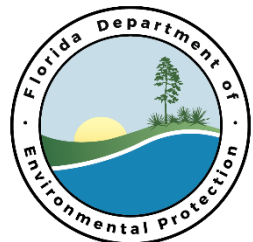


# **NITROGEN SOURCE INVENTORY AND LOADING ESTIMATES FOR THE VOLUSIA BLUE SPRING AND VOLUSIA BLUE SPRING RUN CONTRIBUTING AREA**

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**February 2017**

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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 Volusia Blue Spring and Volusia Blue Spring Run Basin Management Action Plan 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 using whole numbers.

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## **Summary of Findings**

Volusia Blue Spring is the largest first magnitude spring on the St. Johns River. The Upper Floridan aquifer (UFA) is the primary water source for Volusia Blue Spring. Long-term discharge measured from 1932 to 2013 indicates the annual average discharge from Volusia Blue Spring is 155.3 cubic feet per second (cfs), or about 100.4 million gallons per day (mgd). Volusia Blue Spring Run flows about 0.4 miles from Volusia Blue Spring to the St. Johns River.

Volusia Blue Spring and Volusia Blue Spring Run were identified as impaired because of elevated concentrations of nitrate and the corresponding evidence of a biological imbalance in the run. Elevated nitrate concentrations in the spring result from current and historical land use practices that have contributed nitrogen to the aquifer. In 2014, a total maximum daily load (TMDL) of 0.35 milligrams per liter (mg/L) was developed to establish water quality restoration thresholds for both the spring and run (Holland and Bridger 2014).

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

NSILT is an Arc geographic information system (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. The NSILT does not account for legacy loads of nitrogen that may already be present in the aquifer and continue to adversely impact groundwater quality. Several spring basin studies have reported increasing nitrate-N concentrations in groundwater and springs over time. Nitrogen that entered groundwater from past anthropogenic practices may slowly exit the groundwater flow system via springs, given that the average groundwater residence times in large spring basins in Florida is on the order of decades (Katz et al. 1999, Katz 2004, Phelps 2004, Happell et al. 2006, Toth and Katz 2006, Knowles et al. 2010).

This report describes the methods, information, and data sources used in developing the NSILT to estimate nitrogen loads to groundwater in the Volusia Blue Spring 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 Volusia Blue Spring and Volusia Blue Spring Run.

The NSILT is being used in the BMAP development process to identify source categories and areas where nitrogen source reduction efforts could be focused to achieve the most beneficial effects on water quality for Volusia Blue Spring and Volusia Blue Spring Run. The estimated annual nitrogen input to the land surface in the contributing area from current sources is 2.27

million pounds of nitrogen (lb-N). Urban turfgrass fertilizer contributes 33 % of the TN input. The relative contributions from other nitrogen sources, in order of decreasing nitrogen inputs to the land surface, are septic systems (32 %), atmospheric deposition (16 %), sports turfgrass fertilizer (6 %), WWTF reclaimed water for irrigation (5 %), WWTF application sites (3 %), farm fertilizer (3 %), and livestock waste (3 %).

The NSILT results indicate an estimated total annual load of 514,095 pounds of nitrogen to the UFA from current sources in the Volusia Blue Spring groundwater contributing area, representing 23 % of the nitrogen loading 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 Volusia Blue contributing area where recharge rates are categorized as medium (5 to 15 inches per year [in/yr]) or high (greater than 15 in/yr), the UFA is more vulnerable to contamination than in areas where recharge rates are low (0 to 5 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, nonattenuated 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 recharge areas.

The highest estimated nitrogen loads in the groundwater contributing area to Volusia Blue Spring are from septic systems (54 %), followed by urban turfgrass fertilizer (22 %) and WWTFs (8 %). Sources contributing smaller amounts of nitrogen include atmospheric deposition (5 %), WWTF reuse (4 %), sport turfgrass fertilizer (4 %), farm fertilizer (2 %), and livestock waste (1 %).

The NSILT provides a baseline understanding of existing nitrogen loads to groundwater from multiple sources in areas where the Volusia Blue Spring Basin is most susceptible to groundwater contamination. This tool can also be used to evaluate the nitrogen load reduction benefits of various management actions and nitrogen reduction projects at various locations in the area.

## 1. Introduction

In Florida, springs provide sites of recreational and cultural value as well as sources of potable water, and their water quality reflects 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; Toth and Katz 2006). 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. Elevated nitrate concentrations in Volusia Blue Spring are related to sources that impact ground water quality in the spring's groundwater contributing area.

Elevated nitrate concentrations in Florida's springs contribute to water quality degradation in their receiving surface waters. This problem will continue if nitrogen inputs to the land surface 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, including 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 estimate 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 does not account for legacy loads of nitrogen that may already be present in the aquifer and continue to adversely impact groundwater quality. Several spring basin studies have reported increasing nitrate-N concentrations in groundwater and springs over time. Nitrogen that entered groundwater from past anthropogenic practices may slowly exit the groundwater flow system via springs, given that the average groundwater residence times in large spring basins in Florida is on the order of decades (Katz et al. 1999, Katz 2004, Phelps 2004, Happell et al. 2006, Toth and Katz 2006, Knowles et al. 2010).

The NSILT results are used in the development and implementation of the basin management action plans (BMAP) for impaired spring systems, by helping to focus nitrogen source reduction efforts to achieve the greatest improvement in water quality.

### 1.1 Volusia Blue Spring and Volusia Blue Spring Run

Volusia Blue Spring and Volusia Blue Spring Run are located in the 2,644-acre Volusia Blue Spring State Park. In addition to providing recreational opportunities for park visitors, the spring and run provide critical habitat for the threatened West Indian manatee (*Trichechus manatus*) and endemic snail species. The spring discharges from a vent 20 feet beneath the land surface, and divers have mapped a cave system to a depth of 125 feet. The run flows about 0.4 miles from

Volusia Blue Spring to the St. Johns River and ranges from 70 to 100 feet wide with steep, sandy banks and steeply wooded slopes (Holland and Bridger 2014).

In 2009, Volusia Blue Spring and Volusia Blue Spring Run were verified as impaired because ecological imbalances attributed to elevated nutrient concentrations. In 2014, a total maximum daily load (TMDL) was developed to establish a water quality restoration threshold for nitrate-N of 0.35 milligrams per liter (mg/L) for both Volusia Blue Spring and Volusia Blue Spring Run (Holland and Bridger 2014).

Elevated nitrate concentrations in Volusia Blue Spring 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 spring. The NSILT is being used to provide stakeholders with current information on the sources of nitrogen in the Volusia Blue Spring 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 in Volusia County to address the water quality impairment.

## **1.2 Volusia Blue Spring Groundwater Contributing Area**

The groundwater contributing area for Volusia Blue Spring is based on the springshed boundary delineated by the St. Johns River Water Management District (SJRWMD) using the MODPATH/MODFLOW particle tracking methodology (**Figure 1**). This area is also the focus of restoration actions under the BMAP and is known as the "BMAP area." All of the drainage in this area is internal and entirely dependent on recharge by local rainfall (Shoemaker et al. 2004; Holland and Bridger 2014). Land uses within the Volusia Blue Spring contributing area comprise 55 % urban landscapes, 19 % forested areas, 4 % agriculture, and 10 % wetlands and marshes. The remaining 12 % includes waterbodies, rangeland, and miscellaneous land uses. The Volusia Spring BMAP boundary is the same as the Volusia Blue Spring springshed boundary.

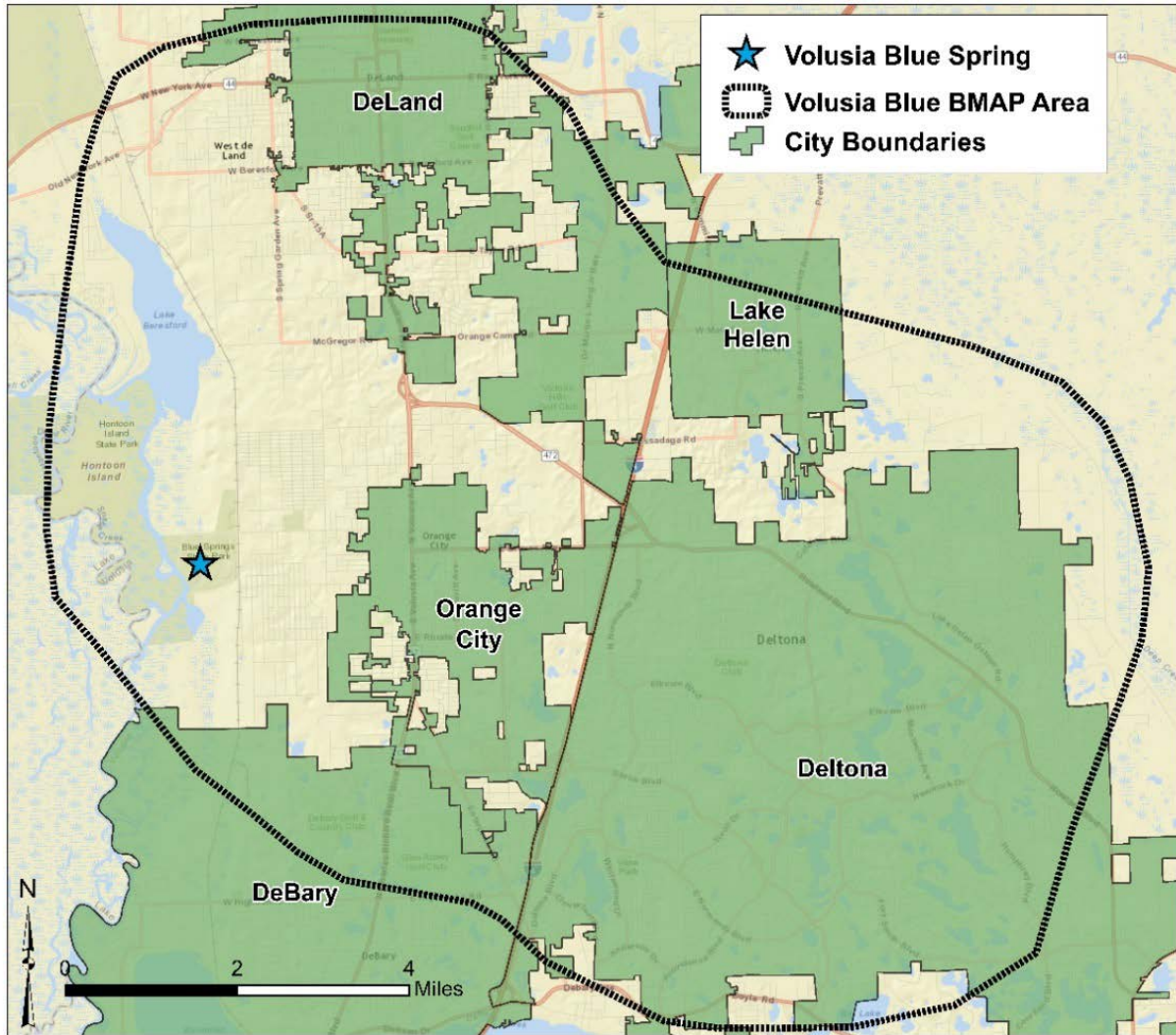


**Figure 1: Map showing the Volusia Blue Spring and Volusia Blue Spring Run BMAP area**

### 1.3 Hydrogeology and Aquifer Recharge

The primary water source discharging from Volusia Blue Spring is the UFA. This aquifer is composed of Eocene-era limestone and dolostone and lies about 100 feet below the land surface in Volusia County. The shallower surficial aquifer system (SAS), which occurs between the land surface and up to 100 feet below the land surface, is also present in the contributing area. Water movement between the SAS and the UFA is slowed by a low permeability layer of clay, silt, and fine sand that forms an intermediate confining unit that is perforated by sinkholes (Holland and Bridger 2014)

The dissolution of carbonate rocks comprising the UFA has created numerous karst features (sinkholes, caves, and conduits) over geologic time in this area. These features can allow water from the land surface to move directly and relatively rapidly into the aquifer in parts of the

contributing area where the intermediate confining unit is breached by sinkholes or absent. Volusia Blue Spring is located on the western edge of the DeLand Ridge, a large area of karst development that has particularly high recharge to the underlying UFA.

