EXECUTIVE SUMMARY

VOLUSIA BLUE SPRING

RESTORATION PLAN
Volusia Blue Spring is located west of Orange City in east-central Florida, south of DeLand and north of Orlando, and is a tributary to the Middle St. Johns River (Figure 1). Volusia Blue Spring and Volusia Blue Spring Run are in the 2,644-acre Blue Spring State Park (Figure 2). In addition to providing recreational opportunities for park visitors, the spring and spring run provide critical habitat for the threatened West Indian manatee (*Trichechus manatus*) and several endemic snail species. The spring discharges from the Upper Floridan Aquifer through a spring vent situated 20-feet beneath the land surface and divers have mapped a cave system to a depth of 125 feet. The spring run flows approximately 0.4-miles from the spring vent to the St. Johns River. This Volusia Blue Spring Restoration Plan Executive Summary integrates data from the entire Volusia Blue Spring Restoration Area, a total of 187 mi$^2$ (119,680 acres) that includes the maximum extent springshed, state park, and the spring and spring run.

Spring flow reductions are a result of lowered pressures in the Floridan Aquifer System which feeds Volusia Blue Spring. The Volusia Blue Spring Recovery Plan approved by the St. Johns River WMD in their minimum flow rule mandated reduced pumping to allow average flows to return to a recovery target flow of 157 cfs (101 MGD) within 20 years (2024). The most recent target average flow was 144 cfs (93 MGD) while actual flows since 2014 have averaged only 131 cfs (85 MGD) - 13 cfs (8.4 MGD), lower than the target mandated by the St. Johns River WMD.

In 2009, the Florida Department of Environmental Protection (FDEP) verified that Volusia Blue Spring and Volusia Blue Spring Run is impaired because of ecological imbalances attributed to elevated nutrient concentrations. In 2014, a total maximum daily load (TMDL) was developed by the FDEP to establish a water quality restoration threshold for
nitrate-nitrogen of 0.35 milligrams-per-liter (mg/L) for both Volusia Blue Spring and Volusia Blue Spring Run. Elevated nitrate-nitrogen concentrations in Volusia Blue Spring result from current and historical land use practices contributing nitrogen to the highly-transmissive Floridan Aquifer. FDEP has determined that stakeholders in and around Volusia Blue Spring will need to reduce their nitrogen loads to the spring by 45% or roughly 434 tons-of-nitrogen-per-year.

**OTHER IMPACTS & ECOLOGICAL CHANGES**

Despite its inclusion in a state park, intensive human recreation and high manatee densities also impact the ecological health of Volusia Blue Spring. The designated swimming area and the upper spring run receive tens-of-thousands of human-use-days during the non-manatee season. Record manatee numbers are recorded most years since this spring is the principal winter warm-water refuge for the expanding Middle St. Johns River manatee population. High human and manatee use also likely contribute to depauperate populations of submerged aquatic vegetation and proliferation of filamentous algae in the spring run.

Depleted and polluted groundwater at Volusia Blue Spring is resulting in significant changes in the type, nature, and function of the spring and spring run ecosystems. Changes in springs ecology are manifested as declining water clarity, loss of native vegetation and aquatic wildlife, and increasing dominance by filamentous algae.

Restoration and protection of Volusia Blue Spring will only be successful by a multi-faceted, integrated effort by multiple stakeholders to identify all external stressors and to deal with them as needed to return this endangered spring ecosystem to health.
Volusia Blue Spring is a first-magnitude artesian spring, discharging groundwater from the Upper Floridan Aquifer. A single spring vent feeds the 2,200-foot long spring run, ending in the St. Johns River at Mile 119, near Hontoon Island, about three miles upstream from Lake Beresford and about 30-miles upstream from DeLeon Springs. Volusia Blue Spring has a long cultural history including a major Amerindian temple mound, a 19th century plantation house, and was historically an important center of commerce throughout the Middle St. Johns River area.

All public access to and viewing of the spring run is from the east/south side of Blue Spring Run. The park also includes a general store, meeting facilities, a historic residential house, camp sites, cabins, pavilions, a playground, and restroom facilities.

The spring run can be divided into three designated reaches (Figure 3) with estimated lengths as follows:

- The Public Use Area (1,280 ft.) extending from the Spring Boil downstream to the Swimming Area and including the Diver Entry dock;
- A Manatee Refuge with limited public access or viewing opportunities (508 ft.) extending from the Swimming Area down to the Upper Observation Deck; and
- Manatee Refuge and Public Viewing Area (410 ft.) extending downstream from the Upper Observation Deck down to the mouth of Blue Spring Run.
Volusia Blue Spring lies at approximately 29 degrees north latitude in a transitional area between the warm, temperate climate of the southeastern U.S. and the subtropical climate of peninsular Florida. Mean monthly temperatures for DeLand range from 56°F in January to 81°F in July. The long-term average rainfall near Blue Spring is about 53 inches (Figure 4). Maximum recorded annual rainfall was 84 inches and the minimum recorded annual rainfall total was 35 inches. Other than a repeating 50-year variation of about 5 to 7 inches per year, there is no long-term trend in annual rainfall at Blue Spring. The period from June through September is normally considerably wetter than the dry season from October through May.

