source: Marion County Water Resources Assessment and Management Study

A separate data set was obtained from the Detailed Water Supply Feasibility Analysis which was done for the Withlacoochee Regional Water Supply Authority (WRWSA) (Water Resources Associates 2010). Using the same base year as the WRAMS, 2005 public supply was listed as 30.13 mgd, and domestic self-supply 20.62 mgd for a total of 50.75 mgd (15.1% less than estimated by the WRAMS). Data from the WRWSA report for Marion County are presented in **Figure 9-5** showing the same usage categories as WRAMS with a total daily usage for 2005 given as approximately 67 mgd (19.5% lower than WRAMS estimates). The major discrepancy appears to be in the estimation of water for agricultural uses. WRAMS estimated 1 mgd for 2005, whereas WRWSA estimated about 6 mgd. The estimates for future agricultural uses are also very different.

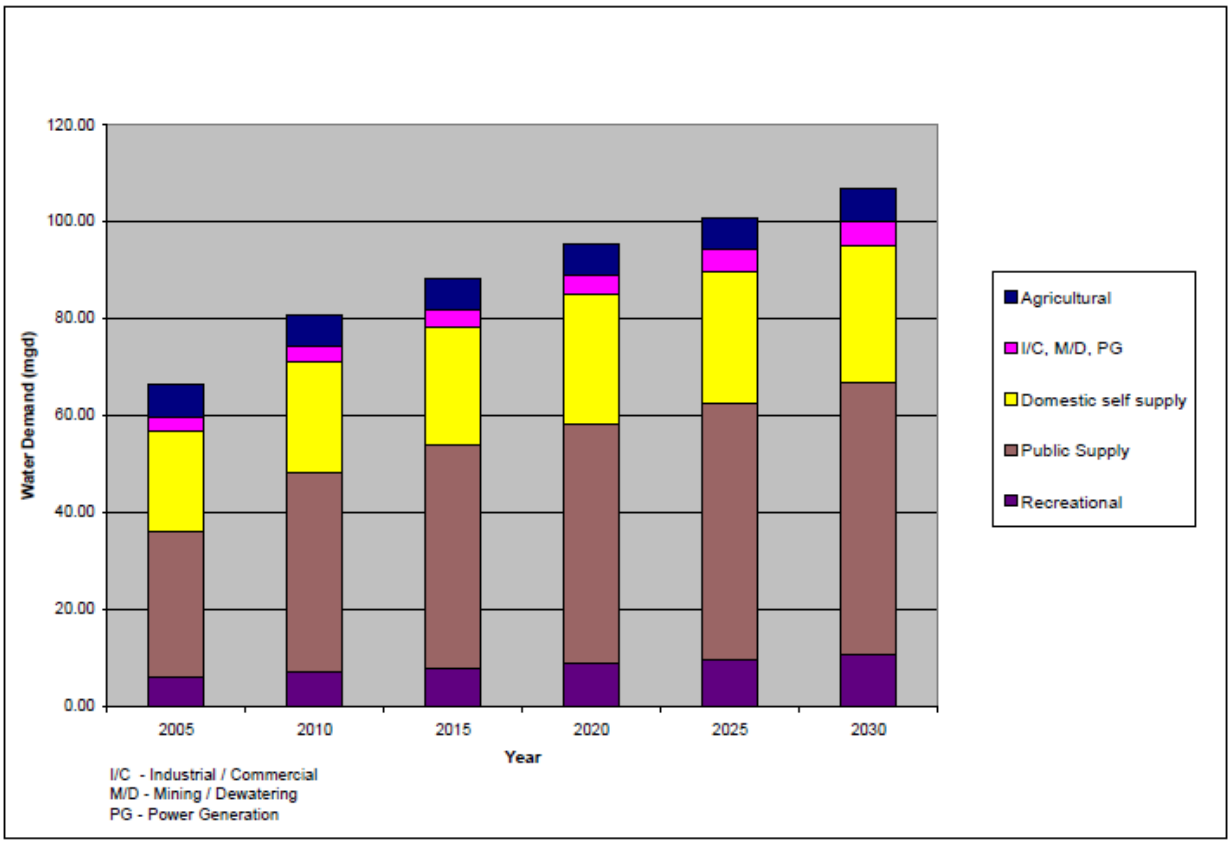

Figure 8-5. Incorporated and unincorporated Marion County projected water demand.
Source: Water Resources Associates 2010