The movement of groundwater into the UFA occurs relatively quickly in response to changes in rainfall and recharge, and groundwater flows directly to springs where conduits are present. Water discharging from the spring originates from both nearby source areas and more distant areas in the springshed. As a result, the water discharging from Volusia Blue Spring is a mixture of groundwater that has resided in the aquifer for varying amounts of time, ranging from days to several decades.

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. In 2015, the SJRWMD updated the Floridan aquifer recharge map for the entire district, which includes the Volusia Blue Spring 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 rate calculations. The SJRWMD estimated the recharge rates to the UFA (in inches per year [in/yr]) for the following ranges: 0 for discharge areas, 1 to 5; 5 to 15; and greater than 15 inches.

The SJRWMD recharge rate information was provided as a geographic information system (GIS) shapefile. The SJRWMD recharge rate ranges were then aggregated into four recharge rate categories: discharge, low recharge (1 to 5 in/yr), medium recharge (5 to 15 in/yr), and high recharge (15 in/yr or greater) (**Figure 2**). The discharge category includes areas where groundwater from the UFA discharges through springs, seepage into lakes, streams, or wetlands. The other categories are areas where some degree of recharge to the UFA occurs.

## **1.4 Land Use**

Land use/land cover (LULC) was assessed with the most recent land use Arc geographic information system (GIS) coverages obtained from the SJRWMD and the local county property appraiser offices. The Volusia Blue Spring BMAP area lies entirely within the SJRWMD boundary. All land use classifications used by the SJRWMD were based on the Florida Land Use/Land Coverage and Forms Classification System (FLUCCS). The 2009 land use was created through the interpretation of digital imagery taken in 2009. The land use classifications were determined through photo interpretation, editing, and quality check processes. **Table A.2** provides additional details of these data.

Additional land use information was obtained from the Volusia County property appraiser. Staff from the 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. 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 agricultural lands. The land use information obtained from property appraisers is designated as "PA" in this report. **Table A.3** provides additional details of these data.

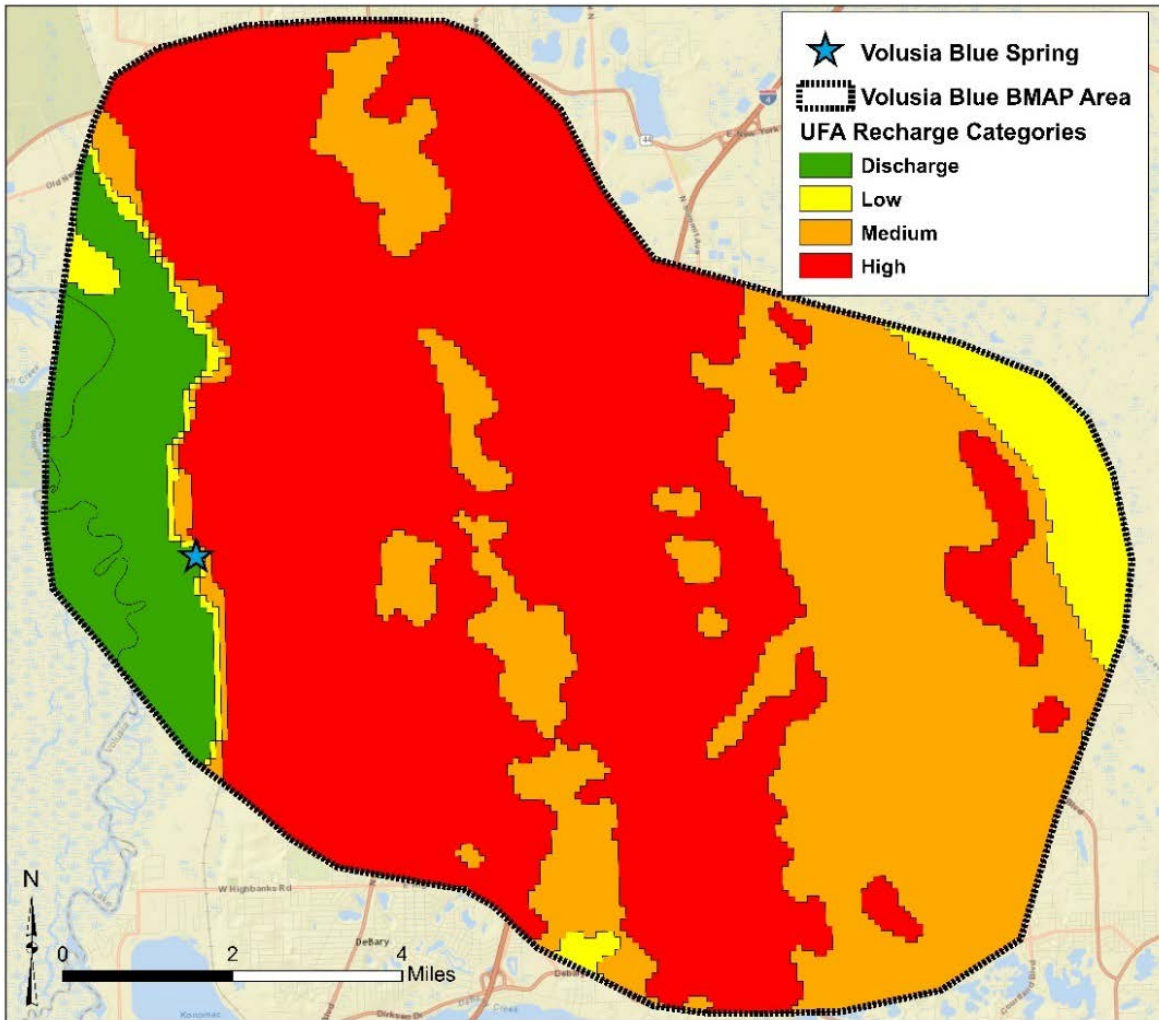


**Figure 2: UFA recharge rate categories in the Volusia Blue Spring BMAP area**

## **2. Estimating Nitrogen Inputs to the Land Surface**

Nitrogen inputs to the land surface in the BMAP area were evaluated for atmospheric deposition, domestic wastewater applied at wastewater treatment facility (WWTF) land application sites, reclaimed water used for irrigation, septic systems, urban and sports turfgrass fertilizer application, agricultural fertilizer application, and livestock waste. The methods used to estimate nitrogen inputs for each type of source are based on a detailed synthesis of information, including direct water quality measurements, Census data, surveys, wastewater permits, published scientific studies and reports, and information obtained in meetings with stakeholders.

For some of the source categories, assumptions and extrapolations were made for estimating nitrogen inputs, and as a result these results 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 input (in pounds per year of nitrogen [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 multiple 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 country. 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 NTN 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 3** illustrates the TDEP model results for TN deposition in the Volusia Blue Spring BMAP area. The total nitrogen deposition inputs in high, medium, and low recharge rate areas are 219,755 lb-N/yr; 118,401 lb-N/yr; and 17,443 lb-N/yr, respectively.

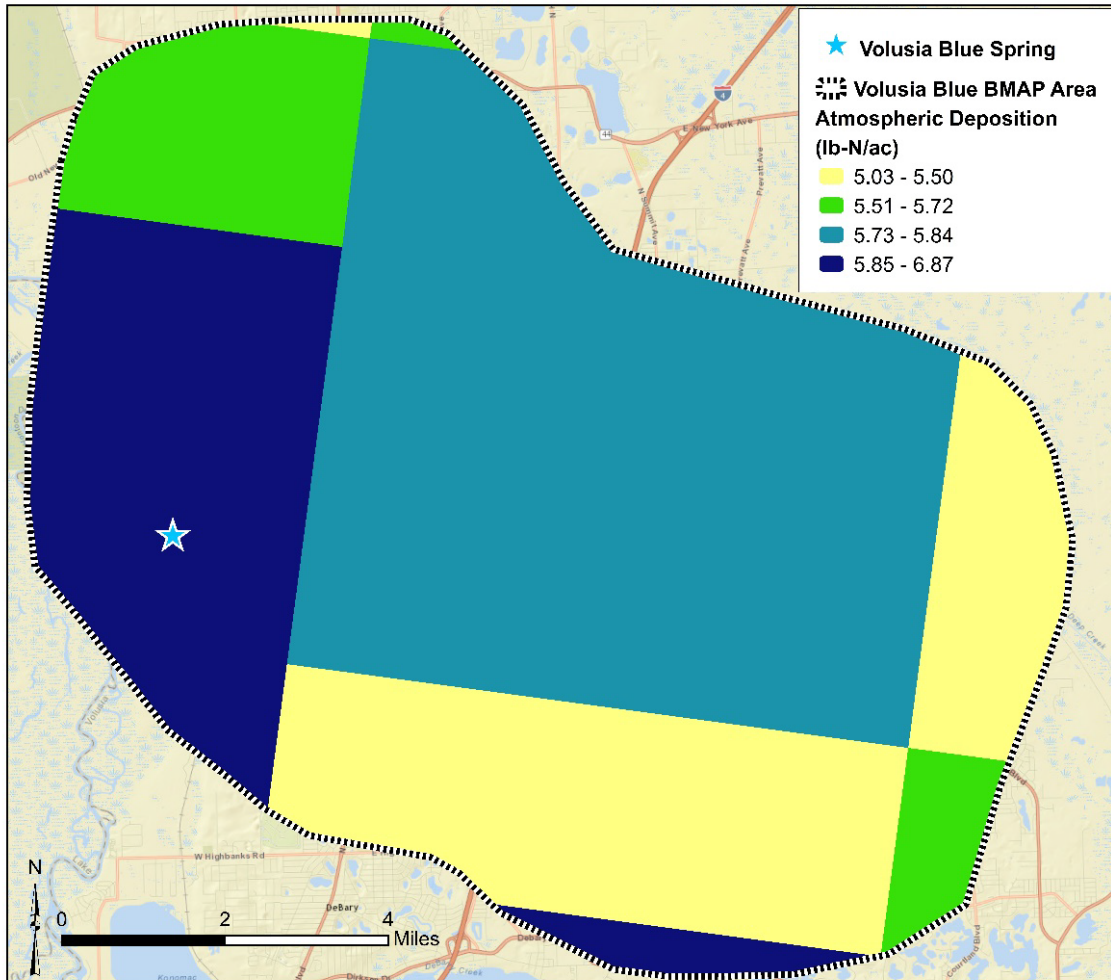


Figure 3: Atmospheric deposition model results used for the NSILT

## 2.2 WWTFs

WWTFs receive and treat domestic wastewater. In the Volusia Blue Spring BMAP area, treated effluent containing nitrogen from WWTFs is discharged to sprayfields, rapid infiltration basins (RIBs), and percolation ponds. It is also reused for irrigation. There are 21 WWTFs located in the Volusia Blue Spring BMAP area. According to their permits, 4 of these facilities have design flows greater than 1 mgd of treated effluent (**Figure 4**). However, according to recent permit records, none of the facilities has recent annual flows greater than 0.1 mgd.

