NITROGEN SOURCE INVENTORY AND LOADING ESTIMATES FOR THE MAGNOLIA-ARIPEKA SPRINGS GROUP CONTRIBUTING AREA

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This assessment was conducted by the Florida Department of Environmental Protection Groundwater Management Section of the Water Quality Evaluation and Total Maximum Daily Loads (TMDL) Program to assist in the development and implementation of the Basin Management Action Plan (BMAP) for the Coastal Springs of Pasco and Hernando Counties to address the TMDL for nitrate. The results of this assessment are based on the information provided in the document.

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

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SUMMARY OF FINDINGS

Magnolia Spring is a fourth magnitude spring that discharges water from the karstic Upper Floridan aquifer (UFA), forming the headwaters of the south fork of Hammock Creek in Hernando County, Florida. The spring discharged an estimated average of 9.35 cubic feet per second (cfs) from 1964 to 2003. There are a number of other smaller springs in the area which constitute the Magnolia-Aripeka Springs Group, including Aripeka Springs #1 and #2, Boat Springs, Bobhill Spring, and Gator Spring. These springs either discharge directly into Hammock Creek or into the lesser creeks flowing into Hammock Creek (Bridger and Dodson 2016).

The Magnolia-Aripeka Springs Group was identified as impaired because of ecological imbalances attributed to elevated nutrient concentrations. In 2016, a total maximum daily load (TMDL) of 0.23 milligrams per liter (mg/L) was developed to establish water quality restoration thresholds for the springs group (Bridger and Dodson 2016). Elevated nitrate concentrations in the springs result from current and historical land use practices that have contributed large amounts of nitrogen to groundwater in the spring basin.

The Florida Department of Environmental Protection (DEP) developed a Nitrogen Source Inventory and Loading Tool (NSILT) to provide information on the major sources of nitrogen (atmospheric deposition, wastewater treatment facilities [WWTFs], urban fertilizers, septic systems, livestock wastes, agricultural fertilizers) in the groundwater contributing area for the Magnolia-Aripeka Springs Group. In addition, this tool is used to estimate nitrogen loads to groundwater from these sources in the spring contributing area.

NSILT is an ArcGIS- and spreadsheet-based tool that provides spatial estimates of the relative contribution of nitrogen from major nitrogen sources, and accounts for the transport pathways and processes affecting the various forms of nitrogen as they move from the land surface through the soil and geologic strata overlying the UFA.

This report describes the methods, information, and data sources used in developing the NSILT to estimate nitrogen loads to groundwater in the Magnolia-Aripeka Springs Group contributing area. The information is provided as a planning tool for the development and implementation of a basin management action plan (BMAP), which addresses the nitrate impairment in the Magnolia-Aripeka Springs Group, Weeki Wachee Spring, and the Weeki Wachee River.

The NSILT is being used in the BMAP development process to identify source categories and areas where nitrogen source reduction efforts from current land uses and activities could be focused to achieve the most beneficial effects on water quality for the Magnolia-Aripeka Springs Group. The total estimated annual nitrogen input to the land surface in the contributing area from all sources is 627,439 pounds of nitrogen (lb-N). Urban turfgrass fertilizers contributes 28% of the TN input. Other nitrogen sources, in order of decreasing nitrogen inputs to the land surface, include atmospheric deposition (29 %), septic systems (20 %), farm fertilizer (8 %), livestock waste (8 %), sports turfgrass fertilizer (5 %), and WWTFs (2 %).

The NSILT results indicate an estimated total annual load of 137,929 pounds of nitrogen to the UFA in the Magnolia-Aripeka groundwater contributing area, representing 22 % of the amount of nitrogen inputs to the land surface. Most of the nitrogen in a given year does not reach groundwater due to nitrogen attenuation processes and variations in the rate of aquifer recharge. In areas of the Magnolia-Aripeka springshed where recharge rates are categorized as medium (3.01 to 10 inches per year [in/yr]) or high (greater than 10 in/yr), the UFA is more vulnerable to contamination than in areas where recharge rates are low (0 to 3 in/yr).Groundwater discharge areas were not included in the calculations of nitrogen loads to the groundwater contributing area, as these areas do not contribute nitrogen to the aquifer. To account for variations in recharge rates to the UFA, non-attenuated nitrogen inputs in high rate recharge areas are multiplied by a weighting factor of 0.9, while nitrogen inputs are multiplied by a weighting factor of 0.5 for medium rate recharge areas and 0.1 for low.

The highest estimated nitrogen loads in the groundwater contributing area to Magnolia-Aripeka Springs Group were estimated to be from septic systems (39 %), followed by urban turfgrass fertilizer (32 %) and atmospheric deposition (11 %). Sources contributing smaller amounts of nitrogen include farm fertilizers (6 %), sport turfgrass fertilizer (6 %), livestock waste (3 %), and the land application of treated wastewater (3 %).

The NSILT results provide a baseline understanding of current nitrogen loads to groundwater from existing sources in the Magnolia-Aripeka BMAP area that are likely to contribute the greatest loads of nitrogen to groundwater. This tool can also be used to evaluate the nitrogen load reduction benefits of various management actions and nitrogen reduction projects at locations within the Magnolia-Aripeka contributing area.

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 groundwater quality. Springs integrate groundwater vertically, spatially, and temporally from the Upper Floridan aquifer (UFA) (Bush and Johnston 1988; Katz 1992, 2004; Davis 1996). Rainfall that infiltrates into the subsurface and recharges the aquifer system contains nitrogen and other dissolved chemicals of concern originating from anthropogenic activities at or near the land surface. Groundwater with elevated nitrate concentrations flows toward the Magnolia-Aripeka Springs Group.

Elevated nitrate concentrations in Florida's springs contribute to water quality degradation in their receiving surface waters. This problem will continue if nitrogen inputs are not reduced. Restoration plans to reduce these inputs must include strategies to address the most significant nitrogen sources by obtaining detailed nitrogen loading information from sources in springsheds such as fertilizer applied to cropland and turfgrass, septic tanks, the land application of treated domestic wastewater, atmospheric deposition, and animal wastes.

To identify and quantify the major sources of nitrogen in groundwater contributing areas to springs, the Florida Department of Environmental Protection (DEP) developed the Nitrogen Source Inventory and Loading Tool (NSILT). This tool quantifies nitrogen inputs to the land surface based on the best available, current information on land uses, agricultural practices, urban fertilizer use, waste disposal methods, and atmospheric sources. The NSILT is also used to estimates nitrogen loads to groundwater in the contributing area by taking into account the attenuation of various forms of nitrogen from sources and recharge rates to the UFA. The NSILT results are used in the development and implementation of the basin management action plan (BMAP) for the Coastal Springs of Pasco and Hernando Counties—including Aripeka Spring #1, Aripeka Spring #2, Boat Spring, Bobhill Spring, and Magnolia Spring—by helping to focus nitrogen source reduction efforts to achieve the greatest improvement in water quality.

1.1 The Magnolia-Aripeka Springs Group

The Magnolia-Aripeka Springs Group includes many springs which are the source waters for the Hammock Creek System on the Western coast of the Florida peninsula **(Figure 1**). The Hammock Creek system is an approximately one-mile-long coastal system formed by multiple lesser-magnitude springs and wetlands discharge. The largest of these springs is Magnolia Spring, which is the headwaters of the south fork of Hammock Creek. Other significant springs include Aripeka Springs #1 and #2, Gator, Bobhill and Boat Springs (Bridger and Dodson 2016).

In 2012, the Magnolia-Aripeka Springs Group was verified as impaired because of ecological imbalances attributed to elevated nutrient concentrations. In 2016, a total maximum daily load (TMDL) was developed to establish a water quality restoration threshold of 0.23 milligrams per liter of total nitrogen (mg N/L) for the Magnolia-Aripeka Springs Group (Bridger and Dodson 2016).

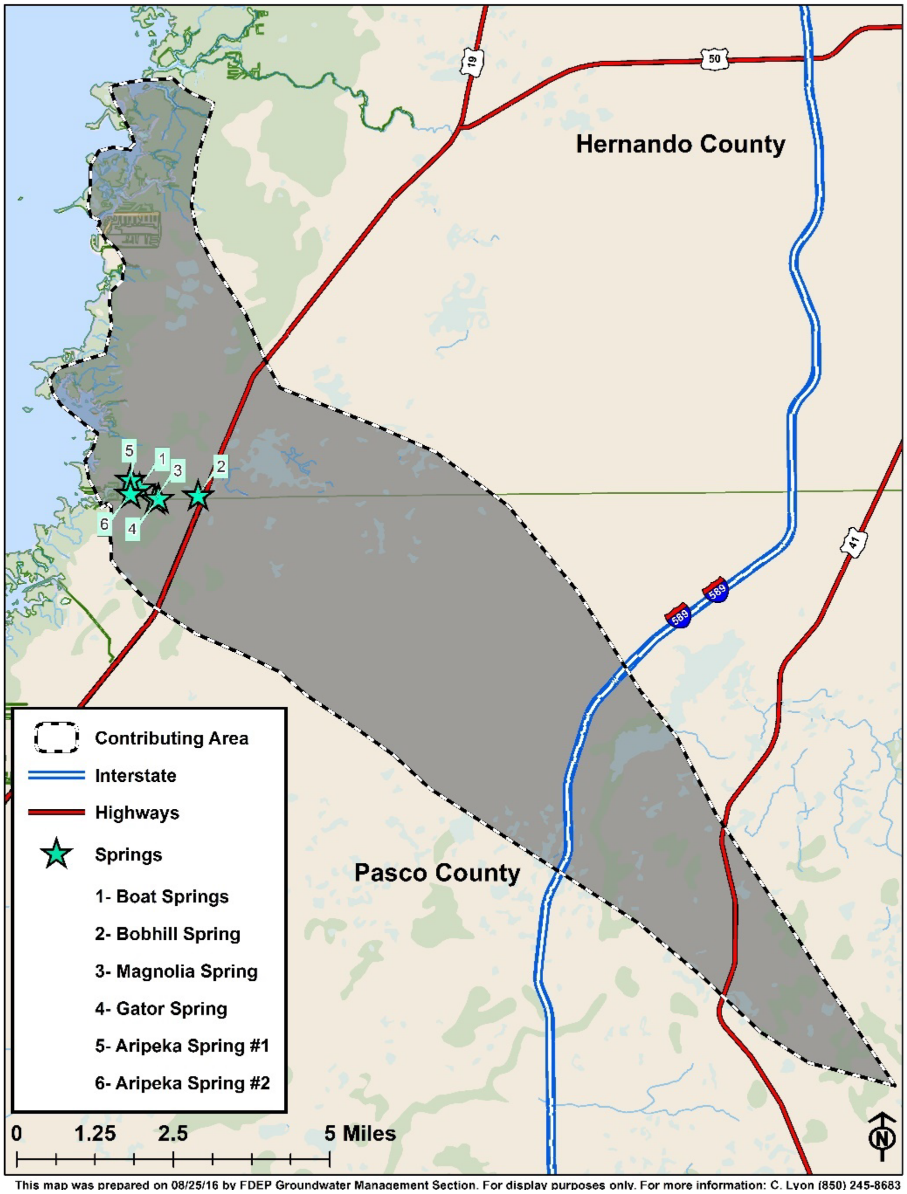

Figure 1: Map showing the Magnolia-Aripeka Springs Group and contributing area

Elevated nitrate concentrations in the Magnolia-Aripeka Springs Group result from current and historical land use practices contributing nitrogen to the UFA, the highly transmissive limestone aquifer that is the source of water flowing from the springs. The NSILT is being used to provide stakeholders with current information on the sources of nitrogen in the Magnolia-Aripeka Springs Group contributing area and the relative nitrogen contributions of each source to the

UFA. More important, the NSILT is being used as a planning tool for the development and implementation of the BMAP for the Coastal Springs of Pasco and Hernando Counties to address the water quality impairment.

1.2 Magnolia-Aripeka Springs Group Groundwater Contributing Area

The Magnolia–Aripeka Springs Group is located in Hernando County immediately north of the Pasco County border. The groundwater contributing area for the springs lie in southern Hernando County and northern Pasco County. This area is largely based on the springshed boundary delineated by the Southwest Florida Water Management District (SWFWMD) (Jones et al. 1997) and is the primary source of groundwater flowing to the Magnolia-Aripeka Springs group. The contributing area covers 37,760 acres; 24,960 acres in Pasco county and 12,800 acres in Hernando County. Land uses comprise 41 % urban landscapes, 22 % wetlands and marshes 20 % forested areas, and 7 % agriculture. The remaining 10 % includes waterbodies, rangeland, and miscellaneous land uses.

The area addressed by the BMAP for the Coastal Springs of Pasco and Hernando Counties is larger than just the Magnolia-Aripeka contributing area. **Figure 2** shows the entire BMAP which includes the Weeki Wachee Spring contributing area. A separate NSILT analysis has been conducted for the groundwater contributing area to Weeki Wachee Spring (Eller and Katz 2016).

1.3 Hydrogeology and Aquifer Recharge

The Floridan aquifer system in this area is composed of thick sequences of limestone and dolostone of Eocene to Miocene age that are exposed at or very near to (10 to 20 feet) the land surface (Bridger and Dodson 2016). The UFA is the predominant source of water discharging from the Magnolia-Aripeka Springs Group (Jones et al. 1997; Faulkner 1970).

The dissolution of the carbonate rocks that comprise the UFA has created numerous karst features (sinkholes, caves, and conduits) over geologic time in this area. These features, along with a thin layer of sediments overlying the UFA, allow water from the land surface to move directly and relatively rapidly into the aquifer.

Consequently, groundwater into the UFA responds relatively quickly to changes in rainfall and recharge, and groundwater flows directly to springs where conduits are present. Groundwater discharging from the springs originate from both nearby source areas and more distant areas in the springshed. As a result, water flowing from springs includes a mixture of groundwater that has resided in the aquifer for varying amounts of time, ranging from days to several decades.