Almost 98% of Marion County's potable water supply is obtained from the Floridan Aquifer, the same source that supplies Rainbow and Silver Springs. Surface water augments agricultural irrigation, and an estimated 2.1 mgd was reported in the WRAMS representing about 3% of the county's total water supply. Reuse water is collected and used to augment irrigation on golf courses, residential and commercial landscapes, and some agriculture by Ocala, Belleview, On Top of the World, Dunnellon, and Marion County. The total amount of reuse water by the utilities listed above was 9.27 mgd in 2005 representing almost all the available, centrally collected wastewater.

The WRAMS attempted to predict future demand for a public water supply based upon a combination of projected population growth to 2055 and estimates of decreasing per capita use due to the implementation of conservation measures. The 2055 population was predicted to be between 615,500 and 966,750. Metered public supply systems create opportunities for measuring per capita water use that are not normally available for domestic self-supply (private wells). Through alternative, widely accepted methodologies, water use for domestic self-supply can be estimated. Additionally, nonpotable uses of water were also projected to 2055 using water management district data. The projections yielded the data shown in **Table 9-4** and indicated a predicted rise in the proportion of the water supply that will need to be potable. It should be

noted that subsequent to publication of the WRAMS that population growth has significantly decreased in Marion County and future projections may be prove lower than reported.

Table 8-4. Future Water Use Projections by Use Category

Water Use Type	Year 2055 Estimate (MGD)	% of total County Estimate
Public Supply and Domestic Self-supply	168.3	83.07%
Agriculture	16.0	7.9%
Recreation	14.3	7.06%
Commercial, Industrial and Mining	4.0	1.97%
Total	202.6	100%

Source: Marion County Water Resources Assessment and Management Study

Predictions for future demand in Marion County according to WRWSA (Water Resource Associates 2010) are shown in **Figure 9-5** up to 2030. Total use is predicted to be about 106 mgd, substantially lower than the projections in WRAMS (interpolated from the 2005-2055 trajectory to be 144.5 mgd). Potable and domestic self-supply are projected by WRWSA to need about 86 mgd by 2030 (**Figure 9-5**), whereas an interpolation of the WRAMS data in 2030 indicates a need for 114 mgd for the same uses.

The WRAMS also compared future water supplies to the projected demand. Limits on groundwater supply were encountered based upon projected effects to the flow of Silver Springs, considered the most sensitive of the larger springs due its proximity to major growth areas of the county. Based on the SJRWMD North Central Groundwater Flow model, it was determined that when total demand for water reaches 110 mgd, there would likely be a direct effect on the flow of water from Silver Springs. Based on the projections of demand, this level of demand will likely occur long before 2055. It was therefore concluded that future demand, as projected, would cause “significant harm” to Silver Springs, assuming continued heavy reliance on groundwater. When an MFL is set for Silver Springs (expected in late 2011) it will be expected to eliminate these negative effects.

The WRAMS process also examined alternative supplies including surface water (primarily the lower Ocklawaha and lower Withlacoochee rivers) and reuse water with conservation programs in place designed to reduce demand. The supply of reuse water was projected to reach 25to 30 mgd by 2055 from 9.27 mgd in 2005. This does not include new technologies becoming more widely available to capture new sources of reuse water. Reuse water has great potential to lower demand for groundwater for nonpotable uses. Stormwater also has some potential to be captured and reused for nonpotable purposes.

The WRWSA report ((Water Resource Associates 2010) analyzed the potential impact for new well fields proposed for northeastern and northwestern Marion County that will withdraw a total

of 30 mgd within the Silver and Rainbow Springs basins respectively (**Figure 9-6**). The possible impact of these well fields on flow from Silver Springs was modeled using the SJRWMD NCF (North Central Florida) model for the northeastern wellfield and the SWFWMD ND (Northern District) model for the northwestern well field. For the north eastern wellfield the projected impact was a decline in flow at Silver Springs of 8.2 cfs or 1.1% of flow based on 1995 average flow. This was described in the report as a "slight effect." Modelling for the northwestern Marion County wellfield in an area that is completely within the mapped spring basin for Rainbow Springs also produced a predicted drawdown for Silver Springs. This predicted drawdown was 8.5 cfs or 1.3% of flow based on 1995 flow data. Again, this effect was described as "slight." The predicted drawdown for Rainbow Springs was only 2 cfs or less than 0.2% of its pre-development flows and therefore a lower impact than for Silver Springs by a factor of 4 or more.

