NITROGEN SOURCE INVENTORY AND LOADING ESTIMATES FOR THE SILVER SPRINGS BMAP CONTRIBUTING AREA

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This assessment was conducted by the Florida Department of Environmental Protection's Ground Water Management Section of the Water Quality Evaluation and Total Maximum Daily Loads Program to assist in the development and implementation of the Silver Springs Basin Management Action Plan to address the TMDL for nitrate. The results of this assessment, updated in June 2015, are based on the information provided in the document.

Disclaimer: Please note all values listed in this report are rounded while the actual calculations were completed utilizing whole numbers.

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Summary of Findings

The Silver Springs Group constitutes one of the largest freshwater springs in the world and is a major discharge point for water from the upper Floridan aquifer (UFA). The Silver Springs Group and segments of the Silver River have been identified as impaired because of ecological imbalances attributed to elevated nitrate in the water discharging from the springs. In 2012, a TMDL was developed to establish a water quality restoration threshold for nitrate as nitrogen in the springs and river of 0.35 mg/L. Elevated nitrate in the springs is a result of current and historical land use practices that have contributed nitrogen to the UFA system, the highly transmissive limestone aquifer that is the source of water flowing from the springs.

The department developed the Nitrogen Source Inventory and Loading Tool, or NSILT, to identify and quantify the major sources contributing nitrogen to Silver Springs and the Silver River in the spring contributing area focused on in the Basin Management Action Plan area. The NSILT is an ArcGIS- and spreadsheet-based tool that provides spatial estimates of the relative contribution of nitrogen from various sources, and takes into consideration the transport pathways and processes affecting the various forms of nitrogen as they move from the land surface through soil and geologic strata that overlie and comprise the UFA. This report describes the methods, information, and data sources used in developing the NSILT to estimate nitrogen loads to ground water in the Silver Springs and Silver River BMAP area. This information has been provided as a planning tool for the development and implementation of the Silver Springs BMAP to address the nitrate impairment.

The NSILT is being used by participants in the Silver Springs BMAP development to identify areas where nitrogen source reduction efforts could be focused to achieve the most beneficial effects on water quality. The NSILT was used to estimate nitrate loads from the following source categories:

- Atmospheric deposition.
- Wastewater land applications.
- Septic systems.
- Livestock waste.
- Agricultural and nonagricultural fertilizers.

— Stormwater runoff to drainage wells.

This report describes the potential inputs and loads from these sources. Estimates of nitrogen loading to ground water take into account the various environmental processes that can attenuate nitrate in the subsurface and the rate of recharge to the UFA. The environmental attenuation factors are averages for each source based on information from previously published studies in Florida and elsewhere on various processes that remove nitrogen as it moves through the subsurface. After the nitrogen inputs are adjusted by applying an average attenuation factor for each source, the rates of recharge to the UFA are considered. Areas where the recharge rates are high are more vulnerable to contamination than areas where recharge rates are low. Thus, non-attenuated nitrogen inputs in areas where recharge rates to the UFA are greater than 12 inches per year are multiplied by a weighting factor of 0.9, while nitrogen inputs are multiplied by a weighting factor of 0.5 where recharge rates are 4 to 12 inches, and a weighting factor of 0.1 where recharge rates are less than 4 inches.

The NSILT results indicate an estimated annual nitrogen load of 752,979 kg-N (1,661,264 lb-N) to the UFA in the BMAP area, representing 13% of the amount of nitrogen inputs to the land surface. The difference between the load to ground water and the input to land is due to various nitrogen attenuation processes and variations in rate of recharge to the aquifer. For the major nitrogen source categories in the BMAP area, the highest estimated load to the UFA is from septic tanks (38%), followed by cattle farms (17%), crop fertilizer (11%), horse farms (9%), urban fertilizer (8%), land application sites of treated wastewater and reclaimed wastewater (4%), atmospheric deposition (10%), stormwater to drainage wells (2%), and miscellaneous livestock (1%). The nitrogen input from septic tanks is attenuated less than the inputs from most other nitrogen sources, and as a result septic tanks contribute potentially more nitrogen to the UFA.

The majority of the nitrogen loading to ground water in the BMAP area (67%) occurs in high-rate recharge areas. In these areas, the relative percentage contribution from each of the major nitrogen sources is as follows: septic tanks (39%), cattle farms (18%), horse farms (13%), crop fertilizer (8%), urban fertilizer (7%), atmospheric deposition (9%), land application of treated wastewater and reclaimed water (4%), stormwater to drainage wells (1%), and miscellaneous livestock (1%).

The NSILT is an effective first step in estimating nitrogen loads to ground water from various sources in areas of spring basins most susceptible to ground water contamination. This tool can also be used to evaluate the nitrogen load reduction benefits of various management actions and nitrogen reduction strategies.

1. Introduction

In Florida, springs provide sites of recreational and cultural value as well as sources of potable water, and afford a way to assess regional ground water quality. Springs integrate ground water vertically, spatially, and temporally from the expanse of the aquifer system (Bush and Johnston 1988; Katz 1992, 2004; Davis 1996). To recharge into the aquifer, infiltrating water travels through the soil profile and underlying geological substrate, a process that influences nutrient concentrations in the water by the time it reaches ground water.

Elevated nitrate concentrations in Florida's springs contribute to ecological imbalances in their receiving surface waters. This problem will continue if nitrogen source inputs are not reduced. Restoration plans to reduce these inputs must include activities to address the major sources and to obtain detailed nitrogen loading information from nonpoint and point sources within springsheds. This information would cover nitrogen sources such as fertilizer applied to cropland and turfgrass, septic tanks, the land application of treated domestic wastewater, atmospheric deposition, animal wastes, and stormwater runoff to sinkholes and other direct conduits to the aquifer.

To help identify and quantify the most significant contributing nitrogen sources to ground water, the Florida Department of Environmental Protection developed a Nitrogen Source Inventory and Loading Tool (NSILT) to estimate nitrogen loading to ground water. This tool, as described in this report and based on the current best available data, provides summary information on nitrogen inputs and estimated loads of nitrogen to ground water, as well as information on the relative loads from regions within spring contributing areas based on their ground water recharge rates and the attenuation of nitrogen from various sources. The results of this tool can be used in the development and implementation of the Silver Springs Basin Management Action Plan to help focus on specific areas and nitrogen source categories to achieve the greatest improvement in water quality.

The technical approach in applying this tool involves the following steps: identifying the area to be assessed, characterizing the ground water recharge within that area, identifying specific land uses and categories of land use that are potential nitrogen sources, calculating estimated nitrogen inputs to the land surface from those potential sources, and, finally, calculating estimated nitrogen loads to the aquifer.

1.1 Silver Springs

Silver Springs has been a noteworthy Florida attraction since the second half of the 19th century. Its popularity has led to early monitoring efforts that have provided over a century of temporal water quality and ecological data (Monroe 2008). Recently, the Silver Springs Group and segments of the Silver River were identified as impaired because of ecological imbalances attributed to elevated nitrate in the water discharging from the springs. In 2012, a Total Maximum Daily Load was developed to establish a water quality restoration threshold for nitrate in the springs and river of 0.35 milligrams per liter (mg/L). Elevated nitrate in the springs is a result of current and historical land use practices that have contributed nitrogen to the upper Floridan aquifer (UFA) system, the highly transmissive limestone aquifer which is the source of water flowing from the springs. The NSILT is being used to provide stakeholders information on the sources of nitrogen in the Silver Springs contributing area and their relative contributions of nitrogen to the Floridan aquifer. It has been provided as a planning tool for the development and implementation of the Silver Springs BMAP to address the nitrate impairment.

The Silver Springs contributing area being addressed in the BMAP is conservatively based on a modeled 1,000-year capture zone for the springs (Upchurch and Farrell 2005). It covers an area of 632,466 acres (255,951 hectares), with agricultural and urban land uses each making up approximately 22% of the total area. The Silver Springs Group is the source of the Silver River, which flows into the Ocklawaha River (**Figure 1**). The majority of the BMAP area is within Marion County; however, small portions of Alachua, Sumter, Putnam, and Lake Counties are also included. The city of Ocala is the largest urban center in the BMAP area.

1.2 Aquifer Recharge

The Floridan aquifer system is composed of limestones and dolostones of Eocene to Miocene age occurring in Florida and parts of Georgia, South Carolina, and Alabama. As a result of dissolution of the carbonate rocks that comprise the Floridan aquifer system, numerous karst features have developed in the UFA in this area, resulting in water from the land surface moving directly into the aquifer through sinkholes. Consequently, the movement of ground water within the UFA can be quickly responsive to changes in precipitation, and ground water can move rapidly within the UFA where conduits occur. In parts of the BMAP area, a surficial aquifer and an intermediate confining unit overlie the UFA and affect the rate and amount of recharge of precipitation to the UFA.

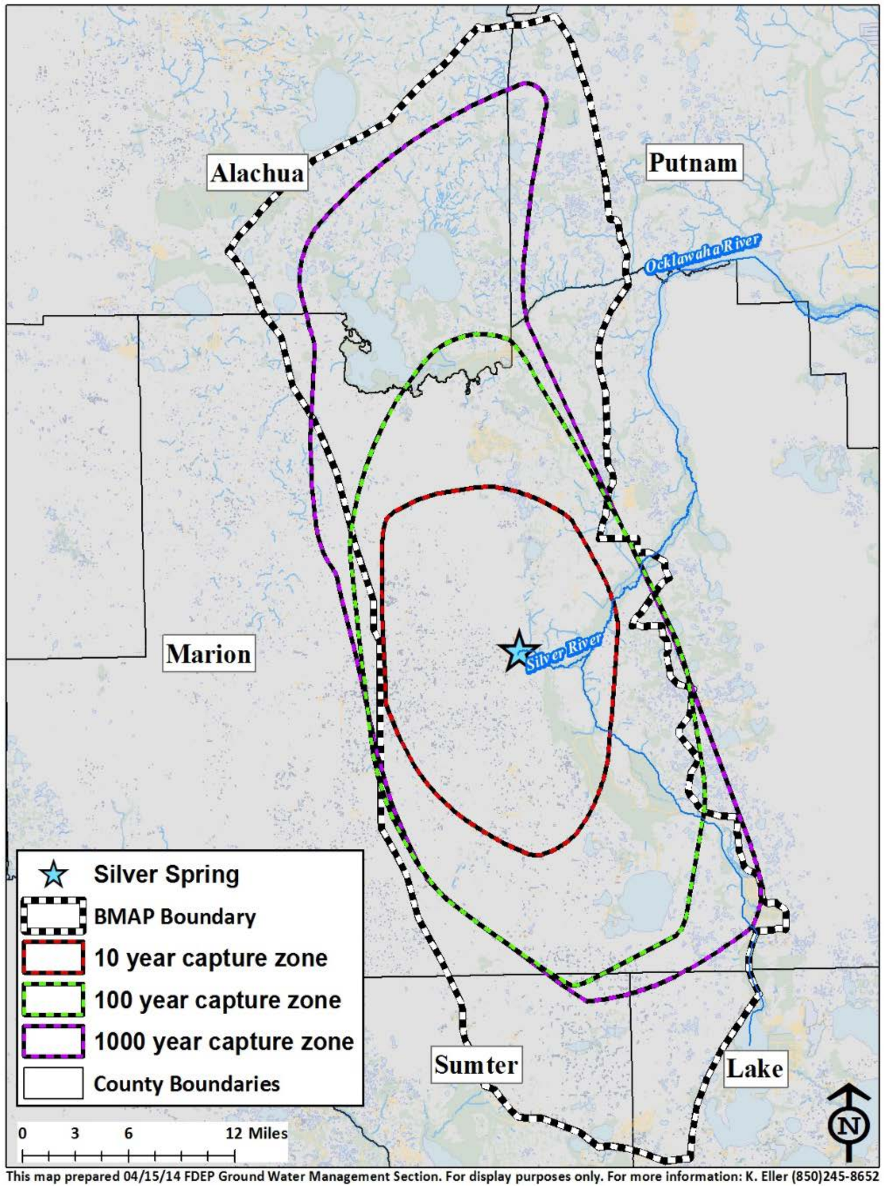
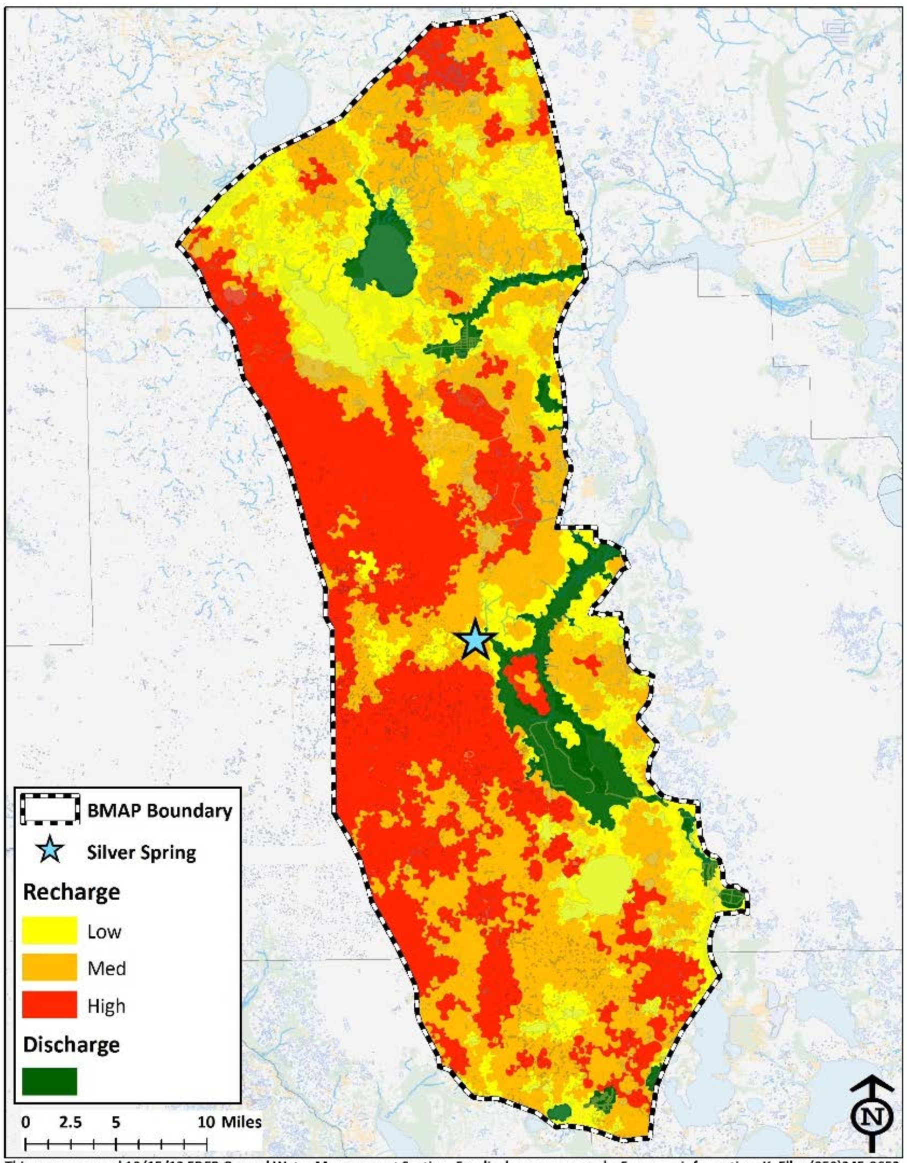


Figure 1: Silver Spring BMAP boundary area and additional capture zones

The hydrogeological characteristics of the surficial aquifer, intermediate confining unit, and Floridan aquifer system determine specific recharge rates to the Floridan aquifer. In 2005, the St. Johns River Water Management District (SJRWMD) developed a Floridan aquifer recharge map for the entire water management district, which includes most of the Silver Springs BMAP area. Average annual recharge rates to the Floridan aquifer were calculated based on an analysis of hydraulic pressure differences between the water table and the potentiometric surface of the UFA. The vertical hydraulic conductivity and thickness of confining units were also factored into the recharge calculations. The SJRWMD estimated the recharge rates to the Floridan aquifer (in inches per year [in/yr]) for the following ranges:

discharge, 0 to 3.9; 4 to 7.9; 8 to 11.9; 12 to 19.9; and greater than 20. This information was supplied in a raster-based format.

The raster data were transformed into polygon features and smoothed to create natural contour lines for the purposes of this evaluation. The SJRWMD recharge ranges were then aggregated into four recharge categories: discharge, low recharge (0 to 3.9 in/yr), medium recharge (4 to 11.9 in/yr), and high recharge (12 in/yr or greater) (**Figure 2**). The discharge category includes areas where water from the Floridan aquifer discharges through springs or seepage into lakes, streams, or wetlands. The other categories are areas where some degree of recharge to the UFA occurs.



This map prepared 10/15/13 FDEP Ground Water Management Section. For display purposes only. For more information: K. Eller (850)245-8652

Figure 2: Recharge categories throughout the Silver Springs BMAP area

1.3 Land Use

Land use/land cover (LU/LC) information can vary depending on the delineation methods. For this assessment, the most recent land use geographic information system (ArcGIS) coverages were obtained from the water management districts and county property appraisers. The land use maps for the water management districts are generated through the analysis of aerial photographs. The Silver Springs BMAP area lies within three water management district boundaries (**Figure 3**): the SJRWMD (which includes most of the area), the Southwest Florida Water Management District (SWFWMD) (the southern and western part) and the Suwannee River Water Management District (SRWMD) (a small area in the northern part).