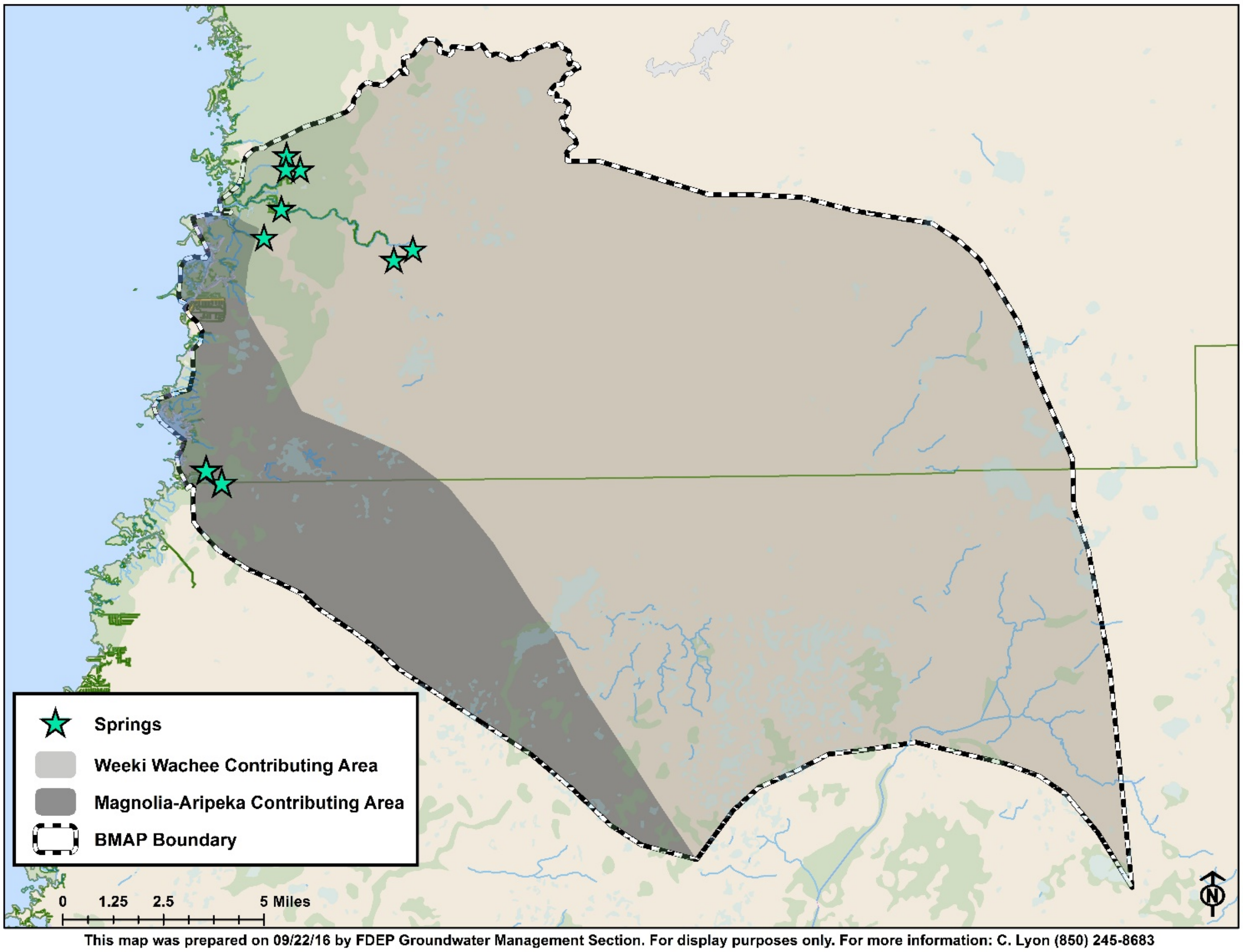

Figure 2: BMAP area for the coastal springs of Pasco and Hernando Counties

Most of the drainage within the Magnolia-Aripeka springshed is internal, and rainwater that recharges the UFA infiltrates from the land surface directly into closed depressions or through thin overlying sediments into the unconfined limestone of the UFA. Recharge rates to the UFA are affected by spatial variations in the hydrogeological characteristics of the surficial aquifer and intermediate confining unit, karst features, and average annual rainfall. Jones *et al.* (1997) and Dodson and Bridger (2016) describe the hydrogeologic framework for this area in greater detail.

In 2013, HydeoGeoLogic, Inc contracted by SJRWMD developed groundwater flow model based on the existing Northern District Model (HydroGeologic, Inc 2013). The model area spans over 5.5 million acres of peninsular Florida and is composed of uniform model grid dimensions of 144 acre cells. The raster-based data were smoothed to create 3 recharge rate categories in the contributing area: low (0 to 3.9 inches per year [in/yr]), medium (4.0 to 9.9 in/yr), and high (10.0 in/yr or greater) **(Figure 3**). The amount of annual recharge affects the transport of nitrogen to the aquifer. Therefore, it is likely that more nitrogen would reach the aquifer annually in high recharge rate areas than in lower recharge rate areas, if both areas were to receive similar nitrogen inputs to the land surface.

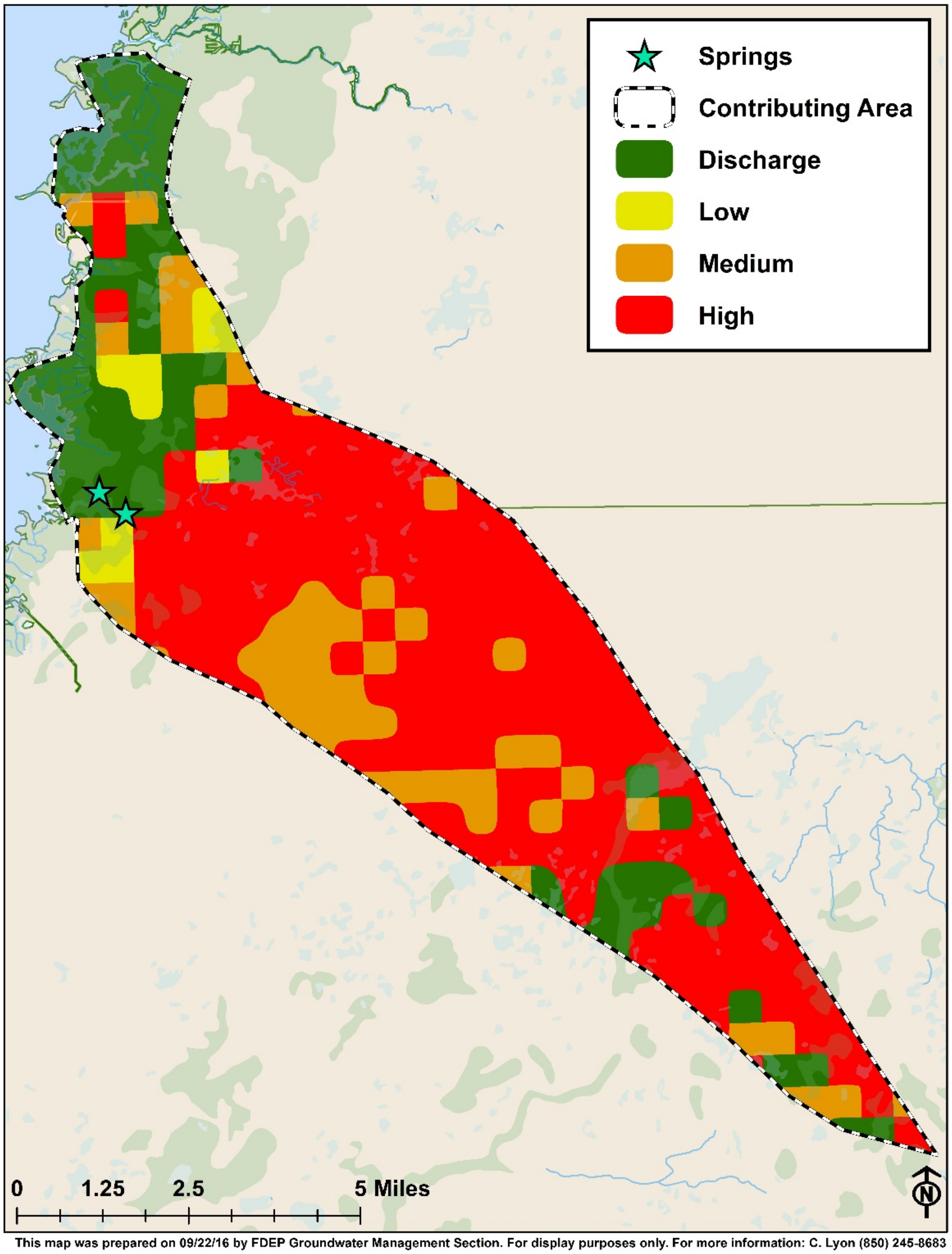

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Figure 3: UFA recharge rate categories in the Magnolia-Aripeka Springs Group contributing area

1.4 Land Use

Land use/land cover (LULC) was assessed with the most recent land use ArcGIS coverages obtained from the SWFWMD and county property appraisers. The Magnolia-Aripeka contributing area lies completely within the SWFWMD boundary. All land use classifications used by the SWFWMD were based on the Florida Land Use/Land Coverage and Forms Classification System (FLUCCS). The 2011 land use was created through the interpretation of digital imagery taken in December 2010. The land use classifications were determined through photo interpretation, editing, and quality check processes. **Table A.2** and **Table A.3** provide additional details of these data.

Additional land use information was obtained from the Hernando and Pasco County property appraisers. Staff from each county property appraiser's office conduct routine field visits to update and verify the land use classification of parcels for tax purposes. These visits occur at least every five years, although most parcels are visited more frequently. This system allows for continual updates and for 2014 data to be used for this analysis (**Table A.4** and **Table A.5**).

For the assessment of current land use, the property appraisers also provided detailed information on the specific agricultural practices used for estimating nitrogen contributions from fertilizer use on farmland. 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 contributing area were estimated for atmospheric deposition, wastewater treatment facility (WWTF) land application sites, septic systems, urban turfgrass, sports turfgrass and agricultural fertilizer use, and livestock waste. The methods used to estimate nitrogen inputs for each source are based on a detailed synthesis of information, including direct water quality measurements, census data, surveys, wastewater facility permits, published scientific studies and reports, and information obtained in meetings with agricultural producers.

For some nitrogen source categories, calculation of nitrogen inputs was achieved using assumptions and extrapolations, and as a result their estimated nitrogen inputs would be subject to further refinement if more detailed information becomes available. The approach and sources of information used to estimate the annual nitrogen input (in pounds per year [lb-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 U.S. In Florida, the Clean Air Status and Trends Network (CASTNET) has two stations that collect dry deposition data for analysis. Wet deposition data currently are 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 model for estimating the total atmospheric deposition (TDEP) of nitrogen and sulfur for the entire U.S. 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 multistep process with National Trends Network wet deposition values to model total deposition in 16-kilometer (km) grid cells.

Multiple TDEP model runs are available, providing atmospheric data for individual and multiple years, with average values calculated for the multiyear models. The TDEP model run used for the NSILT includes data from 2011 to 2013. The total nitrogen (TN) data are available in a nationwide coverage (.e00) file and were converted into ArcGIS shapefiles for the purpose of this analysis. **Figure 4** illustrates the model results for TN deposition in the Magnolia-Aripeka contributing area. The total nitrogen deposition amounts in high, medium, and low recharge rate areas are 139,145 lb-N/yr; 39,345 -N/yr; 5,953 lb-N/yr, respectively.

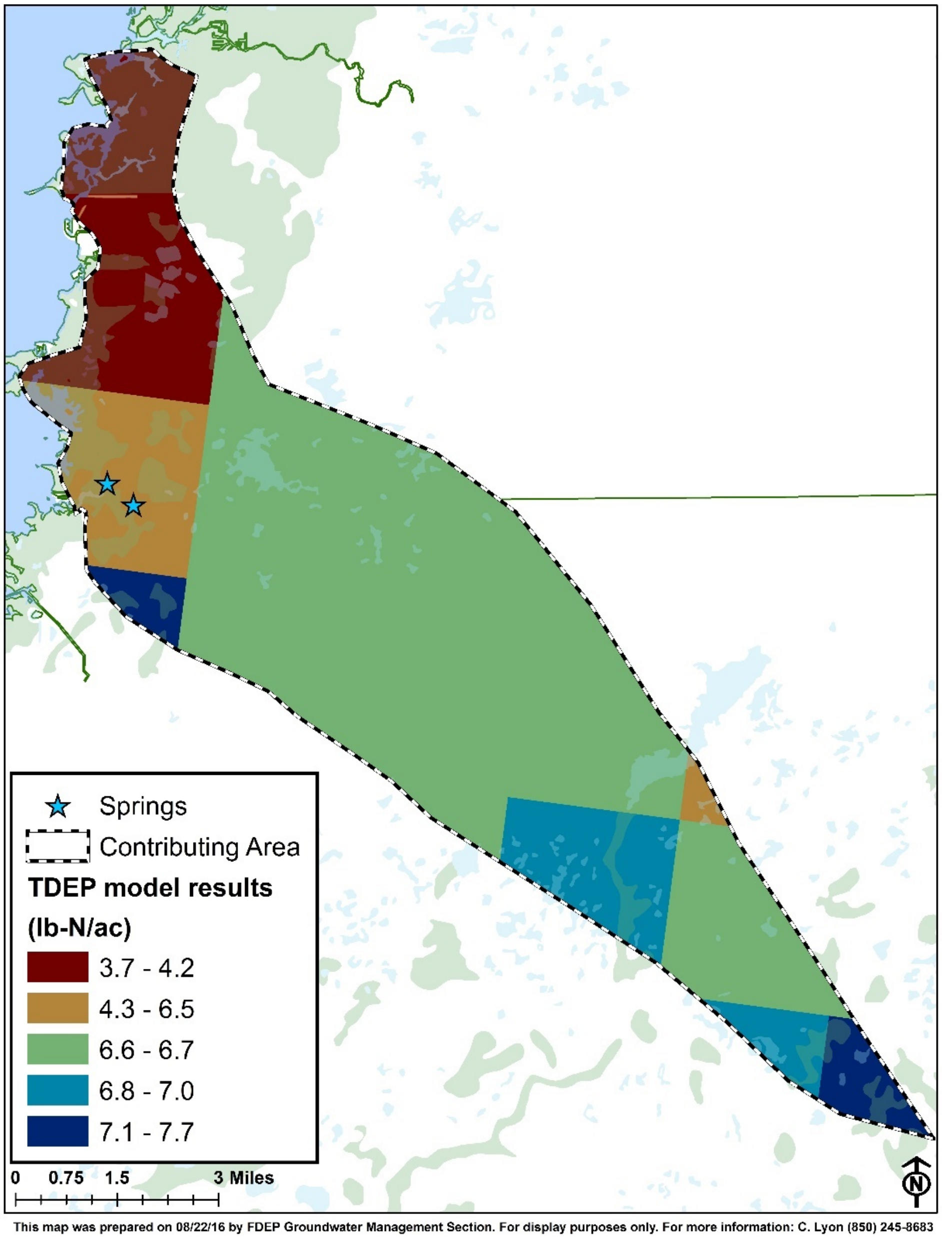

Figure 4: Atmospheric deposition model results used for the NSILT

2.2 Wastewater Treatment Facilities

WWTFs receive and treat domestic wastewater. In the Magnolia-Aripeka contributing area, treated effluent containing nitrogen from WWTFs is discharged to sprayfields, rapid infiltration basins (RIBs), percolation ponds, and distributed for irrigation (**Figure 5**: Distribution of Effluent Disposal Sites). There are 6 WWTFs located in the Magnolia-Aripeka contributing area, 3 in Pasco County and the remaining 2 in Hernando County. There are 2 facilities discharging more than 100,000 gallons of treated effluent per day (**Figure 6**). Additionally, there is one facility outside of the Magnolia-Aripeka contributing area, which sends reuse water to areas within the contributing area.