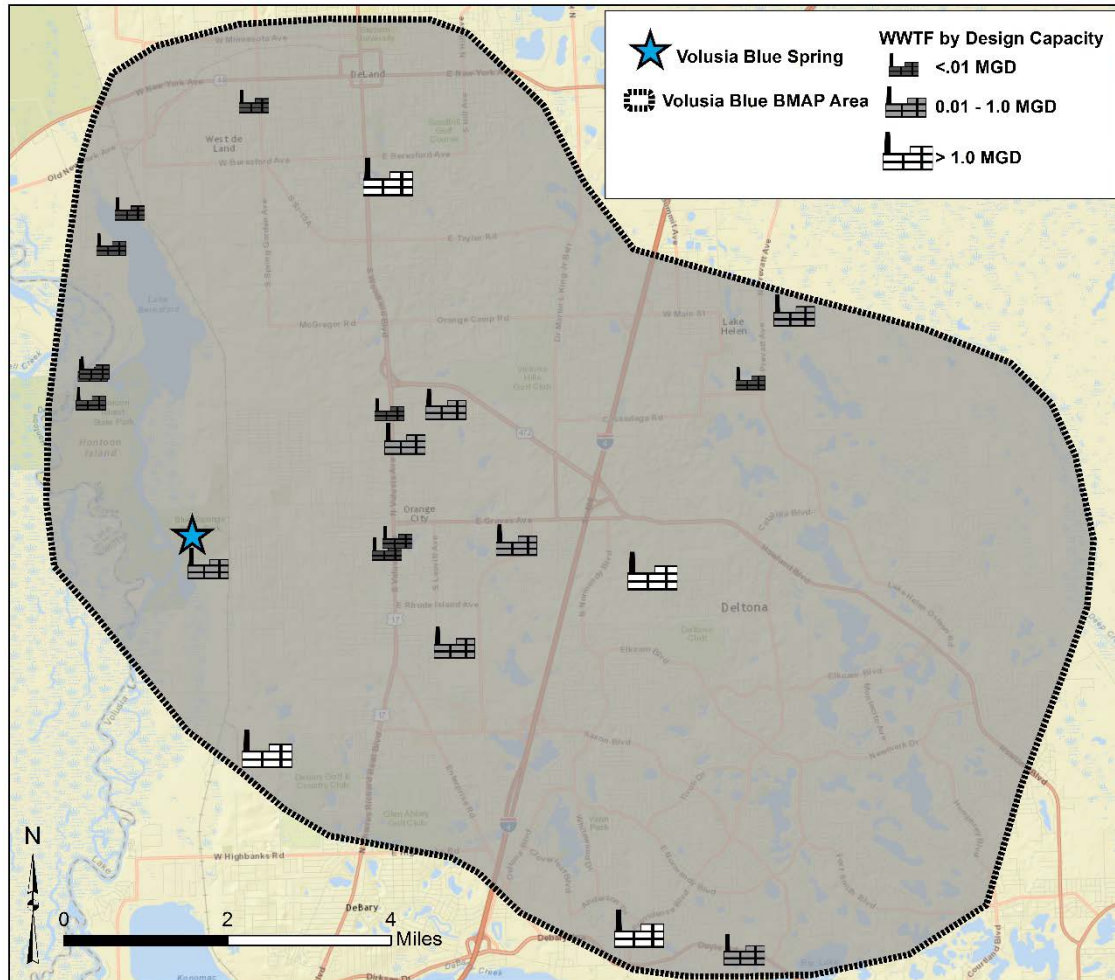


**Figure 4: Distribution of WWTFs in the Volusia Blue Spring BMAP area and their permitted design flows in mgd**

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 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 based on nitrate-N ( $\text{NO}_3\text{-N}$ ) data (assuming the  $\text{NO}_3\text{-N}$  concentration was 38.5 % of the TN, based on a 2009 cooperative study with the Water Reuse Foundation of 40 domestic WWTFs across the state). For this calculation, the  $\text{NO}_3\text{-N}$  value is divided by 0.385, resulting in an estimated TN concentration. The WWTf data were compiled for each facility and included the most recent complete year of data. The range of years

for which data were available varied with the individual facilities; however, the majority of the data were from July 2013 to June 2014.

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, percolation ponds, or absorption fields. For the purpose of this analysis, absorption fields are categorized with RIBs because they have similar environmental nitrogen uptake. The nitrogen inputs for each WWTF were calculated using the average annual TN concentration and the average yearly flow from the facility from recent years. The average annual nitrogen inputs from wastewater facilities were estimated for each recharge rate category based on the locations of the effluent application sites in the BMAP area.

**Table 1** summarizes the nitrogen input data from facilities in the Volusia Blue Spring BMAP area that have absorption fields, percolation ponds, RIBs, and sprayfields. The number of application sites per facility is listed between parenthesis in the field labeled Effluent Disposal Type. In total, an estimated 61,359 lb-N/yr are applied to the land surface from these facilities in the high recharge rate areas, 891 lb-N/yr in the medium recharge rate areas, and an additional 48 lb-N/yr are applied in the low recharge rate areas.

**Table 2** summarizes the nitrogen input data from facilities in the Volusia Blue Spring BMAP area that have reuse. The Wiley M. Nash WRF (FL0020303) distributes reuse water to Sandhill Golf Course (formerly Southridge), Stetson University, and Victoria Park residential area. Deltona Lakes WWTF (FLA111724) distributes reuse water for irrigation to Deltona Hills Golf Course, on-site RIBs, on-site irrigation, and residential areas. Volusia County's Deltona North WWTF (FLA011121) distributes reuse water to Arbor Ridge, while the Southwest WRF (FLA011128) sends reuse to DeBarry Plantation Golf Course. In total, an estimated 95,089 lb-N/yr are distributed as reclaimed water for irrigation in the high recharge rate areas, 6,219 lb-N/yr are distributed in the medium recharge rate areas, and an additional 12,234 lb-N/yr are applied in the low recharge rate areas.

In 2009, a Florida Department of Health (FDOH) contractor developed a statewide model for estimating the number of septic systems based on tax parcel data and known sewer service areas (Hall and Clancy 2009). The model relied on septic system permit data from FDOH, as well as information from public utilities on 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, it was assumed that a septic system would be found in an area where sewer service was unlikely. The output of the model is provided in an ArcGIS geodatabase where the locations of both known and probable septic systems can be mapped.

**Table 1: Data for Volusia County WWTFs in the Volusia Blue Spring BMAP area:  
Absorption fields, percolation ponds, RIBs, and sprayfields**

\* TN data estimated based on available NO<sub>3</sub> data.

| <b>WWTF Name</b>                                                   | <b>Facility ID</b> | <b>Effluent Disposal Method</b> | <b>Treatment Recharge Area</b> | <b>Annual Average TN (mg-N/L)</b> | <b>Annual Flow (mgd)</b> | <b>Nitrogen Input (lb-N/yr)</b> |
|--------------------------------------------------------------------|--------------------|---------------------------------|--------------------------------|-----------------------------------|--------------------------|---------------------------------|
| <b>Volusia County – Four Townes WWTF</b>                           | FLA011118          | RIB (6)                         | High                           | 10.23                             | 0.181                    | 5,631                           |
| <b>Volusia County – Deltona North WWTF</b>                         | FLA011121          | RIB (3)                         | High                           | 11.02                             | 0.190                    | 6,389                           |
| <b>Volusia County – Southwest Water Reclamation Facility (WRF)</b> | FLA011128          | RIB (4)                         | High                           | 5.33                              | 0.36                     | 5,786                           |
| <b>Arlington Square Apartments</b>                                 | FLA011197          | Absorption field (2)            | High                           | 8.97                              | 0.008                    | 229                             |
| <b>Lakeview Terrace WWTF</b>                                       | FLA011198          | RIB                             | Discharge                      | 11.66                             | 0.002                    | 76                              |
| <b>Lake Helen Mobile Home Villas</b>                               | FLA011199          | RIB (2)                         | Medium                         | 8.97                              | 0.017                    | 458                             |
| <b>Quality Inn</b>                                                 | FLA011203          | Absorption field                | Medium                         | 8.97                              | 0.002                    | 56                              |
| <b>Holly Bluff Marina, Inc</b>                                     | FLA011204          | Absorption field (2)            | Discharge                      | 5.28                              | 0.000                    | 8                               |
| <b>Tropical Resort and Marina WWTF</b>                             | FLA011216          | Absorption field                | Low                            | 8.97                              | 0.002                    | 48                              |
| <b>Land O Lakes MHC WWTF</b>                                       | FLA011219          | RIB (2)                         | High                           | 8.97                              | 0.013                    | 355                             |
| <b>Days Inn of Orange City</b>                                     | FLA011220          | Absorption field (2)            | High                           | 8.97                              | 0.003                    | 69                              |
| <b>1876 Heritage Inn</b>                                           | FLA011223          | Absorption field                | Medium                         | 8.97                              | 0.002                    | 41                              |
| <b>Paradise Lakes Campground</b>                                   | FLA011234          | Single-cell percolation pond    | High                           | 8.97                              | 0.003                    | 70                              |
| <b>Clark Family Campground KOA WWTF</b>                            | FLA011237          | RIB (2)                         | Medium                         | 8.97                              | 0.002                    | 52                              |
| <b>St Johns River Club Condominium WWTF</b>                        | FLA011263          | Absorption field (2)            | Discharge                      | 4.50                              | 0.001                    | 14                              |

*Nitrogen Source Inventory and Loading Estimates for the Volusia Blue Spring and Volusia Blue Spring Run  
Contributing Area, February 2017*

| WWTF Name                                   | Facility ID | Effluent Disposal Method | Treatment Recharge Area | Annual Average TN (mg-N/L) | Annual Flow (mgd) | Nitrogen Input (lb-N/yr) |
|---------------------------------------------|-------------|--------------------------|-------------------------|----------------------------|-------------------|--------------------------|
| <b>Candlelight WWTF</b>                     | FLA011265   | Sprayfield               | High                    | 8.97                       | 0.007             | 198                      |
| <b>Hontoon Island State Park</b>            | FLA011276   | Absorption field         | Discharge               | 8.97                       | 0.002             | 44                       |
| <b>Blue Spring State Park</b>               | FLA011279   | RIB (3)                  | Medium                  | 8.97                       | 0.008             | 229                      |
| <b>Volusia Pines Elementary School WWTF</b> | FLA016691   | RIB (2)                  | Medium                  | 8.23                       | 0.002             | 41                       |
| <b>Deltona Lakes</b>                        | FLA111724   | RIB, absorption field    | High                    | 14.33                      | 0.98              | 42,631                   |

**Table 2: Data for WWTFs of Volusia County within the Volusia Blue Spring BMAP area:  
Reuse**

\* TN data estimated based on available NO<sub>3</sub> data.

| WWTF Name                                  | Facility ID | Treatment Type | Recharge Area | Annual Average TN (mg-N/L) | Annual Flow (mgd) | Nitrogen Input (lb-N/yr) |
|--------------------------------------------|-------------|----------------|---------------|----------------------------|-------------------|--------------------------|
| <b>Wiley M Nash WRF</b>                    | FL0020303   | Reuse          | High          | 11.95                      | 1.0               | 72,958                   |
| <b>Wiley M Nash WRF</b>                    | FL0020303   | Reuse          | Medium        | 11.95                      | 0.12              | 4,310                    |
| <b>Volusia County – Deltona North WWTF</b> | FLA011121   | Reuse          | High          | 11.02                      | 0.04              | 1,476                    |
| <b>Volusia County – Deltona North WWTF</b> | FLA011121   | Reuse          | Medium        | 11.02                      | 0.02              | 772                      |
| <b>Volusia County – Southwest WRF</b>      | FLA011128   | Reuse          | High          | 5.33                       | 0.74              | 12,050                   |
| <b>Deltona Lakes</b>                       | FLA111724   | Reuse          | High          | 14.33                      | 0.10              | 8,605                    |
| <b>Deltona Lakes</b>                       | FLA111724   | Reuse          | Medium        | 14.33                      | 0.03              | 1,138                    |
| <b>Deltona Lakes</b>                       | FLA111724   | Reuse          | Low           | 14.33                      | 0.28              | 12,234                   |

## 2.3 Septic Systems

On-site sewage treatment and disposal systems (OSTDS), commonly referred to as septic systems, occur throughout the Volusia Blue Spring BMAP area where municipal sewer is not available. These systems can contribute to elevated nitrogen concentrations in groundwater (Chang et al. 2010).

The model may overestimate the number of septic systems. In some parts of Florida, the land use data used by Hall and Clancy (2009) projected future housing development. However, some of the parcels projected by the model to be subdivided remained intact as one parcel with one septic system rather than multiple septic systems. This resulted in a higher estimate of projected septic systems than what is actually in place.

To improve the accuracy of the septic system estimates, the model results were correlated with current land use information from property appraisers. Any parcel containing more than one septic system was further evaluated as follows:

- Parcels identified as single-family residential were reduced to only one septic system per parcel.
- Parcels with three or fewer septic systems and an associated land use likely to contain more than one septic tank (i.e., condominiums, multifamily dwellings, or businesses) were left unchanged.
- All remaining parcels were individually assessed using current aerial imagery to verify or correct the number of septic systems within the parcel boundary.

This final data layer was used to estimate the total number of septic systems within each recharge rate area in the BMAP area and is referred to as the "modified Hall and Clancy" dataset (**Figure 5**). The DEP methodology estimated 41,171 septic tanks, which compares favorably (within 2 %) with the recently released [Florida Water Management Inventory \(FLWMI\) septic system inventory](#) of Volusia County by FDOH.