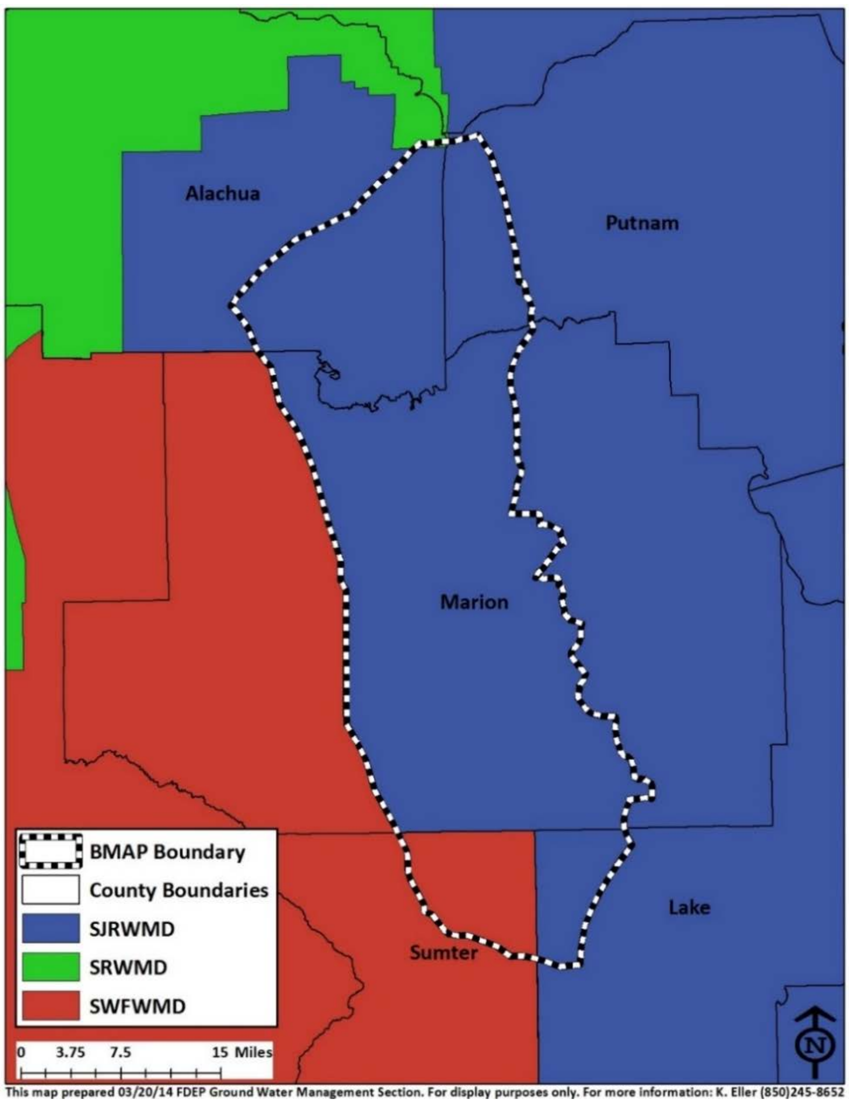


Figure 3: Silver Spring BMAP boundary location relative to the state water management districts

All land use classifications used by the water management districts were based on the Florida Land Use/Land Coverage and Forms Classification System (FLUCCS) using the following methods:

- SJRWMD land use was created using aerial imagery taken between December 2008 and March 2009. This update was based on 2004 land use coverage, and previous and more recent aerial imagery were compared to create the 2009 land use map.

- SWFWMD land use was based on 2009 coverage created by district staff that is an update to the 2006 coverage data. The digital imagery was taken during 2007. The land use classifications were determined through a photo interpretation, editing, and quality check process.

- The SRWMD's land use data from 2010–11 are the most recent for the BMAP area of all three water management districts. These data were compiled by the department's GIS staff. This update was based on true color photography taken on April 3, 2011, for Alachua County. After completing the initial updates to land use, ground-truthing efforts were made to ensure the accuracy of these data.

All three of these land use coverage maps were combined for the NSILT for the BMAP area. In the cases where two datasets overlapped one another, the SJRWMD district data were used because most of the BMAP area lies within the SJRWMD. **Appendix A** (**Table A.2** and **Table A.3**) provides details of the agricultural and urban land use data for each county, as well as the breakdown for each county within the BMAP boundary. The combined land use map based on information from the three water management districts was used throughout this analysis to evaluate the nitrogen loading for different source categories and is referred to as "WMD" land use.

The second type of land use coverage was based on information from county property appraiser offices. Each county provided data specific to the greenbelt or agricultural classifications. Property appraisers in each county visit properties routinely to update and verify the land use classification of parcels for tax purposes. These visits to a given parcel typically occur at least every five years, although most parcels are visited more frequently. This system allows for continual updates, and the land use data from the property appraisers in this report span the period from November 2013 to January 2014. For this assessment, the property appraisers also provided detailed information about the specific agricultural practices in their respective counties that was very helpful for estimating nitrogen contributions from fertilizer use on farmland and for livestock categories. The land use information obtained from property appraisers is designated as “PA” in this report.

2. Estimating Nitrogen Inputs to the Land Surface

Nitrogen inputs to the land surface in the BMAP area were evaluated for atmospheric deposition, wastewater treatment facility (WWTF) application sites (including reclaimed water), septic tanks, urban and agricultural fertilizer application, livestock waste, and stormwater runoff to drainage wells in the city of Ocala. The methods used to estimate nitrogen inputs for each source are based on the synthesis of information, including direct water quality measurements, census data, surveys, farm visits, published scientific studies and reports, and meetings with ranchers and growers. In many cases, several assumptions and extrapolations were made for estimating nitrogen inputs from each type of source, and as a result the estimated nitrogen inputs presented in this report are subject to further refinement as more detailed information becomes available. The approach and sources of information used to estimate the annual nitrogen input (in kilograms per year [kg-N/yr]) to the land surface for each source category are discussed below.

2.1 Atmospheric Deposition

Atmospheric deposition is largely a diffuse, albeit continual, source of nitrogen. Nitrogen species and other chemical constituents are measured in wet and dry deposition at discrete locations around the United States. In Florida, the Clean Air Status and Trends Network (CASTNET) has two stations that collect and analyze dry deposition. Wet deposition currently is collected at nine stations around the state as part of the National Atmospheric Deposition Program (NADP), National Trends Network (NTN). Recently, Schwede and Lear (2014) developed a hybrid approach for estimating total atmospheric deposition of nitrogen and sulfur for the entire United States, referred to as TDEP. Dry deposition data from several monitoring networks including CASTNET, the NADP Ammonia Monitoring Network, the Southeastern Aerosol Research and Characterization Network, and modeled data from the Community Multi-scale Air Quality Model, are combined in a multi-step process with NTN wet deposition values to model total deposition within 16-km grid cells.

Multiple model runs were completed, including a single year’s worth of atmospheric deposition as well as multi-year models representing an average annual deposition for time period. The TDEP model run utilized for the NSILT includes data from 2011 to 2013. This TN data is available in a nationwide coverage (e00) file and was converted into ArcGIS shapefiles for the purpose of this analysis. **Figure 4** illustrates the model results for the Silver Springs BMAP area. The total deposition within each recharge area was calculated within ArcGIS. Table 1 contains a summary of the atmospheric deposition data for the contributing area.

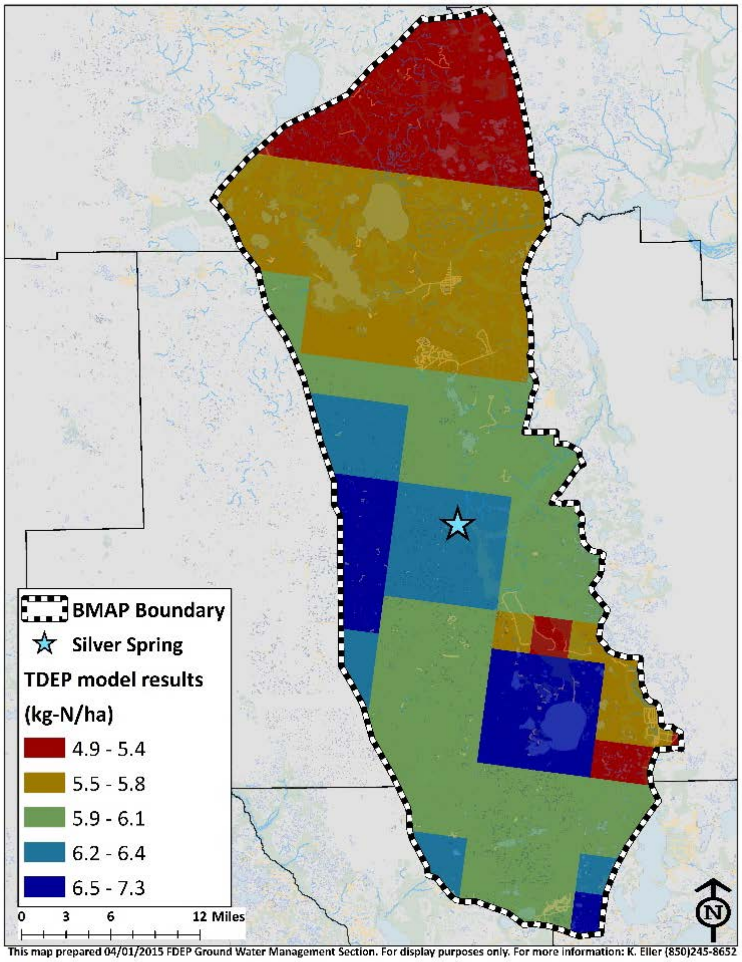


Figure 4: Atmospheric deposition model results used for the NSILT

Table 1: Modeled atmospheric deposition of total nitrogen in Silver Springs BMAP area in kg-N/yr

County	High	Medium	Low	Discharge
Alachua	31,922	103,984	116,954	23,457
Marion	415,686	302,535	142,029	69,401
Lake	27,877	38,517	8,169	3,629
Putnam	30,503	62,685	21,862	1,720
Total BMAP Area	515,573	554,246	331,004	102,325

2.2 Wastewater Treatment Facilities

WWTFs receive and treat domestic wastewater. In this area, treated effluent containing nitrogen is discharged to sprayfields, rapid infiltration basins, or percolation ponds, or is reused for irrigation water. There are 97 WWTFs located within the Silver Springs BMAP boundary, with 17 discharging more than 100,000 gallons of treated effluent per day. Nitrate and TN data were obtained from the department's Wastewater Facility Regulation (WAFR) database in order to calculate average annual input from WWTFs.

The required monitoring varies between facilities, and not all report the same type of data. For larger facilities, the annual effluent input to the land surface was estimated using the average TN concentration and the discharge (volume), but this information was not always available for smaller facilities. Smaller WWTFs (by volume; <0.1 million gallons per day [MGD]) are not always required to monitor and report effluent concentrations, and therefore not all these facilities had available WAFR data. For these facilities, the TN concentration was estimated at 8.97 mg/L based on a 2009 cooperative study with the Water Reuse Foundation of 40 domestic WWTFs across the state.

Also, some facilities reported NO_3-N rather than TN for their effluent concentrations. For these, the department estimated TN concentrations by extrapolating from the NO_3-N data (assuming the NO_3-N concentration was 38.5% of the TN based on the same 2009 study previously mentioned). For this calculation, the NO_3-N value is divided by 0.385 resulting in an estimating TN concentration. Additionally, smaller facilities are not required to report the actual discharge volume, and the nitrogen input was estimated assuming the plant was discharging effluent at 50% of its permitted design capacity.

The WWTF data were compiled for each facility for one complete year, starting approximately in June 2012 through May 2013. Most of these facilities discharge all of their treated wastewater to various land application sites; however, some of the larger facilities also provide treated wastewater for reuse through public access systems for irrigation on urban landscapes or agricultural fields. Specifics on the operation of the facilities providing water for reuse were obtained from their permits.

2.2.1 Land Application of Treated Wastewater

Facilities permitted for land application of treated wastewater, the reported annual average flows were used to calculate an average discharge for the evaluated year applied to spray fields, rapid infiltration basins and absorption fields. The nitrogen inputs for each WWTF were calculated using the average annual TN concentration and the average yearly flow from the facility. The average annual nitrogen inputs were then estimated for the facilities in the BMAP area and categorized based on the location of the wastewater application site in terms of the recharge rate to the aquifer. **Table 2** summarizes the nitrogen input data from the larger facilities in the BMAP area for land application only. For more data utilized for the WWTF estimates, **Table A.9** in **Appendix A** contains the data from all facilities evaluated.

Table 2: Summary data for WWTFs contributing more than 1,000 kg-N annually for land application (June 2012–May 2013)

* TN data estimated based on available NO_3 data.
+ Effluent data not available; average TN value from department study used.

WWTF Name	Facility ID	County	Recharge Area	Annual Average TN (mg-N/L)	Annual Flow (MGD)	Nitrogen Input (kg-N/yr)
City of Ocala #2	FLA010680	Marion	High	6.83*	2.305	21,753
Silver Springs Shores	FLA296651	Marion	High	6.49*	0.823	7,384
Ocala East Villas	FLA01075	Marion	Medium	111.69*	0.04	6,173
North Sumter WWTF	FLA281581	Sumter	Medium	14.95*	0.23	4,692
Marion Correctional Institute	FLA010789	Marion	High	6.05*	0.514	4,298
Town of Lady Lake	FLA399761	Lake	High	5.81	0.042	334
Central Sumter WWTF	FLA499951	Sumter	Medium	16.00	0.073	1,605
Villages WWTF	FLA010555	Lake	Medium	7.26	0.214	2,151
City of Fruitland Park	FLA374245	Lake	High	11.07*	0.094	1,438
Silver Springs Regional	FLA010786	Marion	Medium	7.34*	0.133	1,350

2.2.2 Public Access Reuse Systems

Within the Silver Springs BMAP boundary, there are 11 WWTFs permitted for a combination of land application and reuse, and one permitted reuse facility which only receives waste water from WWTFs other facilities for distribution. The facility permits contain details of the reuse sites which were identified and the flow directed to these sites calculated based on the data reported within the WAFR system. These reported flows in combination with the TN concentrations were used to estimate the total nitrogen applied to the land surface. **Table 3a** through **Table 3c** contain summary information and estimated inputs to land surface from reuse within the three recharge categories of the BMAP area. **Appendix A** contains more detailed information.

Table 3a: Summary of reuse from WWTFs in high-recharge areas

* TN data estimated based on available NO_3 data.

WWTF Name	Facility ID	County	Annual Average TN (mg-N/L)	Annual Flow (MGD)	Nitrogen Input (kg-N/yr)
City of Ocala #2	FLA010680	Marion	6.83*	1.59	14,968
North Sumter Utility Company Master Reuse System	FLA516708	Sumter	6.33*	0.273	2,387
Little Sumter WWTF	FLA017133	Sumter	5.73	0.102	805
Town of Lady Lake	FLA399761	Lake	5.81	0.095	759
City of Ocala #1	FLA010677	Marion	20.9	0.020	564
City of Belleview	FLA010678	Marion	2.35	0.167	541

Table 3b: Summary of reuse from WWTFs in medium-recharge areas

* TN data estimated based on available NO_3 data.

WWTF Name	Facility ID	County	Annual Average TN (mg-N/L)	Annual Flow (MGD)	Nitrogen Input (kg-N/yr)
Little Sumter WWTF	FLA017133	Sumter	5.73	2.26	17,849
City of Ocala #1	FLA010677	Marion	20.90	0.580	16,755
North Sumter Utility Company Master Reuse System	FLA516708	Sumter	6.33*	1.71	14,942
City of Ocala #2	FLA010680	Marion	6.83*	0.95	9,010
Villages WWTF	FLA010555	Lake	7.26	0.706	7,085
City of Wildwood	FLA013497	Sumter	7.73*	0.189	2,018
City of Belleview	FLA010678	Marion	2.35	0.180	582
Town of Lady Lake	FLA399761	Lake	5.81	0.070	558
Stonecrest WWTF	FLA010741	Marion	2.92	0.112	452
Pennbrooke WWTP	FLA010570	Lake	7.77	0.027	292

Table 3c: Summary of reuse from WWTFs in low-recharge areas

* TN data estimated based on available NO_3 data.

WWTF Name	Facility ID	County	Annual Average TN (mg-N/L)	Annual Flow (MGD)	Nitrogen Input (kg-N/yr)
North Sumter Utility Company Master Reuse System	FLA516708	Sumter	6.33*	0.817	7,144
Little Sumter WWTF	FLA017133	Sumter	5.73	0.113	896
Pennbrooke WWTP	FLA010570	Lake	7.77	0.053	573
City of Wildwood	FLA013497	Sumter	7.73*	0.039	414
Villages WWTF	FLA010555	Lake	7.26	0.002	20
City of Ocala #1	FLA010677	Marion	20.90	0.0002	5
City of Ocala #2	FLA010680	Marion	6.83*	0.0004	4

2.3 Septic Tanks

Onsite sewage treatment and disposal systems (OSTDS), commonly referred to as septic tanks, are widely used throughout the Silver Springs BMAP area where municipal sewer is not available. These systems can contribute to elevated nitrogen concentrations in ground water (Chang *et al.* 2010). Marion County provided best-available septic tank data (lasted updated 2012) for the part of the assessment area that falls within its boundaries. These data were derived using ArcGIS and based primarily on property appraiser and sewer service area (utility) information. All parcels identified by the property appraiser as improved with septic tanks were included in the dataset if they were located outside a sewer service area and were not located within the vicinity of a department-permitted domestic WWTF. Parcels identified as improved with a residence or commercial building but having no information regarding sewer or septic were also initially identified as having a septic tank. However, where improved parcels fell within a sewer service area, every effort was made to determine if the property was, in fact, connected to a sewer line by cross-referencing parcel numbers with utility-specific data. If it was determined that the parcel was connected to a sewer line, it was eliminated from the dataset. Data from the department's WAFR sites were included in the analysis in order to eliminate parcels served by community wastewater treatment plants (WWTPs).