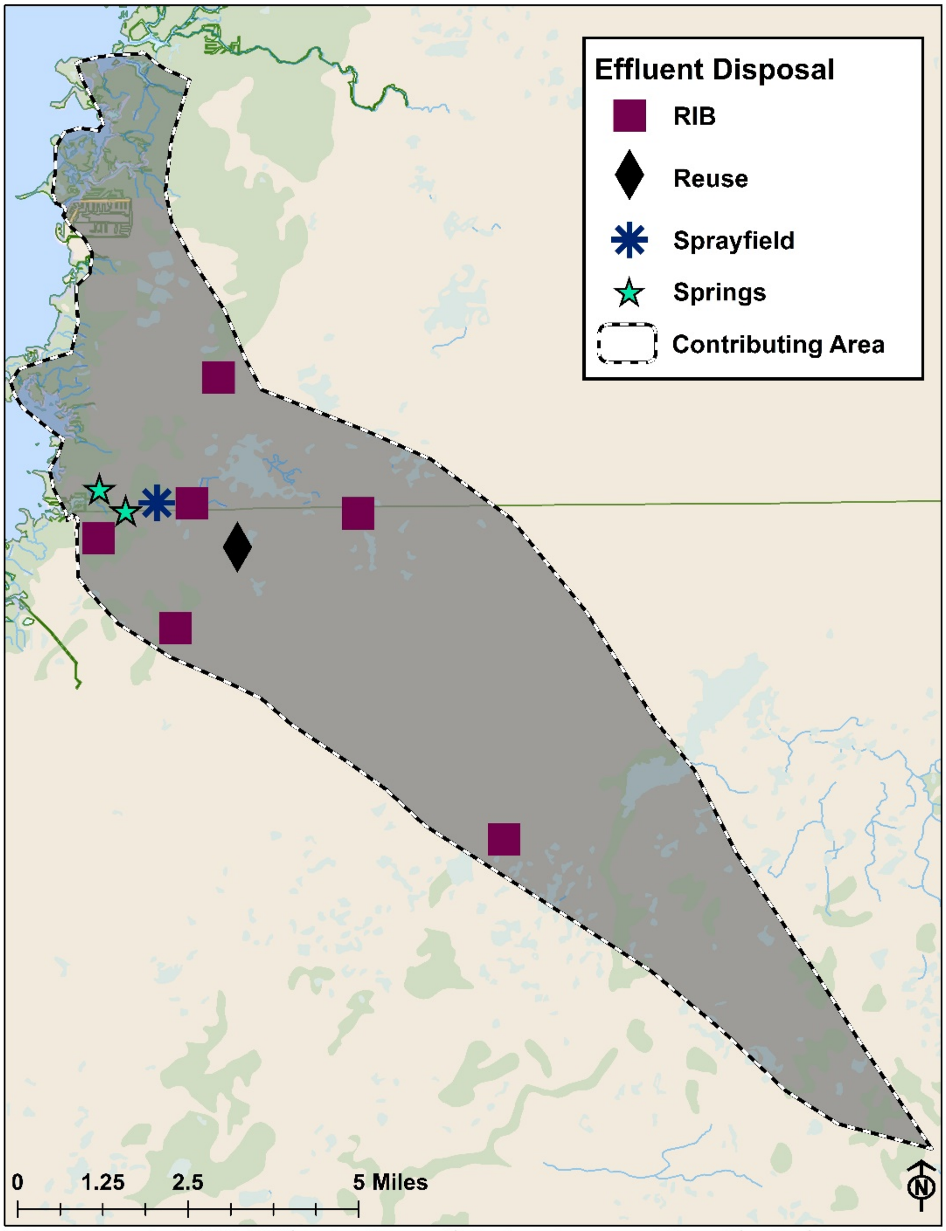

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Figure 5: Distribution of Effluent Disposal Sites

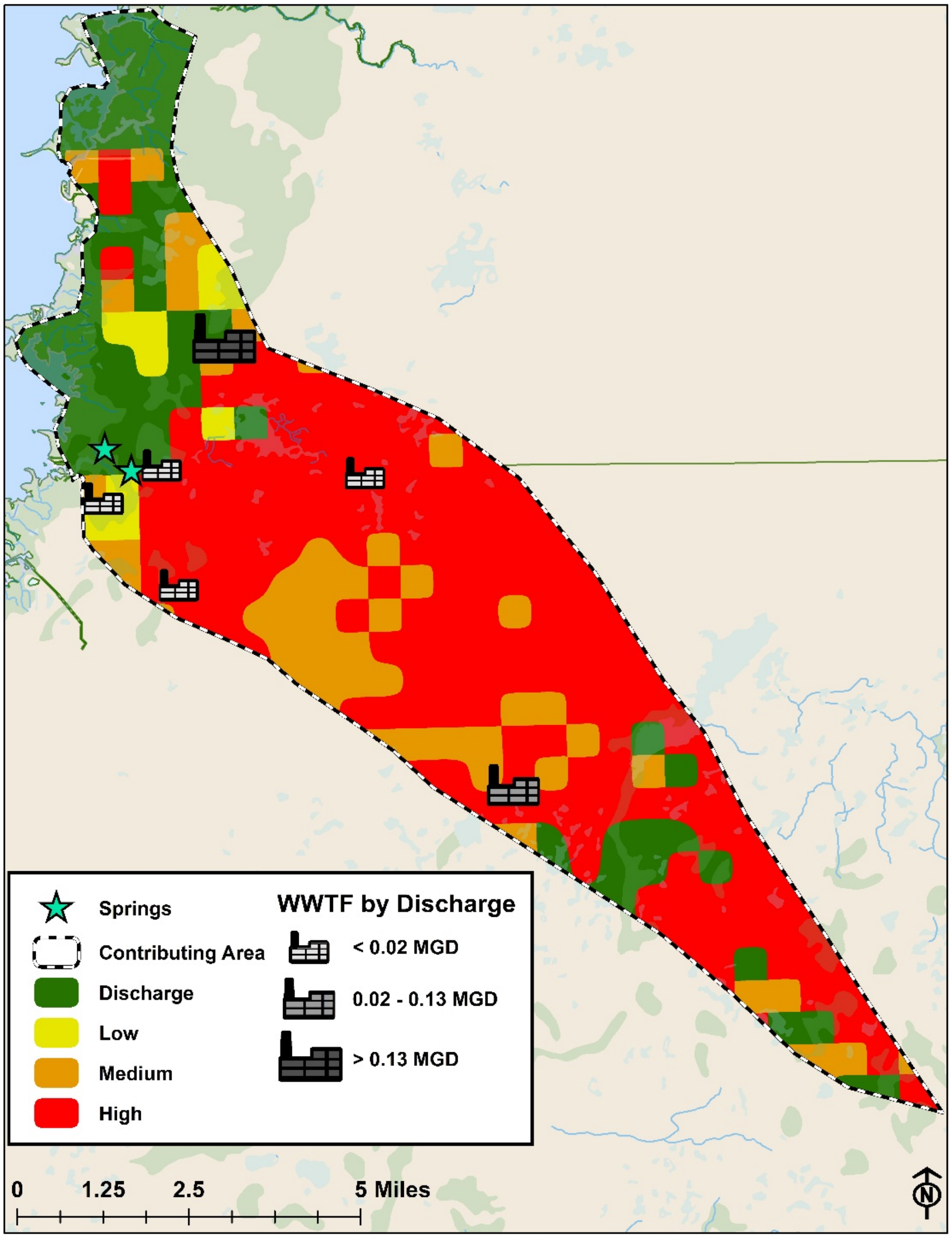

Figure 6: Distribution of WWTFs in the Magnolia-Aripeka contributing area

The required water-quality monitoring varies between facilities depending on permitting requirements, and not all facilities report the same type of data. The annual effluent input of nitrogen 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 (<0.1 million gallons per day [MGD] by volume) are not always required to monitor and report TN effluent concentrations, and therefore not all these facilities had data available in the DEP Wastewater Facility Regulation (WAFR) Database.

For these, DEP estimated TN concentrations from nitrate-N (NO_3-N) data (assuming the NO_3-N concentration was 38.5% of the TN based on the data from a 2009 cooperative study with the Water Reuse Foundation of 40 domestic WWTFs across the state). For this calculation, the NO_3-N value is divided by 0.385, resulting in an estimated TN concentration. The WWTF data were compiled for each facility and include the most recent complete year of data. The years of data vary with the individual facilities; however, the majority of the data is from 2015 to 2016.

For facilities permitted for the land application of treated wastewater, the reported annual average flows were used to calculate an average discharge for the evaluated year applied to sprayfields, RIBs, and absorption fields. For the purpose of this analysis, absorption fields are included with RIBs because they have similar processes that attenuate nitrogen. 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 from wastewater facilities were estimated for each recharge rate category based on the location of the effluent treatment sites in the contributing area.

Table 1 and **Table 2** summarize the nitrogen input data from facilities in the contributing area. In total, an estimated 12,542 lb-N/yr are applied to the land surface from these facilities in the high recharge rate areas, and an additional 28 lb-N/yr are applied in the medium recharge rate areas. Without any facilities, there is no attributable nitrogen input to the land surface in the low recharge rate areas.

Table 1: Data for Hernando County WWTFs in the Magnolia-Aripeka contributing area

* TN data estimated based on available NO_3 data.

WWTF Name	Facility ID	Treatment Type	Recharge Area	Annual Average TN (mg-N/L)	Annual Flow (MGD)	Nitrogen Input (lb-N/yr)
Holiday Springs RV Resort	FLA012070	RIB Sprayfield	High Discharge	7.89*	0.02	400
Spring Hill	FLA012043	RIB	High	15.27	0.73	33,783

Table 2: Data for Pasco County WWTFs in the Magnolia-Aripeka contributing area

* TN data estimated based on available NO_3 data.

WWTF Name	Facility ID	Treatment Type	Recharge Area	Annual Average TN (mg-N/L)	Annual Flow (MGD)	Nitrogen Input (lb-N/yr)
Aripeka West	FLA012832	RIB	Medium	1.80*	0.01	28
East Lake Landings MHP	FLA012819	RIB	High	7.57*	0.01	308
Country Village MHP	FLA012748	RIB	High	1.23*	0.01	28
Pasco County - Shady Hills Subregional	FLA012741	RIB	High	9.62	0.13	3,690
Pasco County Master Reuse System	FL0127272	Reuse	High	7.60	0.35	8,117

Additionally, the Pasco County Master Reuse System (FL0127272), located outside of the Magnolia-Aripeka contributing area, is permitted to distribute reclaimed water for irrigation. This reuse water is sent to the Heritage Pines Community and Golf Course, a 508-acre area located entirely within the high recharge rate area. The golf course and residential areas use 0.35 MGD of reclaimed water, applied 350,000 gallons daily at a concentration of 7.60 mg-N/L in the high recharge area, equaling an annual nitrogen input of 8,117 lb-N to the land surface.

2.3 Septic Systems

On-site sewage treatment and disposal systems (OSTDS), commonly referred to as septic systems, are widely used throughout the Magnolia-Aripeka contributing area where municipal sewer is not available. These systems can contribute to elevated nitrogen concentrations in groundwater (Chang et al. 2010).

Beginning 2014, the Florida Department of Health (FDOH) began the process of updating the septic system inventory for the entire state called the Florida Water Management Inventory. The results of this process can be obtained through FDOH and were utilized to estimate the total number of septic systems within the BMAP boundary. The output of this inventory provided ArcGIS files where the locations of both known and estimated septic systems can be mapped (http://ww10.doh.state.fl.us/pub/bos/Inventory/FloridaWaterManagementInventory/). The distribution of septic systems within the BMAP boundary is shown in **Figure 7**.

After the number of septic systems in the contributing area was determined, the population served by septic systems was estimated using the 2010 United States Census Bureau data for population and household occupancy in each county. The Census makes a distinction between occupied and non-occupied households. The county population was divided by the number of occupied households in the county, resulting in an average number of people per occupied household (2.41 in Hernando County and 2.45 in Pasco County).