After the number of septic systems in the Volusia Blue Spring BMAP area was determined, the population served by septic systems was estimated using the [2010 U.S. Census Bureau data](#) for population and household occupancy in each county. The Census makes a distinction between occupied and nonoccupied 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 (2.38 in Volusia County).

However, many people with a home septic system most likely have access to a facility connected to a sewer system during their weekly routine (i.e., work, school, etc.), reducing nitrogen input to their 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 Volusia County from the 2010 Census. In Volusia County, 61.1 % of the population is of school

or working age and, according to the Bureau of Labor Statistics, spend 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 Volusia County by 15.8 %, resulting in an adjusted number of 2.00 people per household.

The total population in the Volusia Blue Spring BMAP area served by septic systems was estimated by multiplying the estimated number of people per household 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 recharge rate areas (U.S. Environmental Protection Agency [EPA] 2002; Toor et al. 2011; Viers et al. 2012). **Table 3, Table 4, Table 5, and Table 6** summarize the septic system data.

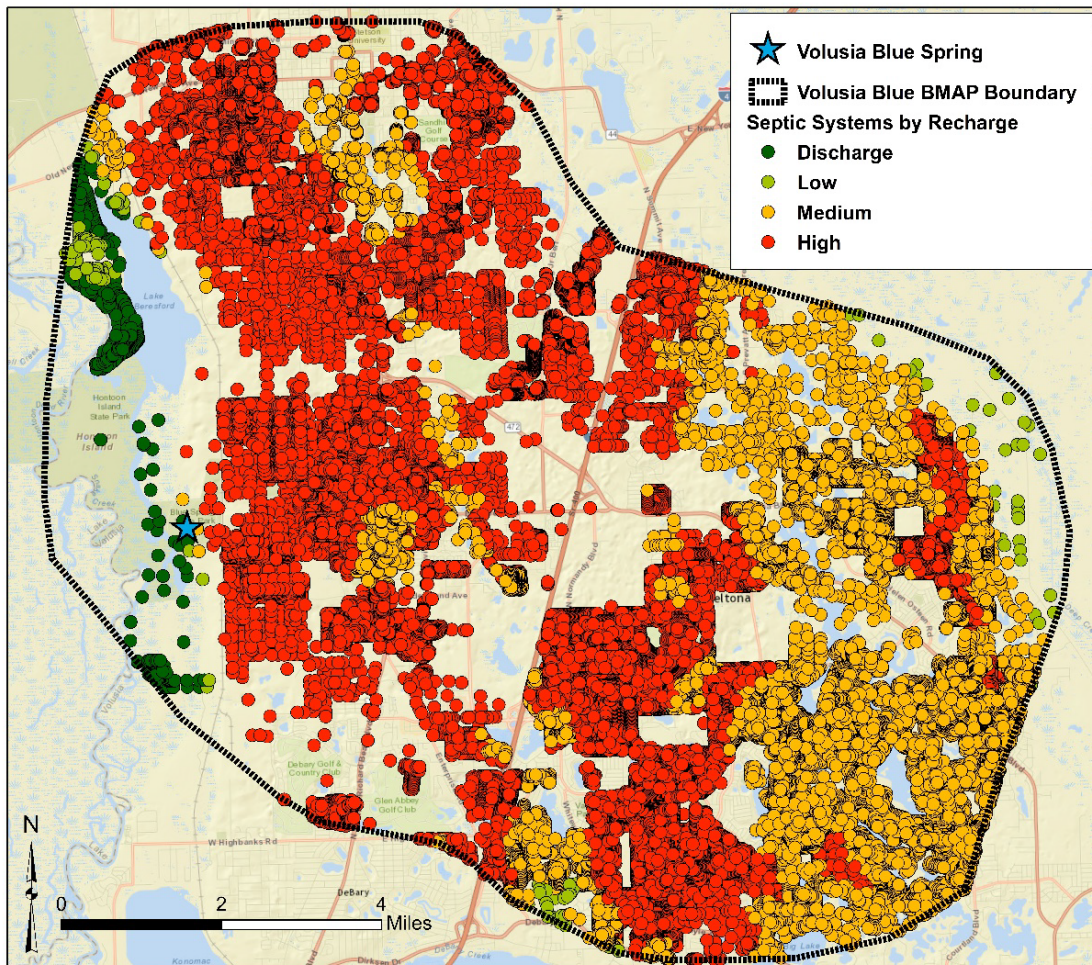


**Figure 5: Distribution of septic systems in the Volusia Blue Spring BMAP area**

**Table 3: 2010 U.S. Census population data for Volusia County**

| Population | Occupied Household | People Per Household | Ages under 18 | Ages 18–64 | Ages 65 or Older |
|------------|--------------------|----------------------|---------------|------------|------------------|
| 494,593    | 208,236            | 2.37                 | 93,273        | 297,031    | 104,289          |

**Table 4: 2010 U.S. labor data for Volusia County**

| Total Labor Force | Employed | Unemployed | Hours in Week for Work | % Time at Work |
|-------------------|----------|------------|------------------------|----------------|
| 238,183           | 208,987  | 29,196     | 43.5                   | 25.9 %         |

**Table 5: Effective population factor based on Volusia County working and school age population**

| Working Population | School Population | % of County Population Working or in School | % Effective Population | Effective People Per Household |
|--------------------|-------------------|---------------------------------------------|------------------------|--------------------------------|
| 208,987            | 93,273            | 61 %                                        | 84.2 %                 | 2.00                           |

**Table 6: Data for septic systems in the Volusia Blue Spring BMAP area**

| Recharge Category | # of Septic Tanks | # of People on Septic Tanks | Total Input (lb-N/yr) |
|-------------------|-------------------|-----------------------------|-----------------------|
| High Recharge     | 26,583            | 53,145                      | 478,943               |
| Medium Recharge   | 13,901            | 27,791                      | 250,453               |
| Low Recharge      | 253               | 506                         | 4,558                 |
| Discharge         | 434               | 868                         | 7,819                 |

## 2.4 Urban Turfgrass Fertilizer

### 2.4.1 Fertilizer Application Rates

Fertilizers applied to turfgrass typically found in residential and nonresidential areas are referred to as urban turfgrass fertilizers (**Figure 6**). 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 Volusia Blue Spring BMAP area.

Fertilizer is applied by either the homeowner or a hired lawn service company on residential properties, and on other properties it may be applied by contractors or maintenance staff. In 2009 DEP contracted the University of Central Florida Stormwater Management Academy to conduct a study of residential fertilizer practices in the Wekiva Basin area (Contract# G0078). Based on the study results, 49.6 % of the population manage their own lawn care and apply lawn fertilizer 3.72 times a year at variable rates that may range as high as 21.78 lb-N/ac (**Table 7**) (Souto et al. 2009). The study results also indicate that 34.4 % of homeowners hire a lawn service company

that typically applies fertilizer at rates consistent with the *Green Industries Best Management Practices Manual* recommendation of 21.78 lb-N/ac twice a year (DEP 2010). Fertilizer application rates on nonresidential/commercial parcels were assumed to be performed by trained staff using application rates and frequencies similar to those recommended in the *Green Industries Best Management Practices Manual*.

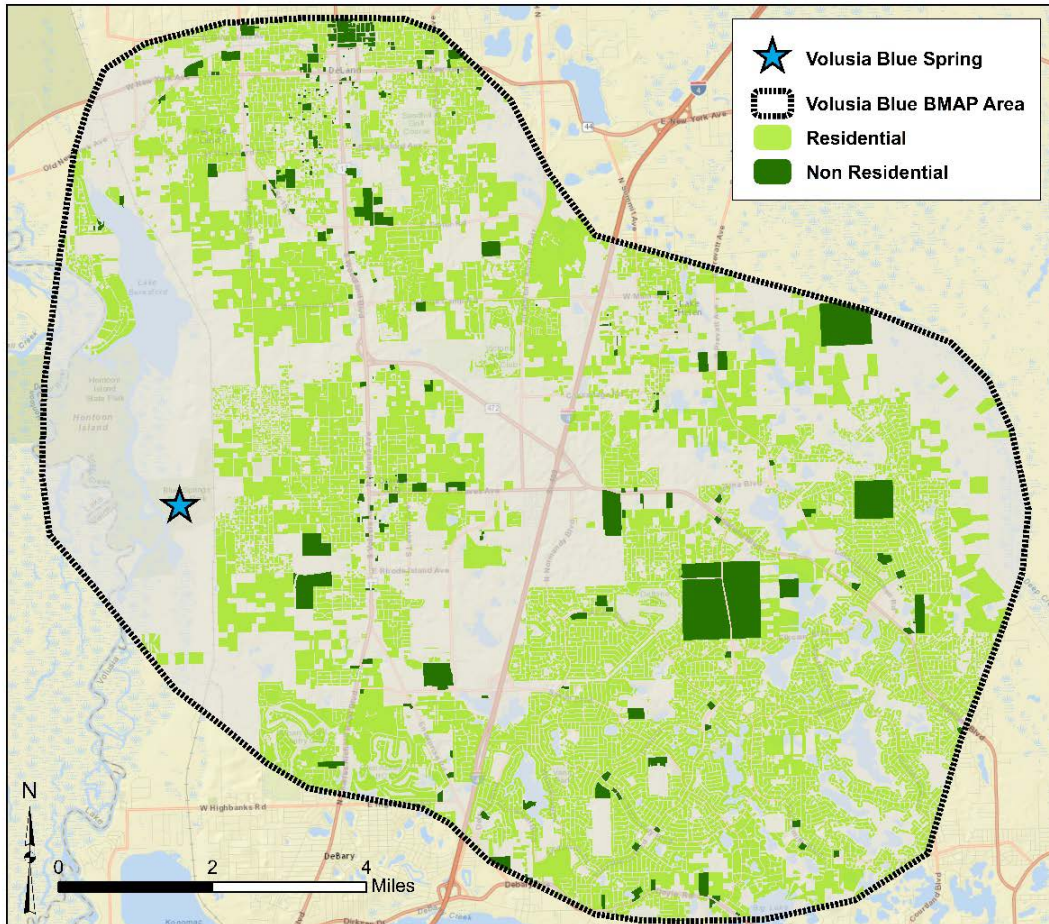


**Figure 6: Urban residential and nonresidential lands in the Volusia Blue Spring BMAP area according to county property appraiser data**

**Table 7: Estimated fertilizer application rates based on the Wekiva residential fertilizer practices study**

\* = Includes homeowners who fertilize based on visual appearance or best judgment.

| Basis for Application Rate | % of Population with Homeowner Applying Fertilizer | Estimated Rate (lb-N/ac) | Average Application Frequency |
|----------------------------|----------------------------------------------------|--------------------------|-------------------------------|
| Self-Fertilize             | 49.6 %                                             | 21.78                    | 3.82                          |
| No Fertilization           | 16 %                                               | 0                        | 0                             |
| Lawn Service               | 34.4 %                                             | 21.78                    | 2                             |

### **2.4.2 Nonresidential Parcel Estimations**

The acreage of nonresidential/commercial parcels receiving fertilizer applications was estimated for each category listed in **Table 8**. Parcel types assessed using the PA data include businesses, hotels, schools, churches, and other facilities. These data were combined with zoning data provided by Volusia County, City of Deltona, City of Deland, City of DeBary, City of Lake Helen, and Orange City. The zoning attributed to each parcel contains information on the amount of impervious surface coverage (i.e., structures, pavement, etc.) allowed on the property, 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 rate and frequency listed in **Section 2.4.1**. Details of the PA data and max lot coverages are listed in **Appendix A, Table A.4**. **Table 8** summarizes the nitrogen input from the nonresidential parcels.