Figure 4. Rainfall trends at ten rainfall stations near Volusia Blue Spring from 1909 to 2017.

Figure 5 provides a generalized geological cross-section near Volusia Blue Spring. The ground surface at Blue Spring State Park is covered with sandy marine sediments of Pleistocene to recent age. The broad, nearly level marine terraces, relic shorelines and karst ridges which characterize the landscape, are of Pleistocene age. The areas adjacent to the St. Johns River are more recent in geologic origin.

The geologic material can be divided into an upper sequence of unconsolidated or poorly consolidated deposits and a lower sequence of limestone and dolomitic rocks. The depth to rock on the eastern edge of the DeLand Ridge is about 65 ft. The thickness of the surface sand/clay/shell deposits varies from 50 to 100 feet under the DeLand Ridge because of differences in local relief. The carbonate rocks of the lower sequence are limestone and dolomite of Middle and Upper Eocene age. These rocks comprise the Floridan Aquifer System.
A springshed occupies areas within ground- and surface-water basins that contribute to the discharge of the spring. The boundary of the ground-water basin varies because of changes in water pressure in the aquifer. The water pressure changes in response to the seasonal pattern of rainfall, and in response to long-term factors such as drought and the amount of groundwater withdrawn from the aquifer. Utilizing historic and recent potentiometric maps for the Floridan Aquifer, the Florida Springs Institute prepared a boundary estimate for the maximum extent springshed east of the St. Johns River (Figure 6). The maximum extent of all of those springshed estimates is 187 mi$^2$ and includes most of the areas that historically and currently may have served as recharge areas feeding Volusia Blue Spring. This is the Volusia Blue Spring springshed map that is used for assessing impairments to the water quantity and quality at Volusia Blue Spring.
Most of the water discharging from Blue Spring is from rain that falls on the land area within the springshed. Assuming the historic flow of 162 cfs (105 MGD) at Volusia Blue Spring and the estimated recharge area, the average rate of recharge is about 14.5 inches per year. Based on an average of 53 inches of annual precipitation, this is equivalent to about 27% of the annual rainfall; and, assuming negligible surface runoff, on average about 73% of annual rainfall or 38.7 inches per year is lost to evapotranspiration.

Blue Spring is a natural breach in a clay layer that separates the surface sands of the surficial aquifer system from the limestone and dolomite rocks of the Floridan Aquifer system. An aquifer is any layer of rock, sand, or other material through which water can flow. The principal features of a spring system include an upland area where rainfall seeps into the surficial aquifer system. There also may be sinkholes or gaps in the clay layer where water can flow downward into the limestone aquifer. Interconnected solution cavities and cracks in the limestone conduct large quantities of water to the spring vent. Large springs, such as Blue Spring, are at the end of a complex drainage system in an aquifer that underlies the land surface.

Water flows upward from a spring vent because the water level of the spring pool is lower than the water level in higher parts of the springshed. Thus, the spring system is analogous to a water-distribution system in which a standpipe, or large water tank, stores water at a higher elevation than homes. Water flows “downhill” from the water tank through the distribution plumbing to the homes and through natural voids in the limestone to Blue Spring. In general, the greater the distance from the rainfall to the spring vent, the longer the travel-time. Speed of water movement in the Floridan Aquifer is not the same everywhere in the springshed. Large systems of interconnected cavities can transport water rapidly through the aquifer system.

Groundwater that discharges from the spring is a mixture of water from different parts of the springshed and of various ages. Additionally, some of this water from rainfall mixes with ancient seawater still present in deep layers of rock. Groundwater flow models indicate that about half of the water discharged from Blue Spring is between about 40 and 110 years old. These age estimates indicate that present-day spring water quality is likely affected by both decades-old and more recent land use practices.
Figure 7 provides the entire period of discharge measurements for Volusia Blue Spring beginning in 1932. Average discharge for years 1932-1974 measured by the USGS was 105 MGD (162 cfs) and is classified as “historic flow.” The mean annual flow for Volusia Blue Spring for the entire period-of-record was 155 cfs (100 MGD), with a range of annual averages between 121 and 184 cfs (78 to 119 MGD). These data show a long-term decline in discharge over the period-of-record.