However, many people with a home septic system potentially have access to a facility connected to a sewer system during their weekly routine (i.e., work, school), reducing nitrogen inputs to the septic system. To estimate the effective number of people per household and the associated nitrogen input to septic systems, population age distribution information was obtained for Hernando and Pasco Counties from the 2010 Census. In Hernando County, 53.0% of the population is of school or working age and, according to the Bureau of Labor Statistics(http://www.bls.gov/cps), spends 43.5 hours or 25.9% of the week away from home and therefore are not using the septic system. This effectively reduces the number of people per household using septic systems in Hernando County by 13.7%, resulting in an adjusted number of 2.08 people per household. A similar calculation was made for Pasco County, which has a school or working age population of 60.5%, resulting in an adjusted number of 2.07 people per household (based on a reduction of 15.7%). For more information, see Appendix **Table A.6, Table A.7** and **Table A.8.**

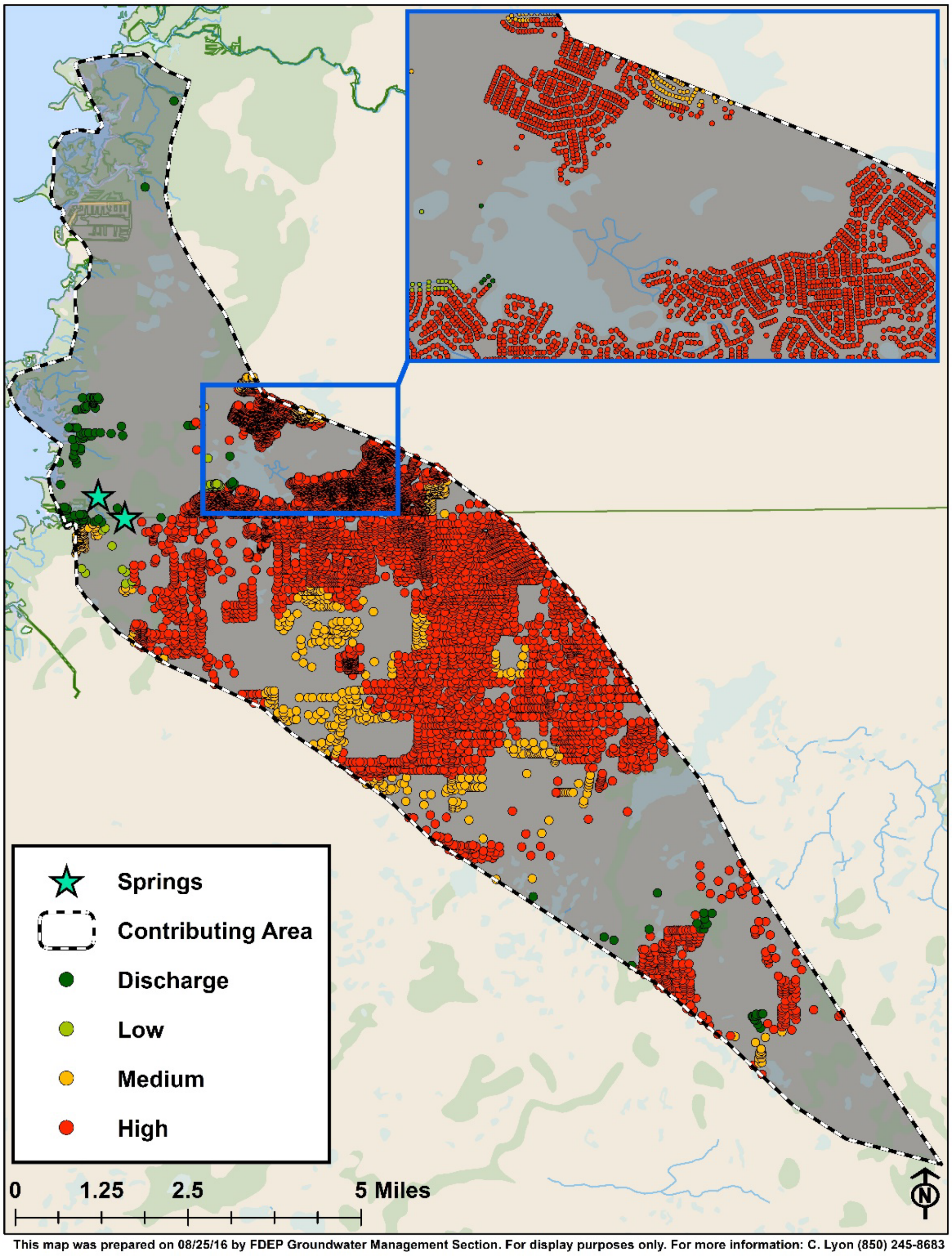

Figure 7: Distribution of septic systems throughout the Magnolia-Aripeka Springs Group BMAP area

The total population in the Magnolia-Aripeka contributing area served by septic systems was estimated by multiplying the estimated number of people per household (adjusted for actual use) by the number of septic systems. Several literature sources have reported a per capita contribution of 9.012 lb-N/yr, and this value was multiplied by the estimated number of people using septic tanks within the different regions of the contributing area (U.S. Environmental Protection Agency [EPA] 2002; Toor et al. 2011; Viers et al. 2012). **Table 3** summarizes the septic system data.

Table 3: Estimated number of septic systems and associated input to the land surface

Land Category	Number of Septic Systems	Estimated Input to Land Surface (lb-N/yr)
Hernando High Recharge	2,469	46,225
Hernando Medium Recharge	192	3,595
Hernando Low Recharge	18	337
Pasco High Recharge	3,489	64,984
Pasco Medium Recharge	464	8,642
Pasco Low Recharge	10	186

2.4 Urban Turfgrass Fertilizer

2.4.1 Fertilizer Application Rates

Fertilizers applied to the turfgrass typically found in urban areas (including residential lawns and commercial and public green spaces) are referred to as "urban turfgrass" fertilizers (**Figure 8).** Results from surveys and workshops pertaining to fertilizer application on turfgrass in nearby counties were used to estimate the nitrogen application rates for urban turfgrass in the Magnolia-Aripeka contributing area.

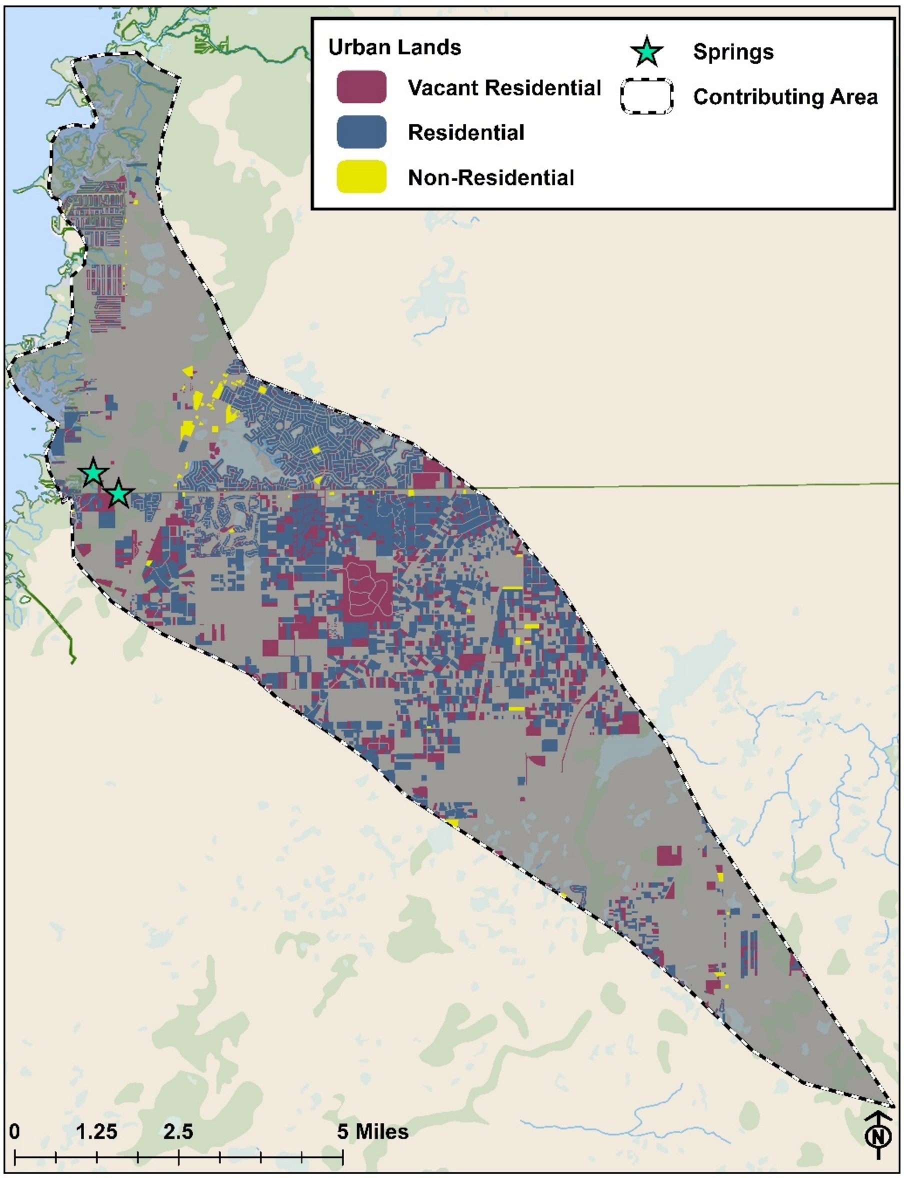

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Figure 8: Urban noncommercial lands in the Magnolia-Aripeka contributing area according to county property appraiser data

Fertilizer is applied by either the homeowner or a hired lawn service company on residential properties and on non-residential properties it may be applied by contractors or maintenance staff. In 2008, a SWFWMD contractor conducted a telephone survey to solicit information about residential fertilizer use in Citrus County and southern Marion County. The results from this survey were used to estimate fertilizer application rates to all urban turfgrass in the Magnolia-Aripeka contributing area. According to the survey (Martin 2008), 68% of the surveyed population applied fertilizer to their own lawn care and applied lawn fertilizer 3 times a year at variable rates that may range as high as 45.56 lb-N/ac (**Table 4)**. Additionally, 32% of the population surveyed hired lawn service companies. Lawn service companies typically apply fertilizer at rates consistent with the Green Industries Best Management Practices Manual recommendation of 21.78 lb-N/ac twice a year (Martin 2008; DEP 2010; Downs et al. 2012). Fertilizer application on commercial and public green spaces was assumed to be performed by lawn service professionals or trained staff using application rates and frequencies similar to those recommended in the Green Industries Best Management Practices Manual.

Table 4: Estimated fertilizer application rates by homeowners from surveys completed in Citrus and Marion Counties

* = Includes homeo
wners who fertilize based on visual appearance or best judgment.

Basis for Application Rate	% of Population and Basis for Fertilizer Rate Selection	Estimated Rate (lb-N/ac)
Green Industry BMP Guidelines	15 %	21.78
Fertilizer Bag Label	74 %	34.78
Do Not Apply Fertilizer	11 %	Not applicable

2.4.2 Nonresidential Parcel Estimations

The acreage of nonresidential land areas receiving fertilizer applications was estimated to obtain nitrogen inputs for each category listed in **Table 5**. Parcel types assessed using the PA data include businesses, hotels, schools, churches, and other facilities. These data were combined with zoning data provided by Hernando and Pasco Counties. The zoning attributed to each parcel contains information on the areas of impervious surfaces (i.e., structures, pavement, etc.), referred to as the "max lot coverage." For each parcel, the max lot coverage was used to estimate the acreage of impervious and pervious land areas. For this analysis, it was assumed that all pervious acreage was fertilized by lawn service companies at the previously mentioned rate and frequency.. **Table 5** summarizes these data. Details of the PA data and max lot coverages are listed in **Appendix A**, **Table A.4, Table A.5, Table A.9** and **Table A.10.**

Table 5: Summary of the fertilizable urban land area and associated N input for nonresidential parcels

* = Parcel type descriptions include forest-parks-recreational, outdoor parkland-recreational, and counties other than public schools.

Parcel Type	Hernando High Recharge (acres)	Pasco High Recharge (acres)	Hernando Medium Recharge (acres)	Pasco Medium Recharge (acres)	Total Input (lbN/yr)
Hotels	2				**2**
Churches	33	34	8	7	**82**
Schools					**0**
Hospitals					**0**
Homes for the Aged		1			**1**
Clubs, Lodges, Union Halls	19	2	1		**22**
Park and County Land*					**0**
TOTAL	**55**	**37**	**9**	**7**	**108**

2.4.3 Residential Parcel Estimations

For residential parcels, including single and multifamily homes, the acreage (pervious area) receiving fertilizer applications was estimated in the same manner as for nonresidential parcels. Prior to applying the fertilizer application rates to the pervious land area, one other factor was taken into account: the probability a homeowner will fertilize the lawn.

The majority of homeowners will apply fertilizer to all the pervious area on their property (lawns and beds), but for those with larger lot sizes, this is less likely. For this analysis, it was assumed that the owners of properties greater than one acre of pervious land area would regularly apply fertilizer to no more than one acre.

The second factor taken into account is the probability of a homeowner fertilizing their property. Based on socioeconomic studies, property value can be generally correlated with landscape fertilization in a residential setting, with higher valued properties receiving more fertilizer (Kinzig et al. 2005; Law et al. 2004; Zhou et al. 2008; Cook et al. 2012). To apply this factor, the range of property values for single-family homes was evaluated for all counties in the springs coast (Citrus, Hernando and Pasco) and subdivided into three categories based on property value: high, medium, and low (**Appendix B**). **Table 6** lists the estimated probability of fertilization for each property value category based on the literature

Table 6: Distribution of property values and the probability of fertilization for the Magnolia-Aripeka contributing area

Property Value Label	Property Value	Probability of Fertilization
High	> $150,000	90%
Medium	$50,001 – $150,000	75%
Low	≤ $50,000	10%

The probability that a homeowner will fertilize some or all of a property in a given year was based on socioeconomic studies of lawn care trends in urban environments (Kinzig et al. 2005; Grove et al. 2006; Carey et al. 2012). These factors were applied to the pervious acreage of residential properties to adjust the land area presumed to be fertilized. The land area presumed to receive fertilizer applications was multiplied by the annual application rate listed in **Table 4** to obtain the estimated total input of nitrogen in fertilizer to the land surface in residential areas (**Table 7**).

Table 7: Summary of urban fertilizer data attributed to residential parcels

Parcel Type	Hernando High Recharge (acres)	Hernando Medium Recharge (acres)	Pasco High Recharge (acres)	Pasco Medium Recharge (acres)	Pasco Low Recharge (acres)	Total Input (lb-N/yr)
Single-Family Residential	533	65	1,340	116	5	**2,059**
Multifamily Residential	2		192	30	1	**226**
Mobile Home						
Condominium						
Vacant Residential	31	16	106	42	2	**196**
TOTAL	**566**	**81**	**1,637**	**188**	**8**	**2,481**

2.5 Sports Turfgrass Fertilizer

Fertilizer applied to sports turfgrass areas is another potential source of nitrogen. These areas fall into two main categories that were evaluated separately: golf courses and sporting facilities such as baseball, football, and soccer; and other fields where fertilizers are likely applied.

To estimate the nitrogen input for golf courses, the NSILT used a statewide annual average application rate (previously vetted by golf course professionals) of 141.1 lb-N/ac/yr (or 72 % of the course area at 4.5 lb-N/1,000 ft2) (Sartain 2002; DEP 2007). There is only one golf course located within the Magnolia-Aripeka contributing area, Heritage Pines Golf Course. In total, this golf course applies fertilizers at a rate of 27,423 lb N/yr to the land surface in high recharge rate area.