For parts of the BMAP area not in Marion County, another method was used. In 2009, a contractor for the Florida Department of Health (FDOH) developed a statewide model for estimating the number of septic tanks based on tax parcel data and known sewer service areas (Hall and Clancy 2009). This model relied on septic tank permit data from FDOH, as well as information from public utilities about their sewer collection systems and service areas, to estimate the type of service provided to individual land parcels not accounted for by a permit or sewer connection. For example, an estimated septic tank parcel was assumed to be located in areas where no sewer service was likely. The output of this model was provided in an ArcGIS geodatabase from which the locations of both the known and the estimated septic tanks can be mapped.

The Marion County septic tank data were combined with the 2009 FDOH model data for parts of Alachua, Lake, Sumter, and Putnam Counties to estimate the number of septic tanks within the BMAP area. **Figure 5** shows the location of septic tanks relative to the areas covered by the three recharge categories.

After the number of septic tanks in the BMAP area was established, the population served by septic tanks was estimated using the 2010 United States Census Bureau data on population and household occupancy in each county. The Census makes a distinction between occupied and unoccupied households. The populations of counties included in the BMAP area were divided by the number of occupied households in each county, resulting in the average number of people per household. **Table 4** summarizes these data.

The number of people in the BMAP area served by septic tanks was estimated by multiplying the average number of people in each household (based on county census data) by the number of septic tanks in a given area. Several sources in the literature have estimated a 4.5 kg-N/person/year contribution of nitrogen and this factor was applied to the number of people utilizing septic tanks within the different subdivisions of the BMAP area (United States Environmental Protection Agency [EPA] 2002; Roeder 2008; Toor *et al.* 2011; Viers *et al.* 2012). **Table 5** summarizes the estimated septic tank nitrogen input for each county and by land area representing each recharge category.

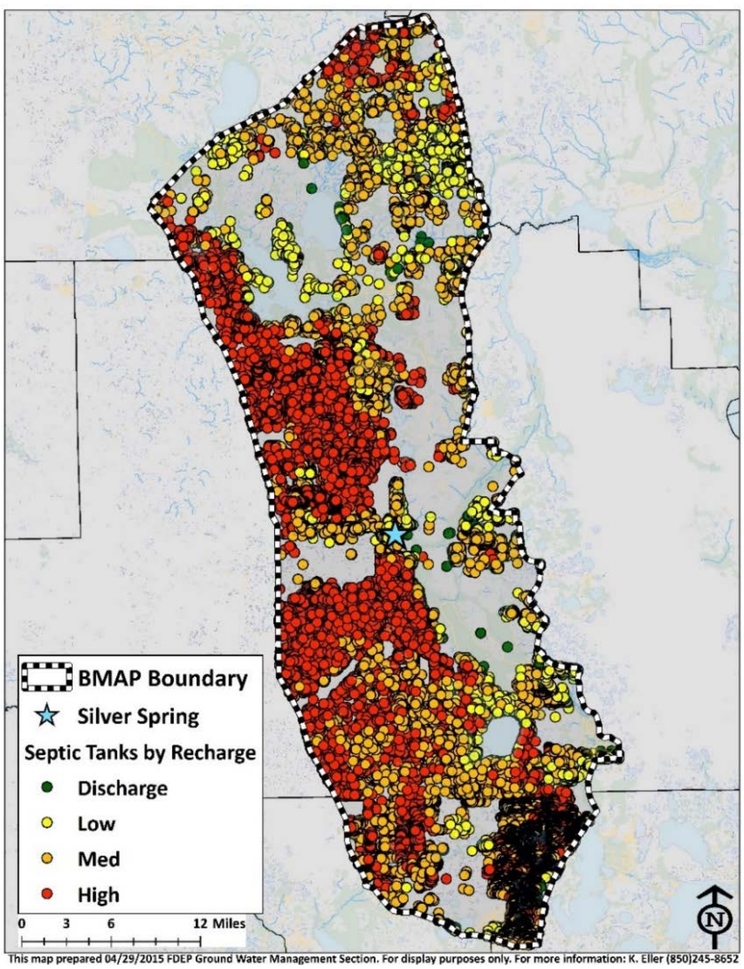


Figure 5: Distribution of septic tanks throughout the Silver Springs BMAP area

Table 4: Population and household information for the BMAP area from the 2010 Census

County	Population	Occupied Household	People Per Household
Alachua	247,336	100,516	2.46
Lake	297,052	121,289	2.45
Marion	331,298	137,726	2.41
Sumter	93,420	41,361	2.26
Putnam	74,364	29,409	2.53

Table 5: Estimated number of septic tanks and the associated inputs in the Silver Spring BMAP area

County	Septic Tanks in High Recharge	Septic Tanks in Medium Recharge	Septic Tanks in Low Recharge	Nitrogen Input (kg-N/yr)
Alachua	818	1,299	583	29,897
Lake	3,328	3,807	532	84,499
Marion	28,088	17,926	3,732	538,485
Sumter	713	1,682	184	26,213
Putnam	372	1,551	1,719	41,441
Total BMAP	33,319	26,265	6,705	720,535

2.4 Livestock

The Silver Springs BMAP area and surrounding areas contain an abundance of livestock. Marion County is the self-proclaimed "horse capital of the world," with more than 70,000 acres of thoroughbred breeding and horse training farms. Additionally, the cow-calf industry is very active in the region, with considerable acreage devoted to raising beef cattle. Other types of livestock in the area have a much smaller footprint. Livestock information and potential loadings were broken into three categories: horse farms, cattle farms, and miscellaneous livestock. The horse farm and cattle farm categories were also further subdivided to account for animal waste and fertilizer use. The practices for each of the farm categories were considered and evaluated to estimate their nitrogen inputs in the Silver Springs BMAP area.

2.4.1 Livestock Populations

Every five years the United States Department of Agriculture (USDA) releases a Census of Agriculture (CoA). This comprehensive report provides summary data on the agricultural practices and livestock populations for each state and county in the United States. The 2012 census report was used to provide data on livestock populations for this assessment. **Table 6** summarizes the livestock populations for the counties contributing land areas to the Silver Springs BMAP area.

2.4.2 Horse Farms

The CoA reports entire county data, while only a portion of each county is included in the Silver Springs BMAP boundary. To estimate the number of horses in the BMAP area, the WMD land use coverage was used to provide a breakdown of land areas that are likely to contain horses, *i.e.*, specialty farms and horse farms. The land areas were totaled for the entire counties as well as the individual land areas representing recharge categories. These summations were used to calculate a land use percentage relative to the entire county for horse farms in the different recharge categories. These percentages were applied to the populations provided by the CoA to estimate the number of animals in the BMAP area and the recharge-based subdivisions (**Table 6**). For example, if 100,000 horses were reported for a particular county in the CoA, but only 10% of the horse lands in that county were inside the BMAP area, it was assumed that only 10,000 horses would be in the BMAP area. The WMD land use coverage was utilized for these calculations because the land use subclasses can be used to distinguish between horse farms and other livestock pasturelands, while the PA land use data provide only pasture or livestock land areas without categorizing the type of animals present. **Table 7** lists detailed information on the land areas, land use percentages, and estimated numbers of horses in the BMAP area.

Table 6: County livestock populations as reported in the 2012 CoA

Livestock	Alachua County	Marion County	Lake County	Sumter County	Putnam County
Horses	3,308	37,880	2,425	2,524	458
Cows	25,567	30,219	15,698	30,097	6,045
Calves	13,753	17,034	7,087	16,164	3,122
Broiler Chickens	1,230	1,235	319	257	16
Layer Chickens	5,236	10,441	3,749	3,235	60,699
Goats	3,406	3,538	1,888	1,130	660
Hogs	431	848	322	193	149
Sheep	718	942	718	312	16
Turkeys	211	135	37	53	73

Table 7: Land areas used to calculate horse farm land use percentages and estimated BMAP horse populations

\- = Empty cell/no data

Land Category	Land Area (ha)	Land Use Percentage	Estimated BMAP Population
Alachua County	975	-	-
Alachua High Recharge	0	0%	0
Alachua Medium Recharge	1	0.1%	5
Alachua Low Recharge	19	2.0%	66
Marion County	27,861	-	-
Marion High Recharge	9,783	35%	13,301
Marion Medium Recharge	1,544	5.5%	2,100
Marion Low Recharge	233	0.8%	303
Lake County	2,060	-	-
Lake High Recharge	97	4.7%	114
Lake Medium Recharge	59	2.9%	69
Lake Low Recharge	0	0%	0
Sumter County	847	-	-
Sumter High Recharge	51	6.0%	151
Sumter Medium Recharge	251	30%	747
Sumter Low Recharge	84	9.9%	250
Putnam County	443	-	-
Putnam High Recharge	0	0%	0
Putnam Medium Recharge	3	0.7%	3
Putnam Low Recharge	10	2.3%	11

The evaluation of nitrogen inputs from horse farms also relied on data collected during horse farm visits conducted by the Marion County Extension Office during 2011–13. Survey data from nearly 200 individual farms were collected to evaluate their manure management and fertilizer practices (J. Cohen, Marion County University of Florida Institute of Food and Agricultural Sciences [UF–IFAS] Extension Service, personal communication, 2013). **Figure 6** summarizes the survey results for manure management, which is an important factor in estimating nitrogen inputs from horse farms. The nitrogen input from horses varies based on the manure management practices used on individual farms. Composting and physically removing the waste (accumulating waste in dumpsters for haul off) are considered the most effective manure management options for reducing nitrogen inputs. The composting process removes most of the nitrogen from manure through biochemical processes and minimizes its impact on the environment. The physical removal of the manure from horse farms in the BMAP area removes all of the potential input from manure. With both practices considered and extrapolating the UF–IFAS survey results to all of the horse farms in the BMAP area, it is estimated that manure from 62% of the horse population will contribute nitrogen within the BMAP area (**Table 8**).

With the contributing horse population established, a nitrogen waste factor derived from per animal nitrogen contributions was used to quantify the nitrogen input. For this assessment, a horse will produce 0.124 kg-N/day or 45.3 kg-N/yr (Goolsby *et al.* 1990; Ruddy *et al.* 2006; Katz *et al.* 2009). **Table 8** details the estimated nitrogen input from the contributing horse population in the BMAP area and the land areas representing the three recharge categories.

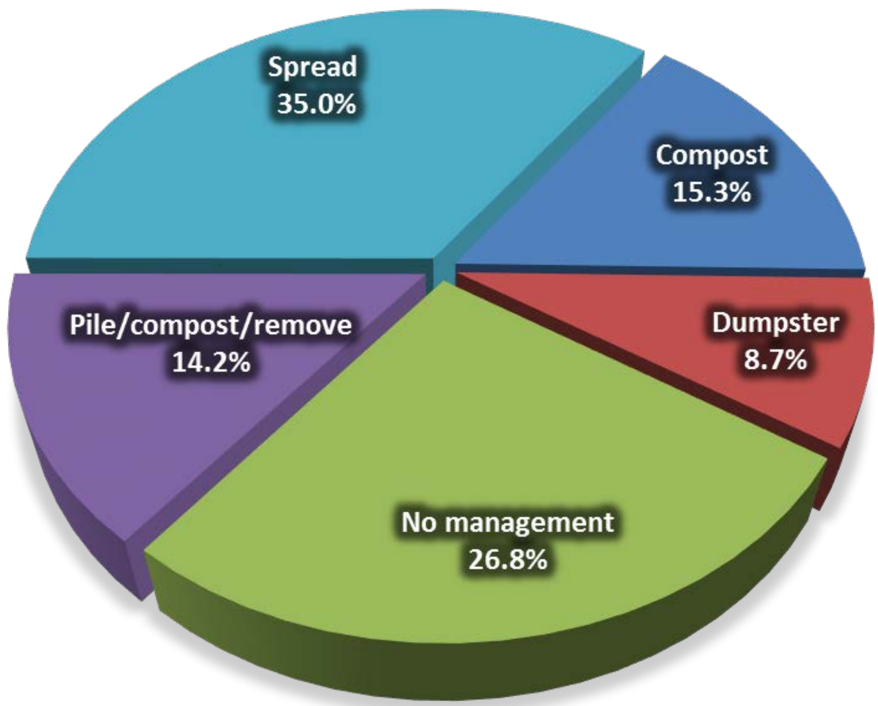


Figure 6: Manure management results from the UF–IFAS horse farm surveys (percent of farms surveyed)

The other main source of nitrogen from horse farms is pasture fertilization. For pastures, both WMD and PA land use coverages were utilized to estimate fertilizer nitrogen inputs. The PA data provided detailed information on pastures, including the varying levels of improvement in each of the counties. However, the PA information does not differentiate between lands grazed by different animals, while the WMD land use coverage does. In the WMD LU/LC livestock land use categories, the distinction between horse farms and pastures is used to distinguish between pastures associated with horse farms and pastures used for cattle. For each county and recharge category, the percentage of horse farmlands was calculated.

Table 8: Estimated nitrogen input from animal waste at horse farms within the BMAP area

Land Category	Contributing Horse Population	Nitrogen Input (kg-N/yr)
Alachua High Recharge	0	0
Alachua Medium Recharge	3	129
Alachua Low Recharge	41	1,841
Marion High Recharge	8,246	373,233
Marion Medium Recharge	1,302	58,920
Marion Low Recharge	188	8,515
Lake High Recharge	71	3,199
Lake Medium Recharge	43	1,944
Lake Low Recharge	0	0
Sumter High Recharge	94	4,249
Sumter Medium Recharge	462	20,971
Sumter Low Recharge	155	7,022
Putnam High Recharge	0	0
Putnam Medium Recharge	2	92
Putnam Low Recharge	7	296
Total High Recharge	8,411	380,682
Total Medium Recharge	1,813	82,056
Total Low Recharge	390	17,673

The total land area devoted to livestock practices was calculated using the WMD land use data. These land use types included pasturelands, feeding operations, and specialty farms. The total land area was then calculated for the specialty and horse farms. A percentage was computed using these land areas to estimate the percentage of horse farmlands relative to the other livestock land uses. For example, Marion County has 7,658 ha of livestock lands in the medium-recharge category in WMD land use. There are 1,544 ha allotted to specialty or horse farms, or 20% of the livestock lands. For medium-recharge areas of Marion County, there are 7,710 ha of either improved or semi-improved pastures or hayfields, according to the PA data. Woodland pastures were not included in these calculations because these types of pastures do not receive fertilizer. Hayfields are included because hayfields and pasturelands are used rotationally by livestock farmers. This practice was confirmed in meetings with agricultural producers in the Silver Springs BMAP area. Of the 7,710 fertilized pasture and hayfields, it was estimated that 20% of this land, or 1,555 ha, is utilized for horse farms, while the remaining 6,155 ha are devoted to cattle operations in the medium-recharge area of Marion County. These same calculations were made for all recharge categories within each county. **Table 9** summarizes these data for the land areas representing the three recharge categories.

Table 9: Comparison of summary pasture land use data from water management districts and property appraisers for the Silver Springs BMAP area

County	WMD Livestock Land (ha)	WMD Horse Farms (ha)	WMD % Horse Farms	PA Fertilized Pasture (ha)	PA Horse Pasture (ha)	PA Cattle Pasture (ha)
Alachua High Recharge	1,340	0	0%	1,569	0	1,569
Alachua Medium Recharge	2,160	1	0.1%	2,281	1	2,279
Alachua Low Recharge	1,221	19	2%	1,727	27	1,699
Marion High Recharge	22,829	9,783	43%	23,350	10,006	13,344
Marion Medium Recharge	7,658	1,544	20%	7,710	1,555	6,155
Marion Low Recharge	1,190	223	19%	1,195	224	971
Lake High Recharge	1,413	97	7%	985	67	917
Lake Medium Recharge	1,358	59	4%	1,102	48	1,054
Lake Low Recharge	201	0	0%	390	0	390
Sumter High Recharge	2,087	51	2%	1,727	42	1,685
Sumter Medium Recharge	3,283	251	8%	1,829	140	1,689
Sumter Low Recharge	1,020	84	8%	501	41	460
Putnam High Recharge	423	0	0%	164	0	164
Putnam Medium Recharge	688	3	0.5%	609	3	606
Putnam Low Recharge	376	10	3%	496	13	483

After the land area utilized for horse pasture was established, data synthesized from information obtained from the horse farm visits by the Marion County Extension Office were used to represent fertilizer application practices and rates of application for the BMAP area. The UF–IFAS recommended fertilizer rate for pastures is 100 to 150 lbs-N/ac (112 to 168 kg-N/ha) every two to three years. Information compiled from the UF–IFAS surveys indicated that approximately 21% of horse farms apply fertilizer at least once a year, while 26% apply fertilizer every few years or as needed (**Figure 7**). For this assessment, it was estimated that 21% of the horse pasturelands were fertilized at 112 kg-N/ha/yr (representing "annual," and "2-3 times per year" categories) and 26% at an annual rate of 34 kg-N/ha/yr (representing "every 2-3 yrs," "as needed," and "will" categories), with the remaining 53% not fertilized at all. **Table 10** summarizes the horse farm fertilizer nitrogen input as well as the horse manure input in the BMAP area and its recharge-based subdivisions.