Unlike streams, the temperature of spring water discharging from the Floridan Aquifer System is nearly constant. Geologic material is a good insulator, and rocks and sediments buffer changes in the temperature of groundwater that might result from recent recharge. Spring water temperature tends to reflect the average annual air temperature near the spring, or about 68 to 74°F in Florida’s Springs Region. This nearly constant temperature makes spring water feel cold to swimmers in the summer in contrast to warmer air temperature, and warm in the winter when spring water temperature is warmer than the air temperature. Springs and spring runs are attractive to wildlife, as well as people, because of the nearly constant flow of water at a uniform temperature.

The dissolution of limestone and dolomite rock creates the caves and solution cavities that are characteristic of the Floridan Aquifer System. This dissolution occurs when rain, which becomes acidic due to the inclusion of atmospheric carbon dioxide, percolates through the surficial aquifer sediments and reacts with the limestone and dolomite. The dissolving process also affects the chemistry of water discharged by a spring, adding calcium, magnesium, bicarbonate, and sulfate ions to the water. Another major factor affecting groundwater quality is the occurrence of seawater that borders the Florida peninsula, and underlies the entire state at various depths. Seawater is chemically complex but is predominately a sodium-chloride type of water. At some locations, including along the St. Johns River, ancient seawater can move upward from deep layers of rock and become part of the water discharged by springs. Such is the case for Blue Spring, which discharges water of a predominately sodium-chloride type.

Water from Blue Spring generally is not suitable for drinking because the chloride concentration at times exceeds the recommended secondary drinking water level of 250 mg/L. Chloride concentrations exceeding 250 mg/L may have an objectionable salty taste for many people. The concentration of chloride in Blue Spring is rising over time and has exceeded 700 mg/L.
Figure 8 provides a map of recent land uses within the Volusia Blue Springshed. Urban and built-up land uses occupy the highest percentage of the springshed at 41.6%, followed by wetlands at 21.4%, and upland forest at 20.1%. Intensive agriculture makes up 6.2% of the springshed, followed by rangeland at 4%. Remaining categories include transportation at 2.8% and barren lands at 0.2%. Volusia and Orange counties have a combined estimated 2016 population of 855,129. The total estimated population in the Blue Spring springshed is 128,920, or an average of 1,236 people per square mile.

Figure 8. Land use in the Volusia Blue Springshed for 2013 - 2016.
CONCEPTUAL SPRINGS MODEL

A conceptual model provides a tool for summarizing the most important components of the Blue Spring ecosystem (energy and matter storages) and their inter-relationships (Figure 9). The Blue Spring conceptual ecosystem model defines boundaries with external influences clearly identified, as well as quantifying internal energy and matter flows and their hypothesized interactions.

The Volusia Blue Spring Ecosystem Model includes the following components:

**External Forcing Functions**
Inflows of energy from outside the model domain that are powering the ecosystem

- Sunlight
- Rainfall with dissolved and particulate nutrients
- Groundwater inputs of water and dissolved nutrients
- Atmospheric gas diffusion
- Temperature
- Watershed/springshed interactions
- St. Johns River
- Human goods and services

**Downstream Exchanges**
Exports out of the ecosystem model domain connecting it to adjacent sources of plant and animal diversity

- Manatees moving in and out from the St. Johns River
- Fish, amphibians, reptiles, birds moving in and out from the St. Johns River and surrounding uplands
- Aesthetic and economic benefits to humans both within and outside the aquatic environment

**Internal State Variables**
Storages of energy in the ecosystem

- Water
- Nutrients and suspended solids
- Detritus/microbes
- Periphytic algae/aquatic macrophytes
- Aquatic herbivores (other than manatees, such as mullet, tilapia, turtles, aquatic insects, etc.)
- Manatees
- Aquatic carnivores (catfish, bream, bass, aquatic insects, etc.)
- Aquatic top carnivores (e.g., alligators and otters)
- Humans and aesthetics
Water quality in Blue Spring and Blue Spring Run is characteristic of the Floridan Aquifer, with relatively high clarity, high dissolved solids, and generally low pollutant concentrations. The mean temperature of the spring is 73.4°F. Dissolved oxygen is typically quite low in Blue Spring (average 0.6 mg/L) and increases downstream in the run to an average of 1.4 mg/L at the confluence with the St. Johns River. The average specific conductance in Blue Spring Run was 1,976 µS/cm with an observed range from 1,210 to 2,420 µS/cm. Color in the spring run is very low and averages 3.2 platinum cobalt units.