**Table 8: Summary of the fertilizable urban land area and associated nitrogen input for nonresidential parcels**

| Parcel Type                | High-Recharge Fertilizable Land Area (acres) | Medium-Recharge Fertilizable Land Area (acres) | Low-Recharge Fertilizable Land Area (acres) | Total Input (lb-N/yr) |
|----------------------------|----------------------------------------------|------------------------------------------------|---------------------------------------------|-----------------------|
| Hotels                     | 3                                            | 8.5                                            | 2.2                                         | 609                   |
| Churches                   | 187                                          | 131.3                                          | 2.1                                         | 13,590                |
| Private Schools            | 43                                           | 22.6                                           | 0.3                                         | 2,584                 |
| Public Schools             | 589                                          | 558.8                                          | 4.9                                         | 50,231                |
| Colleges                   | 0.5                                          | 2.3                                            | 0.0                                         | 119                   |
| Private Hospitals          | 1                                            | 0.0                                            | 0.0                                         | 42                    |
| Hospitals                  | 74                                           | 0.0                                            | 0.0                                         | 3,231                 |
| Clubs, Lodges, Union Halls | 26                                           | 89.3                                           | 104.9                                       | 9,586                 |
| Cultural Organizations     | 0.0                                          | 0.1                                            | 0.0                                         | 6                     |
| <b>TOTAL</b>               | <b>924</b>                                   | <b>813</b>                                     | <b>114</b>                                  | <b>80,629</b>         |

### **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 that a homeowner will fertilize the lawn.

Based on socioeconomic studies, property value can be used as an indicator of probability of fertilization by homeowners in residential areas (Kinzig et al. 2005, Law et al. 2004, Zhou et al. 2008, Cook et al. 2012). The range of property values for single-family homes was evaluated for the Volusia Blue Spring BMAP area and subdivided into three categories: high, medium, and low. **Table 9** lists the estimated probability of fertilization for each property value category.

**Table 9: Distribution of property values and the probability of fertilization for the Volusia Blue Spring BMAP area**

| Property Value Label | Property Value    | Probability of Fertilization |
|----------------------|-------------------|------------------------------|
| High                 | > \$90,000        | 90 %                         |
| Medium               | \$50,001–\$90,000 | 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 10** to obtain the total input of nitrogen to the land surface in residential areas.

**Table 10: Summary of the fertilizable urban land area and associated nitrogen input for residential parcels**

| Parcel Type                              | High-Recharge<br>Fertilizable Land<br>Area<br>(acres) | Medium-Recharge<br>Fertilizable Land<br>Area<br>(acres) | Low-Recharge<br>Fertilizable<br>Land Area<br>(acres) | Total Input<br>(lb-N/yr) |
|------------------------------------------|-------------------------------------------------------|---------------------------------------------------------|------------------------------------------------------|--------------------------|
| <b>Condominiums</b>                      | 25.7                                                  | 0.4                                                     | 0.0                                                  | <b>1,439</b>             |
| <b>Homes for the Aged</b>                | 98.0                                                  | 69.8                                                    | 0.0                                                  | <b>9,258</b>             |
| <b>M/F/R Communities</b>                 | 102.2                                                 | 10.7                                                    | 1.5                                                  | <b>6,315</b>             |
| <b>Multifamily Less<br/>Than 5 Units</b> | 43.9                                                  | 18.6                                                    | 0.0                                                  | <b>3,444</b>             |
| <b>Multifamily More<br/>Than 5 Units</b> | 122.4                                                 | 71.3                                                    | 0.0                                                  | <b>10,685</b>            |
| <b>Residential Mobile<br/>Homes</b>      | 95.6                                                  | 102.3                                                   | 22.9                                                 | <b>12,177</b>            |
| <b>Residential Single<br/>Family</b>     | 7,458.8                                               | 3,517.0                                                 | 206.5                                                | <b>616,947</b>           |
| <b>TOTAL</b>                             | <b>7,946.7</b>                                        | <b>3,790</b>                                            | <b>231</b>                                           | <b>660,266</b>           |

## 2.5 Sports Turfgrass Fertilizer

Fertilizer applied to sports turfgrass areas is another potential source of nitrogen. These areas fall into two main categories: golf courses and other sports facilities such as baseball, football, 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 ft<sup>2</sup>) (Sartain 2002; DEP 2007). In total, all 5 golf courses in the Volusia Blue Spring BMAP area apply approximately 91,227 lb-N/yr to the land surface in high recharge rate areas, 28,390 lb N/yr in medium recharge rate areas, and an additional 3,670 N/yr in the low recharge rate areas. **Table 11** summarizes the input to the land surface from each golf course in the BMAP area.

**Table 11: Summary of urban fertilizer input for golf courses**

- = Empty cell/no data

| Golf Club Name                             | County  | High-Recharge Fertilizable Land Area (acres) | Medium-Recharge Fertilizable Land Area (acres) | Low-Recharge Fertilizable Land Area (acres) | Average Application Rate (lb-N/ac) | Total Input (lb-N/yr) |
|--------------------------------------------|---------|----------------------------------------------|------------------------------------------------|---------------------------------------------|------------------------------------|-----------------------|
| <b>DeBary Golf and Country Club</b>        | Volusia | 123.75                                       | 3.56                                           | 0                                           | 141.1                              | <b>17,966</b>         |
| <b>Deltona Hills Golf and Country Club</b> | Volusia | 86.65                                        | 76.61                                          | 0                                           | 141.1                              | <b>23,040</b>         |
| <b>Glen Abbey Golf Course</b>              | Volusia | 114.32                                       | 23.33                                          | 7.86                                        | 141.1                              | <b>20,533</b>         |
| <b>Sandhill Golf Course</b>                | Volusia | 85.83                                        | 33.25                                          | 0                                           | 141.1                              | <b>16,805</b>         |
| <b>Victoria Hills Golf Course</b>          | Volusia | 235.90                                       | 64.43                                          | 18.15                                       | 141.1                              | <b>44,944</b>         |

Fertilizers applied to 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, an estimated 106 acres are used for sports facilities in the Volusia County high-recharge areas and 31 acres of land in the medium-recharge areas. No sporting facilities were identified in the low-recharge areas. It was assumed that these lands are fertilized at rates and frequencies applied by lawn service companies (21.78 lb N/ac), as described in **Section 2.4**, resulting in 5,933 lb-N/yr input to the land surface. **Table 12** summarizes the sports facility turfgrass fertilizer calculations.

**Table 12: Summary of sporting facility turfgrass fertilizer nitrogen input to the land surface**

- = Empty cell/no data

| Parcel Type                            | High-Recharge Fertilizable Land Area (acres) | Medium-Recharge Fertilizable Land Area (acres) | Total Input (lb-N/yr) |
|----------------------------------------|----------------------------------------------|------------------------------------------------|-----------------------|
| <b>Institutional – Private Schools</b> | 6.1                                          | 0                                              | <b>265</b>            |
| <b>Colleges</b>                        | 0.9                                          | 0                                              | <b>38</b>             |
| <b>Other County</b>                    | 9.3                                          | 4.3                                            | <b>592</b>            |
| <b>Other Municipal</b>                 | 43.5                                         | 22.9                                           | <b>2,895</b>          |
| <b>Schools, Public</b>                 | 45.9                                         | 3.3                                            | <b>2,143</b>          |
| <b>TOTAL</b>                           | <b>106</b>                                   | <b>31</b>                                      | <b>5,933</b>          |

## 2.6 Livestock Waste

Only 4 % of the Volusia Blue Spring BMAP area is in agricultural land use, and the livestock population in the area is small. Agricultural practices specific to this area were identified through conversations with the Florida Farm Bureau Federation and a meeting with Volusia County agricultural producers and stakeholders. Cattle are the most abundant livestock species in the BMAP area. Typical cattle stocking rates in Volusia County were estimated as 8 acres of pasture per cow. The pasture acreage for these operations was estimated using PA data and include improved, semi-improved, and native pastures. **Table 13** lists the estimated pasture acreage and the associated cattle populations within the BMAP area boundary. It is assumed for cattle that each animal contributes 0.337 lb-N/day.

**Table 13: PA pasture data and estimated cattle populations based on stocking rates**

| Property Code | PA Land Description | High-Recharge Area (acres) | Medium-Recharge Area (acres) | Low-Recharge Area (acres) | Estimated Cattle Population | Total Input (lb-N/yr) |
|---------------|---------------------|----------------------------|------------------------------|---------------------------|-----------------------------|-----------------------|
| <b>61</b>     | Improved            | 565                        | 345                          | 262                       | 146                         | <b>18,012</b>         |
| <b>62</b>     | Semi-Improved       | 353                        | 105                          | 27                        | 61                          | <b>7,462</b>          |
| <b>63</b>     | Native              | 244                        | 92                           | 274                       | 76                          | <b>9,376</b>          |
| <b>TOTAL</b>  |                     | <b>1,162</b>               | <b>542</b>                   | <b>563</b>                | <b>283</b>                  | <b>34,850</b>         |

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 (most recent) was used to provide data on livestock populations for this assessment. However, since the CoA reports entire county data, additional analyses were carried out for the groundwater BMAP area for Volusia Blue Spring.

To estimate the number of livestock animals in the BMAP area, SJRWMD 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 Volusia County and subdivided by recharge rate category. The livestock area summations were used to calculate a land use percentage for the entire county area for livestock populations in each recharge rate category.

These percentages were applied to the populations provided by the CoA to estimate the number of cattle and other animals in the BMAP area and the different recharge rate areas of Volusia County (**Table 14**, **Table 15**, and **Table 16**). For example, if 10,000 cows were reported in the CoA for Volusia County, but only 10 % of the livestock lands in that county were inside the BMAP area, it was assumed that the BMAP area contained 1,000 cows.

**Table 14: 2009 SJRWMD livestock land use acreage in Volusia County**

| Volusia County Land Category | Acres  |
|------------------------------|--------|
| Volusia County               | 72,229 |

**Table 15: 2009 SJRWMD land use acreage in the Volusia Blue Spring BMAP area and percentage relative to the county livestock acreage used to estimate percentage of BMAP livestock population**

| Recharge Category | Acres    | Land Use % |
|-------------------|----------|------------|
| High Recharge     | 1,558.25 | 2.2 %      |
| Medium Recharge   | 1,445.51 | 2.0 %      |
| Low Recharge      | 230.19   | 0.3 %      |

**Table 16: 2012 USDA CoA livestock population data for Volusia County and recharge rate areas**

| Recharge Category | Horses | Chicken, Broilers | Chicken, Layers | Goats | Hogs | Sheep | Turkeys |
|-------------------|--------|-------------------|-----------------|-------|------|-------|---------|
| Volusia County    | 2,416  | 5,564             | 5,520           | 2,178 | 424  | 721   | 129     |
| High Recharge     | 52     | 120               | 119             | 47    | 9    | 16    | 3       |
| Medium Recharge   | 48     | 111               | 110             | 44    | 8    | 14    | 3       |
| Low Recharge      | 8      | 18                | 18              | 7     | 1    | 2     | 0       |

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; horses, 0.273; broiler chickens, 0.159; layer chickens, 0.003; goats, 0.035; hogs, 0.190; sheep, 0.198; and turkeys, 0.006 (Goolsby et al. 1990; Katz et al. 1999; Chelette et al. 2002; Ruddy et al. 2006; Meyer 2012; Sprague and Gronberg 2013). **Table 17** lists the TN input to the land surface attributable to livestock waste for each recharge rate areas in the BMAP area.

**Table 17: Estimated nitrogen input (lb-N/yr) from animal waste to the land surface in the Volusia Blue Spring BMAP area**

| Recharge Category | Cattle | Horses | Chicken, Broilers | Chicken, Layers | Goats | Hogs | Sheep | Turkeys | Total Input |
|-------------------|--------|--------|-------------------|-----------------|-------|------|-------|---------|-------------|
| High Recharge     | 17,866 | 5,194  | 6,966             | 130             | 600   | 634  | 1,124 | 6       | 32,521      |
| Medium Recharge   | 8,330  | 4,818  | 6,462             | 121             | 557   | 588  | 1,043 | 6       | 21,925      |
| Low Recharge      | 8,655  | 767    | 1,029             | 19              | 89    | 94   | 166   | 1       | 10,820      |

## 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 of Volusia County 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 18** summarizes the nitrogen inputs to the land surface from fertilizers applied to cropland for each recharge rate area in the Volusia Blue Spring BMAP area.