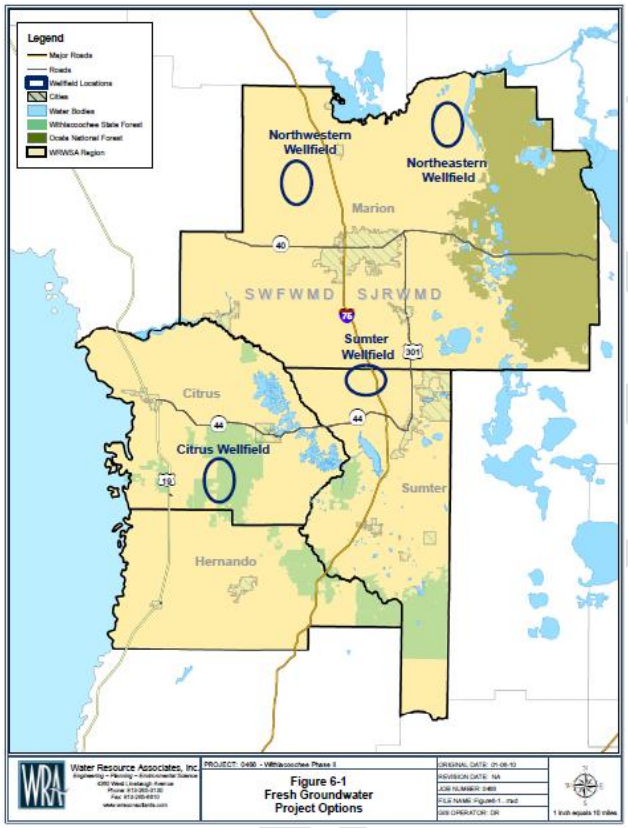

Figure 8-6. Locations of new wellfields planned within Marion and Citrus counties.
Source: Water Resource Associates 2010

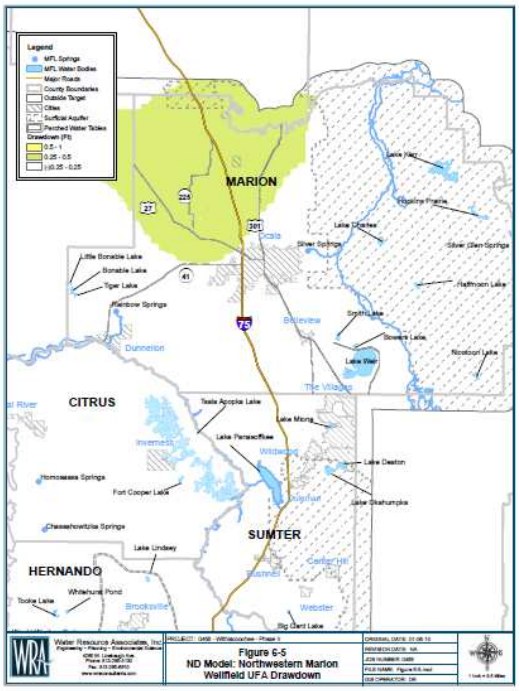

Figure 8-7. Projected drawdown of the Floridan Aquifer System by the proposed Northwestern Marion Wellfield.
Source: Water Resource Associates 2010