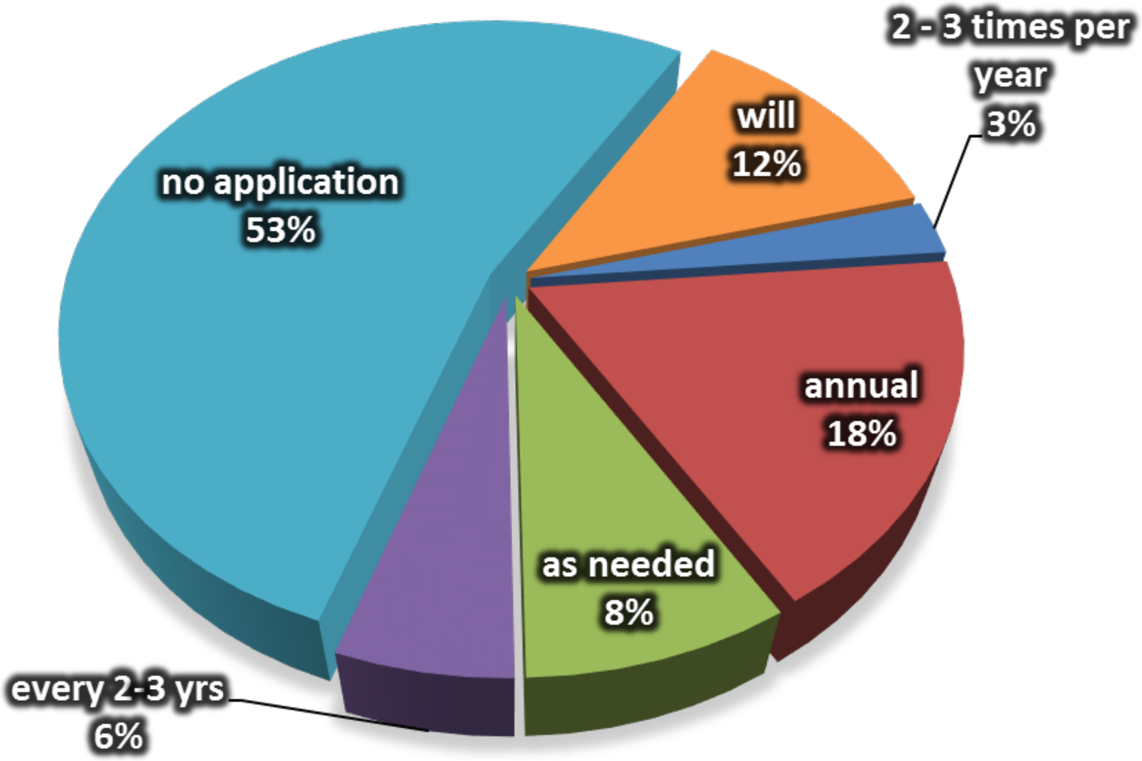


Figure 7: UF–IFAS horse farm survey results for fertilizer application

Table 10: Summary of horse farm nitrogen input from fertilizer and waste by recharge category in the BMAP area

Recharge Category	112 kg-N/ha Horse Pasture (ha)	34 kg-N/ha Horse Pasture (ha)	No Fertilization Horse Pasture (ha)	Total N from Horse Farm Fertilizer	Total N from Horse Farm Waste	Total N for Horse Farms
High	2,124	2,630	5,361	326,533	380,682	707,214
Medium	367	454	926	56,377	82,056	138,433
Low	64	80	162	9,882	17,673	27,555
Total BMAP	2,555	3,164	6,449	392,792	480,411	873,202

2.4.3 Cattle Farms

The nitrogen input to the land surface from cattle farms was estimated using an approach similar to that used for horse farms. The full county population data and land use percentages were used to estimate the number of cows and calves in the Silver Springs BMAP area. The land use percentages were calculated based on the WMD land use coverage data and the following land use categories: pastures, feeding operations, and dairies. **Table 11** summarizes the land areas and percentages for cattle farms in the BMAP area by county and recharge-based subdivision.

Beef cow-calf operations comprise most of the cattle industry in the BMAP area and surrounding areas. Each year, the cows are bred and raise their calves for six to nine months, after which the calves are sold and shipped out of the state to be raised as beef cattle. The nitrogen contributions from adult cows and calves vary because of their differences in body mass and residence time in the BMAP area. Based on a detailed literature review, a calf produces approximately 20% of the nitrogen that its mother produces (Sutton *et al.* 2001; Berry *et al.* 2002; Estermann *et al.* 2002; USDA Agricultural Research Service [ARS] 2003; Hubbard and Lowrence 2005). For this assessment, a cow produces 0.153 kg-N/day or 56 kg-N/yr as waste and contributes nitrogen throughout the year (Chelette *et al.* 2002; Ruddy *et al.* 2006; Katz *et al.* 2009; Meyer 2012; Sprague and Gronberg 2013). A calf produces only 0.031 kg-N/yr or 8 kg-N as waste in the first 183 days of its life, which is an average residence time in this area for calves (Marion County Cattlemen's Association, personal communication, 2014). These waste factors are multiplied by the populations in the BMAP area to estimate the nitrogen input from cattle waste.

As was the case with horse farms, cattle farm managers also apply fertilizers to pastures and use their lands for forage hay production on a rotational basis. The area of fertilized pasture lands devoted to cattle was calculated in the same manner as for horse farms. **Table 12** contains the estimated land areas fertilized for cattle grazing and hay production. The application rates of fertilizer to cattle lands vary and depend on the use of individual fields (such as hay production, animal forage, or idle between uses). Estimates of average annual fertilizer applications to pasture were developed based on information received in meetings with members of the Marion County Cattlemen's Association, UF–IFAS, and Florida Farm Bureau.

Based on these discussions, it was learned that fertilization rates can vary widely from one year to another but that an average annual rate for a cattle ranch that includes a combination of fertilized pasture and hayfields would be approximately 17 lb-N/ac or 19.05 kg-N/ha. This information and the information on cattle waste were used to develop estimates of total inputs from cattle production. **Table 12** contains the estimated annual average nitrogen contribution from cattle farms within the BMAP area and subdivisions based on recharge.

Table 11: Land areas used to calculate cattle farm land use percentages and estimated cattle populations within the Silver Springs BMAP area

- = Empty cell/no data

Land Category	Land Area (ha)	Land Use Percentage	Estimated BMAP Cow Population	Estimated BMAP Calf Population	Nitrogen Input (kg-N)
Alachua County	23,373	-	-	-	-
Alachua High Recharge	1,340	5.7%	1,465	788	86,250
Alachua Medium Recharge	2,158	9.2%	2,361	1,270	138,966
Alachua Low Recharge	1,202	5.1%	1,315	707	77,376
Marion County	51,011	-	-	-	-
Marion High Recharge	13,046	25.6%	7,729	4,357	456,008
Marion Medium Recharge	6,113	12.0%	3,622	2,041	213,675
Marion Low Recharge	967	1.9%	573	323	33,803
Lake County	38,878	-	-	-	-
Lake High Recharge	1,316	3.4%	531	240	31,024
Lake Medium Recharge	1,299	3.3%	525	237	30,628
Lake Low Recharge	201	0.5%	81	37	4,733
Sumter County	40,223	-	-	-	-
Sumter High Recharge	2,036	5.1%	1,524	818	89,670
Sumter Medium Recharge	3,033	7.5%	2.269	1,219	133,541
Sumter Low Recharge	936	2.3%	700	376	41,219
Putnam County	11,124	-	-	-	-
Putnam High Recharge	423	3.8%	230	119	13,498
Putnam Medium Recharge	685	6.2%	372	192	21,855
Putnam Low Recharge	366	3.3%	199	103	11,673

Table 12: Summary of total nitrogen input to the land surface attributed to cattle farming operations (kg-N/yr)

Recharge Category	Total N Input from Cattle Farm Fertilizer	Total N Input from Cattle Farm Waste	Total N Input from Cattle Farms
High	336,873	676,451	1,013,324
Medium	224,525	538,665	763,189
Low	76,263	168,804	245,067
Total BMAP	637,661	1,383,920	2,021,581

2.4.4 Miscellaneous Livestock

While cattle and horses are the most significant livestock animals in the study area, an estimate was made for other livestock animals in the BMAP area. The animal populations reported by the 2012 CoA were evaluated for chickens (broilers and layers), goats, hogs, sheep, and turkeys. The livestock land use percentages were utilized to estimate the number of animals within the BMAP area and recharge-based subdivisions (**Table 11**). Nitrogen waste factors were assigned for each animal type and applied to the estimated livestock populations. These nitrogen waste factors included broiler chickens at 0.072 kg-N/day, layer chickens at 0.0012 kg-N/day, goats at 0.016 kg-N/day, hogs at 0.086 kg-N/day, sheep at 0.09 kg-N/day, and turkeys at 0.0025 kg-N/day (Goolsby *et al.* 1990; Katz *et al.* 1999; Chelette *et al.* 2002; Ruddy *et al.* 2006; Meyer 2012; Sprague and Gronberg 2013). **Table 13** summarizes the estimated populations and their nitrogen contribution. **Table A.19** in **Appendix A** contains a full listing of the CoA data for these miscellaneous livestock species.

Table 13: Estimated BMAP and associated nitrogen input from miscellaneous livestock within the BMAP area

County	Broiler Chickens	Layer Chickens	Goats	Hogs	Sheep	Turkeys	Total N Input (kg-N/yr)
Alachua High Recharge	70	300	195	25	41	12	5,263
Alachua Medium Recharge	114	484	315	40	66	19	8,479
Alachua Low Recharge	63	269	175	22	37	11	4,721
Marion High Recharge	316	2,670	905	217	241	35	29,509
Marion Medium Recharge	148	1,251	424	102	113	16	13,827
Marion Low Recharge	23	198	67	16	18	3	2,187
Lake High Recharge	11	127	64	11	24	1	1,855
Lake Medium Recharge	11	125	63	11	24	1	1,831
Lake Low Recharge	2	19	10	2	4	0	283
Sumter High Recharge	13	164	57	10	16	3	1,576
Sumter Medium Recharge	19	244	85	15	24	4	2,347
Sumter Low Recharge	6	75	26	4	7	1	724
Putnam High Recharge	1	2,307	25	6	1	3	1,373
Putnam Medium Recharge	1	3,736	41	9	1	4	2,224
Putnam Low Recharge	1	1,995	22	5	1	2	1,188
Total High Recharge	411	5,568	1,246	269	323	54	87,248
Total Medium Recharge	293	5,840	928	177	228	44	63,290
Total Low Recharge	95	2,556	300	49	67	17	20,070

2.5 Crop Fertilizer

Nitrogen in fertilizer is applied at varying rates, depending on the crop and individual farm practices. The county property appraiser offices provided detailed information on the types of crops grown on properties in their respective counties. The type of information varied by county, and estimates used in this evaluation vary by county based on the level of detail available from the respective county property appraisers. Rates of nitrogen applied were estimated based on the most likely crops that would be grown in each land use code group. Fertilizer nitrogen application rates are based on those recommended by UF–IFAS (Hochmuth and Hanlon 2000; Hochmuth and Hanlon 2010; Wright *et al.* 2011; Mylavarapu *et al.* 2012; Liu *et al.* 2012; Hochmuth and Hanlon 2013). **Table 14a** through **Table 14e** summarize the data used to estimate crop fertilization in the BMAP area and the areas representing the recharge categories.

Table 14a: Summary of crop types and nitrogen application rates for Marion County

[a] Nitrogen application rate for peanuts was used because very little cotton is grown in the area.

PA code	Probable Crop	N Application Rate (kg-N/ha)	High Recharge Land Area (ha)	Medium Recharge Land Area (ha)	Low Recharge Land Area (ha)	Total Input (kg-N/yr)
51	Peanuts, cotton	0[a]	440	301	163	0
66	Oranges	168	97	316	171	98,232
69	Blueberries, pecans, ornamentals	90	260	404	42	63,283

Table 14b: Summary of crop types and nitrogen application rates for Lake County

- = Empty cell/no data

PA code	Probable Crop	N Application Rate (kg-N/ha)	High Recharge Land Area (ha)	Medium Recharge Land Area (ha)	Low Recharge Land Area (ha)	Total Input (kg-N/yr)
5100	Fernery	90	-	-	6	530
5200	Sod	90	-	10	-	896
5300	Vegetables	135	141	139	10	38,995
6600	Orchards	168	81	79	2	27,165
6900	Ornamentals	90	17	23	-	3,567

Table 14c: Summary of crop types and nitrogen application rates for Putnam County

- = Empty cell/no data

PA code	Probable Crop	N Application Rate (kg-N/ha)	High Recharge Land Area (ha)	Medium Recharge Land Area (ha)	Low Recharge Land Area (ha)	Total Input (kg-N/yr)
51	Potatoes, cabbage	135	-	34	15	6,623
66	Citrus	168	25	22	20	11,292
69	Ornamentals, sod	90	4	4	-	661

Table 14d: Summary of crop types and nitrogen application rates for Sumter County

- = Empty cell/no data

PA code	Probable Crop	N Application Rate (kg-N/ha)	High Recharge Land Area (ha)	Medium Recharge Land Area (ha)	Low Recharge Land Area (ha)	Total Input (kg-N/yr)
5100	Watermelon, peanut	0	2	14	5	0
5200	Watermelon, peanut	135	277	369	50	93,604
5250	Watermelon, peanut	135	47	34	-	10,902
6600	Orchards	168	2	-	-	393
6900	Nursery	90	28	5	-	2,915

Table 14e: Summary of crop types and nitrogen application rates for Alachua County

+ = Application rates estimated based on other county information.

PA code	Probable Crop	N Application Rate (kg-N/ha)	High Recharge Land Area (ha)	Medium Recharge Land Area (ha)	Low Recharge Land Area (ha)	Total Input (kg-N/yr)
5100	Unspecified crops	0+	88	381	10	0
5200	Unspecified crops	135+	55	199	31	38,453
5300	Unspecified crops	135+	5	9	0	1,785
6600	Orchards	168	94	264	63	70,784
6900	Ornamentals	90	9	25	5	6,505

2.6 Urban Fertilizer

Nitrogen in fertilizer applied in urban areas was assumed to be applied mostly to golf courses and residential lawns. Previous studies have used fertilizer sales data compiled by the Florida Department of Agriculture and Consumer Services (FDACS) to estimate the fertilizer nitrogen inputs in urban areas (Chelette *et al.* 2002; Gronberg and Spahr 2012). This method was employed for estimating urban fertilizer inputs in the Silver Springs BMAP area, and it assumes that the majority of the fertilizer used was purchased locally and that out-of-county sales of fertilizer were not significant.

Amounts of nitrogen fertilizer sold by county are available from FDACS. For this analysis, data from two different FDACS reports were used: *Summary by County* and *Nutrients by County*. These .pdf documents contain historical annual sales records by county, based on the state fiscal year (July 1 of one year to June 30 of the following year). The annual average fertilizer inputs were calculated using the data for the state fiscal year. For example, the FDACS report from July 2011 to June 2012 was used to calculate the nitrogen inputs for 2012.

The total nonfarm or urban fertilizer sold is in the *Summary by County* report, while the TN in the fertilizer sold and total fertilizer sold is available in the *Nutrients by County* report. Fertilizer sales quantities are reported in tons and were converted to kilograms for this assessment. Data for each county were obtained from 2007–12, the most recent reporting period. The TN sold in urban fertilizers was calculated based on the known amount of urban fertilizer and the percent of nitrogen in all of the fertilizers sold within the county. **Table 15** summarizes these data by county.

Table 15: County fertilizer sales data (2007–12) utilized for the Silver Springs nitrogen inventory

County	Total Fertilizer Sold (kg)	Total N Sold in Fertilizer (kg)	% N in Fertilizer	Total Urban Fertilizer Sold (kg)	Total N Sold in Urban Fertilizers (kg)
Alachua	19,061,178	1,424,185	7.6%	6,277,541	480,321
Marion	17,655,113	1,744,203	9.9%	5,547,560	567,714
Lake	27,190,429	2,137,475	7.7%	9,392,346	752,000
Sumter	5,156,063	418,434	8.4%	1,493,364	129,805
Putnam	9,693,503	1,021,183	10.4%	2,029,511	195,831

As was the case with the USDA census data used for estimating livestock populations in the BMAP area, fertilizer sales data are for the entire county, while only a portion of each county is within the BMAP boundary. Land use percentages were calculated from the WMD land use data based on urban land uses: high-, medium- and low-density residential areas, as well as golf courses, recreational areas, and parks and zoos. **Table 16** summarizes the land use percentages and the TN input attributed to urban fertilizers in the BMAP area and its recharge-based subdivisions. **Table A.3** in **Appendix A** contains a complete list of land use data for urban land uses.

2.7 Drainage Wells

The city of Ocala constructed stormwater drainage wells in the early development of the Ocala Urban Core Area to control the elevations of detention ponds without natural outfall systems. Most of the drainage wells are in the bottoms of sinkholes, in closed depressions that naturally receive stormwater runoff, or in excavated detention ponds (Kimrey and Fayard 1984). Drainage wells range in depth from 27 to 243 feet and in diameter from 4 to 18 inches (Dyer, Riddle, Mills, and Precourt, Inc. 1984). As most drainage wells are generally less than 200 feet deep, stormwater flowing into drainage wells directly recharges the highly transmissive UFA in this area (Kimrey and Fayard 1984).