**Table 18: Summary of crop types and nitrogen application rates in the Volusia Blue Spring BMAP area**

- = Empty cell/no data  
AG = Agricultural

| PA Property Code | PA Land Description        | Estimated Crop Type                              | N Application Rate (lb-N/ac) | High-Recharge Area (ac) | Medium-Recharge Area (ac) | Low-Recharge Area (ac) | Total Input (lb-N/yr) |
|------------------|----------------------------|--------------------------------------------------|------------------------------|-------------------------|---------------------------|------------------------|-----------------------|
| 52 and 53        | AG Cropland                | Watermelons, corn, hayfield, berries, tree crops | 120                          | 122                     | 0                         | 0                      | 14,658                |
| 61               | AG Pastures, Improved      | Semi-improved pastures                           | 25                           | 565                     | 345                       | 262                    | 29,286                |
| 62               | AG Pastures, Semi-Improved | Rotated, mixed native grasses                    | 25                           | 353                     | 105                       | 27                     | 12,133                |
| 63               | AG Pastures, Native        | Winter pastures                                  | 0                            | 244                     | 92                        | 274                    | 0                     |
| 66               | AG Citrus                  | Oranges, tangerines, navel oranges, grapefruits  | 150                          | 18                      | 3                         | 0                      | 3,079                 |
| 69               | AG Ornamental              | Ornamentals                                      | 80                           | 105                     | 25                        | 13                     | 11,443                |
| <b>TOTAL</b>     |                            |                                                  |                              | <b>1,407</b>            | <b>570</b>                | <b>576</b>             | <b>70,599</b>         |

## 2.8 Summary of Estimated Nitrogen Inputs to the Land Surface

**Figure 7** summarizes the relative contributions of nitrogen from the existing sources in the Volusia Blue Spring BMAP area. The estimated annual nitrogen input to the land surface in the BMAP area from all sources is 2.27 million lb-N. Urban turfgrass fertilizers contribute 33 % of the TN input. Other sources, in order of decreasing nitrogen inputs to the land surface, include

septic systems (32 %), atmospheric deposition (16 %), sports turfgrass fertilizers (6 %), WWTF reuse (5 %), WWTFs (3 %), farm fertilizer (3 %), and livestock waste (3 %).

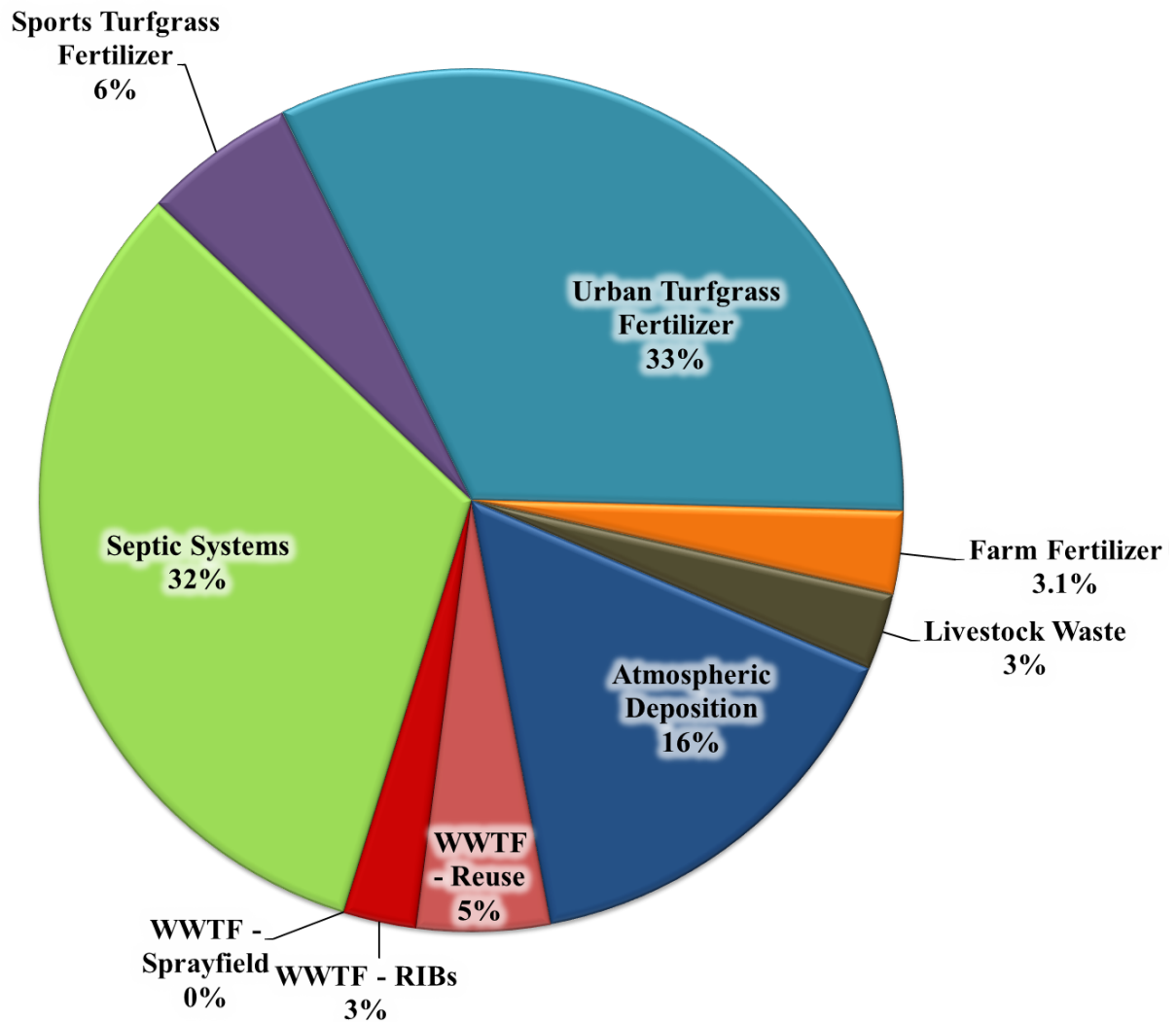


**Figure 7: Relative percentages of nitrogen inputs to the land surface in the Volusia Blue Spring BMAP area from major anthropogenic source categories**

### **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 Volusia Blue Spring BMAP 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 subsurface geological properties that affect the rate of water recharging the UFA. Both factors control the amount of nitrogen reaching the UFA annually and in the groundwater moving to Volusia Blue Spring.

#### **3.1 Biochemical Attenuation**

Several near-surface biochemical processes 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 throughout Florida as well as other areas with similar environmental characteristics. Additionally, research scientists in Florida (UF–IFAS, universities, and USDA Agricultural Research Service [ARS]), and local stakeholders provided additional guidance. The BAFs, listed in **Table 19**, represent the average percentage of the nitrogen attenuated or removed by subsurface processes and thus reducing the amount of nitrogen reaching 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 BAFs (**Table 19**). For example, atmospheric deposition has an average nitrogen attenuation of 90% (mainly from uptake by vegetation). This means that only 10 % of the atmospheric nitrogen input to the land surface has the potential to infiltrate to groundwater.

**Table 19: 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                                                                                                                                                                                                                  |
|-------------------------------|-------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Atmospheric Deposition</b> | 90 %  | Katz et al. 2009; Lombardo Associates 2011;<br>Howard T. Odum Florida Springs Institute 2011                                                                                                                                           |
| <b>WWTFs-Reuse</b>            | 75 %  | Jordan et al. 1997; Candela et al. 2007; Rahil and Antonopoulos 2007                                                                                                                                                                   |
| <b>WWTFs-RIBs</b>             | 25 %  | Merritt and Toth 2006; Sumner and Bradner 1996                                                                                                                                                                                         |
| <b>WWTFs-Sprayfield</b>       | 60 %  | Katz et al. 2009; Lombardo Associates 2011;<br>Howard T. Odum Florida Springs Institute 2011                                                                                                                                           |
| <b>Urban Fertilizer*</b>      | 80 %  | Goolsby et al. 1999; Erikson et al. 2001; Barton and Colmer 2006; Katz et al. 2009                                                                                                                                                     |
| <b>Septic Systems</b>         | 50 %  | Poiani et al. 1996; Aravena and Robertson 1998; Tomasko et al. 2001;<br>Corbett et al. 2002; Otis 2007; Toor et al. 2011                                                                                                               |
| <b>Livestock Waste</b>        | 90 %  | Dubeux et al. 2007; Silveira et al. 2007; Burns et al. 2009; Dubeux et al. 2009;<br>Obour et al. 2010; Sigua 2010; Sigua et al. 2010; Silveira et al. 2011;<br>Woodard et al. 2011; White-Leech et al. 2013a; White-Leech et al. 2013b |
| <b>Farm Fertilizer</b>        | 80 %  | McNeal et al. 1995; Wang and Alva 1996; Paramasivam and Alva 1997;<br>Newton et al. 1999; Hochmuth 2000a; Hochmuth 2000b; Simonne et al. 2006;<br>He et al. 2011; Liu et al. 2013                                                      |

### 3.2 Hydrogeological Attenuation

Any nitrogen remaining (nonattenuated, usually in the form of nitrate) after taking into account biochemical attenuation processes can readily 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 assigned as follows: 90 % in high recharge rate areas ( $\geq 15$  in/yr), 50 % in medium recharge rate areas (5 to 15 in/yr), and 10 % in low-recharge areas (0 to 5 in/yr). For example, in high rate recharge areas, 90 % of the nonattenuated nitrogen mass is assumed to reach the aquifer in a year, while only 50 % of the nonattenuated nitrogen mass is assumed to reach the aquifer annually in medium rate recharge areas. In low rate recharge areas, 10 % of the nonattenuated nitrogen mass is assumed to reach the aquifer in a year. These attenuation factors are based on the recharge characteristics specific to the hydrogeological conditions in the Volusia Blue Spring BMAP area.

### 3.3 Estimated Nitrogen Load to Groundwater

**Table 20**, **Table 21**, and **Table 22** summarize estimated annual nitrogen inputs, attenuation factors, and loads to the UFA, respectively, in the Volusia Blue Spring BMAP area and its recharge-based subdivisions. The results indicate an estimated annual load of 514,095 lb-N to the UFA in the BMAP area, representing 23 % 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 (54 % of the total estimated load to groundwater), followed by urban turfgrass fertilizer at 22 %. **Figure 8** shows the relative contribution of estimated annual loads of nitrogen to the UFA by source category.

**Table 20: Estimated inputs to the land surface by nitrogen source category in the Volusia Blue Spring BMAP area (lb-N/yr)**

| Recharge Category | Atmospheric Deposition | WWTFs–Reuse    | WWTFs–RIBs    | WWTFs–Sprayfield | Septic Systems | Sports Turfgrass Fertilizers | Urban Turfgrass Fertilizers | Crop Fertilizers | Livestock Waste |
|-------------------|------------------------|----------------|---------------|------------------|----------------|------------------------------|-----------------------------|------------------|-----------------|
| <b>High</b>       | 219,755                | 95,089         | 61,161        | 198              | 478,943        | 95,830                       | 478,662                     | 48,681           | 32,521          |
| <b>Medium</b>     | 118,401                | 6,219          | 891           | 0                | 250,453        | 29,720                       | 244,510                     | 13,676           | 21,925          |
| <b>Low</b>        | 17,443                 | 12,234         | 48            | 0                | 4,558          | 3,670                        | 17,723                      | 8,242            | 10,820          |
| <b>TOTAL</b>      | <b>355,599</b>         | <b>113,542</b> | <b>62,100</b> | <b>198</b>       | <b>733,954</b> | <b>129,220</b>               | <b>740,895</b>              | <b>70,599</b>    | <b>65,265</b>   |

**Table 21: Average BAFs by source category in the Volusia Blue Spring BMAP area (lb-N/yr)**

| Recharge Category | Atmospheric Deposition | WWTFs–Reuse   | WWTFs–RIBs    | WWTFs–Sprayfield | Septic Systems | Sports Turfgrass Fertilizers | Urban Turfgrass Fertilizers | Farm Fertilizers | Livestock Waste |
|-------------------|------------------------|---------------|---------------|------------------|----------------|------------------------------|-----------------------------|------------------|-----------------|
| <b>BAF</b>        | 90 %                   | 75 %          | 25 %          | 60 %             | 60 %           | 80 %                         | 80 %                        | 80 %             | 90 %            |
| <b>High</b>       | 21,976                 | 23,772        | 45,871        | 79               | 239,471        | 19,166                       | 95,732                      | 9,736            | 3,252           |
| <b>Medium</b>     | 11,840                 | 1,555         | 669           | 0                | 125,226        | 5,944                        | 48,902                      | 2,735            | 2,192           |
| <b>Low</b>        | 1,744                  | 3,059         | 36            | 0                | 2,279          | 734                          | 3,545                       | 1,648            | 1,082           |
| <b>TOTAL</b>      | <b>35,560</b>          | <b>28,385</b> | <b>46,575</b> | <b>79</b>        | <b>366,977</b> | <b>25,844</b>                | <b>148,179</b>              | <b>14,120</b>    | <b>6,527</b>    |