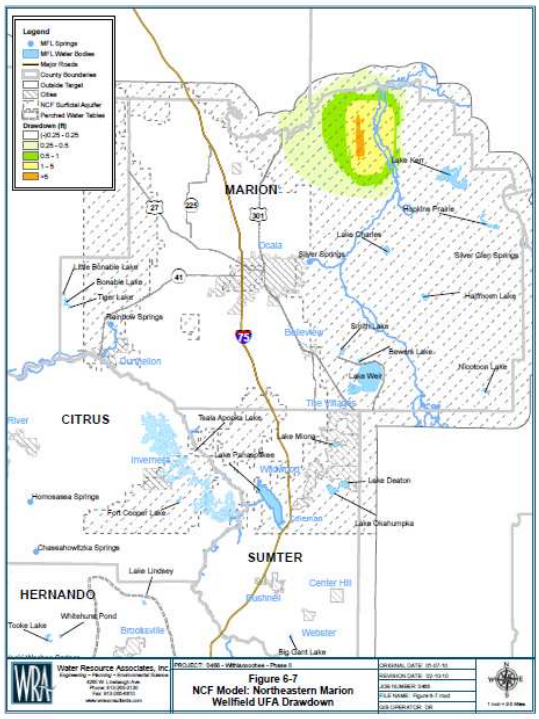

Figure 8-8. Projected drawdown of the Floridan Aquifer System by the proposed Northwestern Marion Wellfield.
Source: Water Resource Associates 2010

This prediction raises some questions. First, combined together, these two projected withdrawals (**Figures 9-7 and 9-8**) would represent 16.7 cfs and total 2.4% of 1995 flows. Second, the area west of I-75 is part of the SWFWMD and is firmly within what is recognized as the Rainbow Springs basin. Why then is the drawdown predicted to be higher for Silver Springs than Rainbow Springs? This adds to the recent uncertainty of staff at the SJRWMD over exactly what represents the "boundary" between the Rainbow and Silver Springs basins.

The southern end of the Silver Springs Basin has seen dramatic land use changes in the past 2 decades as the The Villages has been built and residents have moved in. The Villages is developed on land within 3 counties, Marion, Lake and Sumter and they receive water use permits from both the SWFWMD and SJRWMD. The water use permits both approved and pending for the Villages total more than 30 mgd at average usage rates and almost 50 mgd at peak use. Combined with the proposed northern basin withdrawals together with existing withdrawals to support the growing population of Ocala, its surrounding suburbs and agricultural land uses within the basin, attention needs to be focused on the flows at Silver Springs. Observed declines will be hard to reverse if large consumptive use permits continue to be issued.

Conservation also has potential to lower demand through some combination of watering restrictions, pricing incentives, metering, structural measures (e.g., low flow fixtures and xeriscaping), and education.

There is limited conservation in place at the time of this writing: nonenforced watering restrictions (water management districts), a water conserving rate structure in the City of Ocala, and some education efforts by Ocala, Marion County, and water management districts. The fact that Marion County residents use almost double the per capita statewide average indicates a lack of effectiveness of conservation programs at this time but also indicates a high potential for savings in the future.

The WRAMS projected conservation lowering the Marion County per capita use rate to 138 gpcd, a reduction of 58 gpcd or a 30% reduction in per capita demand. While this is an ambitious goal, the per capita water use in Marion County in 2055 would still be 33 gpcd higher than the statewide per capita water use in 2005. Perhaps a more aggressive and successful campaign can lower per capita water use still further.

Goals

1. Bring residential per capita water use to under 105 gpd (statewide average) per day by 2020.
2. Protect areas for aquifer recharge.
3. Set an MFL for Silver River that emphasizes the benefit of fish and wildlife.
4. Encourage landscape rules adopted by homeowner associations to include Florida Friendly landscape guidelines.

Goals with Suggested Actions

1. Bring residential per capita water use to under 105 gallons (statewide average) per day by 2020.
    - Encourage optional inspections of plumbing and potential rebates or cost sharing for repair/replacement/upgrade.

- Provide incentives for installation of low flow fixtures.
- Promote use of rainwater butts and cisterns.
- Increase infrastructure for the use of reclaimed water
- Increase monitoring and fines for violating water restrictions.

2. Protect areas for aquifer recharge.
   - Promote use of pervious surfaces in new development.
   - Promote land protection/conservation.
   - Emphasize protection of areas of high recharge.
   - Emphasize protection of karst features.