Table 16: Urban land use summary and fertilizer input

County	Land Area (ha)	Land Use Percentage	Nitrogen Input (kg-N)
Alachua County	33,097	-	480,321
Alachua High Recharge	612	1.8%	8,877
Alachua Medium Recharge	1,218	3.7%	17,677
Alachua Low Recharge	476	1.4%	6,906
Marion County	64,867	-	567,714
Marion High Recharge	17,179	26.5%	150,350
Marion Medium Recharge	11,846	18.3%	103,679
Marion Low Recharge	2,532	3.9%	22,157
Lake County	40,358	-	752,000
Lake High Recharge	1,423	3.5%	26,509
Lake Medium Recharge	2,452	6.1%	45,690
Lake Low Recharge	385	1.0%	7,181
Sumter County	15,416	-	129,805
Sumter High Recharge	1,231	8.0%	10,362
Sumter Medium Recharge	4,283	27.8%	36,060
Sumter Low Recharge	871	5.7%	7,336
Putnam County	20,408	-	195,831
Putnam High Recharge	227	1.1%	2,181
Putnam Medium Recharge	1,247	6.1%	11,962
Putnam Low Recharge	982	4.8%	9,420

The drilling of drainage wells was discontinued because of the potential for ground water quality degradation (Dyer, Riddle, Mills, and Precourt, Inc. 1984), and many of the drainage wells in the area are no longer in use. In 1980 water samples were collected from six drainage wells along with a sample of urban stormwater runoff (Kimrey and Fayard 1984). Two of the wells were receiving injection water at the time of sampling. The other four wells were not receiving injection water at the time of sampling but had probably received stormwater within the past few days. TN concentrations in drainage wells ranged from 0.39 to 8.0 mg/L as N. Nitrite-Nitrate-N concentrations generally were low (0.01 to 3.1 mg/L); however, ammonia plus organic nitrogen concentrations ranged from 0.17 to 4.9 mg/L as N. In a sample of stormwater runoff, the ammonia plus organic nitrogen concentration was 13.4 mg/L, and the nitrate-N concentration was 0.72 mg/L.

Historical information about stormwater drainage wells in the city of Ocala was obtained from the *Ocala Storm Water Management Plan* (Dyer, Riddle, Mills, and Precourt, Inc. 1984). According to this plan, the Ocala study area includes 154 basins, some of which were further subdivided into a total of 254 subbasins. For each drainage subbasin that contained drainage wells, information was tabulated on the basin area (acreage), the number of drainage wells, and their diameter. A total of 40 drainage wells were located in 19 delineated drainage subbasins. Also, each drainage subbasin had land use information for the number of acres of high-density residential, business, industrial, and government areas.

The following procedure was used to estimate nitrogen inputs from stormwater runoff to drainage wells. The area receiving stormwater runoff for each land use in each subbasin was obtained by multiplying the land use acreage by a Soil Conservation Service (SCS) runoff coefficient (**Table 17**). This runoff curve area was multiplied by mean annual rainfall (50.8 inches; Florida Climate Center 1981–2010) to obtain the annual volume of runoff for each land use in the drainage basin. The annual volume of stormwater runoff from each land use type was multiplied by the nitrogen event mean concentration (EMC) for each land use (H.H. Harper, Environmental Research and Design, Inc., written communication, updated 12/8/11) to obtain the nitrogen load. The nitrogen loads from each land use were summed for each drainage basin, and the nitrogen loads for all basins were summed to obtain the TN load from stormwater runoff to all drainage wells. The estimated annual TN load from stormwater drainage wells is 18,279 kg-N/yr.

Table 17: Runoff curve numbers and EMC used for drainage well calculations

Land Use Type	Runoff Coefficient	EMC N (mg/L)
Low-Density Residential	0.61	1.51
High-Density Residential	0.77	2.1
Business/Commercial	0.89	1.6
Industrial	0.81	1.2
Government	0.64	1.2

Several assumptions were made in estimating the nitrogen loads in stormwater that flows into the drainage wells: (1) during any given year, on average each rainfall event generated stormwater runoff to drainage wells regardless of the rainfall amount or intensity; (2) land use in each drainage subbasin containing drainage wells in Ocala has not changed substantially from that described by Dyer, Riddle, Mills, and Precourt, Inc. (1984); (3) the drainage wells identified in the 1984 report are still intact; and

(4) the estimated TN load from stormwater runoff to drainage wells represents a maximum potential value. According to the available spatial data, 42 wells are estimated to still be in use in the BMAP area (**Figure 8**), with 19 located in high-recharge areas, nine in areas of medium recharge, and 14 in low-recharge areas. The annual load attributed to drainage wells was assigned to the recharge-based subdivisions for locational purposes only, since these wells provide a direct pathway for recharging the aquifer. The final estimates for input from drainage wells are as follows: 435.2 kg-N/yr per well or 8,269 kg-N/yr in high-recharge, 3,917 kg-N/yr in medium-recharge, and 6,093 kg-N/yr in low-recharge areas.

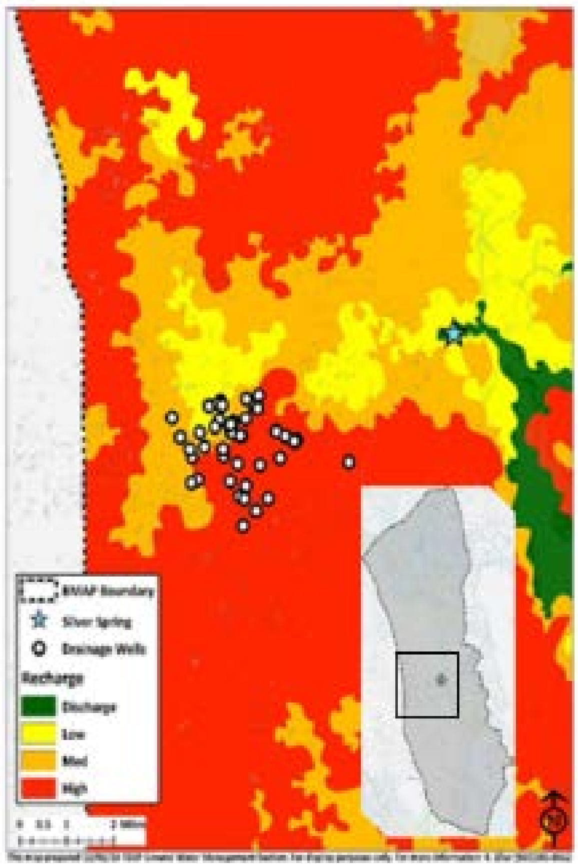


Figure 8: City of Ocala drainage well locations within the BMAP boundary

2.8 Summary of Estimated Nitrogen Inputs to the Land Surface

Figure 9 summarizes all estimated inputs of nitrogen to the land surface in the BMAP area. The total annual nitrogen input from all sources is just over 6.0 million kg-N. The most significant inputs to the land surface include cattle farms, horse farms, atmospheric deposition, and septic tanks.

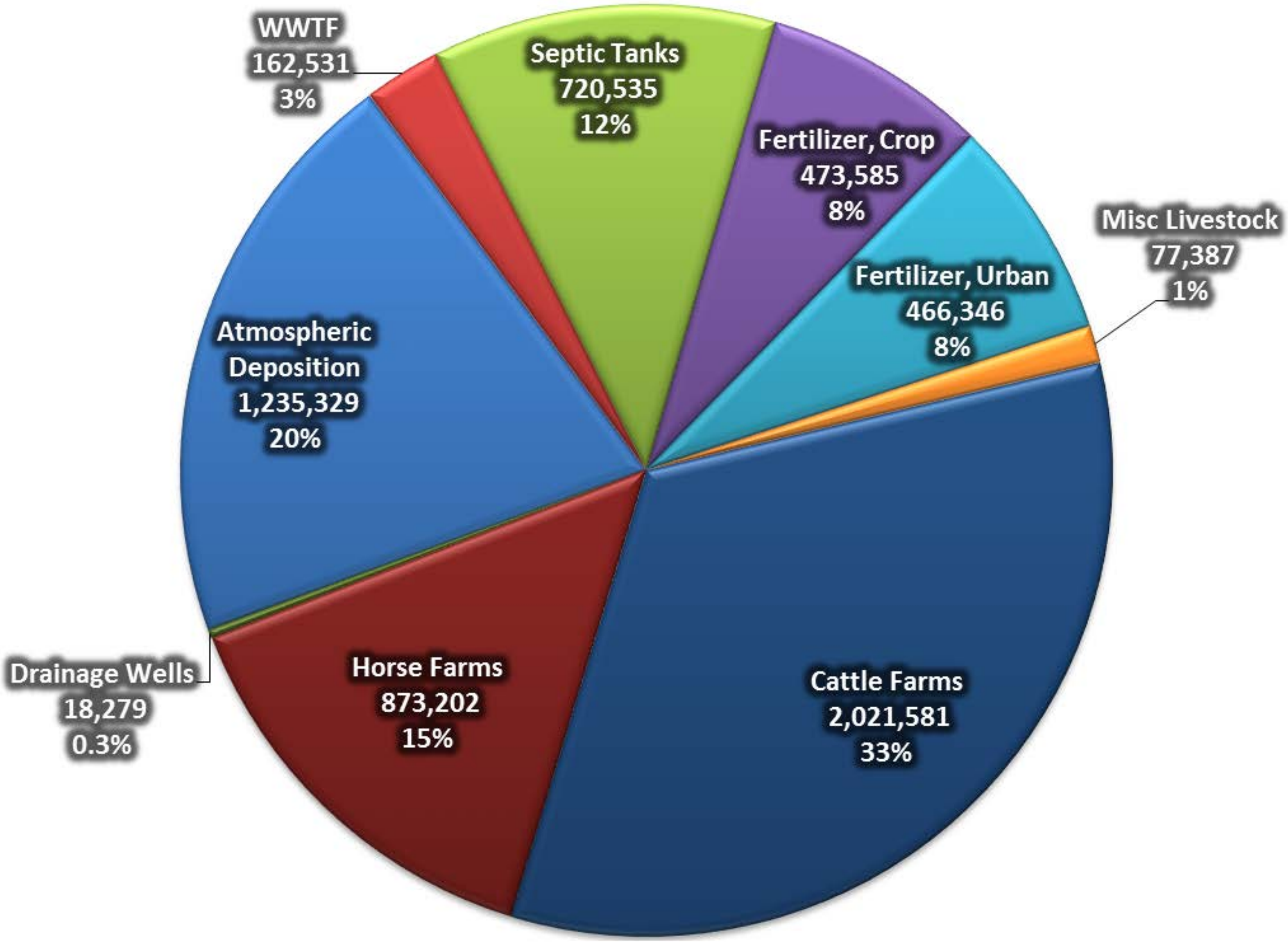


Figure 9: Relative nitrogen inputs to the land surface in the Silver Springs BMAP area from major anthropogenic source categories

3. Environmental Attenuation, Recharge, and Nitrogen Loading to Ground Water

The movement of nitrogen from the surface to ground water is controlled by biological and chemical processes that are part of the nitrogen cycle as well as hydrogeologic processes. Many of these processes attenuate (impede or remove) the amount of nitrogen that is transported to ground water. Therefore, to estimate the amount of nitrogen loading to the aquifer in the Silver Springs BMAP area, the department applies environmental attenuation factors (EAFs): one that accounts for biochemical processes that remove or transform the different forms of nitrogen, and the other that accounts for the movement of recharge water through the subsurface. The biochemical attenuation is specific for each nitrogen source category, whereas the hydrogeological attenuation varies depending on the spatial differences in the subsurface geologic properties. Both of these attenuation factors control the amount of nitrogen reaching the UFA in the area contributing flow to Silver Springs on an annual basis. An understanding of how water moves through the subsurface and the processes that transform the different forms of nitrogen is needed to estimate the loading of nitrogen to ground water from the various sources (Liao *et al.* 2012; Wang *et al.* 2013).

3.1 Biochemical Attenuation

Several near-surface biochemical processes increase nitrogen availability for plants such as fixation (conversion of atmospheric nitrogen to a plant available form), mineralization (conversion of organic nitrogen to ammonium), and nitrification (conversion of ammonium to nitrate). Losses of nitrogen from the root zone can result from denitrification, volatilization, and immobilization, and cation exchange (affecting ammonium). These processes occur to varying degrees depending on how the form of nitrogen is introduced, soil properties, and several other factors (Cockx and Simonne 2011; Costa *et al.* 2002; Horsley Witten Group 2009).

Specific biochemical attenuation factors were used to account for the various processes that affect the movement of nitrogen from each source category in the subsurface. The EAFs utilized for this assessment were obtained through an extensive literature review of relevant studies throughout Florida as well as other areas with similar environmental characteristics. Additionally, research scientists in Florida (UF–IFAS, universities, and USDA–ARS) and local stakeholders were sought out for their expertise. The biochemical attenuation factors, shown in **Table 18**, represent the average percentage of the nitrogen mass attenuated or removed by processes occurring in the environment and thus prevented from reaching ground water.

As a first step in estimating loading to ground water, the previously mentioned nitrogen inputs at the land surface from each category are multiplied by their associated EAFs. For example, atmospheric deposition has an average 90% environmental attenuation (*e.g.*, uptake by vegetation). This means that an average of 10% of the atmospheric nitrogen input to the land surface has the potential to leach to ground water. The next step in estimating nitrogen loads to ground water takes into account additional attenuation associated with variations in hydrogeological properties in the BMAP area.

3.2 Hydrogeological Attenuation

Any nitrogen remaining after taking into account biochemical attenuation processes, which is usually in the form of nitrate, can readily leach to ground water. However, leaching to ground water is a function of the properties of the soil and unsaturated zone, such as composition (particularly the organic matter content), texture, drainage, wetness, and thickness. The rate of ground water recharge (from rainfall or irrigation water) ultimately controls how rapidly nitrogen moves from below the root zone to the UFA. The amount of water recharging the UFA each year also depends on amount of rainfall, evapotranspiration, runoff, as well as subsurface hydrogeologic properties. The final step in estimating nitrogen loads to ground water is to account for additional attenuation associated with the rate of recharge in a given year.

Table 18: EAFs applied to the nitrogen input calculations. These percentages represent the amount of nitrogen removed by the environment.

[1] Selected references listed; **Appendix B** contains a full listing.
[2] Estimation for established turfgrass.

N Source Category	Attenuation Factor	Literature References
Atmospheric Deposition	90%	Katz *et al.* 2009; Lombardo Associates 2011; Howard T. Odum Florida Springs Institute 2011
WWTFs	60%	Katz *et al.* 2009; Lombardo Associates 2011; Howard T. Odum Florida Springs Institute 2011
WWTF Reuse	75%	Jordan *et al 1997*; Candela *et al* 2007; Rahil and Antonopoulos 2007
Septic Tanks	40%	EPA 2002; Costa *et al.* 2002; Otis *et al.* 2007; Katz *et al.* 2009; Chang *et al.* 2010; Katz *et al.* 2010; Toor *et al.* 2011
Livestock Operations[1]	90%	Dubeux *et al.* 2007; Silveira *et al.* 2007; Burns *et al.* 2009; Dubeux *et al.* 2009; Obour *et al.* 2010; Sigua 2010; Sigua *et al.* 2010; Silveira *et al.* 2011; Woodard *et al.* 2011; White-Leech *et al.* 2013a; White-Leech *et al.* 2013b
Crop Fertilizer[1]	70%	McNeal *et al.* 1995; Wang and Alva 1996; Paramasivam and Alva 1997; Newton *et al.* 1999; Hochmuth 2000a; Hochmuth 2000b; Simonne *et al.* 2006; He *et al.* 2011; Liu *et al.* 2013
Urban Fertilizer[2]	80%	Goolsby *et al.* 1999; Erikson *et al.* 2001; Barton and Colmer 2006; Katz *et al.* 2009
Drainage Wells	35%	Harper unpublished

The recharge rate is a parameter that can be geospatially assessed and incorporates soil and unsaturated zone properties (based on a synthesis of the SJRWMD recharge map discussed in **Section 1.2, Aquifer Recharge**). The rate of recharge is used in NSILT as an aggregated indicator of the various hydrogeological processes that can further attenuate the movement of nitrate to ground water. In areas with lower recharge potential on an annual basis, the vertical movement of the water and associated chemical constituents is impeded, which may allow for increased biological uptake and denitrification (Liao *et al.* 2012; Wang *et al.* 2013). In contrast, for areas with higher recharge rates, water will spend less time in the soil/root zone decreasing the opportunity for biochemical attenuation. This would likely result in increased leaching of nitrogen as well as a higher potential for nitrogen transport to the aquifer in a given year (Scanlon *et al.* 2002; Liao *et al.* 2012).

The recharge weighting factors used in this nitrogen loading assessment are applied as follows: 90% for high-recharge rate areas (≥12 in/yr), 50% for medium-recharge rate areas (4 to 11.9 in/yr) and 10% for low recharge areas (0 to 3.9 in/yr). For example, in high-rate recharge areas, 90% of the non-attenuated nitrogen mass (in kg) is assumed to reach the aquifer in a year; while only 50% of the non-attenuated nitrogen mass is assumed to reach the aquifer in any given year in medium-rate recharge areas. These factors are based on the recharge characteristics specific to the aquifer conditions in the Silver Springs BMAP area. Different recharge factors may be assigned to other areas, based on their distinct geological and hydrological characteristics. The associated recharge factors are applied to the nonattenuated nitrogen based on the location of the land use utilized to estimate the nitrogen input.

3.3 Estimated Nitrogen Loads to Ground Water

Table 19a, Table 19b, and **Table 19c** summarize estimated annual nitrogen inputs, attenuation factors, and loads to the UFA, respectively, in the BMAP area and its recharge-based subdivisions. The results indicate that there is an estimated 752,979 kg-N load to the UFA in the BMAP area annually. This represents 13% of the amount of nitrogen inputs to the land surface. The difference is due to various nitrogen attenuation processes and variations in the quantity and movement of water that recharges the aquifer. These results indicate that of the source categories evaluated, the greatest annual load of nitrogen to the UFA in the BMAP area is from septic tanks, with 38% of the total estimated load to ground water. Cattle farms, crop fertilizer, horse farms, and urban fertilizer are also significant nitrogen loading categories. **Figure 10** shows the distribution of estimated annual loads of nitrogen to the UFA by source category.