**Table 22: Load to groundwater with recharge factors applied by nitrogen source category in the Volusia Blue Spring BMAP area (lb-N/yr)**

§ = Combination of all WWTF subcategories: RIBs and sprayfields

| Recharge Category    | Atmospheric Deposition | WWTFs         | WWTFs– Reuse  | Septic Systems | Sports Turfgrass Fertilizers | Urban Turfgrass Fertilizers | Farm Fertilizers | Livestock Waste |
|----------------------|------------------------|---------------|---------------|----------------|------------------------------|-----------------------------|------------------|-----------------|
| <b>High (90 %)</b>   | 19,778                 | 41,355        | 21,395        | 215,524        | 17,249                       | 86,159                      | 8,763            | 2,927           |
| <b>Medium (50 %)</b> | 5,920                  | 334           | 777           | 62,613         | 2,972                        | 24,451                      | 1,368            | 1,096           |
| <b>Low (10 %)</b>    | 174                    | 4             | 306           | 228            | 73                           | 354                         | 165              | 108             |
| <b>TOTAL</b>         | <b>25,872</b>          | <b>41,693</b> | <b>22,478</b> | <b>278,365</b> | <b>20,295</b>                | <b>110,965</b>              | <b>10,295</b>    | <b>4,131</b>    |

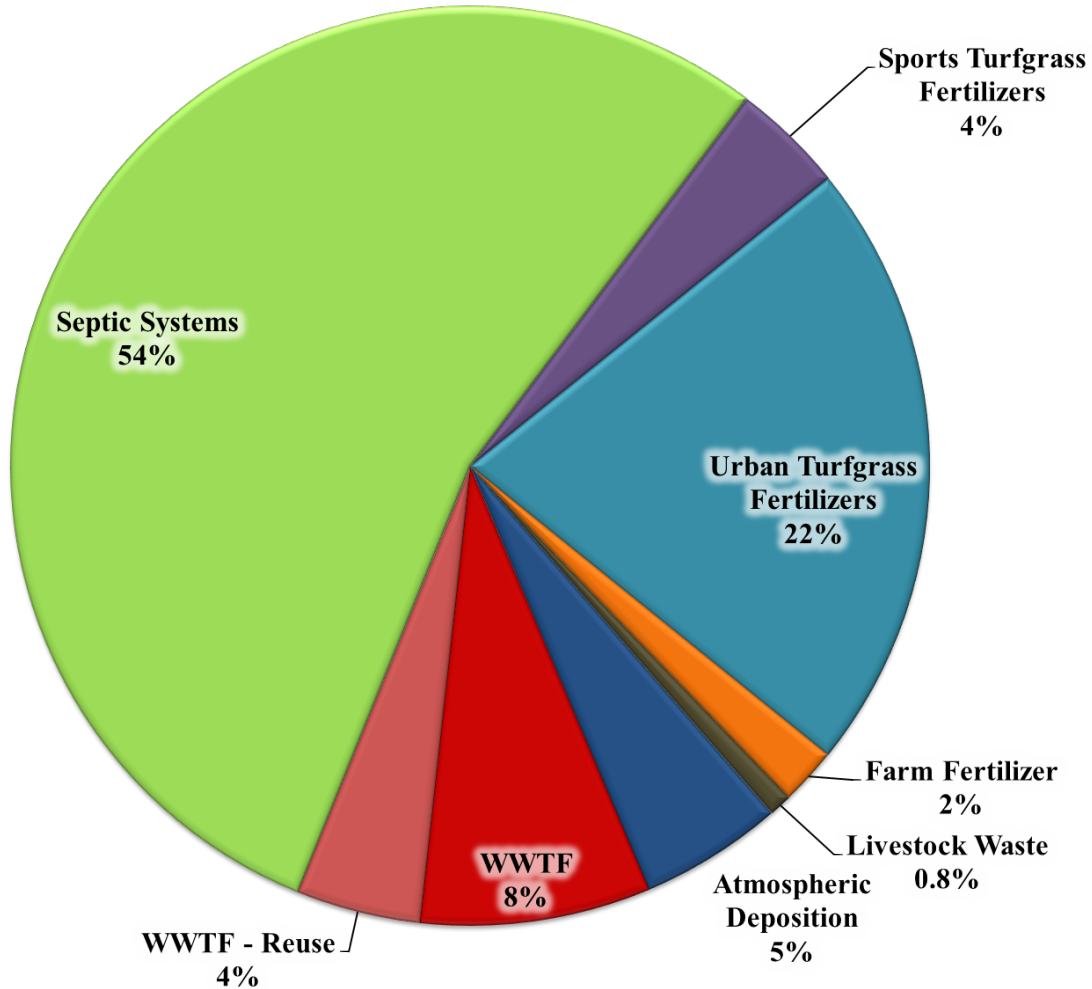


**Figure 8: Relative percent contributions of nitrogen loading to groundwater for source categories in the Volusia Blue Spring BMAP area**

**Figure 9** summarizes the estimated nitrogen loads to groundwater for the different recharge rate areas, including a breakdown for each source category. The majority of the nitrogen loading to groundwater in the Volusia Blue Spring BMAP area (81 %) occurs in high rate recharge areas. For both the high and the medium recharge rate areas, the dominant sources of nitrogen loading to groundwater are septic systems and farm and urban fertilizers.

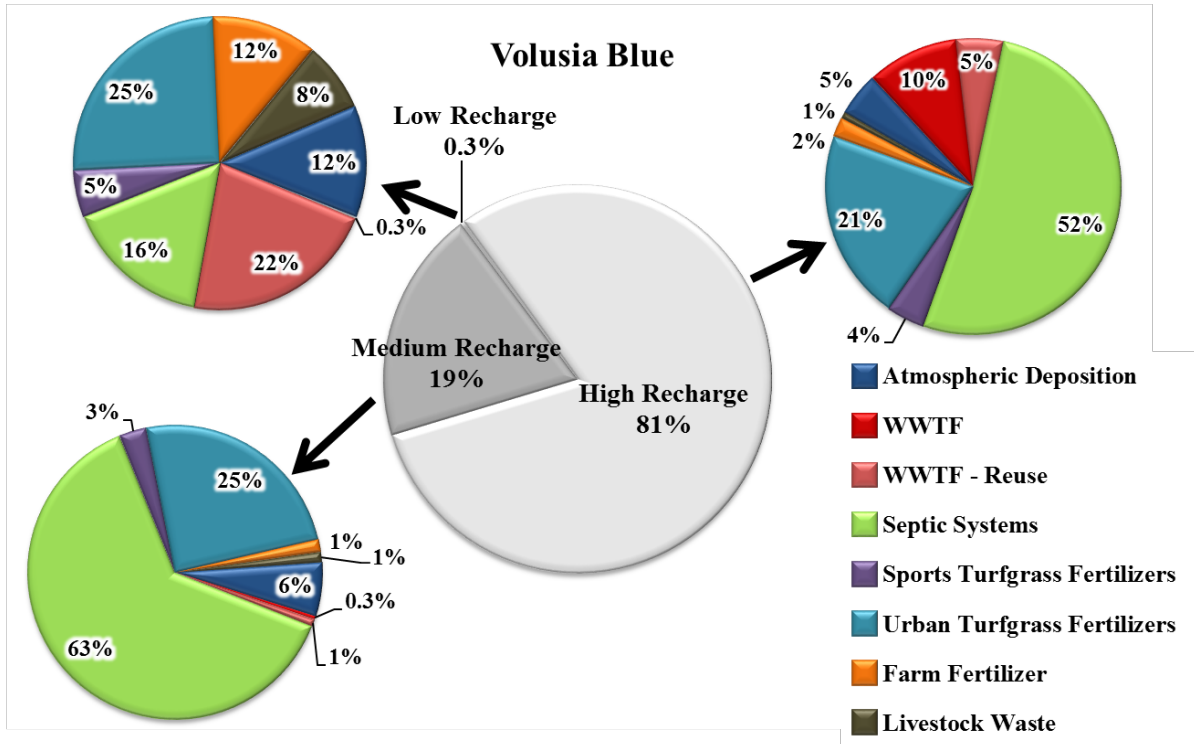


**Figure 9: Estimated annual nitrogen loading to groundwater by recharge category**

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

The pie charts (**Figure 8** and **Figure 9**) provide information about the relative contribution of nitrogen loading to groundwater from each source (and are based on average nitrogen attenuation factors). 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, particularly septic tank systems, can also significantly affect the amount of attenuation in the subsurface.

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 Volusia Blue Spring BMAP area. Greater emphasis was placed on information on nitrogen attenuation from studies in central Florida, other locations in Florida, or areas with very similar soil and vegetation characteristics. **Table 23** lists the range in nitrogen attenuation for each source.

**Table 23: Range of environmental attenuation of nitrogen from a detailed literature review**

\* = Both sports and urban turfgrass.

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

Using the minimum and maximum BAFs in **Table 20**, DEP estimated a corresponding range of nitrogen loading to groundwater from each source in the BMAP area (**Figure 10**). Even with the relatively large range in nitrogen attenuation for each source, the total estimated nitrogen load to groundwater in the Volusia Blue Springshed greatly exceeds the target load (TMDL) estimated for Volusia Blue Spring. The target N load is based on the most recent discharge data and the TN concentration discharging from the spring vent.

For Volusia Blue, the discharge is 126 cfs (USGS gauge station 02235500; January 2013–January 2014), and the adopted TMDL is 0.35 mg/L for the spring and run (Holland and Bridger 2014), resulting in a target nitrogen load of 86,683 lb-N/yr. Using the mean nitrogen attenuation factors for each source, the total load to groundwater in the BMAP area is 514,095 lb-N/yr, which is considerably higher than the TMDL target nitrogen load for Volusia Blue Spring (**Figure 11**).

Elevated nitrate concentrations in Volusia Blue Spring and other springs in Florida are contributing to water quality degradation in spring runs and other receiving surface waters. The NSILT results for spring BMAP areas will help develop strategies for restoration to reduce nitrogen loading to groundwater from major anthropogenic sources in spring contributing areas.

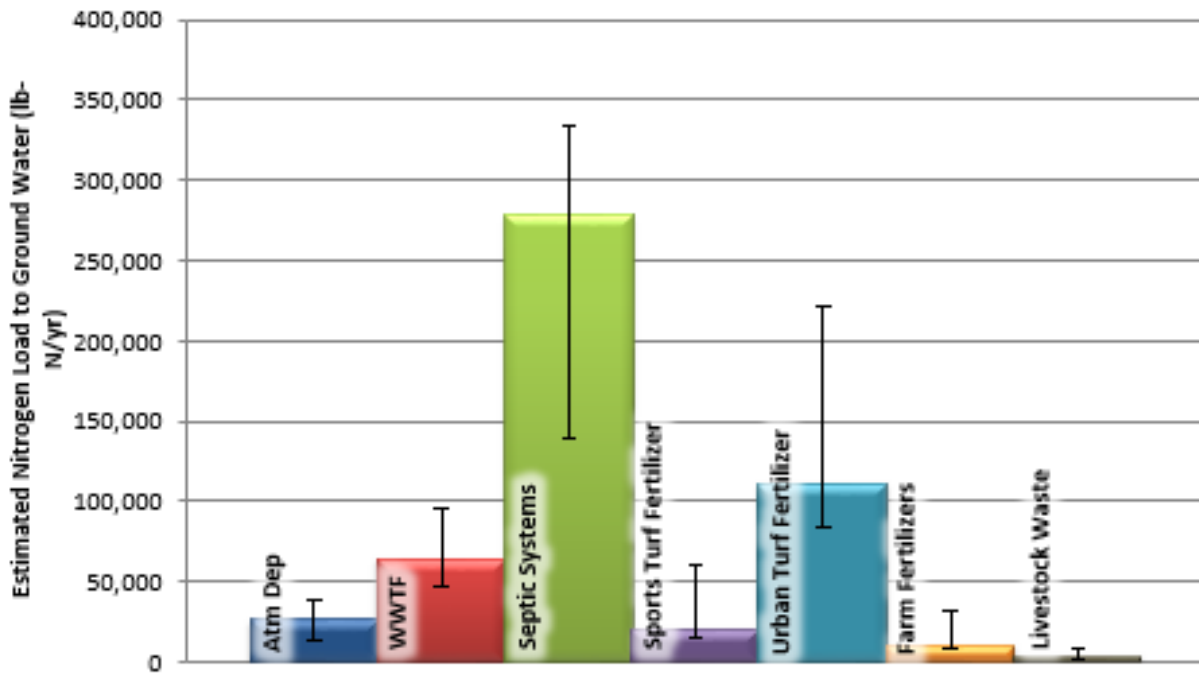


Figure 10: Influence of the range of attenuation factors on estimated nitrogen loads to groundwater from each category in the Volusia Blue Spring BMAP area