Between 2010 and 2012, total nitrogen (TN) average concentrations in Blue Spring Run ranged from 0.56 to 0.67 mg/L. On average, approximately 74% of this nitrogen was in the nitrate form with average concentrations between 0.39 and 0.55 mg/L. Ammonia nitrogen averages ranged from 0.05 to 0.09 mg/L (about 12% of TN) and organic nitrogen ranged from 0.06 to 0.12 mg/L (14% of TN). Nitrate concentrations in Volusia Blue Spring since 1975 have ranged from below natural background levels to 1.2 mg/L. Although concentrations of nitrate have shown considerable fluctuation, an overall increasing trend in concentrations is apparent since 1974 (Figure 10).

Total phosphorus (TP) average concentrations in Blue Spring Run ranged from 0.070 to 0.082 mg/L, primarily in the form of dissolved ortho-phosphate. There is no apparent increasing trend in TP concentrations in Volusia Blue Spring.
Based on microscopic identification of material captured in plankton nets, a variety of periphyton and macroalgae exist in Blue Spring. Individual and colonial diatoms were observed. Filamentous macroalgae observed included cyanobacteria (blue-green algae), as well as green algal species. FDEP sampling suggests that filamentous algae dominate vegetative cover in Volusia Blue Spring Run. In a 2007-2008 study, the only recorded submerged aquatic plant was southern naiad. Emergent and floating aquatic plants included pennywort, duckweed, water lettuce, buttonbush, water fern at low densities, primarily along the edges of the spring run. Alligatorweed and water hyacinth were the most common exotic plant species. Although these floating aquatic plants appeared to persist along the shoreline of the spring run, they were most abundant when the St. Johns River water and floating plants entered the lower spring run.

Low concentrations of dissolved oxygen may be inhibiting colonization of the spring run by submerged aquatic macrophytes. High recreational use and manatee grazing may also be contributing to the observed low diversity and abundance of submerged, floating, and emergent aquatic plants in Blue Spring.

CONSUMERS

The FDEP estimated Volusia Blue Spring’s Stream Condition Index (SCI) in the mid-2000s, finding values considered to be “Very Poor” to “Poor.” Low values of the SCI are typically found in aquatic systems with low dissolved oxygen concentrations. Since dissolved oxygen is low in Blue Spring Run due to natural conditions, the low SCI for this site may be a natural condition and not related to human influences. Macroinvertebrates collected in Blue Spring Run included between 9 and 22 taxa. A large portion of this macroinvertebrate population was comprised of organisms tolerant of low-dissolved oxygen concentrations (e.g., non-biting midges).
FDEP assessed the snail community in Volusia Blue Spring Run using two methods, a Petite Ponar dredge and a standard D-frame dip net. Average snail densities were higher in the middle and lower spring run (10,123 and 10,505 snails/m², respectively) and lowest upstream (3,031 snails/m²). The endemic hydrobiid snail species were the dominant taxa at all three sampling sites.

Fish populations in Blue Spring Run have been surveyed on multiple occasions by researchers from Stetson University. A total of 32 fish species have been observed in the spring run. Fish counts were generally higher in the winter months than in the summer. Dominant fish species in terms of numbers were: mosquitofish, bluegill, sailfin molly, rainwater killifish, and least killifish. These species are generally small fish and their total biomass is relatively low; however, due to their short life histories and high turnover rates, they contribute significantly to secondary productivity in the spring run. Larger fish that were present at significant densities included warmouth, golden shiner, suckermouth catfish, redear sunfish, spotted sunfish, striped mullet, largemouth bass, longnose gar, and tarpon. Some of these fish are very large (tarpon over 40 inches in length were observed). While these larger fish are generally not feeding in the spring run, their presence may be important as prey species for other carnivores (e.g., otters and piscivorous birds) or may be indicative of other life history needs (e.g., temperature refuge or osmotic regulation in the relatively salty spring water). The presence of non-indigenous (exotic) fish species can be quite dramatic in Blue Spring, as blue tilapia, vermiculated sailfin catfish, grass carp, and pacu can be routinely observed. However, these species were estimated to comprise a small proportion of the total fish assemblage density.

Population surveys for aquatic turtles found seven species. Most captured turtles belonged to three species: peninsula cooters (62%), Florida red-bellied turtles (16%), and loggerhead musk turtles (20%). The remaining species were uncommon with red-eared sliders, common musk turtles, Florida snapping turtles, and Florida softshell turtles together comprising less than 2% of all turtle captures.