Table 19a: Estimated inputs by nitrogen source category in the Silver Springs BMAP area (kg-N/yr)

Recharge Category	Atmospheric Deposition	WWTFs & Reuse	Septic Tanks	Urban Fertilizers	Crop Fertilizers	Misc Livestock	Cattle Farms	Horse Farms	Drainage Wells	Total
High	515,573	57,535	361,259	198,279	149,341	39,575	1,013,324	707,214	8,269	3,050,369
Medium	554,246	48,835	285,129	215,067	262,112	28,708	763,189	138,433	3,917	2,299,637
Low	165,510	9,480	74,147	53,000	62,132	9,104	245,067	27,555	6,093	652,087
Total Input	1,235,329	115,850	720,535	446,346	473,858	77,387	2,021,581	873,202	18,279	6,002,093

Table 19b: Attenuation estimates by source category in the Silver Springs BMAP area (kg-N/yr)

- = Empty cell/no data

Recharge Category	Atmospheric Deposition	WWTFs & Reuse	Septic Tanks	Urban Fertilizers	Crop Fertilizers	Misc Livestock	Cattle Farms	Horse Farms	Drainage Wells	Total
Attenuation Factors	90%	60%/75%	40%	80%	70%	90%	90%	90%	35%	-
High	51,557	21,551	216,756	39,656	44,802	3,958	101,332	70,721	5,375	555,709
Medium	55,425	26,235	171,077	43,013	78,634	2,871	76,319	13,843	2,546	469,963
Low	16,551	2,433	44,488	10,600	18,639	910	24,507	2,755	3,960	124,844
Total	123,533	50,219	432,321	93,269	142,076	7,739	202,158	87,320	11,881	1,150,516

Table 19c: Load to ground water with recharge factors applied by nitrogen source category in the Silver Springs BMAP area (kg-N/yr)

Recharge Category	Atmospheric Deposition	WWTFs & Reuse	Septic Tanks	Urban Fertilizers	Crop Fertilizers	Misc Livestock	Cattle Farms	Horse Farms	Drainage Wells	Total
High (90%)	46,402	19,396	195,080	35,690	40,322	3,562	91,199	63,649	5,375	500,675
Medium (50%)	27,712	13,118	85,539	21,507	39,317	1,435	38,159	6,922	2,546	236,255
Low (10%)	1,655	243	4,449	1,060	1,864	91	2,451	276	3,960	16,049
Total Load	75,769	32,757	285,067	58,257	81,503	5,088	131,809	70,847	11,881	752,979

Aquifer recharge has a significant influence on the loading of nitrogen to the UFA in the BMAP area. **Figure 11** summarizes the estimated nitrogen loads to the recharge areas, including a breakdown of each source category. The majority of the nitrogen loading to ground water in the BMAP area (67%) occurs in high-rate recharge areas. Within each recharge category, the dominant sources of loading are similar: septic tanks and livestock are the largest contributors of nitrogen loading to ground water, with a higher percentage of crop fertilizers in the medium-recharge rate category.

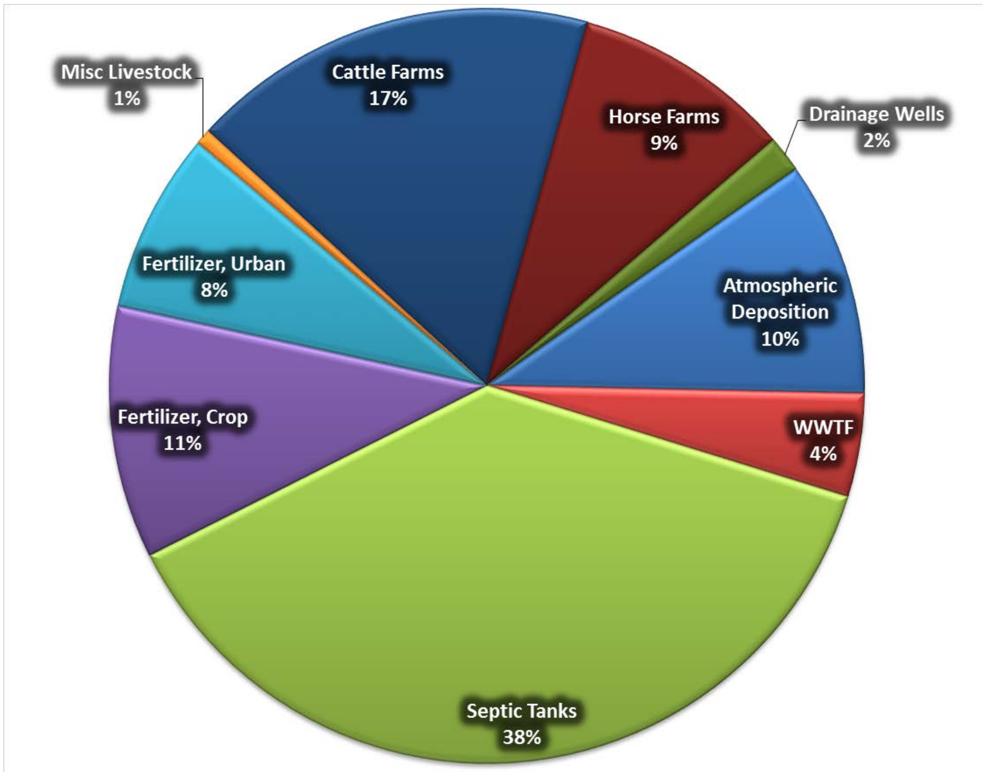


Figure 10: Relative nitrogen contributions based on source category in the Silver Springs BMAP area

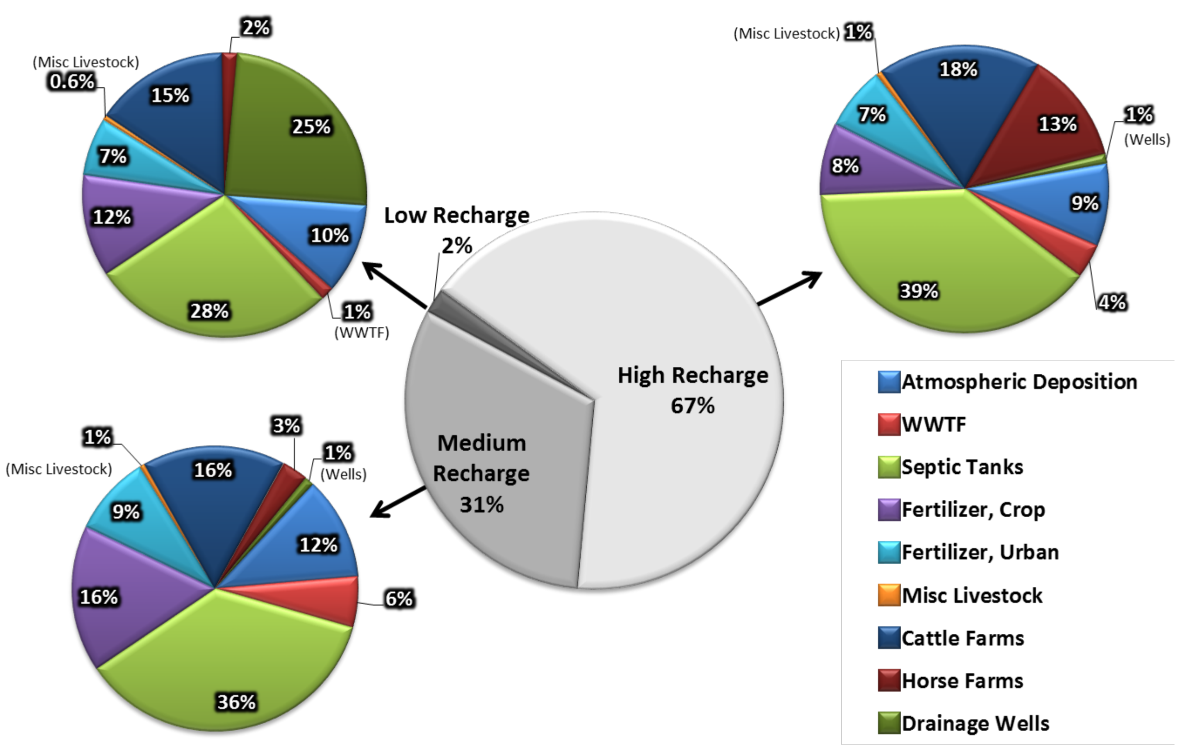


Figure 11: Estimated annual nitrogen loading to ground water by recharge category

3.4 Accounting for Uncertainty in Nitrogen Attenuation Factors in Estimating Loading to Ground Water

The pie charts above only provide information about the relative contribution of nitrogen loading to ground water from each source. If the contribution from one source category were to increase or decrease, the contribution of all other sources would change proportionally. The environmental attenuation of nitrogen from specific sources within the categories can vary substantially, as shown in previous studies, and will affect the relative contribution of nitrogen from each source category. This range in nitrogen attenuation can result from variability in soil properties, crop types, agricultural practices, nitrogen storage, volatilization of ammonia to the atmosphere, uptake by vegetation, denitrification, and other removal processes.

Given the relatively large range in nitrogen attenuation for each source, the department opted to use an average attenuation factor that was estimated based on land use practices and hydrogeological conditions in the Silver Springs BMAP area. Greater emphasis was placed on information about nitrogen attenuation from studies in central Florida, other locations in Florida, or areas with very similar soil and vegetation characteristics. **Table 20** lists the range in nitrogen attenuation for each source, and **Appendix B** contains a detailed listing of the literature sources analyzed for agricultural attenuation.

Table 20: Range of environmental attenuation of nitrogen from a detailed literature review

N Source Category	Low-Level Attenuation	Attenuation Used for This Study	High-Level Attenuation
Atmospheric deposition	85%	90%	95%
WWTFs	50%	60%	75%
Septic tanks	30%	40%	50%
Livestock operations	80%	90%	95%
Crop fertilizers	40%	70%	85%
Urban fertilizers	40%	80%	85%
Drainage wells	25%	35%	45%

Using the range of nitrogen attenuation factors in **Table 20**, the department estimated the corresponding range of nitrogen loading to ground water from each source in the BMAP area (**Figure 12**). Even with the large range in nitrogen attenuation for each source in the BMAP area, the total estimated nitrogen load to ground water greatly exceeds the target load estimated for the Silver Springs TMDL. Based on a current discharge of Silver Springs at 483 cubic feet per second (cfs), and the adopted TMDL of 0.35

mg/L, the target nitrogen load in Silver Springs is 163,688 kg-N/yr. Using the highest nitrogen attenuation level, the total estimated load to ground water in the BMAP area is 488,897 kg-N/yr, which is considerably higher than the TMDL target (**Figure 13**).

3.5 Assessing the Proximity of Nitrogen Sources to Silver Springs

The presence of subterranean conduits and other known karst features in areas near Silver Springs enhances aquifer transmissivity and the rate of ground water flow toward the spring. Dye-trace studies in these areas have shown that ground water moves rapidly toward Silver Springs and thus affects the rate of nitrogen transport to Silver Springs (McGurk *et al.* 2011). In areas within the BMAP boundary located farther away from the spring where conduits are less prevalent, ground water moves more slowly toward the spring, and consequently the rate of nitrogen transport from distant sources to Silver Springs also is slower. Therefore, the proximity of a nitrogen source to Silver Springs is an additional factor that affects spring nitrogen concentrations.

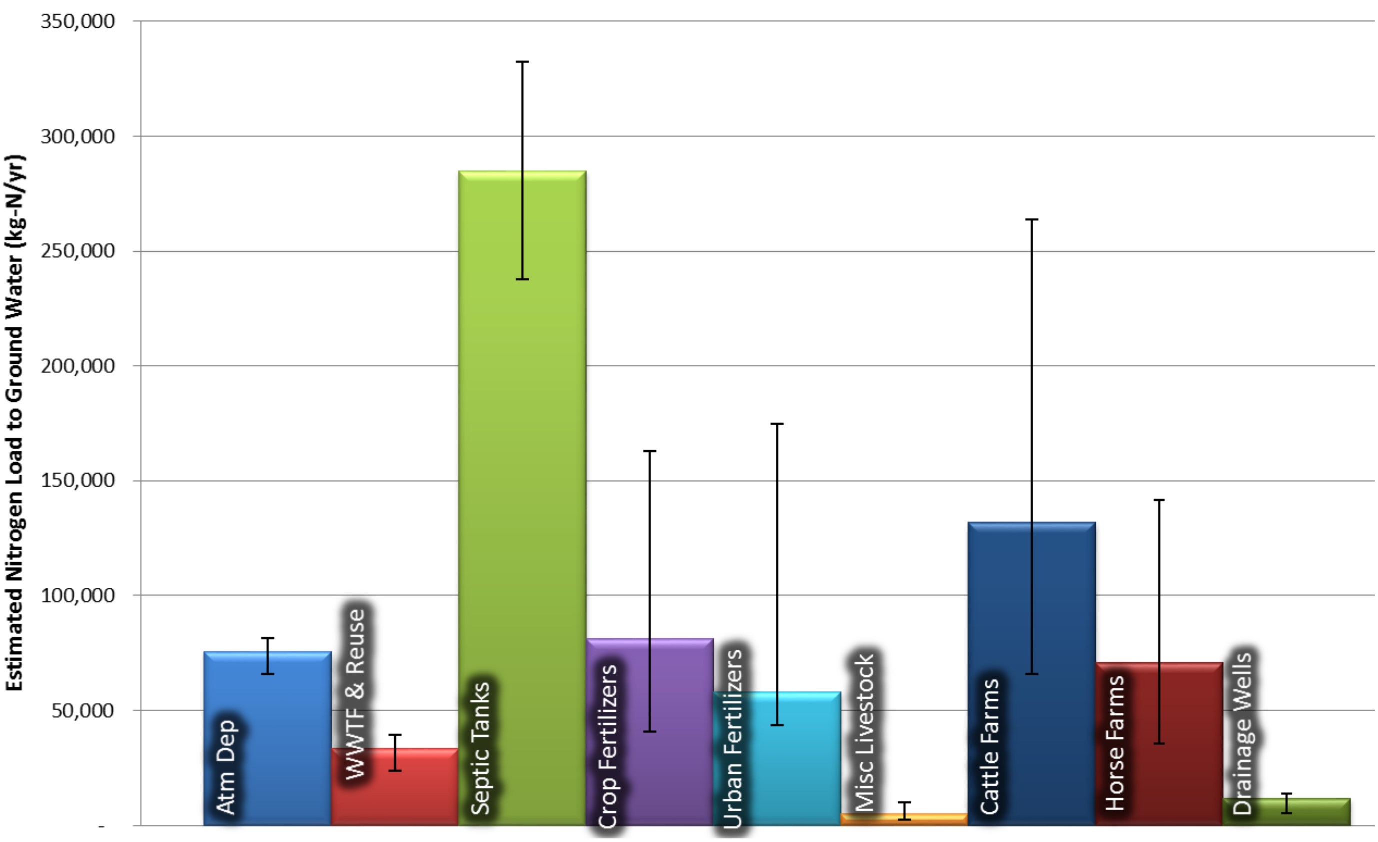


Figure 12: Influence of the range of attenuation factors on estimated nitrogen loads to ground water from each source category in the Silver Springs BMAP area

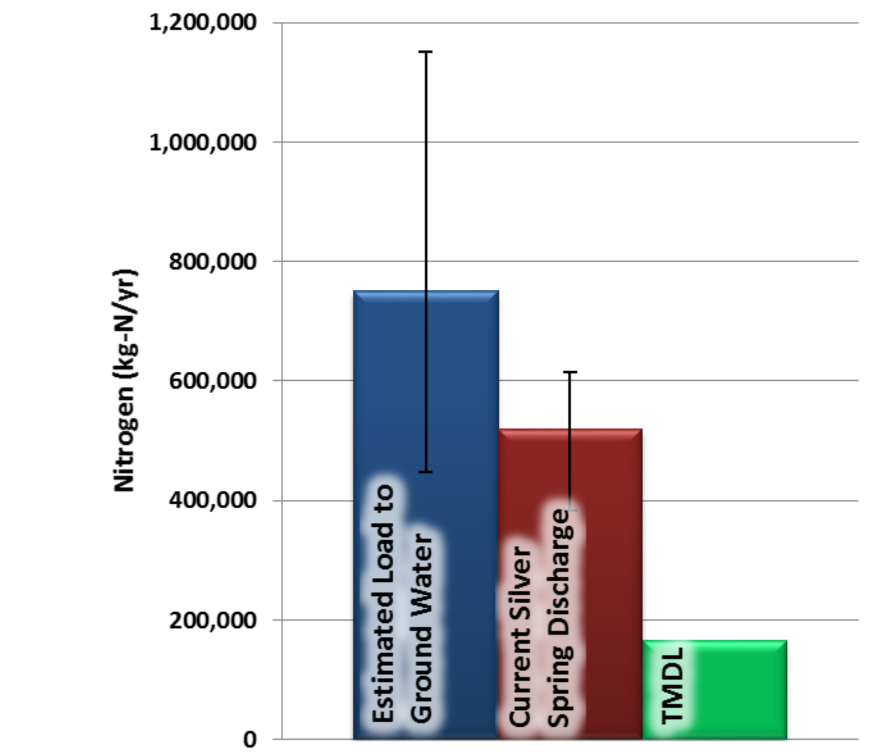


Figure 13: Influence of the range of attenuation factors on estimated nitrogen load to ground water

As a first step in assessing the impact of nitrogen source proximity to Silver Springs, the department estimated the nitrogen loading to ground water in the "10-year travel time" area near the spring that was created based on ground water transport modeling by the SJRWMD. Recent dye trace work has called into question the validity of the actual travel times in this area, but it remains as a radius around the springs in which source contributions would be capable of impacting the springs in a short time compared with the 10-, 100-, and 1,000-year capture zones (representing travel times) that were also modeled for the Silver Springs area.

While the BMAP boundary is largely based on the 1,000-year capture zone, an additional NSILT analysis was completed on the 10-year capture zone because it has been established as a priority area to address nearby sources. Actions to address nitrogen sources in this zone may have a greater impact on spring water quality in a shorter period because of the shorter travel times to Silver Springs. The methods utilized for estimating nitrogen loading in the 10-year capture zone are identical to those described for the entire BMAP area, and **Figure 14** shows the result.