Sports facilities were assessed based on PA land use data. The parcel types likely to contain these facilities were identified and evaluated based on aerial imagery. In total, 15 acres of land were associated with sports facilities in the Magnolia-Aripeka high-recharge areas (5 acres in parcel type forest-parks-recreational, 6 acres in parcel type schools-public-county, and 4 acres in parcel type schools-colleges-private). 27 acres of land were associated with the medium-recharge area (13 acres in parcel type schools-public-county, and 14 acres in parcel type counties-other than public schools). There were no sports facilities located in the low recharge rate area of the contributing area. It is assumed turf areas at sports facilities are fertilized at rates applied by lawn service companies, as described in **Section 2.4**, resulting in the estimated inputs of 631 lb-N/yr, and 1,172 lb-N/yr, applied to the high and medium rate recharge areas, respectively. **Table 8** summarizes all sports turfgrass fertilizer calculations.

Table 8: Summary of total sports turfgrass fertilizer nitrogen applied to the land surface

Land Type	High Recharge	Medium Recharge	TOTAL
Golf Courses	27,423		**27,423**
Sporting Facilities	631	1,172	**1,803**
TOTAL	**28,054**	**1,172**	**29,226**

2.6 Livestock Waste

The Magnolia-Aripeka contributing area contains a small number of livestock farms, mostly cow-calf operations. Agricultural practices specific to this area were obtained through meetings with agricultural producers and stakeholders. Typical cattle stocking rates in Hernando and Pasco Counties were estimated as 1 cow per 6 to 8 acres of pasture (based on a stakeholder meeting in Lecanto, Florida, July 2014). The estimation of pasture acreage for these operations was based on PA data and included improved, semi-improved, and native pastures. **Table 9** lists the estimated pasture acreage and the associated cattle populations in the contributing area boundary. There were no agricultural lands within the low recharge area of Pasco County. Additionally, there were no agricultural lands for the entirety of the Hernando County portion of the Magnolia-Aripeka contributing area.

For other livestock animals, the populations were estimated using data from the U.S. Department of Agriculture (USDA), which publishes a Census of Agriculture (CoA) every five years. This comprehensive report provides summary data on the agricultural practices and livestock populations for each state and county in the U.S. The 2012 CoA report was used to provide data on livestock populations for this assessment. However, since the CoA reports entire county data, assumptions of livestock populations in the BMAP area were made based on land use coverage. Please note that according to the CoA there are approximately 900,000 layer chickens in Hernando County. Both SWFWMD and the PA office confirmed, there was a large scale chicken operation in the area, but has closed since the CoA was taken. Based on this information, layer chickens are not included in this analysis

Table 9: PA pasture data and estimated cattle populations based on stocking rates

County	Property Code	PA Land Description	Estimated Improvement	High-Recharge Area (acres)	Medium-Recharge Area (acres)	Estimated Cattle Population
Pasco	60	Improved Pastureland	Improved	1,256	216	210
Pasco	61	Improved Pastureland	Improved Below Average	83	67	21

To estimate the number of livestock animals in the contributing area, the SWFWMD land use coverage was used to identify land use categories likely to contain livestock, i.e., pastures, feeding operations, and specialty farms. These land areas were totaled for Hernando and Pasco Counties and subdivided by recharge rate category. The livestock area summations were used to calculate percentages of county wide livestock area that occur in the BMAP area and the high and medium recharge areas in it.

These percentages were applied to the populations provided by the CoA to estimate the number of animals in the contributing area and in the medium and high recharge rate areas of Hernando and Pasco Counties (**Table 10** and **Table 11**, respectively). For example, if 10,000 cows were reported for a particular county in the CoA, but only 10% of the livestock lands in that county were inside the BMAP area, it was assumed that the contributing area contained 1,000 cows.

Table 10: WMD land use percentages and miscellaneous livestock population data for Hernando County

Land Category	Land Area (acres)	Land Use %	Horses	Broiler Chickens	Goats	Hogs	Sheep	Turkeys
Hernando County	33,826		2,080	546	1,034	328	318	0
High Recharge	13,447	0.03%	1					

Table 11: WMD land use percentages and miscellaneous livestock population data for Pasco County

Land Category	Land Area (acres)	Land Use %	Horses	Broiler Chickens	Goats	Hogs	Sheep	Turkeys
Pasco County	84,680		2,008	604	1,410	165	251	63
High Recharge	1,300	2%	31	9	22	3	4	1
Medium Recharge	216	0.3%	5	2	4		1	

Nitrogen waste factors were assigned for each animal type and applied to the estimated livestock populations to estimate the nitrogen input to the land surface. The nitrogen waste factors in lb N/day per animal were as follows: cattle, 0.337; broiler chickens, 0.159; layer chickens, 0.003; goats, 0.035; hogs, 0.190; sheep, 0.198; turkeys, 0.006; and horses, 0.273 (Goolsby et al. 1999; Katz et al. 1999; Chelette et al. 2002; Ruddy et al. 2006; Meyer 2012; Sprague and Gronberg 2013). **Table 12** lists the estimated TN input to the land surface from livestock waste for the high and medium recharge rate parts of the contributing area.

Table 12: Estimated nitrogen applied (lb-N/yr) as animal waste to the land surface in the contributing area

Land Category	Cattle	Horses	Broiler Chickens	Goats	Hogs	Sheep	Turkeys	Total N Input (lb-N/yr)
Hernando–High Recharge		68	10	4	7	8		**98**
Pasco–High Recharge	32,595	3,073	538	277	176	279	2	**42,920**
Pasco–Medium Recharge	7,989	511	90	46	29	46		**9,706**
Pasco–Low Recharge		25	4	2	1	2		**83**
Total Contributing Area	**40,584**	**3,677**	**643**	**329**	**214**	**335**	**2**	**52,807**

2.7 Farm Fertilizer

Nitrogen in agricultural fertilizer is applied at widely varying rates, depending on the crop, time of year, and individual farm practices. The PA offices in Hernando and Pasco Counties provided detailed information on the types of crops grown in the area. Nitrogen inputs to the land surface were estimated based on the type of crops grown in each PA land use category and the recommended nitrogen application rates for crops by the University of Florida Institute of Food and Agricultural Sciences (UF–IFAS) (Hochmuth and Hanlon 2000, 2010, 2013; Wright et al. 2011; Mylavarapu et al. 2012; Liu et al. 2012).

Table 13 summarizes the nitrogen inputs to the land surface from fertilizers applied to cropland for the high, and medium recharge rate areas in the Magnolia-Aripeka contributing area in Pasco County. Based on the available data, there are not any croplands within the Hernando County section of the Magnolia-Aripeka contributing area.

2.8 Summary of Estimated Nitrogen Inputs to the Land Surface

Figure 9 summarizes the relative contributions of nitrogen (in percent) from the major sources in the Magnolia-Aripeka contributing area. The estimated total annual nitrogen input to the land surface from all sources is 627,439 lb-N. Urban turfgrass fertilizers comprise 29 % of the TN input to the land surface in the contributing area. Other nitrogen sources, in order of decreasing contributions of nitrogen inputs to the land surface, include atmospheric deposition (28 %), septic systems (20 %), farm fertilizer (8 %), livestock waste (8 %), sports turfgrass fertilizer (5 %), and WWTFs (2 %).

Table 13: Summary of crop types, assumed nitrogen application rate, and estimated inputs in the Pasco County portion of the Magnolia-Aripeka contributing area

Property Code	PA Land Description	Estimated Crop Type	N Application Rate (lb-N/ac)	High-Recharge Area (ac)	Medium-Recharge Area (ac)	Total Input (lb-N/yr)
51	Cropland Soil Capability I	Hay Crop	80	227	43	**270**
66	Orchard Groves	Orchards	150	15		**15**
69	Ornamentals	Ornamentals	90	52		**52**

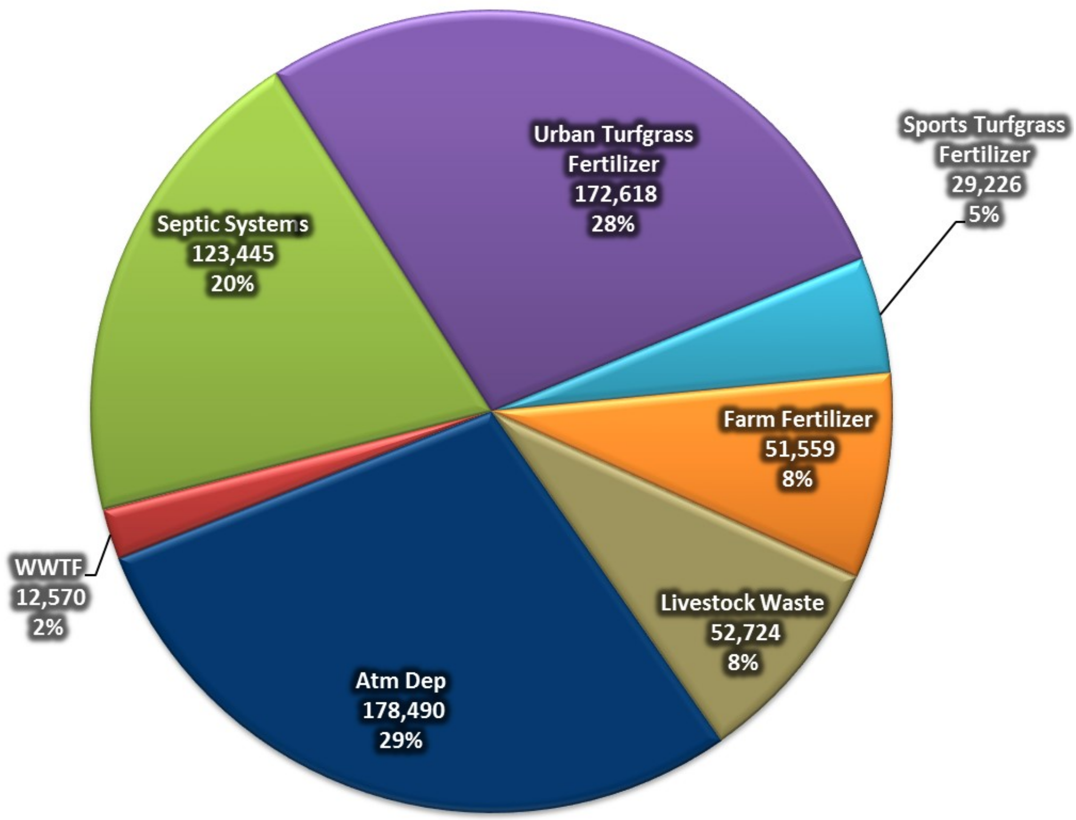

Figure 9: Relative estimated nitrogen inputs to the land surface in the Magnolia-Aripeka contributing area from major anthropogenic source categories in lb-N/yr

3. Nitrogen Attenuation and Loading to Groundwater

The movement of nitrogen from the land surface to groundwater is controlled by biological and chemical processes that occur as part of the nitrogen cycle, as well as hydrogeological processes. Many of these processes attenuate (impede or remove) the amount of nitrogen transported to groundwater. An understanding of how water moves through the subsurface and the processes that transform the different forms of nitrogen is essential for estimating nitrogen loading to groundwater from various sources (Liao et al. 2012; Wang et al. 2013).

To estimate the amount of nitrogen loading to the aquifer in the Magnolia-Aripeka contributing area, DEP applied two nitrogen attenuation factors. The specific biochemical attenuation factor (BAF) is applied to each nitrogen source category to account for biochemical processes that remove or transform the different forms of nitrogen. The hydrogeological attenuation factor (HAF) accounts for spatial variations in hydrogeological properties that affect the rate of water infiltrating through geologic media to recharge the UFA. Both factors control the amount of nitrogen reaching the UFA annually and in the movement of groundwater to the Magnolia-Aripeka Springs Group.

3.1 Biochemical Attenuation

Several near-surface biochemical processes within the nitrogen cycle increase nitrogen availability for plants, including fixation (the conversion of atmospheric nitrogen to a plant-available form), mineralization (the conversion of organic nitrogen to ammonium), and nitrification (the conversion of ammonium to nitrate). Losses of nitrogen from the root zone can result from denitrification, volatilization, 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 BAFs were used to account for the various processes that affect the movement of nitrogen from each source category in the subsurface and were obtained through an extensive literature review of relevant studies conducted in Florida as well as other areas with similar environmental characteristics. Additionally, research scientists in Florida (UF–IFAS, other universities, and USDA Agricultural Research Service [ARS]), and local stakeholders provided additional guidance. The biochemical attenuation factors, listed in **Table 14**, represent the average percentage of the nitrogen attenuated or removed by subsurface processes not available to leach to groundwater.

As a first step in estimating loading to groundwater, the nitrogen inputs at the land surface from each category, discussed previously, are multiplied by their respective biochemical attenuation factors (**Table 14**). For example, atmospheric deposition has an average nitrogen attenuation of 90% (mainly from uptake by vegetation). This means that 10 % of the atmospheric nitrogen input to the land surface has the potential to infiltrate to groundwater.

Table 14: BAFs applied to the nitrogen input calculations

* = Both sports and urban turfgrass.
** These percentages represent the average amount of nitrogen removed by the environment over varying soil characteristics.

N Source Category	BAF**	Literature References
Atmospheric Deposition	90%	Katz et al. 2009; Lombardo Associates 2011; Howard T. Odum Florida Springs Institute 2011
WWTFs-RIBs	25%	Merritt and Toth 2006; Sumner and Bradner 1996
WWTFs-Sprayfield	60%	Katz et al. 2009; Lombardo Associates 2011; Howard T. Odum Florida Springs Institute 2011
WWTFs-Reuse	75%	Jordan et al. 1997; Candela et al. 2007; Rahil and Antonopoulos 2007
Urban Fertilizer*	80%	Goolsby et al. 1999; Erikson et al. 2001; Barton and Colmer 2006; Katz et al. 2009
Septic Systems	50%	Poiani et al. 1996; Aravena and Robertson 1998; Tomasko et al. 2001; Corbett et al. 2002; Otis 2007; Toor et al. 2011
Livestock Waste	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
Farm Fertilizer	80%	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

3.2 Hydrogeological Attenuation

Nitrogen (usually in the form of nitrate) that is not attenuated by biochemical attenuation processes can leach to groundwater. Leaching to groundwater is a function of the properties of the soil and unsaturated zone, such as composition (particle size, organic matter content), texture, drainage, wetness, and thickness. The rate of groundwater 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 the amount of rainfall, evapotranspiration, and runoff, in addition to subsurface hydrogeological properties.

The final step in estimating nitrogen loads to groundwater is to account for the additional attenuation associated with the rate of recharge in a given year. The recharge rate can be geospatially assessed and incorporates soil and unsaturated zone properties (recharge rates are based on a USGS recharge map discussed in **Section 1.3, Aquifer Recharge**). Therefore, the rate of recharge to the UFA is used in the NSILT as an aggregated indicator of the various hydrogeological processes that can further attenuate the movement of nitrate to groundwater. In areas with lower annual recharge rates, the vertical movement of 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 spends less time in the soil/root zone, decreasing the opportunity for biochemical attenuation. This likely results in the 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).