Manatee use has been documented at Blue Spring State Park since the 1970s. A growing number of manatees that inhabit the middle part of the St. Johns River and its tributaries rely on Blue Spring as a critical winter refuge. Because the temperature of the St. Johns River can drop into the 40°F-50°F range manatees must come into the warmer spring water to survive. Manatee use of Blue Spring as a winter, warm-water refuge has increased markedly during the forty-two years of observation (Figure 11). Total observed manatees have increased from about 11 individuals in 1970-71 to 400 in 2011-12. Manatees utilize Blue Spring Run seasonally (Figure 12). Highest seasonal use is typically between December and January.
Figure 11. Volusia Blue Spring manatee counts by year for the period-of-record.

Figure 12. Observed seasonality of manatee use at Volusia Blue Spring from 1979 to 2006.
As of 2017, there were a total of 242 groundwater consumptive use permits (CUPs) within the Volusia Blue Springshed. The permitted average groundwater extraction from the Floridan Aquifer for these CUPs is 30.6 million gallons per day (MGD). Estimated groundwater pumping in Volusia and Lake counties in 2010 was about 185 MGD and the estimated average pumping in the Volusia Blue Springshed was 12.1 MGD.

Groundwater in the Floridan Aquifer is relatively mobile between areas of high recharge and areas of high pumping. Pumping effects on spring flows are local and regional. Increasing groundwater use for irrigating agricultural, residential, and golf course lands in the Volusia Blue Spring groundwater basin and in the entire St. Johns River Water Management District has led to declining spring flows. Over time, groundwater withdrawals may lower aquifer water levels to the point where there is no longer sufficient pressure gradient to support a discharge at Volusia Blue Spring.

The Florida Springs Institute has determined that average flows from Florida’s 1,000+ springs have declined by 32% as of 2010. In 2010, the estimated average spring flow reduction in the St. Johns River WMD springs was about 22% or 276 MGD. The estimated average recharge to the Floridan Aquifer System in the St. Johns River WMD is about 1,530 MGD. Total estimated groundwater extraction from the Floridan Aquifer System in the St. Johns River WMD in 2010 was 979 MGD or 64% of estimated average recharge. These estimates indicate that a large fraction of the groundwater extracted in the St. Johns River WMD recharges the Floridan Aquifer in neighboring WMDs, and especially the Suwannee River WMD where estimated gross groundwater pumping is about 7% of the estimated recharge but spring flows have declined on average by 48%.

Period-of-record total monthly discharge data from Volusia Blue Spring indicate that before the 1960s when regional groundwater pumping in Central Florida began a marked increase, average flows at Blue Spring were about 160 cfs (103 MGD). However, measured spring flows have been following a mostly downward trend since the 1960s, with a more rapid decline beginning around 2000. By 2014, average flows at Blue Spring were about 20 cfs (13 MGD) below their required 148 cfs (96 MGD) minimum flow (Figure 7).

Spring discharge and resulting current velocities have been shown to be one of the most important factors affecting springs ecological health. Spring ecosystems are more productive when they have higher flows, and inversely, they have lower productivity and food-chain support when flows decline. This finding illustrates one critical measure of ecological harm caused by any reduction in average spring flows. Current velocity is also part of the springs hydraulic regime. Recent research conducted at several springs in Florida has shown that colonization of springs by harmful filamentous algae is accelerated by declining current velocities. Above known thresholds, spring run currents strip away attached algae.
Elevated concentrations of nitrate-nitrogen are widespread in the Floridan Aquifer and in the area that recharges Volusia Blue Spring (Figure 13). Anthropogenic sources of nitrogen to the Floridan Aquifer in this region include septic systems (Figure 15), human wastewater disposal systems such as sprayfields and rapid infiltration basins, animal wastes, and urban and agricultural fertilizers. The total estimated nitrogen load to the land surface in the Volusia Blue Springshed is 1,135 tons/yr. A summary of estimated anthropogenic nitrogen contributions to Blue Spring by source includes:

- Urban fertilizer  443 tons/yr
- Septic wastes   363 tons/yr
- Wastewater facilities  91 tons/yr
- Farm fertilizer   34 tons/yr
- Livestock wastes  34 tons/yr

Uncontrollable atmospheric deposition within the Volusia Blue Springshed was estimated by FDEP as 182 tons of nitrogen per year. The total nitrogen load to groundwater in the Volusia Blue Spring basin was estimated by FDEP as 257 tons/yr.

In summary, the nitrate-nitrogen concentrations discharging from Volusia Blue Spring are above the Florida numeric nutrient standard of 0.35 mg/L. FDEP is requiring a 45% reduction in nitrogen loading in the Volusia Blue Springshed to achieve the numeric nutrient criterion for nitrate.

Figure 13. Groundwater nitrate concentrations measured near Volusia Blue Spring, 2000-2004.