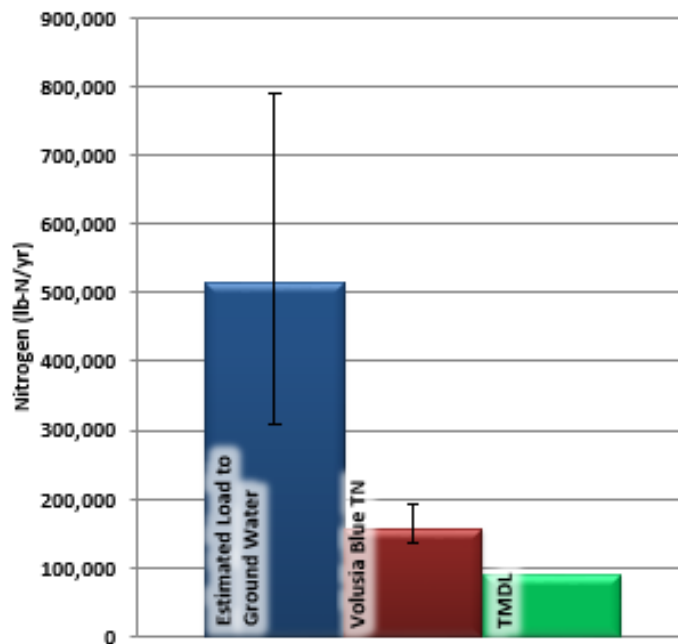


Figure 11: Estimated nitrogen load to groundwater compared with the current nitrogen discharging from Volusia Blue Spring and the TMDL goal

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## Appendices

### Appendix A: Tables

**Table A.1: Useful conversion factors**

| Convert from                               | To                                       | Multiply by                 |
|--------------------------------------------|------------------------------------------|-----------------------------|
| <b>Pounds</b>                              | kilograms                                | 0.4535924                   |
| <b>NO<sub>3</sub> milligrams per liter</b> | NO <sub>3</sub> grams-nitrogen per liter | 2.260 X 10 <sup>-4</sup>    |
| <b>NH<sub>4</sub> milligrams per liter</b> | NH <sub>4</sub> grams-nitrogen per liter | 7.765 X 10 <sup>-4</sup>    |
| <b>milligrams</b>                          | grams                                    | 0.001                       |
| <b>grams</b>                               | kilograms                                | 0.001                       |
| <b>milligrams</b>                          | kilograms                                | 1 X 10 <sup>-6</sup>        |
| <b>acre</b>                                | hectares                                 | 0.4046873                   |
| <b>square meters</b>                       | hectares                                 | 0.0001                      |
| <b>cubic centimeters</b>                   | liters                                   | 0.001                       |
| <b>tons</b>                                | kilograms                                | 907.1847                    |
| <b>cubic feet</b>                          | liters                                   | 28.31685                    |
| <b>second</b>                              | year                                     | 3.170979 X 10 <sup>-8</sup> |
| <b>rainfall (centimeters)</b>              | rainfall (liters per hectare)            | 104                         |

**Table A.2: Summary of SJRWMD land use data in Volusia County**

| Category         | Land Use Code | Land Use Description                                                     | County Acres | High Recharge | Medium Recharge | Low Recharge | Discharge |
|------------------|---------------|--------------------------------------------------------------------------|--------------|---------------|-----------------|--------------|-----------|
| <b>Livestock</b> | 2110          | Improved pastures (monocult, planted forage crops)                       | 27,690.39    | 572.80        | 579.18          |              | 51.86     |
| <b>Livestock</b> | 2120          | Unimproved pastures                                                      | 4,118.90     |               |                 | 17.84        |           |
| <b>Livestock</b> | 2130          | Woodland pastures                                                        | 4,310.87     | 203.48        | 155.17          |              |           |
| <b>Livestock</b> | 2310          | Cattle feeding operations                                                | 17.41        |               |                 |              |           |
| <b>Livestock</b> | 2320          | Poultry feeding operations                                               | 145.68       | 5.80          | 4.15            |              |           |
| <b>Livestock</b> | 2500          | Specialty farms                                                          | 6.43         | 3.95          |                 | 2.42         |           |
| <b>Livestock</b> | 2510          | Horse farms                                                              | 3,211.17     | 36.42         | 90.02           |              | 5.38      |
| <b>Livestock</b> | 2520          | Dairies                                                                  | 125.42       |               |                 | 23.28        |           |
| <b>Livestock</b> | 3100          | Herbaceous upland nonforested                                            | 4,216.48     | 109.95        | 164.71          | 78.67        | 48.17     |
| <b>Livestock</b> | 3200          | Shrub and brushland (wax myrtle or saw palmetto, occasionally scrub oak) | 20,681.53    | 311.44        | 372.19          | 107.99       | 18.70     |
| <b>Livestock</b> | 3300          | Mixed upland nonforested                                                 | 7,705.13     | 314.40        | 80.10           |              | 7.72      |
| <b>Farm</b>      | 2140          | Row crops                                                                | 283.34       | 7.89          |                 |              |           |
| <b>Farm</b>      | 2143          | Potatoes and cabbage                                                     | 0.07         |               |                 | 1.60         |           |
| <b>Farm</b>      | 2150          | Field crops                                                              | 4,092.92     | 61.64         |                 |              | 1.02      |
| <b>Farm</b>      | 2160          | Mixed crop                                                               | 102.15       |               |                 |              |           |
| <b>Farm</b>      | 2200          | Tree crops                                                               | 266.90       | 6.78          | 0.24            |              |           |

*Nitrogen Source Inventory and Loading Estimates for the Volusia Blue Spring and Volusia Blue Spring Run  
Contributing Area, February 2017*

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| Category     | Land Use Code | Land Use Description                                       | County Acres | High Recharge | Medium Recharge | Low Recharge | Discharge |
|--------------|---------------|------------------------------------------------------------|--------------|---------------|-----------------|--------------|-----------|
| <b>Farm</b>  | 2210          | Citrus groves                                              | 2,644.77     | 82.68         | 25.13           |              |           |
| <b>Farm</b>  | 2240          | Abandoned tree crops                                       | 128.55       |               |                 |              |           |
| <b>Farm</b>  | 2400          | Nurseries and vineyards                                    | 91.58        |               |                 |              |           |
| <b>Farm</b>  | 2410          | Tree nurseries                                             | 1,076.71     | 1.79          |                 |              |           |
| <b>Farm</b>  | 2420          | Sod farms                                                  | 1,850.45     |               |                 |              |           |
| <b>Farm</b>  | 2430          | Ornamentals                                                | 1,192.63     | 48.72         | 4.90            |              |           |
| <b>Farm</b>  | 2431          | Shade ferns                                                | 4,557.99     | 39.43         | 4.07            |              |           |
| <b>Farm</b>  | 2432          | Hammock ferns                                              | 4,239.95     | 121.47        | 1.54            |              |           |
| <b>Farm</b>  | 2450          | Floriculture                                               | 7.98         |               |                 |              |           |
| <b>Urban</b> | 1100          | Residential, low density – less than 2 dwelling units/acre | 18,670       | 2,106         | 852             | 96           | 79        |
| <b>Urban</b> | 1180          | Residential, rural – 1 unit on 2 or more acres             | 26,883       | 4,594         | 1,726           |              | 65        |
| <b>Urban</b> | 1190          | Low density under construction                             | 224          | 25            |                 | 132          |           |
| <b>Urban</b> | 1200          | Residential, medium density – 2–5 dwelling units/acre      | 54,220       | 12,062        | 6,973           |              | 283       |
| <b>Urban</b> | 1290          | Medium density under construction                          | 1,896        | 634           | 49              | 2            |           |
| <b>Urban</b> | 1300          | Residential, high density – 6 or more dwelling units/acre  | 10,245       | 1,052         | 302             |              | 6         |
| <b>Urban</b> | 1390          | High density under construction                            | 540          | 201           | 29              | 19           |           |
| <b>Urban</b> | 1850          | Parks and zoos                                             | 1,021        | 95            | 197             |              | 26        |

**Table A.3: Summary of property appraiser land use acres in the Volusia Blue Spring  
BMAP area by recharge zone**

- = Empty cell/no data  
AG = Agricultural

| Property Code | Land Use Description              | High Recharge | Medium Recharge | Low Recharge | Discharge |
|---------------|-----------------------------------|---------------|-----------------|--------------|-----------|
| 77            | Clubs, Lodges, Halls              | 33            | 139             | 144          |           |
| 84            | Colleges                          | 3             | 9               |              |           |
| 4             | Condominiums                      | 85            | 7               |              | 1         |
| 79            | Cultural Organ., Facilities       |               | 0               |              |           |
| 74            | Homes for the Aged                | 134           | 83              |              |           |
| 85            | Hospitals                         | 74            |                 |              |           |
| 39            | Hotels/Motels                     | 5             | 11              | 2            | 2         |
| 71            | Institutional – Churches          | 283           | 208             | 3            |           |
| 73            | Institutional – Hospitals Private | 2             |                 |              |           |
| 72            | Institutional – Private Schools   | 79            | 40              | 0            | 5         |
| 7             | M/F/R Communities                 | 1,098         | 125             | 23           | 2         |
| 8             | Multi-Family Less Than 5 Units    | 93            | 34              |              | 0         |
| 3             | Multi-Family More Than 5 Units    | 171           | 107             |              |           |
| 2             | Residential Mobile Homes          | 215           | 209             | 31           | 5         |
| 1             | Residential Single Family         | 14,061        | 7,006           | 318          | 360       |
| 0             | Residential Vacant Land           | 4,016         | 2,365           | 463          | 91        |
| 83            | Schools, Public                   | 686           | 635             | 5            |           |
| 99            | Acreage Not Zoned Agricultural    | 1,321         | 646             | 616          |           |
| 66            | AG Citrus                         | 18            | 3               |              |           |
| 52 or 53      | AG Cropland                       | 122           |                 |              |           |
| 69            | AG Ornamental                     | 105           | 25              | 13           |           |
| 61            | AG Pastures, Improved             | 565           | 345             | 262          | 76        |
| 63            | AG Pastures, Native               | 244           | 92              | 274          |           |
| 62            | AG Pastures, Semi-Improved        | 353           | 105             | 27           |           |
| 38            | Golf Courses                      | 903           | 70              |              |           |

**Table A.4: Volusia County zoning data**

- = Empty cell/no data

| Zoning Code | Zoning Description                             | % Max 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           |                    |
| 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)                             |                    |

| <b>Zoning Code</b> | <b>Zoning Description</b>                              | <b>% Max Lot Coverage</b> |
|--------------------|--------------------------------------------------------|---------------------------|
| <b>PDP(SU)</b>     | PDP (Single-Family)                                    |                           |
| <b>PDP(SU)</b>     | PDP (Special Use)                                      |                           |
| <b>R1A</b>         | R1A Residential District                               | 0.35 %                    |
| <b>R1B</b>         | R1B Residential District                               | 0.35 %                    |
| <b>R1C</b>         | R1C Residential District                               | 0.35 %                    |
| <b>R1MH</b>        | R1MH Residential Single-Family<br>Manufactured Housing |                           |
| <b>R2</b>          | R2 Residential District                                | 0.35 %                    |
| <b>R2.5</b>        | R2.5 Residential District                              | 0.35 %                    |
| <b>R3</b>          | R3 Residential District                                | 0.45 %                    |
| <b>R4</b>          | R4 Residential District                                | 0.45 %                    |
| <b>RC</b>          | RC Recreational Commercial District                    |                           |
| <b>RM</b>          | RM Residential Mobile Home District                    | 0.35 %                    |
| <b>RR</b>          | Residential District                                   | 0.45 %                    |