Additional nitrogen attenuation factors related to recharge rates were arbitrarily assigned as follows: 90 % in high recharge rate areas (≥10 in/yr), 50 % in medium recharge rate areas (3.01 to 10 in/yr), and 10 % in low-recharge areas (0 to 3 in/yr) (Sepulveda 2002). For example, in high-rate recharge areas, 90 % of the non-attenuated nitrogen mass is assumed to reach the aquifer in a year, while only 50 % of the non-attenuated nitrogen mass is assumed to reach the aquifer annually in medium rate recharge areas. These attenuation factors are based on the recharge characteristics specific to the hydrogeological conditions in the Magnolia-Aripeka contributing area.

3.3 Estimated Nitrogen Loads to Groundwater

Table 15, Table 16 and **Table 17** summarize estimated annual nitrogen inputs, attenuation factors, and loads to the UFA, respectively, in the Magnolia-Aripeka contributing area and its recharge-based subdivisions. The results indicate that there is an estimated annual load of 139,692 lb-N to the UFA in the BMAP area, representing 22 % of the amount of nitrogen inputs to the land surface. As discussed previously, the difference is due to various nitrogen attenuation processes and variations in the quantity and movement of water recharging the aquifer. The results indicate that the greatest annual load of nitrogen to the UFA in the BMAP area comes from septic systems (39 % of the total estimated load to groundwater), followed by urban turfgrass fertilizers (32 %).

Figure 10 shows the relative contribution of estimated annual loads of nitrogen to the UFA by source category. Aquifer recharge rates have strongly influenced the loading of nitrogen to the UFA in the groundwater contributing area.

Figure 11 summarizes the estimated nitrogen loads to groundwater for the high, medium, and low recharge rate areas, including a breakdown for each source category. The majority of the nitrogen loading to groundwater in the Magnolia-Aripeka contributing area (93%) occurs in high rate recharge areas. For both the medium and low rate recharge areas, the dominant sources of nitrogen loading to groundwater are atmospheric deposition and septic systems.

Table 15: Estimated inputs to the land surface by nitrogen source category in the Magnolia-Aripeka contributing area (lb-N/yr)

Recharge Category	Atmospheric Deposition	WWTF-RIB	WWTF-Reuse	Septic Systems	Sports Turf Fertilizer	Urban Turf Fertilizer	Farm Fertilizers	Livestock Waste	TOTAL
High	139,145	4,425	8,117	111,209	28,054	155,755	44,429	43,018	**534,152**
Medium	39,345	28		12,237	1,172	16,863	7,130	9,706	**86,481**
Low	5,953			523		811		83	**7,370**
TOTAL	**178,490**	**4,453**	**8,117**	**123,445**	**29,226**	**172,618**	**51,559**	**52,724**	**620,633**

Table 16: Average biochemical attenuation factors by source category in the Magnolia-Aripeka contributing area (lb-N/yr)

Recharge Category	Atmospheric Deposition	WWTF-RIB	WWTF-Reuse	Septic Systems	Sports Turf Fertilizer	Urban Turf Fertilizer	Farm Fertilizers	Livestock Waste	TOTAL
BAF	*90%*	*25%*	*75%*	*50%*	*70%*	*70%*	*80%*	*90%*	
High	13,915	3,319	2,029	55,604	8,416	46,727	8,886	4,302	**143,197**
Medium	3,934	21		6,118	352	5,059	1,426	971	**17,881**
Low	595			262		243		8	**1,109**
TOTAL	**17,849**	**3,340**	**2,029**	**61,723**	**8,768**	**51,785**	**10,312**	**5,272**	**161,078**

Table 17: Estimated load to groundwater with recharge factors applied by nitrogen source category in the Magnolia-Aripeka contributing area (lb-N/yr)

§ = Combination of all WWTF subcategories: RIBs, sprayfields, and reuse.

Recharge Category	HAF	Atmospheric Deposition	WWTF§	Septic Systems	Sports Turf Fertilizer	Urban Turf Fertilizer	Farm Fertilizer	Livestock Waste	TOTAL
High	90%	12,523	4,813	50,044	7,575	42,054	7,997	3,872	**128,877**
Medium	50%	1,967	11	3,059	176	2,529	713	485	**8,941**
Low	10%	60		26		24		1	**11**
TOTAL		**14,550**	**4,824**	**53,129**	**7,750**	**44,608**	**8,710**	**4,358**	**137,929**

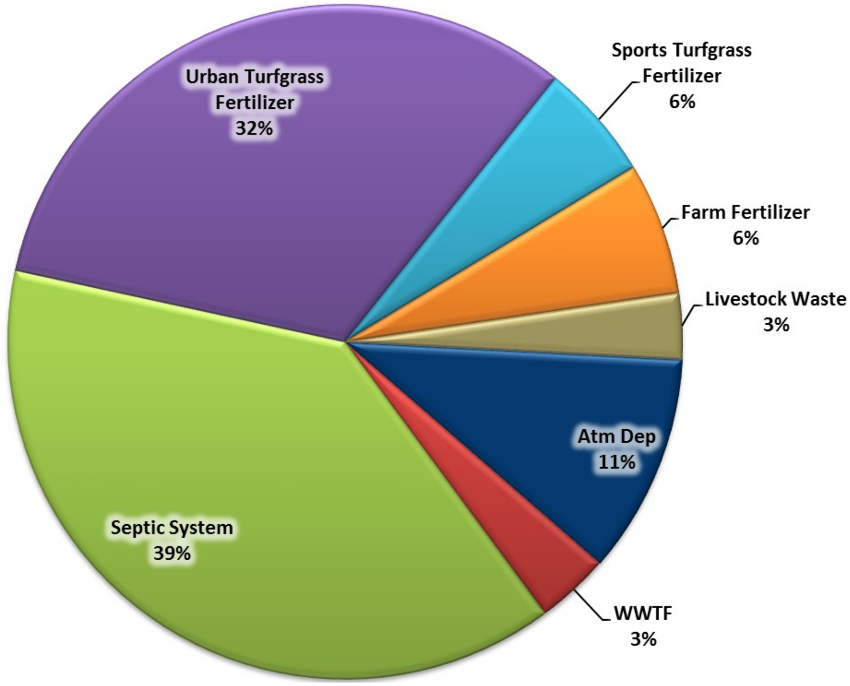

Figure 10: Relative percent contributions of nitrogen loading to groundwater for source categories in the Magnolia-Aripeka contributing area

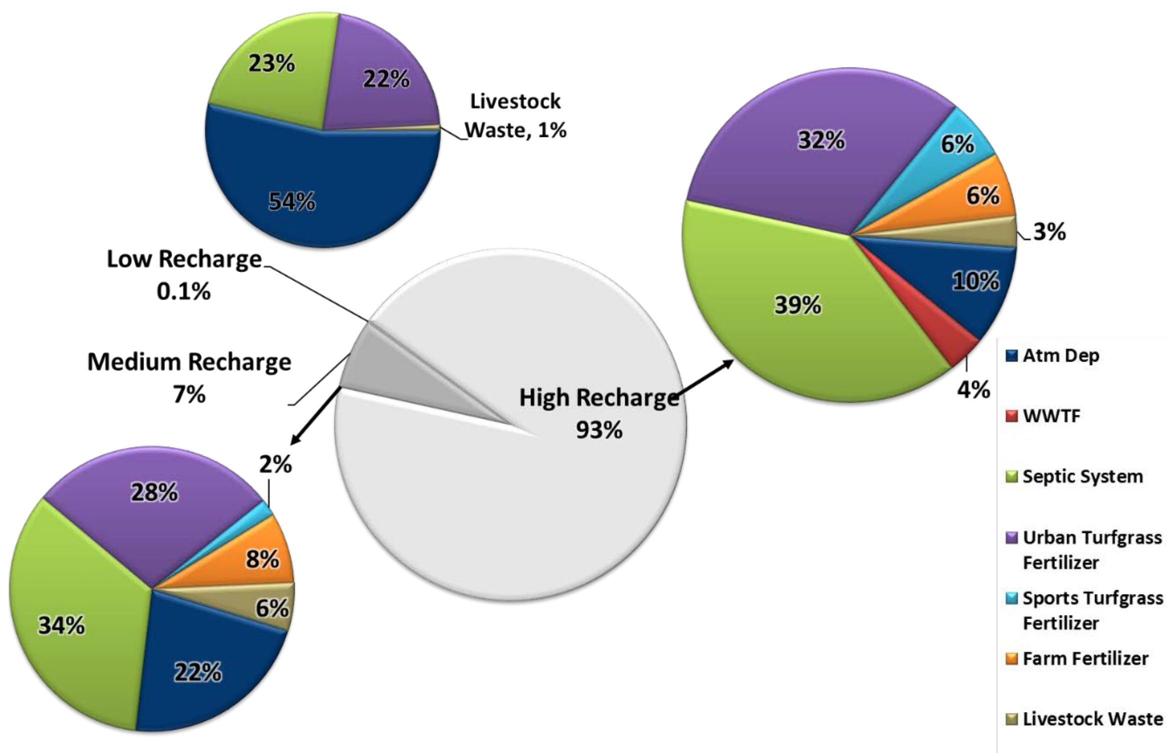

Figure 11: Estimated annual nitrogen loading to groundwater by recharge category

3.4 Accounting for Uncertainty in Nitrogen Attenuation Factors in Estimating Loading to Groundwater

The pie charts (**Figure 10** and **Figure 11**) provide information about the relative contribution of nitrogen loading to groundwater from each source. However, if the contribution from one nitrogen source category were to increase or decrease, the contribution of all the other sources would change proportionally. The amount of nitrogen attenuation for each source can vary substantially, both spatially and with depth in the subsurface, and can affect the amount of nitrogen leaching to groundwater and its relative contribution. The range (or uncertainty) in nitrogen attenuation can result from variability in soil properties, crop types, agricultural practices, nitrogen storage, the volatilization of ammonia to the atmosphere, uptake by vegetation, denitrification, and other removal processes. The density of nitrogen sources can also dramatically affect the attenuation potential of the environment.

Given the relatively large range in nitrogen attenuation for each source, DEP opted to use an average attenuation factor estimated based on land use practices and hydrogeological conditions in the Magnolia-Aripeka contributing area. Greater emphasis was placed on information from studies in central Florida, other locations in Florida, or areas with very similar soil and vegetation characteristics. **Table 18** lists the potential range in nitrogen attenuation for each source type.

Table 18: Range of environmental attenuation of nitrogen from a detailed literature review

* = Both sports and urban turfgrass.

N Source Category	Minimum BAF	Average BAF Used To Estimate N loads to Groundwater	Maximum BAF
Atmospheric Deposition	85%	90%	95%
WWTFs-RIBs	10%	25%	40%
WWTFs-Sprayfield	50%	60%	75%
WWTFs-Reuse	50%	75%	85%
Septic Systems	40%	50%	75%
Livestock Waste	80%	90%	95%
Farm Fertilizers	50%	80%	85%
Urban Fertilizers*	50%	70%	85%

Using the minimum and maximum BAFs in **Table 18,** DEP estimated a corresponding range of nitrogen loading to groundwater from each source in the contributing area (**Figure 12**). Even with the relatively large range in nitrogen attenuation for each source, the total estimated nitrogen load to groundwater in the Magnolia-Aripeka springshed greatly exceeds the target load (TMDL) estimated for the Magnolia-Aripeka Springs Group. The target N load is based on the most recent discharge data and the TN concentration discharging from the spring vents.

For the Magnolia Spring Run, the estimated discharge is 9.35cfs (April 1964–January 2003), based on limited discharge data found only for Magnolia Springs, and the adopted TMDL is 0.23 mg/L for the Springs Group (Bridger and Dodson 2016), resulting in a target nitrogen load of 4,228 lb-N/yr. Using the maximum nitrogen attenuation factors for each source, the minimum estimated load to groundwater in the contributing area is 137,929 lb-N/yr, which is considerably higher than the TMDL target nitrogen load for Magnolia-Aripeka Springs Group.

(**Figure 13**).

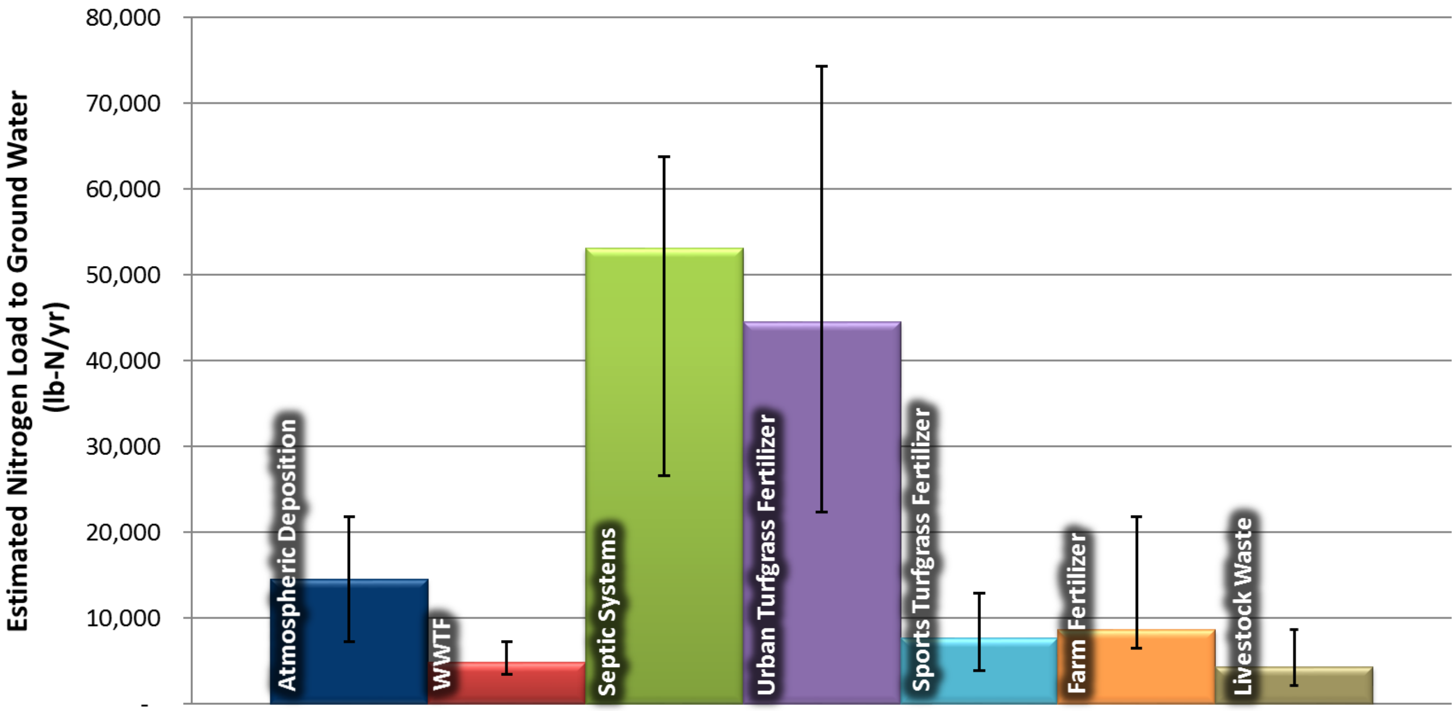

Figure 12: Influence of the range of attenuation factors on estimated nitrogen loads to groundwater from each category in the Magnolia-Aripeka contributing area