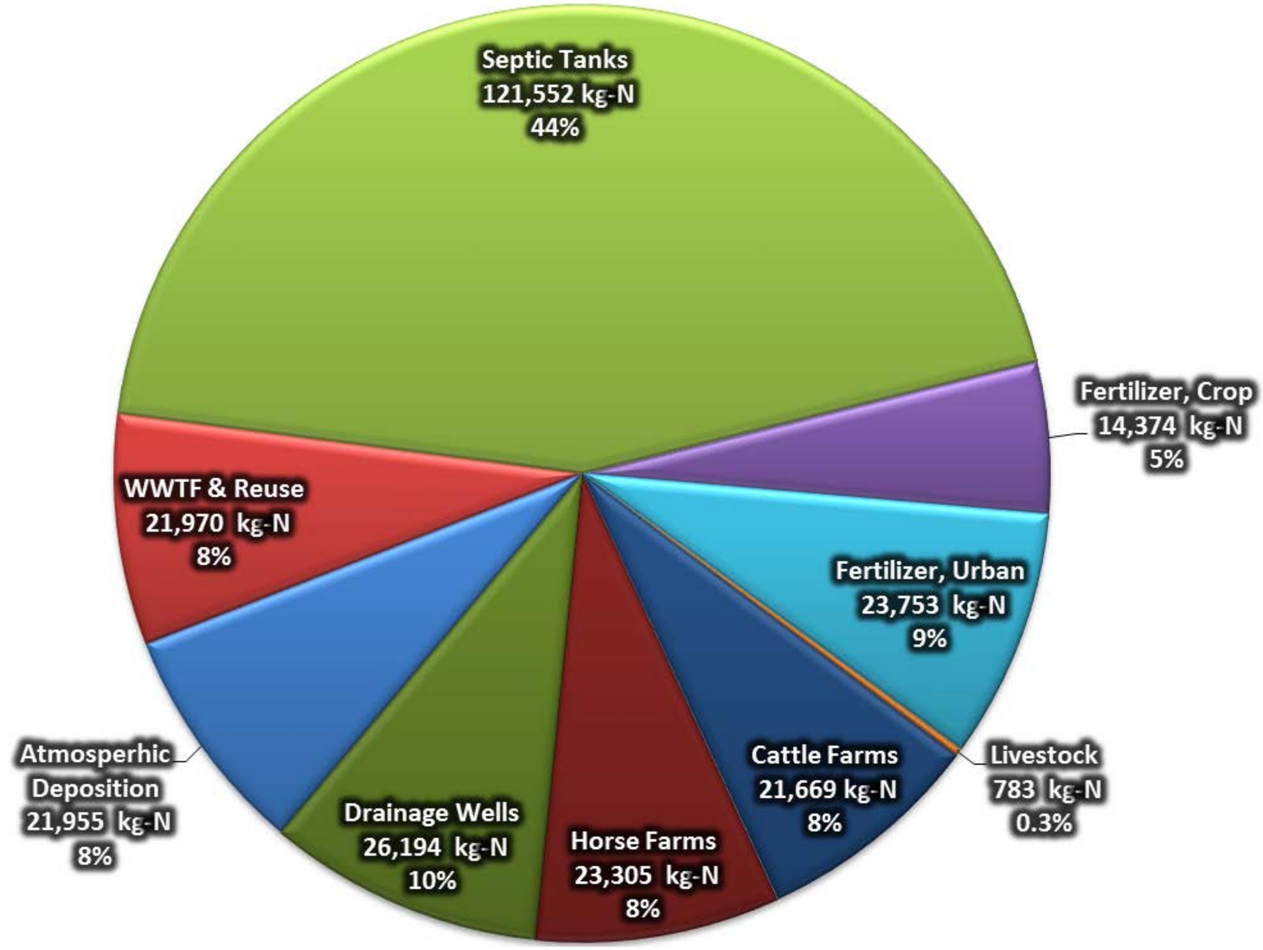


Figure 14: Estimated nitrogen load to ground water in the 10-year capture zone

The nitrogen load estimated to enter the aquifer in the 10-year capture zone is 275,556 kg-N/yr. This represents 37% of the estimated load to the BMAP boundary, while the land area in the 10-year capture zone is only 22% of the entire BMAP area. There is a larger influence from urban source categories in or near Ocala, which is included in this 10-year capture zone.

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Appendices

Appendix A: Tables

Table A.1: Useful conversion factors

Convert from	To	Multiply by
kilograms	pounds	2.204623
NO_3 milligrams per liter	NO_3 grams-nitrogen per liter	2.260 X 10-4
NH_4 milligrams per liter	NH_4 grams-nitrogen per liter	7.765 X 10-4
milligrams	grams	0.001
grams	kilograms	0.001
milligrams	kilograms	1 X 10-6
acre	hectares	0.4046873
square meters	hectares	0.0001
cubic centimeters	liters	0.001
tons	kilograms	907.1847
cubic feet	liters	28.31685
second	year	3.170979 X 10-8
rainfall (centimeters)	rainfall (liters per hectare)	104

Table A.2a: Summary of land use in hectares compiled from the water management district data for agricultural lands: Marion and Alachua Counties

- = Empty cell/no data

Marion County

Land Use Code	Land Use Description	Marion County	Marion High Recharge	Marion Medium Recharge	Marion Low Recharge
2100	Cropland and pastureland	22,517	99	4	-
2110	Improved pastures	23,263	10,672	5,044	820
2120	Unimproved pastures	1,537	693	399	32
2130	Woodland pastures	3,593	1,501	647	116
2310	Cattle feeding operations	28	28	-	-
2320	Poultry feeding operations	26	7	19	-
2500	Specialty farms	12,076	103	42	2
2510	Horse farms	15,785	9,679	1,503	221
2520	Dairies	47	47	-	-
2140	Row crops	935	55	82	6
2143	Potatoes and cabbage	4	-	-	-
2150	Field crops	7,848	4,174	1,917	396
2153	Hayfields	-	-	-	-
2160	Mixed crop	296	137	158	-
2200	Tree crops	57	36	7	-
2210	Citrus groves	709	264	260	114
2230	Other groves	-	-	-	-
2240	Abandoned tree crops	24	4	18	2
2400	Nurseries and vineyards	294	5	0	-
2410	Tree nurseries	228	52	40	-
2420	Sod farms	510	-	115	-
2430	Ornamentals	192	63	44	18

Alachua County

Land Use Code	Land Use Description	Alachua County	Alachua High Recharge	Alachua Medium Recharge	Alachua Low Recharge
2100	Cropland and pastureland	55	1	-	-
2110	Improved pastures	19,732	1,183	1,690	819
2120	Unimproved pastures	727	44	64	55
2130	Woodland pastures	2,805	105	383	325
2310	Cattle feeding operations	21	-	5	-
2320	Poultry feeding operations	5	2	-	3
2500	Specialty farms	18	-	-	-
2510	Horse farms	958	-	1	19
2520	Dairies	29	5	16	-
2140	Row crops	816	46	88	3
2143	Potatoes and cabbage	-	-	-	-
2150	Field crops	3,572	264	484	260
2153	Hayfields	14,973	-	-	-
2160	Mixed crop	8	-	0.2	1
2200	Tree crops	474	94	112	10
2210	Citrus groves	38	-	6	16
2230	Other groves	352	17	0.1	-
2240	Abandoned tree crops	2	-	-	2
2400	Nurseries and vineyards	20	-	3	-
2410	Tree nurseries	342	1	11	-
2420	Sod farms	-	-	-	-
2430	Ornamentals	204	-	17	1

Table A.2b: Summary of land use in hectares compiled from the water management district information for agricultural lands: Lake and Sumter Counties

- = Empty cell/no data

Lake County

Land Use Code	Land Use Description	Lake County	Lake High Recharge	Lake Medium Recharge	Lake Low Recharge
2100	Cropland and pastureland	2,240	5	37	7
2110	Improved pastures	27,867	1,048	1,018	170
2120	Unimproved pastures	5,344	80	7	1
2130	Woodland pastures	2,993	100	119	15
2300	Feeding operations	-	-	-	-
2310	Cattle feeding operations	11	-	-	-
2320	Poultry feeding operations	36	-	-	-
2500	Specialty farms	84	-	-	-
2510	Horse farms	1,976	97	59	-
2520	Dairies	388	83	119	8
2140	Row crops	331	-	-	-
2150	Field crops	6,471	148	139	27
2160	Mixed crop	52	-	-	-
2200	Tree crops	201	2	-	-
2210	Citrus groves	9,436	91	54	7
2240	Abandoned tree crops	156	7	-	-
2400	Nurseries and vineyards	79		10	4
2410	Tree nurseries	809	38	10	-
2420	Sod farms	306	-	-	-
2430	Ornamentals	1,364	8	70	0
2431	Shade ferns	340	-	-	-
2432	Hammock ferns	45	-	-	-
2450	Floriculture	2	-	-	-

Sumter County

Land Use Code	Land Use Description	Sumter County	Sumter High Recharge	Sumter Medium Recharge	Sumter Low Recharge
2100	Cropland and pastureland	30,425	1,268	2,057	228
2110	Improved pastures	8,603	682	893	597
2120	Unimproved pastures	80	29	-	13
2130	Woodland pastures	960	58	62	99
2300	Feeding operations	154	0	20	-
2310	Cattle feeding operations	-	-	-	-
2320	Poultry feeding operations	1	-	1	-
2500	Specialty farms	370	-	24	0
2510	Horse farms	477	51	227	84
2520	Dairies	0	0	-	-
2140	Row crops	853	131	21	-
2150	Field crops	381	83	70	42
2160	Mixed crop	2	-	-	-
2200	Tree crops	4	-	-	-
2210	Citrus groves	89	-	17	49
2240	Abandoned tree crops	-	-	-	-
2400	Nurseries and vineyards	513	14	38	0
2410	Tree nurseries	100	37	43	-
2420	Sod farms	-	-	-	-
2430	Ornamentals	32	24	0	-
2431	Shade ferns	-	-	-	-
2432	Hammock ferns	-	-	-	-
2450	Floriculture	-	-	-	-

Table A.2c: Summary of land use compiled from the water management district data for agricultural lands: Putnam County

- = Empty cell/no data

Land Use Code	Land Use Description	Putnam County	Putnam High Recharge	Putnam Medium Recharge	Putnam Low Recharge
2110	Improved pastures	9,188	385	480	288
2120	Unimproved pastures	637	5	33	6
2130	Woodland pastures	1,263	33	171	72
2310	Cattle feeding operations	22	-	-	-
2320	Poultry feeding operations	13	-	-	-
2500	Specialty farms	2	-	-	-
2510	Horse farms	441	-	3	10
2140	Row crops	135	2	18	6
2143	Potatoes and cabbage	2,643	-	-	-
2150	Field crops	1,756	22	165	58
2160	Mixed crop	2	2	-	-
2200	Tree crops	110	68	30	-
2210	Citrus groves	183	-	7	-
2230	Other groves	-	-	-	-
2240	Abandoned tree crops	4	-	-	-
2400	Nurseries and vineyards	15	-	-	-
2410	Tree nurseries	250	-	-	-
2420	Sod farms	226	-	-	-
2430	Ornamentals	96	19	6	7
2431	Shade ferns	410	-	-	-
2432	Hammock ferns	382	-	-	-

Table A.3: Summary of land use compiled from the water management district data for urban lands

- = Empty cell/no data

County	Low-Density Residential	Medium-Density Residential	High-Density Residential	Recreational	Golf Courses	Parks and Zoos
Alachua County	23,202	6,851	2,507	-	-	-
Alachua High Recharge	547	63	-	340	-	-
Alachua Medium Recharge	1,092	111	8	197	2	8
Alachua Low Recharge	420	41	7	-	-	-
Marion County	43,056	16,506	2,747	176	-	14
Marion High Recharge	10,342	5,928	605	1,923	239	511
Marion Medium Recharge	6,426	3,666	1,093	460	64	135
Marion Low Recharge	1,545	780	139	176	-	14
Lake County	18,290	14,022	5,496	50	-	9
Lake High Recharge	715	593	73	1,945	41	169
Lake Medium Recharge	854	787	631	555	0	1
Lake Low Recharge	72	133	79	50	-	9
Sumter County	9,338	1,799	2,843	242	14	105
Sumter High Recharge	706	55	364	1,188	93	769
Sumter Medium Recharge	1,261	288	1,861	7	-	-
Sumter Low Recharge	125	152	341	242	14	105
Putnam County	17,218	2,884	119	-	-	-
Putnam High Recharge	214	11	2	75	-	-
Putnam Medium Recharge	1,191	38	-	113	-	18
Putnam Low Recharge	956	10	-	-	-	-

Table A.4: Summary of land use in hectares for Alachua County provided by the county property appraiser office

* = Only property codes with land are inside the Silver Springs BMAP boundary are listed.
\- = Empty cell/no data

Property Code*	Description	High Recharge Area	Medium Recharge Area	Low Recharge Area	Discharge Area
5100	Cropsoil Class 1	88	381	10	-
5200	Cropsoil Class 2	55	199	31	-
5300	Cropsoil Class 3	5	9	-	-
6000	Grzgsoil Class 1	992	948	143	6
6100	Grzgsoil Class 2	407	1,065	1,173	28
6200	Grzgsoil Class 3	12	4	64	-
6500	Grzgsoil Class 6	158	264	347	4
6600	Orchard groves	94	264	63	27
6800	Dairies/feed lots	44	92	34	-
6900	Ornamentals/ miscellaneous agriculture	9	25	5	-

Table A.5: Summary of land use in hectares for Marion County provided by the county property appraiser office

* = Only property codes with land are inside the Silver Springs BMAP boundary are listed.
\- = Empty cell/no data

Property Code*	Description	High Recharge Area	Medium Recharge Area	Low Recharge Area	Discharge Area
51	Cropland Class 1	440	301	163	84
52	Cropland Class 2	580	131	27	-
53	Cropland Class 3	3,810	1,320	99	1
61	Grazing Class 2	6	50	70	47
62	Grazing Class 3	8,146	1,698	396	22
63	Grazing Class 4	10,760	4,500	599	65
64	Grazing Class 5	997	838	150	8
65	Grazing Class 6	368	593	90	-
66	Citrus grove orchard	97	316	171	-
67	Bees fish rabbits, etc.	48	10	3	-
69	Ornamental miscellaneous agriculture	260	404	42	2

Table A.6: Summary of land use in hectares for Lake County provided by the county property appraiser office

* = Only property codes with land are inside the Silver Springs BMAP boundary are listed.
\- = Empty cell/no data

Property Code*	Description	High Recharge Area	Medium Recharge Area	Low Recharge Area	Discharge Area
5100	Cropland, nursery, fernery	-	-	6	-
5200	Muck land sand	-	10	-	-
5300	Cropland row crop	141	139	10	162
6200	Pasture improved good	590	489	319	5
6300	Pasture improved hay average	311	365	51	-
6301	Pasture improved average	84	248	20	-
6600	Orchards	81	79	2	-
6900	Ornamental nursery	17	23	-	-

Table A.7: Summary of land use in hectares for Sumter County provided by the county property appraiser office

* = Only property codes with land are inside the Silver Springs BMAP boundary are listed.
\+ = based on personal communication with Sumter County Property Appraiser Office
\- = Empty cell/no data

Property Code*	Description	High Recharge Area	Medium Recharge Area	Low Recharge Area	Discharge Area
5100	Crops+	2	14	5	-
5200	Crops+	277	369	50	-
5250	Crops+	47	34	-	
6000	Pasture+	1,719	1,829	501	34
6200	Pasture+	8	-	-	-
6600	Orchards+	2	-	-	-
6800	Agricultural+	-	15	-	-
6900	Nursery+	28	5	-	-

Table A.8: Summary of land use in hectares for Putnam County provided by the county property appraiser office

* = Only property codes with land are inside the Silver Springs BMAP boundary are listed.
\- = Empty cell/no data

Property Code*	Description	High Recharge Area	Medium Recharge Area	Low Recharge Area	Discharge Area
51	Tillable soil	-	34	15	-
60	Improved pasture	-	16	6	-
62	Improved pasture	3	234	145	110
63	Improved pasture	95	196	154	-
64	Semi improved pasture	66	163	191	87
65	Range pasture	9	81	23	-
67	Citrus, fruit trees	25	22	20	14
69	Sod, ornamentals	4	16	6	-

Table A.9: WAFR data used to calculate annual average input for WWTFs land application

* = TN data estimated based on available NO_3 data.
+ = Effluent data not available; average TN value from department study used.
§ = Discharge data not available; 50% of the design capacity was used.
- = Empty cell/no data.