3. Set an MFL for Silver River that emphasizes the benefit of fish and wildlife.

4. Encourage landscape rules adopted by homeowner associations to include Florida Friendly landscape guidelines.

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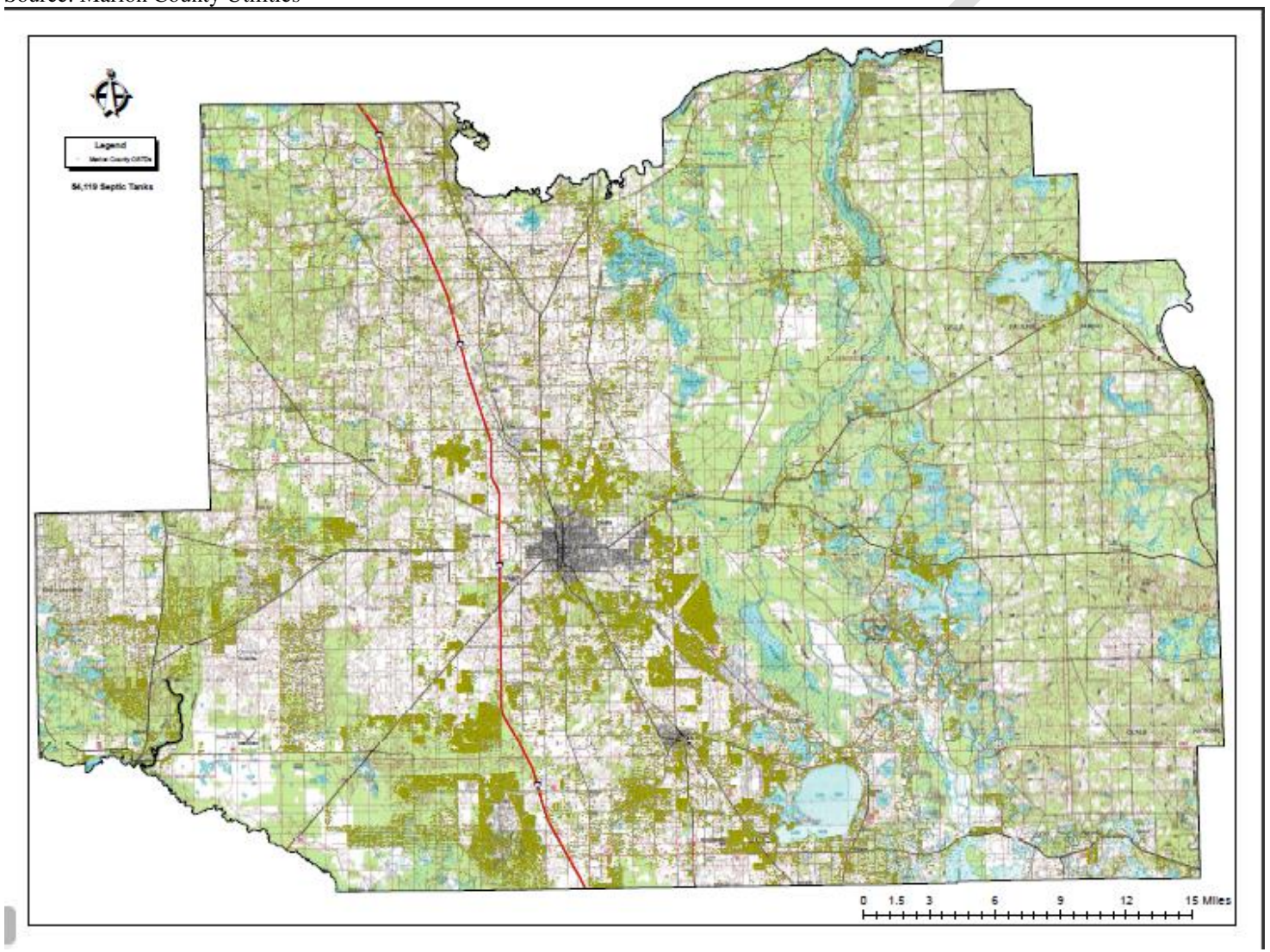
10 Appendices

Appendix A. Location of Onsite Sewage Treatment Systems in Marion County

Source: Marion County Utilities



Appendix B. Figures from the Silver Springs Water Quality Improvement Report as Presented in Appendix L of the 20-Year Water and Wastewater Master Plan (Marion County 2009).

There are 6 figures depicted that will be helpful with nitrate loading calculations. The references to them use the figure numbers from the Marion County Report.

These are as follows:

Figure 3-2 Nitrate content 5 miles from the springs
Figure 4-2 WWTPs within 2 miles from the springs
Figure 5-1 Septic Tanks within 5 miles from the springs
Figure 6-2 Subdivisions within 2 miles from the springs
Figure 6-1 Median Household Income Classification
Figure 6-4 Septic Tank Retrofit Prioritization