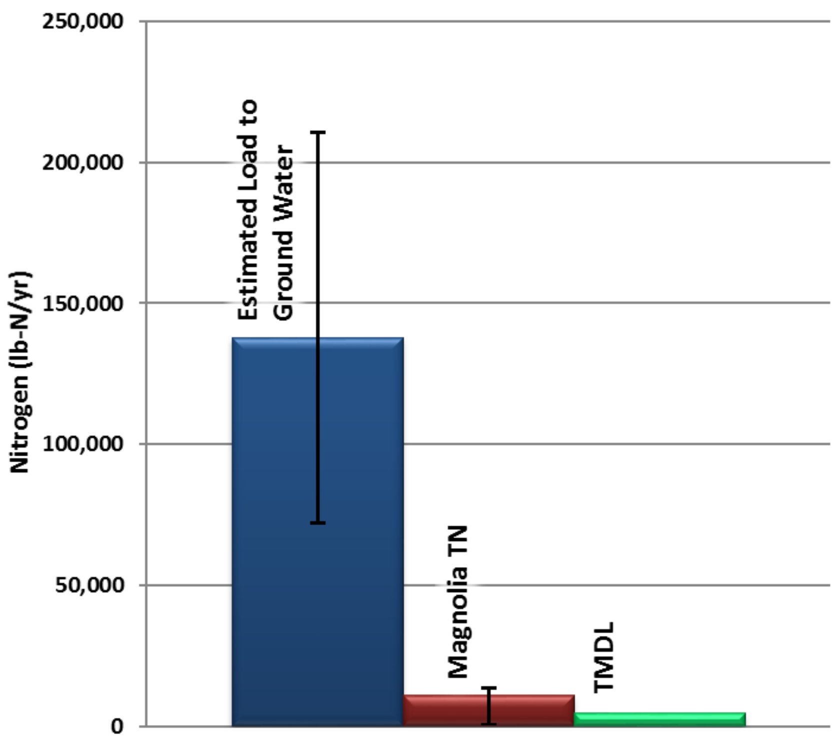

Figure 13: Estimated nitrogen load to groundwater compared with the current nitrogen discharging from the Magnolia-Aripeka Springs Group and the TMDL goal

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APPENDICES

Appendix A: Tables

Table A.1: Useful conversion factors

Convert from	To	Multiply by
Pounds	kilograms	0.4535924
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.2: Summary of SWFWMD land use data in Hernando County

Land Use Code	Land Use Description	Hernando County	High Recharge	Medium Recharge	Discharge
2100	Cropland and Pastureland	31,912	12,727	8,773	0
2300	Feeding Operations	393	96	0	0
2500	Specialty Farms	1,547	625	174	0
2140	Row Crops	105	96	7	0
2200	Tree Crops	877	229	249	0
2400	Nurseries and Vineyards	1,279	417	105	0
1100	Residential Low Density <2 Dwelling Units	41,835	15,798	2,270	0
1200	Residential Medium Density 2–5 Dwelling Units	24,602	19,448	0	275
1300	Residential High Density	5,388	3,817	52	1,040
1800	Recreational	939	515	0	14
1820	Golf Courses	2,567	1,638	0	212

Table A.3: Summary of SWFWMD land use data in Pasco County

Land Use Code	Land Use Description	Pasco County	High Recharge	Medium Recharge	Low Recharge
2100	Cropland and Pastureland	82,029	18,245	17,652	5,209
2300	Feeding Operations	856	55	135	23
2500	Specialty Farms	1,788	415	69	0
2140	Row Crops	74	9	37	0
2200	Tree Crops	7,371	587	1,091	196
2400	Nurseries and Vineyards	994	223	171	0
1100	Residential Low Density <2 Dwelling Units	54,042	6,982	2,869	729
1200	Residential Medium Density 2–5 Dwelling Units	27,410	3,440	43	43
1300	Residential High Density	27,687	117	49	0
1800	Recreational	1,924	24	0	0
1820	Golf Courses	3,276	36	36	0

Table A.4: Summary of land use provided by the Hernando County property appraiser office

Property Code	Description	High-Recharge Area	Medium-Recharge Area	Discharge Area
0	VACANT RESIDENTIAL	5,495	180	23
1	SINGLE FAMILY	14,371	978	167
2	MOBILE HOME	3,893	340	
3	MULTI FAMILY 10 UNITS OR MORE	110		
4	CONDOMINIUM	24		
5	COOPERATIVES			
6	RETIREMENT HOMES			
7	MISC RES(BOARDING HOMES,CAMPS)			
8	MULTI FAMILY LESS THAN 10 UNIT	75		
10	VACANT COMMERCIAL	526	1	4
11	STORES, 1 STORY	194	1	2
12	STORE/OFFICE/OR RESID COMBIN	15		
13	DEPARTMENT STORE	5		1
15	SHOPPING CENTERS (REGIONAL)	6		
16	SHOPPING CENTERS (COMMUNITY)	51		2
17	OFFICE BUILDINGS, 1 STORY	127		1
18	OFFICE BUILDINGS, MULTI STORY	11		
19	PROFESSIONAL BUILDINGS	189		
20	AIRPORTS, BUS TERM, MARINAS,	1		
21	RESTAURANT AND CAFETERIAS	43		2
22	DRIVE IN RESTAURANTS	17		2
23	FINANCIAL INSTITUTIONS	24		1
25	SERVICE SHOP, RADIO & TV REPIR	4		
26	SERVICE STATIONS	23		
27	AUTO SALES, REPAIR & STORAGE	54		
28	PARKING LOTS, COMM, MH PARKS	47	4	
29	WHOLESALE OUTLETS, PRODUCE	1		
30	FLORIST, GREENHOUSES	3		
32	THEATERS, (ENCLOSED) AUDITORIM	2		
33	NIGHT CLUBS, COCKTAIL LOUNGES	2		
34	BOWLING ALLEYS, SKATING RINKS	3		
35	TOURIST ATTR. OTHER ENTERTNMT	2		
36	CAMPS	4	2	
38	GOLF COURSES, DRIVING RANGES	64		4
39	HOTELS - MOTELS	7		
40	VACANT INDUSTRIAL	22		
41	LIGHT MANUFACTURING	34		
44	PACKING PLANTS, FRUIT & VEGE	1		

Property Code	Description	High-Recharge Area	Medium-Recharge Area	Discharge Area
46	OTHER FOOD PROCESSING, CANDY	1		
48	WAREHOUSING, DISTRIBUTION	145	1	
49	OPEN STORAGE, NEW AND USED	12		
51	CROPLAND SOIL CAPABILITY CLS I	65	40	
54	TIMBER NATURAL STAND	183	26	2
55	TIMBER PLANTED	58	5	
56	TIMBERLAND	2		
59	WOODS - NATIVE PASTURE	95	36	
60	IMPROVED PASTURE LAND	342	98	
65	GRAZING LAND SOIL CAPAB VI	1		
66	ORCHARD GROVES	20	13	
67	POULTRY, BEES, HOGS IN FIELD	3		
69	ORNAMENTALS	22	2	
70	VACANT INSTITUTIONAL	59		1
71	CHURCHES	63		
72	SCHOOLS, COLLEGES PRIVATE	11		
73	HOSPITALS PRIVATELY OWNED	5		
74	HOMES FOR THE AGED	25		
75	CHARITABLE/NON PROFIT	3		
76	MORTUARIES, CEMETERIES, CREMAT	16	2	
77	CLUBS, LODGES, UNION HALLS	67		1
80	VACANT GOVERNMENTAL	82	1	
81	MILITARY	4		
82	FOREST PARKS RECREATIONAL	41		4
83	SCHOOLS - PUBLIC COUNTY	13		
85	HOSPITALS	1		
86	COUNTIES OTHER THAN PUBLIC SCH	59		
87	STATE OTHER THAN MILITARY FORE	134		19
88	FEDERAL OTHER THAN MILITARY	1		
89	MUNICIPAL OTHER THAN PARKS	3		
90	LEASEHOLD INTERESTS	204		
91	UTIL,RR,GAS,COMMICATIONS,ELECT	122		2
94	RIGHT OF WAY STREETS/ROADS	586	19	39
95	RIVERS AND LAKES, SUBMERGED	57	1	4
96	DRA,LIFT STAT,MARSH,BORROWPIT	1,324	2	16
97	OUTDOOR PARKLAND/REC	11		
99	ACREAGE NOT CLASSIFIED	365	41	2

Table A.5: Summary of land use provided by the Pasco County property appraiser office

Property Code	Description	High-Recharge Area	Medium-Recharge Area	Low-Recharge Area
0	VACANT RESIDENTIAL	1,824	427	38
1	SINGLE FAMILY	3,029	1,055	157
2	MOBILE HOME	1,912	448	34
3	MULTI FAMILY 10 UNITS OR MORE			
4	CONDOMINIUM			
5	COOPERATIVES			
6	RETIREMENT HOMES			
7	MISC RES(BOARDING HOMES,CAMPS)			
8	MULTI FAMILY LESS THAN 10 UNIT	686	152	10
10	VACANT COMMERCIAL	205	36	1
11	STORES, 1 STORY	10	18	5
12	STORE/OFFICE/OR RESID COMBIN	57	13	0
13	DEPARTMENT STORE			
14	SUPER MARKETS			
15	SHOPPING CENTERS (REGIONAL)			
16	SHOPPING CENTERS (COMMUNITY)			
17	OFFICE BUILDINGS, 1 STORY	4	2	
18	OFFICE BUILDINGS, MULTI STORY	1		
19	PROFESSIONAL BUILDINGS	1	10	
20	AIRPORTS, BUS TERM, MARINAS,			
21	RESTAURANT AND CAFETERIAS			
22	DRIVE IN RESTAURANTS			
23	FINANCIAL INSTITUTIONS			
24	INSURANCE COMPANY NATL REG OFF			
25	SERVICE SHOP, RADIO & TV REPIR	6	4	
26	SERVICE STATIONS			
27	AUTO SALES, REPAIR & STORAGE	4		
28	PARKING LOTS, COMM, MH PARKS	124	33	
29	WHOLESALE OUTLETS, PRODUCE			
30	FLORIST, GREENHOUSES			
31	THEATERS, (DRIVE IN) STADIUMS			
32	THEATERS, (ENCLOSED) AUDITORIM			
33	NIGHT CLUBS, COCKTAIL LOUNGES	2	3	2
34	BOWLING ALLEYS, SKATING RINKS			
35	TOURIST ATTR. OTHER ENTERTNMT			
36	CAMPS			
37	RACE TRACKS, HORSE, AUTO OR DO			
38	GOLF COURSES, DRIVING RANGES			

Property Code	Description	High-Recharge Area	Medium-Recharge Area	Low-Recharge Area
39	HOTELS - MOTELS			
40	VACANT INDUSTRIAL	19	43	
41	LIGHT MANUFACTURING	20	9	
42	HEAVY INDUSTRIAL, HEAVY EQUIP			
43	LUMBER YARDS, SAWMILLS			
44	PACKING PLANTS, FRUIT & VEGE			
45	CANNERIES, FRUIT & VEGETABLE			
46	OTHER FOOD PROCESSING, CANDY			
47	MINERAL PROCESSING, PHOSPHATE	22		
48	WAREHOUSING, DISTRIBUTION	43	51	
49	OPEN STORAGE, NEW AND USED			
50	IMPROVED AGRICULTURAL			
51	CROPLAND SOIL CAPABILITY CLS I	939	1,107	242
52	CROPLAND SOIL CAPABILITY II			
53	CROPLAND SOIL CAPABILITY III	24	57	
54	TIMBER NATURAL STAND	11,015	512	45
55	TIMBER PLANTED	604	311	
56	TIMBERLAND			
57	TIMBERLAND			
58	TIMBERLAND			
59	WOODS - NATIVE PASTURE			
60	IMPROVED PASTURE LAND	12,137	11,031	1,477
61	GRAZING LAND SOIL CAPAB II	700	283	267
62	GRAZING LAND SOIL CAPAB III	553	4	100
63	GRAZING LAND SOIL CAPAB IV	984	370	283
64	GRAZING LAND SOIL CAPAB V	2,276	1,151	
65	GRAZING LAND SOIL CAPAB VI	2,525	342	
66	ORCHARD GROVES	630	561	147
67	POULTRY, BEES, HOGS IN FIELD			
68	DAIRIES, FEED LOTS,PENNED HOGS	432	455	173
69	ORNAMENTALS	172	72	
70	VACANT INSTITUTIONAL	1	1	
71	CHURCHES	31	13	
72	SCHOOLS, COLLEGES PRIVATE			
73	HOSPITALS PRIVATELY OWNED			
74	HOMES FOR THE AGED			
75	CHARITABLE/NON PROFIT			

Table A.6: 2010 Labor and Statics Data for Hernando and Pasco Counties

Category	Hernando County	Pasco County
Total Labor Force	66,470	207,364
Employed Labor Force	57,464	182,593
Unemployed Labor Force	9,006	24,771

Table A.7: 2010 Census Population Data for Hernando and Pasco Counties

Population Category	Hernando County	Pasco County
Under 18	34,158	98,573
18 to 64	94,097	269,879
65 or older	44,523	96,245
Total	172,778	464,697

Table A.8: Estimated population data for calculation of effective septic systems population