RECREATIONAL USE

The total number of people visiting Blue Spring State Park in 2011 was 532,549, and included 50,428 overnight and 482,121 daily visitors (approximately 91% were in the park for day use only). Visitation to Blue Spring has been consistently increasing throughout the period-of-record (Figure 14). Human use is seasonal with two peaks of activity: The colder months during high periods of manatee use in the spring run (December to March) and the summer period when the spring and adjacent river are most popular for swimming and boating activities. Unlike most other spring-themed Florida state parks, Volusia Blue has seasonal and spatial limits on in-water recreational uses. Vegetation trampling and resulting increases in turbidity and reductions in water clarity are evident from the swim dock upstream to the spring boil during the summer, non-manatee season when in-water activities are allowed.
Volusia Blue Spring is protected through existing federal, state, and local ordinances, all designations that are intended to limit or totally prevent ecological impairment. However, as documented by the environmental information summarized in this report, piecemeal or lax enforcement of existing regulations has not been successful at halting the continuing decline in the health of Volusia Blue Spring or the Floridan Aquifer it depends on for nourishment. Examination of existing policies, and elimination of their inadequacies and/or lax enforcement of existing laws is necessary to reverse the ongoing decline of ecological health in Volusia Blue Spring.

REGULATORY PROGRAMS FOR COMPREHENSIVE PROTECTION AND RESTORATION OF VOLUSIA BLUE SPRING

GENERAL PROTECTIONS
Blue Spring and Hontoon Island State Parks are a component of the Florida Greenways and Trails System. All waters within the units have been designated as Outstanding Florida Waters. Surface waters in Blue Spring State Park are also classified as Class III waters by FDEP with the following designated uses: “recreation, propagation and maintenance of a healthy, well-balanced population of fish and wildlife.” Florida surface water quality standards and criteria (e.g., dissolved oxygen, pH, temperature, bacteria, metals, pesticides, and other organic chemicals) are described in Chapter 62-302 of the Florida Administrative Register and Administrative Code. In 1998, the EPA issued a strategy requesting each state to develop a plan for adopting Numeric Nutrient Criteria, in addition to already established numeric criteria for other parameters. To comply, Florida adopted statewide numeric nitrogen and phosphorus criteria for springs and rivers. (F.A.C. Rules 62-302.531 and 62-302.532). In addition to numeric criteria, there are also narrative criteria such as the prohibition of discharging toxic materials in toxic amounts.

Under Section 303(d) of the Clean Water Act, states are required to compile a list of impaired waters and submit that list to EPA for approval. Impaired waters do not meet applicable state water quality standards, (i.e., do not support their designated use(s)). The Florida Watershed Restoration Act (FWRA; Section 403.067(4), Florida Statutes) requires the listing of all impaired waters. These waters are scheduled for development of a Total Maximum Daily Load (TMDL) for each regulated pollutant that exceeds standards.

The TMDL provides a regulatory pollutant reduction goal that can be implemented to restore the designated use of the water.

FDEP adopted nutrient TMDLs for Volusia Blue Spring and Volusia Blue Spring Run in 2014. The TMDLs established a target of an annual average of 0.35 milligrams per liter (mg/L) of nitrate and a mandatory reduction in nitrogen loading of 45%.

Chapter 373, Part VIII, Florida Statutes (F.S.), created the “Florida Springs and Aquifer Protection Act” to provide for the protection and restoration of Outstanding Florida Springs (OFS), which comprise 24 first-magnitude springs, six additional named springs, and their associated spring runs. FDEP has assessed water quality in each OFS and has determined that 24 of the 30 OFS are impaired for the nitrate form of nitrogen. Volusia Blue Spring is one of the impaired first magnitude OFS.

FDEP is currently working to develop a Basin Management Action Plan (BMAP) for Volusia Blue Spring and Volusia Blue Spring Run. FDEP published a draft BMAP for Volusia Blue Spring in August 2017. The deadline for completion of this BMAP is July 2018 as required by the Florida Springs and Aquifer Protection Act of 2016. The draft Volusia Blue Spring BMAP provides for a phased implementation schedule (5-, 10-, and 15-year targets) designed to achieve incremental reductions within the first 15 years, while simultaneously monitoring and conducting studies to better understand the water quality dynamics in the basin.
Among other provisions, Section 403.067(7), F.S., specifies that a BMAP must include the following components:

- The delineation of priority focus areas (PFAs);
- Identification and estimated pollutant load within the PFA of each point source or category of nonpoint sources;
- A list of all specific projects and programs identified to implement a nutrient TMDL;
- A septic system remediation plan, including all specific projects in the plan;
- A priority ranking, planning-level cost estimate, estimated completion date, and estimated nutrient load reduction for each listed project;
- The source and amount of financial assistance to be made available by FDEP, a water management district, or other entity for each listed project; and
- A description of best management practices adopted by rule.
FDEP determined that septic systems represent 54%, urban turfgrass fertilizer (22%), and wastewater treatment facilities (12%) of the total nitrogen loading to the spring. The total nitrogen load reduction to the Floridan Aquifer required to meet the TMDL is 48,743 pounds of nitrogen per year (lbs-N/yr). To measure progress towards achieving the necessary load reductions, FDEP has established the following milestones:

- 14,623 lbs-N/yr (30%) within 5 years;
- 24,371 lbs-N/yr (50%) within 10 years;
- 9,749 lbs-N/yr (20%) within 15 years; and
- Total of 48,743 lbs-N/yr within 20 years.

It should be noted that these required reductions are at the aquifer and are much lower than what is required at the land surface. The draft BMAP as currently written does not recognize this disconnect and all project nitrogen load reduction estimates are calculated for the land surface and not at the point of entry to the aquifer. For example, the draft BMAP includes 37 stakeholder projects to improve water quality, of which 17 projects have estimated load reductions. Included are wastewater facility upgrades and projects to reduce urban turfgrass fertilizer application. The 37 projects are estimated to achieve a reduction of 47,745 lbs-N/yr. FDEP estimates the balance needed for compliance to be achieved is only 997 lbs-N/yr. In fact, based on the NSILT evaluation of nitrogen loads to the land surface of 2,270,000 lbs-N/yr, the required load reduction of 45% is equal to 1,021,500 lbs-N/yr, leaving a balance of 973,755 lbs-N/yr required for compliance. In summary, the draft BMAP is inadequate to achieve the Blue Spring TMDL in a timely fashion.

**WATER WITHDRAWALS**

The St. Johns River WMD regulates all water uses within its boundaries pursuant to the provisions of Chapter 373, F.S. and consistent with Chapter 62-40, F.A.C. A consumptive use permit (CUP) is required prior to the withdrawal or diversion of water (typically more than 100,000 gallons per day) for any water use except those expressly exempted by law or District rule. Individual residential water wells, exempted from the permitting process, are required to be permitted during installation, tested for contamination, and permitted for abandonment.

A permit applicant must meet three conditions to receive a consumptive use permit, as per Section 373.223, F.S. The use must be a reasonable-beneficial use, which is defined as “the use of water in such quantity as is necessary for economic and efficient utilization for a purpose and in a manner, which is both reasonable and consistent with the public interest”. Second, the use must not cause harm to other users. Finally, the use must be consistent with the public interest. The Florida Water Resources Act of 1972 specifies that FDEP create a state water use plan which includes policies related to water supply, water quality, flood protection, and regional supply plans. Fla. Stat. § 373.036(1). The St. Johns River WMD is required by Chapter 373, F.S., to assess water supplies every five years to determine if natural systems will be able to maintain a healthy condition and supply demands for water.
The St. Johns River WMD establishes Minimum Flows and Levels (MFLs) for lakes, wetlands, streams, and springs. The minimum flow for a surface water course defines the limit at which further water withdrawals would be significantly harmful to the water resources or ecology of the area. MFLs are determined using the best available information and also consider non-consumptive uses of water. Fla. Stat. § 373.042.

The St. Johns River WMD adopted a MFL for Volusia Blue Spring in 2006, following many years of analyses. Data indicated that Blue Spring flows were below the point of significant harm to critical water and human use values, and the resulting MFL included a recovery strategy to restore average flows to protective levels. The first increment set the minimum long-term mean flow at 133 cubic feet per second (cfs) until March 31, 2009. This minimum long-term mean flow then increases during each of four subsequent 5-year intervals to the following:

- April 1, 2009 through March 31, 2014 – 137 cfs;
- April 1, 2014 through March 31, 2019 – 142 cfs;
- April 1, 2019 through March 31, 2024 – 148 cfs; and
- After March 31, 2024 – 157 cfs.

As indicated earlier in this report, Volusia Blue Spring flows are currently well below the stated requirements of the WMD’s MFL.

ENVISIONING A FUTURE FOR VOLUSIA BLUE SPRING

American Indians occupied the lands along the St. Johns River and springs for thousands of years before European conquest. While they left no written history, archaeological explorations have documented stable human populations, a large shellfish industry, and construction of temple mounds, numerous human burials, and extravagant grave goods, including artistic and practical works of stone, bone, and wood.

The famous travel writer and botanist, John Bartram, visited the area in 1766. European habitation is documented from as early as 1856, with a citrus plantation centered at the Louis Thursby Family House, located immediately adjacent to Blue Spring and constructed on a former American Indian mound. With development of steamboat traffic on the St. Johns River and the Florida East Coast Railroad through Orange City, the spring became a travel destination for northern tourists. The State of Florida purchased the land around Blue Spring and developed the Blue Spring State Park beginning in 1972.