WWTF Name	Facility ID	County	Recharge Area	Annual Average TN (mg-N/L)	Annual Average NO_3 (mg-N/L)	Annual Flow (MGD)	Nitrogen Input (kg-N/yr)
Ocala, City of - WRF #2 Site	FLA010680	Marion	High	6.93*	2.63	2.305	21,753
Silver Springs Shores	FLA296651	Marion	High	6.49*	2.50	0.823	7,384
Silver Springs Regional	FLA010786	Marion	Medium	7.34*	2.83	0.133	1,350
Belleview, City of	FLA010678	Marion	High	2.35	-	0.021	66
Marion Correctional Institute	FLA010789	Marion	High	6.05*	2.33	0.514	4,298
Rolling Greens MHP	FLA010757	Marion	Medium	7.37	-	0.077	784
Associated Grocers of Florida	FLA010735	Marion	High	28.70*	11.05	0.006	238
Stonecrest WWTF	FLA010741	Marion	Medium	2.92	-	0.095	384
Landfair	FLA010722	Marion	High	11.62	-	0.015	241
Spanish Oaks WWTF	FLA010744	Marion	Medium	0.24*	0.094	0.021	7
Central Process - Lime Stabilization	FLA010776	Marion	High	8.97+	-	0.045§	558
Tradewinds WWTF	FLA010699	Marion	Medium	0.28	0.19	0.065	25
Springs RV Resort WWTF	FLA010700	Marion	Medium	8.97+	-	0.012	149
Grand Lake RV Resort WWTF	FLA010770	Marion	High	8.97+	-	0.013	161
Oak Bend Community	FLA010693	Marion	High	4.16*	1.6	0.028	161
Ocala East Villas WWTF	FLA010725	Marion	Medium	111.69*	43	0.04	6,173
Amadeus Hotel & Conference Center WWTF	FLA010754	Marion	Medium	8.97+	-	0.019	235
Paddock Park South WWTF	FLA010705	Marion	High	8.97+	-	0.017	211
Petro PSC Truck Stop	FLA016154	Marion	High	4.99*	1.92	0.016	110
Smith Lake Shores WWTF	FLA010701	Marion	Medium	8.97+	-	0.028	347
Lake View Woods WWTF	FLA010709	Marion	Medium	7.53*	2.9	0.012	125
North Marion High School	FLA010663	Marion	High	8.97+	-	0.01	124
Victory MHP LLC	FLA010692	Marion	High	8.97+	-	0.01	124
Shady Rd Villas WWTF	FLA010704	Marion	High	1.48*	0.57	0.008	16
Sleepy Hollow WWTF	FLA010788	Marion	High	8.97+	-	0.009	112
Hilltop Estates	FLA010703	Marion	Medium	0.30*	0.117	0.02	8
Spanish Palm Estates WWTF	FLA010740	Marion	Medium	0.73*	0.28	0.005	5
Plantation Landing WWTF	FLA017026	Marion	Medium	18.65*	7.18	0.023	593

WWTF Name	Facility ID	County	Recharge Area	Annual Average TN (mg-N/L)	Annual Average NO_3 (mg-N/L)	Annual Flow (MGD)	Nitrogen Input (kg-N/yr)
Wilderness RV Park Estates	FLA107077	Marion	Medium	12.84	7.995	0.013	231
Cedar Hills WWTF	FLA010771	Marion	High	2.05*	0.79	0.034	96
North Marion Middle School	FLA010664	Marion	High	8.97+	-	0.034	421
Phoenix Houses Of Florida	FLA010698	Marion	High	8.97+	-	0.005	62
Lake Waldena Resort WWTF	FLA010688	Marion	Medium	8.91*	3.43	0.011	135
Lake Weir Middle School	FLA010662	Marion	Medium	15.92*	6.128	0.028	616
Motor Inns/ Ocala WWTF	FLA010721	Marion	Medium	31.17*	12	0.012	517
Vacation Host Inn	FLA010731	Marion	High	12.99*	5	0.006	108
State Fire College	FLA010790	Marion	High	103.90*	40	0.013	233
On Golden Pond Mobile Home Park WWTF	FLA010685	Marion	Medium	4.83*	1.86	0.007	47
Camp Sonlight	FLA010689	Marion	Medium	4.42*	1.7	0.0008	5
Pilot Travel Center #424	FLA277134	Marion	Medium	0.25*	0.095	0.006	2
Sharpes Ferry MHC WWTF	FLA010729	Marion	Medium	8.97+	-	0.008	99
Ocala Jai Alai - WWTF	FLA010737	Marion	High	8.97+	-	0.006	74
Wandering Oaks RV Resort	FLA010756	Marion	High	8.97+	-	0.001	12
Belleview Santos Elementary	FLA010661	Marion	Medium	11.17*	4.3	0.002	31
Fessenden Elementary School	FLA010666	Marion	High	6.75*	2.6	0.002	19
Sparr Elementary School	FLA010667	Marion	High	8.97+	-	0.001	12
Cliftwood MHP WWTF	FLA010745	Marion	High	10.65*	4.1	0.007	103
Sportsman Cove WWTF	FLA010690	Marion	Medium	8.97+	-	0.005	62
Days Inn - Ocala West WWTF	FLA010763	Marion	Medium	8.97+	-	0.005	62
Fort McCoy School K-8	FLA010665	Marion	Discharge	37.79*	14.55	0.0046	0
Nautilus Trailer Park	FLA010708	Marion	High	2.42*	-	0.008	27
Ocala Springs Shopping Center	FLA010773	Marion	Medium	8.97+	0.93	0.005	62
Pilot SSA #92 WWTF	FLA016765	Marion	Medium	28.57*	-	0.005	197
Shady Hills Elementary School	FLA010669	Marion	High	8.97+	11	0.002	25
Harbor View Elementary	FLA010670	Marion	High	8.97+	-	0.004	50
Reddick Collier Elementary	FLA010672	Marion	High	8.97+	-	0.004	50
Baseline Square WWTF	FLA010766	Marion	High	8.97+	-	0.002	25
Our Lucaya	FLA010784	Marion	High	8.97+	-	0.005	62
Stanton Weirsdale Elementary	FLA010668	Marion	Medium	8.97+	-	0.003	37

WWTF Name	Facility ID	County	Recharge Area	Annual Average TN (mg-N/L)	Annual Average NO_3 (mg-N/L)	Annual Flow (MGD)	Nitrogen Input (kg-N/yr)
Whispering Oaks WWTF	FLA010706	Marion	Medium	8.97+	-	0.003	37
Big Lake Village WWTF	FLA010750	Marion	Medium	8.97+	-	0.002	25
Robins Nest RV Park	FLA010696	Marion	Medium	2.6	2.1	0.001	4
Marie's Mobile Home Park	FLA010764	Marion	Medium	8.97+	-	0.0025§	31
Golden Holiday WWTF	FLA010765	Marion	High	8.97+	-	0.0014	17
Villages WWTF	FLA010555	Lake	Medium	7.26	-	0.214	2,151
Fruitland Park, City of	FLA374245	Lake	High	11.07*	4.26	0.094	1,438
Recreation Plantation RV Park	FLA010593	Lake	High	2.98*	1.15	0.0326	134
Lady Lake Mobile Home Park	FLA010575	Lake	Medium	8.97+	-	0.0135§	167
Lady Lake, Town of	FLA399761	Lake	High	5.81	-	0.0416	334
Leisure Meadows Mobile Home Park WWTF	FLA010592	Lake	Medium	1.27*	0.49	0.0103	18
Water Oak Country Club Estates	FLA010529	Lake	High	11.43*	4.40	0.057	900
Pennbrooke WWTP	Fla010570	Lake	Low	7.77	-	0.0292	313
Lake North Apartments	FLA010549	Lake	High	8.97+	-	0.0075§	900
Sunshine Mobile Home Park	FLA010611	Lake	Medium	2.08*	0.80	0.00392	11
ACA Academy	FLA010595	Lake	High	17.49*	6.73	0.00425	103
Blue Parrot	FLA010623	Lake	Low	1.86*	0.716	0.013	33
Valencia Terrace	FLA010599	Lake	Medium	1.56*	0.6	0.025	54
Harbor Hills	FLA010608	Lake	Low	5.80	4.1	0.006	48
Fruitland Park Elementary	FLA010497	Lake	High	8.97+	-	0.006	74
Mirron Lake Manor Apartments WWTF	FLA010571	Lake	High	8.97+	-	0.007	87
Fruitland Acres WWTF	FLA010643	Lake	High	4.13*	1.59	0.005	29
City of Hawthorne	FLA011291	Alachua	Medium	3.28	-	0.211	534
Camp McConnell YMCA	FLA011293	Alachua	Medium	11.53*	4.44	0.0015	24
Little Sumter Utility Co WWTF	FLA017133	Sumter	Medium	5.73	-	0.0277	219
Wildwood City of WWTF	FLA013497	Sumter	Medium	7.73*	2.98	0.008	80
Central Sumter Utility Company WWTF	FLA499951	Sumter	Medium	16.00	-	0.127	2,807
North Sumter Utilities WWTF	FLA281581	Sumter	Medium	14.95*	5.76	0.227	4,692
Orange Blossom Utilities	FLA358134	Sumter	Low	19.29*	7.43	0.004	108
Rails End MHP RV & MHP WWTF	FLA013519	Sumter	Low	3.08*	1.18	0.002	8

WWTF Name	Facility ID	County	Recharge Area	Annual Average TN (mg-N/L)	Annual Average NO_3 (mg-N/L)	Annual Flow (MGD)	Nitrogen Input (kg-N/yr)
Lake Deaton RV Park WWTF	FLA013517	Sumter	Low	3.87*	1.49	0.003	16
Ochwilla Elementary School WWTF	FLA011701	Putnam	High	9.92*	3.82	0.004	55
Sandhill Forest Two WWTF	FLA011739	Putnam	Medium	5.92*	2.28	0.003	25
Melrose Community School WWTF	FLA011697	Putnam	High	42.86*	16.5	0.007	415

Table A.10: Reuse data for the city of Ocala #1 WWTF

- = Empty cell/no data.

Reuse Site	Permitted Flow (MGD)	Actual Flow (MGD)	Area- High Recharge (ha)	Area-Med Recharge (ha)	Area- Low Recharge (ha)
Pine Oaks Golf Course/ North Forty Site	1.465	0.32	5	106	-
Lillian Bryant Park	0.175	0.16	-	9	-
Crosky Park and SR 40 Medians	0.178	0.11	1	13	0.02
Ocala Palms Golf Course	0.776	0.19	-	-	-

Table A.11: Reuse data for the city of Ocala #2 WWTF

- = Empty cell/no data.

Reuse Site	Permitted Flow (MGD)	Actual Flow (MGD)	Area- High Recharge (ha)	Area-Med Recharge (ha)	Area- Low Recharge (ha)
Irrigation to Municipal Golf Course	0.349	0.11	41	22	-
Softball fields	0.041	0.01	8	-	-
Soccer fields	0.058	0.02	15	-	-
Marion County 4H Farm	0.116	0.04	8	-	-
Jerry Grant Recreation Park	0.159	0.05	27	-	-
Summerset Subdivision	0.058	0.02	9	-	-

Table A.12: Reuse data for the city of Belleview WWTF

- = Empty cell/no data.

Reuse Site	Permitted Flow (MGD)	Actual Flow (MGD)	Area- High Recharge (ha)	Area-Med Recharge (ha)	Area- Low Recharge (ha)
Baseline Golf Course	0.3	0.063	3	31	-
Spruce Creek Golf Course	1.0	0.283	81	50	-

Table A.13: Reuse data for The Villages WWTF

\- = Empty cell/no data.

Reuse Site	Permitted Flow (MGD)	Actual Flow (MGD)	Area- High Recharge (ha)	Area-Med Recharge (ha)	Area- Low Recharge (ha)
Chula Vist/Mira Mesa	0.462	0.101	-	35	-
Hacienda Hills	1.11	0.244	-	79	-
Silver Lake	0.182	0.040	-	10	1
Hill Top/Orange Blossom	1.08	0.236	-	59	0.08
Avenida Central Medians	0.115	0.025	-	7	-
US 41 Medians	0.170	0.037	-	-	-
Paradise Rec. Frontage	0.109	0.024	-	10	-
Aqua range	0.012	-	-	-	-

Table A.14: Reuse data for the city of Wildwood WWTF

\- = Empty cell/no data.

Reuse Site	Permitted Flow (MGD)	Actual Flow (MGD)	Area- High Recharge (ha)	Area-Med Recharge (ha)	Area- Low Recharge (ha)
Miona Lake Golf Course	1.0	0.180	**-**	**30**	**8**
Millennium Park	0.267	0.048	**-**	**45**	**-**
Transferred to NSU MRS	2.0	1.21	**-**	**-**	**-**

Table A.15: Reuse data for the city of Lady Lake WWTF

\- = Empty cell/no data.

Reuse Site	Actual Flow (MGD)	Area- High Recharge (ha)	Area-Med Recharge (ha)	Area- Low Recharge (ha)
Fields and Sport Facilities	0.011	5.50	1.18	-
Tree Top Driving Range	0.005	3.34	0.00	-
Lake Ella Estates	0.038	23.93	0.00	-
Lady Lake Driving Range	0.014	0.94	6.35	-
Blownt Meyer	0.051	12.66	15.02	-
Tyla Clark	0.015	5.51	3.15	-
Lugano	0.043	19.99	5.39	-
Louis George	0.097	26.70	26.70	-
Rhys Allen Cobb	0.025	0.05	12.51	-
Richardson	0.013	5.09	2.47	-
Atlantic Properties	0.009	5.85	0.00	-
Ohan Rahan	0.010	0.11	5.03	-
Stonewood Valley	0.032	1.89	14.40	-

Table A.16: Reuse data for North Sumter Master Reuse Facility

\- = Empty cell/no data.

Reuse Site	Permitted Flow (MGD)	Actual Flow (MGD)	Area- High Recharge (ha)	Area-Med Recharge (ha)	Area- Low Recharge (ha)
Belvedere Executive Golf Course	0.24	0.147	7	39	-
Arnold Palmer Championship Golf Course	0.69	0.422	-	59	58
Sunset Pointe Executive Golf Course	0.20	0.122	-	4	27
Mallory Hill Championship Golf Course	0.56	0.342	19	33	66
Cane Garden Championship Golf Course	0.62	0.379	-	31	6
Key Largo Executive Golf Course	0.20	0.122	44	81	-
Havana Championship Golf Course	0.64	0.391	0.001	30	2
Duval Executive Golf Course	0.19	0.116	-	36	-
Double Palm Golf Course	0.18	0.110	4	33	-
Bonifay Championship Golf Course	0.61	0.373	-	-	-
Fairwinds Executive Golf Course	0.22	0.134	29	6	-
Evans Prairie Championship Golf Course	0.60	0.367	-	30	48
Kingfisher Executive Golf Course	0.24	0.147	9	39	-

Table A.17: Reuse data for the Little Sumter WWTF

- = Empty cell/no data.

Reuse Site	Permitted Flow (MGD)	Actual Flow (MGD)	Area- High Recharge (ha)	Area-Med Recharge (ha)	Area- Low Recharge (ha)
El Santiago/El Diablo Golf Course	0.21	0.104	-	27	-
Glenview Golf Course	0.76	0.375	-	110	-
Marion County East Executive Golf Course	0.25	0.123	-	33	-
Hawks Bay/Saddlebrook Golf Course	0.16	0.079	-	11	-
Polo Field	0.13	0.064	-	19	1
Softball Field	0.04	0.020	-	3	0
Buena Vista Boulevard R/W	0.14	0.069	-	20	-
El Camino Real R/W	0.14	0.069	-	12	-
Nancy's Legacy Golf Course	0.60	0.296	12	92	-
Amberwood/Oakleigh Golf Course	0.18	0.089	19	13	-
De La Vista Golf Course	0.07	0.035	-	14	1
Tierra Del Sol Golf Course	0.43	0.212	-	34	36

Table A.18: Reuse data for remaining WWTFs

- = Empty cell/no data.

WWTF Facility	Reuse Site	Permitted Flow (MGD)	Actual Flow (MGD)	Area- High Recharge (ha)	Area- Med Recharge (ha)	Area- Low Recharge (ha)
Stonecrest	Stonecrest Golf Course	0.35	0.112	-		-
Pennbrooke	Pennbrooke Fairways Golf Course	0.180	0.08	-	19	37
Central Sumter	Transferred to NSU MRS	1.60	0.31	-	-	-
North Sumter	Transferred to NSU MRS	2.80	1.66	-	-	-

Table A.19: 2012 CoA livestock populations for the miscellaneous livestock waste category

CoA Population	Alachua	Marion	Lake	Sumter	Putnam
Broiler Chickens	1,230	1,235	319	257	16
Layer Chickens	5,236	10,441	3,749	3,235	60,699
Goats	3,406	3,538	1,888	1,130	660
Hogs	431	848	322	193	149
Sheep	718	942	718	312	16
Turkeys	211	135	37	53	73

Appendix B: References Pertaining to Nitrogen Input and Attenuation for Agricultural Activities

Legend

† Cow-Calf Loading

§ Pasture/Hay Fertilization

* Manure Distribution

◊ Crop Fertilization

Study Area Located in Florida

§ Angima *et al.* 2009

† Berry *et al.* 2002

§◊ Bohlke 2002

§ Burns *et al.* 2009

◊ Carpenter-Boggs *et al.* 2000

†§* Dubeux *et al.* 2007

†§* Dubeux *et al.* 2009

† Esterman *et al.* 2002

† Estermann *et al.* 2003

*◊ Goolsby *et al.* 1999

◊ He *et al.* 2011

◊ Hochmuth 2000a

◊ Hochmuth 2000b

◊ Hochmuth and Hanlon 2000a

◊ Hochmuth and Hanlon 2000b

† Hubbard and Lowrance 2002

◊ Kesner and Meentemeyer 1989

◊ Liu *et al.* 2013

◊ Mattos *et al.* 2003

◊ McNeal *et al.* 1995

§ Newton *et al.* 1995

§ Newton *et al.* 1999

†§* Obour *et al.* 2010

◊ Sebilo *et al.* 2013

†§* Sigua *et al.* 2010

†§* Sigua 2010

†§* Sigua *et al.* 2012

†§* Silveira *et al.* 2007

†§* Silveira *et al.* 2011

◊ Simonne *et al.* 2006

† Smith and Frost 2000

†* Stout 2003

†§* Stout *et al.* 2000

§ Sumner *et al.* 1992

† Sutton *et al.* 2001

† University of Massachusetts Extension 2009

† USDA Agricultural Research Service 2003

† EPA 1999

◊ Volk and Bell 1945

◊ Wang and Alva 1996

§* White-Leech *et al.* 2013a

§* White-Leech *et al.* 2013b

§ Woodard and Sollenberger 2011

§ Woodard *et al.* 2006