Population Category	Equation	Hernando County	Pasco County
Non-working	= 18 to 64 population – employed labor force	36,633	87,286
Retired	= 65 or older	44,523	96,245
School	= under 18	34,158	98,573
Work	= employed labor force	57,464	182,593

Table A.9: Hernando County zoning data

Zoning Code	Zoning Description	% Maximum Lot Coverage
AC	AC Agricultural Commercial District	
AG	AG Agricultural District	
AR	AR Agricultural Residential District	
AR1	AR1 Agricultural Residential District	
AR2	AR Agricultural Residential District	
C1	C1 General Commercial District	
C2	C2 Highway Commercial District	
C3	C3 Neighborhood Commercial District	
C4	C4 Heavy Highway Commercial District	

Zoning Code	Zoning Description	% Maximum Lot Coverage
CITY	City	
CM1	CM1 Marine Commercial District	
CM2	CM2 Heavy Marine Commercial District	
CPDP	CPDP (Combined)	
CV	CV Conservation District	
I1	I1 Industrial District	
I2	I2 Heavy Industrial District	
M	M Mining District	
OP	OP Office-Professional District	
PDP(AF)	PDP (Aviation Facilities)	
PDP(CM)	PDP (Commercial Marine)	
PDP(CP)	PDP (Corporate Park)	
PDP(GC)	PDP (General Commercial)	
PDP(GHC)	PDP (General Highway Commercial)	
PDP(HC)	PDP (Highway Commercial)	
PDP(HHC)	PDP (Heavy Highway Commercial)	
PDP(HID)	PDP (Heavy Industrial)	
PDP(IND)	PDP (Industrial)	
PDP(LI)	PDP (Light Industrial)	
PDP(MF)	PDP (Multifamily)	0.35
PDP(MH)	PDP (Mobile Home)	0.35
PDP(NC)	PDP (Neighborhood Commercial)	
PDP(OP)	PDP (Office/Professional)	
PDP(OP)	PDP (Single-Family)	0.35
PDP(PSF)	PDP (Public Service Facility Overlay District)	
PDP(REC)	PDP (Recreational)	
PDP(RR)	PDP (Resort Residential)	0.35
PDP(RUR)	PDP (Rural)	
PDP(SF)	PDP (Single-Family)	0.35
PDP(SU)	PDP (Recreational)	
PDP(SU)	PDP (Single-Family)	
PDP(SU)	PDP (Special Use)	
R1A	R1A Residential District	0.35
R1B	R1B Residential District	0.35
R1C	R1C Residential District	0.35
R1MH	R1MH Residential Single-Family Manufactured Housing	
R2	R2 Residential District	0.35
R2.5	R2.5 Residential District	0.35
R3	R3 Residential District	0.45

Zoning Code	Zoning Description	% Maximum Lot Coverage
R4	R4 Residential District	0.45
RC	RC Recreational Commercial District	
RM	RM Residential Mobile Home District	0.35
RR	Residential District	0.45

Table A.10: Pasco County zoning data

Zoning Code	Zoning Description	% Maximum Lot Coverage
AC	Agricultural District	0.15
AC1	Agricultural District	0.15
AR	Agricultural-Residential District	0.25
AR1	Agricultural-Residential District	0.25
AR5	Agricultural-Residential District	0.3
AR5MH	Agricultural-Mobile Home District	0.3
C1	Neighborhood Commercial District	0.5
C2	General Commercial District	0.5
C3	Commercial/Light Manufacturing District	0.5
ER	Estate-Residential District	0.35
ER1	Estate-Residential District	0.35
I1	Light Industrial Park District	0.5
I2	Light Industrial Park District	0.5
MF1	Multiple Family Medium Density District	0.4
MF2	Multiple Family High Density District	0.55
MF3	Multiple Family High Density District	0.55
PO1	Professional Office District	0.35
PO2	Professional Office District	0.35
R1	Rural Density Residential District	0.35
R1MH	Mobile Home District	0.35
R2	Low Density Residential District	0.65
R2MH	Mobile Home District	0.35
R3	Medium Density Residential District	0.65
R4	High Density Residential District	0.65
RMH	Mobile Home District	0.35

Table A.11: 2012 CoA livestock populations for Hernando and Pasco Counties

CoA Population	Hernando County	Pasco County
Beef Cattle	11,402	21,509
Calves	4,397	8,352
Dairy Cows		1,092
Horses	2,080	2,008
Broiler Chickens		604
Goats	1,034	1410
Hogs	328	165
Sheep	318	251
Turkey		63

Appendix B: Comparison of Methods and Results for the NSILT and Jones et al. (1997)

In 1997, the SWFWMD Ambient Ground Water Quality Monitoring Program conducted a study to determine the sources of increasing nitrate concentrations in Aripeka Spring Complex (Jones et al.1997). The study objectives were to delineate the areas where nitrate was entering the aquifer system, identify the land uses contributing nitrate, and determine management actions to slow or reduce nitrate loading to groundwater in the Magnolia-Aripeka contributing area.

This appendix compares the methods and results from the SWFWMD study and the DEP NSILT. In addition, several factors are listed to account for the differences in estimated nitrogen inputs for the two studies. This comparison provides insights into how the relative contributions of nitrogen may have changed for various potential nitrogen sources and land uses over the past 20 years.

Study Area

- The NSILT used the spring contributing area largely based on the Magnolia-Aripeka springshed. This area encompasses 36,533 acres of land with varying degrees of associated recharge. However, the analysis used only data from high-, medium-, and low-recharge areas which covers 7,897 acres.
- The Jones et al. (1997) study area comprised 60 square miles, or 38,400 acres, with no acreage estimates for the varying recharge areas.
- The study areas used in both methods were based on the same shape of the springshed and groundwater flow direction to the spring vent.

Atmospheric Deposition

- The NSILT used data from the multiyear TDEP model developed by the EPA. The annual nitrogen input to the land surface from atmospheric deposition was 178,490 lb-N.
- The SWFWMD study (Jones et al. 1997) used an average wet deposition concentration of 1.0 mg/L of total N, based on 9 rainfall samples collected from a station in northwestern Citrus County, north of Weeki Wachee Spring. Using an average annual rainfall of 56 inches, researchers calculated a total of 244 tons/yr, or 488,000 lbs, over the entire study area.
- The SWFWMD estimate was larger by 309,510 lb-N/yr, likely because of the higher nitrogen concentration in rainfall used in the study. Several factors may

have accounted for these differences, including the period when the rainfall was collected or differences in collection and analytical methods.

Septic Systems

- The NSILT relied on estimate of septic systems provided by FDOH. An average of 2.08 people contribute to each septic system in Hernando County and 2.07 people in Pasco County. With an annual input of 9.012 lb-N/person, this equaled an input of 18.7 lb-N per septic system. With 13,756 systems in the contributing area, 123,969 lb-N were applied to the land surface every year.

- Jones et al. (1997) estimated 4,000 septic systems within the boundary area based on an aerial imagery survey. With 3 people per household and an average nitrogen input of 55 lb-N/yr per tank, the total input attributable to septic systems was 110 tons/yr or 220,000 lb-N/yr.

- There were two main differences between these methods: the number of estimated septic systems and the annual input per system. The NSILT analysis included slightly more than 1.5 times the number of septic systems compared with Jones et al. (1997). This could be attributable to the more accurate counting methods used for the NSILT as well as population growth in the area. Additionally, the annual input per system used by the SWFWMD was almost 3 times greater compared with that used by DEP. The combination of these factors resulted in the SWFMD estimate to be greater by 96,031 lb-N/yr.

Urban Turfgrass Fertilizers

- The NSILT relied on regional fertilizer application rates for the pervious land area associated with urban land uses. The estimated TN input was 172,618 lb-N/yr over the 2,462 acres fertilized within the contributing area.

- Jones et al. (1997) used FDACS annual fertilizer sales data. The residential acreage was calculated from land use maps developed from 1990 aerial photography. It was assumed the fertilizer was applied evenly across this acreage, resulting in 128,000 lb-N/yr applied within the Aripeka Spring Complex study area.

- The higher NSILT calculation is likely due to a combination of factors, including the different methods used, the increased urbanization of the area over the past 20 years, and the inclusion of nonresidential urban land uses in the NSILT calculations.

Sports Turfgrass Fertilizer

- For the NSILT, 1 golf course covering 194 acres was identified. An average application rate of 196 lb-N/ac resulted in an input to the land surface of 27,423 lb-N/yr. Calculations for sporting facilities were made based on fertilization rates for lawn service companies. These added 1,803 lb-N/yr, for a total of 29,226 lb-N/yr attributable to sports turfgrass fertilizers.

- Jones et al. (1997) included 2 golf courses covering a total of 170 acres. The authors used an application rate of 260 lb-N/acres based on a study completed in Sarasota Bay, for a total of 44,000 lb-N/yr, or 22 tons-N/yr.

- The difference of 14,774 lb-N/yr was likely due to changing trends in golf course maintenance over the past 20 years and because only one golf course remains in the NSILT area. While the golf course acreage was largely in the NSILT area, the application rates were lower, resulting in a lower input to the land surface.

Wastewater Treatment Facilities

- The NSILT used reported effluent data from 6 facilities in the contributing area, and one facility outside the contributing area. These had a combined actual flow of 0.18 MGD, with an average nitrogen concentration of 7.28 mg/L. The annual input attributable to these facilities equaled 12,570 lb-N/yr. The assessment did not include input associated with domestic WWTF residuals because of the lack of supporting data.

- Jones et al. (1997) evaluated WWTFs by assessing the total effluent disposal for 9 facilities with an average flow 2.93 MGD. The total input was estimated using an average nitrogen concentration of 40 mg/L, equaling 268,000 lb-N/yr.

- There is a very large difference between the two studies because the Jones et al. (1997) study used the much higher effluent concentration. Additionally, since the first study was completed, considerable advances in waste treatment were made and applied in this area that would contribute to the lower effluent concentration used in the NSILT. Also, there are fewer WWTFs in the NSILT area today than 20 years ago, and the average flow rate is significantly lower.

Farm Fertilizers

- To obtain nitrogen inputs from farm fertilizers, the NSILT used property appraiser data, known crops grown in the area, and agricultural producer feedback, as well as UF IFAS–recommended fertilizer application rates. The 4,297 acres of cropland and pastures in the contributing area contributed 51,559 lb-N/yr.

- Jones et al. (1997) estimated fertilization for citrus, row crops, and pasturelands. Row crops were not present in the Magnolia-Aripeka springshed at the time of this study, and were therefore not included. Citrus fertilization was based on the application of 180 lb-N/ac/yr over 89 acres. Pastureland was estimated using FDACS fertilizer sales data. The amount of fertilizer attributable to row crops and citrus was subtracted from the amount of reported fertilizer sold for farming practices. The remaining fertilizer was assumed to be used for pasture fertilization. The estimated pasture acreage in the study area was not disclosed. In the Magnolia-Aripeka study area, the nitrogen attributed to farm fertilization equaled 52,000 lb-N/yr.

- The results from these two methods were nearly identical, with a difference of 441. The application rates used for the Jones et al. (1997) study were higher; however, the acreage utilized in the NSILT was considerably larger. These differences resulted in a similar estimated nitrogen input for farm fertilizer.

Livestock Waste

- The NSILT included cattle as well as other livestock animals within the BMAP boundary. Based on stocking rates gathered from feedback from cattle farmers, the cattle population was 330. Additional livestock animal populations estimated from the 2012 CoA were assigned to the contributing area based on the distribution of livestock lands (such as improved pasture). Daily waste factors were applied based on the nitrogen content for each animal. The total input to the land surface equaled 52,724 lb-N/yr.

- The SWFWMD separated livestock waste estimates into 3 different categories: poultry, dairies, and cattle. FDACS estimated the animal populations, and daily waste factors were applied. There were no poultry or dairies present in the area at the time of this study, therefore the nitrogen loading for both poultry and dairy cows was not included in the total loading for livestock. Cattle, which were assumed to represent beef cattle, have a daily waste factor of 0.33 lb-N/1,000 of body weight, with an associated input of 46 tons/yr, or 92,000 lb-N/yr. The individual Magnolia-Aripeka study area populations were not specified. In total, Jones et al. (1997) calculated livestock waste at 92,000 lb-N/yr.

- There was a significant difference between these two estimates (39,276 lb-N/yr). The daily waste factors used in both studies were comparable and likely did not contribute to the discrepancy. Without knowing the exact population used in the Jones et al. (2007) study, DEP could not directly determine the population differences. However, this was the most likely factor leading to such a large difference.

Stormwater

- The NSILT did not estimate the influence of stormwater-sourced nitrogen on groundwater.
- Jones et al. (1997) calculated that 32,000 lb-N/yr runs off from golf courses, residential areas, commercial properties, and cropland via stormwater.

Comparison of TN Inputs

The TN inputs to the land surface calculated by Jones et al. (1997) were 1,232,000 lb-N/yr (based on 38,400 acres of land area, resulting in an average of 32 lb-N/ac). The three sources that contributed the highest percentages of nitrogen to the land surface were atmospheric deposition (40 %), septic tank effluent (18 %) and wastewater treatment facilities (17 %).

The NSILT estimated TN inputs of 620,633 lb-N/yr to the land surface (36,533 acres) in the Magnolia-Aripeka Springs BMAP area, or an average of 17 lb-N/ac. The three sources contributing the largest percentages of nitrogen inputs to the land surface were atmospheric deposition (29 %), urban turfgrass fertilizer (28 %), and septic systems (20 %). **Table C.1** compares the relative percentages calculated using both methods.

As described above, there were notable differences between the two studies in the methods used to estimate nitrogen inputs to the land surface. The biggest differences were attributable to the development of more accurate methods to identify land uses and changes in land use, and the application of nitrogen for different land use practices.

The SWFWMD study (Jones et al. 1997) provided an important baseline for comparison with the nitrogen inventory for the Magnolia-Aripeka contributing area. Current information on the nitrogen source inventory and nitrogen loads to groundwater generated from the NSILT for the Magnolia-Aripeka Springs Group BMAP will be used to determine where present-day nitrogen loading to groundwater can be reduced to restore water quality in the Magnolia-Aripeka Springs Group.

Table B.1: Comparison of nitrogen input percentages to the land surface calculated by the NSILT and Jones et al. (1997)

N Loading Category	NSILT (2016)	Jones et al. (1997)
Atmospheric Deposition	29%	40%
Septic Systems	20%	18%
WWTFs	2%	17%
Urban Turfgrass Fertilizers	28%	10%
Sports Turfgrass Fertilizers	5%	4%
Farm Fertilizers	8%	2%
Livestock Waste	8%	7%
Stormwater	0%	2%