These early records present a vision of a recovering wild Florida along the St. Johns River. The original inhabitants had been exterminated or removed from the area during Spanish rule through the early 18th century. Northern American Indian tribes, principally the Creeks from South Carolina, colonized Florida during the 1700s. The new inhabitants, named the Seminoles, lived as agriculturalists and hunters up through the time of expanding U.S. colonization in the late 1700s and early 1800s, and were largely removed after the Second Seminole War in the 1830s.

The vision of Volusia Blue Spring, relatively untouched by the developed human world, is a spring boil with a strong flow of crystal-clear, unpolluted water, and a spring run colonized by waving submerged grasses and supporting a high density of fish and other wildlife, including a stable manatee population. Anecdotal reports indicate Blue Spring matching this description as late as the 1970s. In quantitative terms, this vision for a restored Volusia Blue Spring will only be achieved if the following general recommendations are followed:

- Reduce regional groundwater extractions by 50 percent or more as needed to restore average spring flows to 95 percent of their historic levels;
- Reduce nitrogen loadings to the springshed from fertilizer and human/animal wastewater disposal by 45 percent or more as needed to achieve the springs nitrate numerical standard of 0.35 mg/L; and
- Place a carrying capacity on recreational activities negatively affecting the spring cave/vent and the upper spring run area.
KEY STAKEHOLDERS

There are tens of thousands of private landowners who will be affected by any comprehensive restoration of the Volusia Blue Spring because the majority of the springshed is in private ownership. Based on our current understanding of the actions that will need to be taken to achieve the desired spring restoration goals, many of these private landowners will be affected by groundwater and fertilizer use restrictions and possibly increased fees for water and wastewater management, either through local utility rate increases or by possible upgrades to on-site sewage disposal systems.

HOLISTIC ECOLOGICAL RESTORATION

In summary, the anticipated final Volusia Blue Spring BMAP must provide realistic but stringent groundwater use and nitrogen reduction measures, regardless of whether they adversely affect agriculture or urban land use practices. Costs for these upgrades may be significant. The flow reduction and nitrate contamination at the Volusia Blue Spring will not be solved unless all options are on the table and evaluated for cost effectiveness simultaneously, rather than a piecemeal approach of divided responsibilities by an array of state and local agencies. The most logical approach is to use financial incentives to encourage increases in the efficiency of groundwater uses and nitrogen fertilizers. All groundwater uses should be monitored and reported and subject to an Aquifer Protection Fee per gallon of groundwater extracted from the aquifer. All nitrogen fertilizer sales should also be reported and subject to an Aquifer Protection Fee per pound of nitrogen purchased.

Ongoing public education about the threats facing the long-term health of Volusia Blue Spring will be essential for achieving ultimate restoration. This Volusia Blue Spring Restoration Plan provides a preliminary roadmap to fully accomplish restoration goals. However, getting this information out to the public and to the state officials and legislators who are most concerned with springs’ protection is an important part of this educational process. This will require public presentations, public meetings, newspaper and television reporting, rallies at area springs, and many partnerships.

The Howard T. Odum Florida Springs Institute and the Volusia Blue Spring Alliance can provide technical support and educational materials and will be joined with other springs advocacy and educational organizations throughout North Central Florida.

Groundwater is one of the most important natural resources in Florida. Currently, the groundwater that feeds the Volusia Blue Spring Restoration Focus Area is neither clean nor abundant. As evidenced so clearly by the deteriorating water quality and declining flows at Volusia Blue Spring, Florida’s groundwater resources are also on a declining trajectory. Fortunately, if it rains, groundwater is a renewable resource. Hope for the future health of the Volusia Blue Spring Restoration Focus Area and for Florida’s springs in general is in the hands of the people who have learned to appreciate the unique value of these public resources.
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Technical information relevant to this study was extracted from the FDEP Blue Springs Total Maximum Daily Load (TMDL) and Basin Management Action Plan (BMAP) reports, and from work conducted and summarized by Wetland Solutions, Inc. and Stetson University researchers.

The Florida Springs Institute accepts full responsibility for all findings and conclusions and any errors or omissions in this executive summary.

ABOUT US

The Howard T. Odum Florida Springs Institute (FSI) is a private, non-profit corporation funded by grants and donations. The mission of FSI is to provide technically-sound information about Florida’s 1,000+ artesian springs needed for their protection and wise management. Since 2011, FSI has prepared holistic restoration plans for many of the major springs in Florida including the springs that feed the Santa Fe, Ichetucknee, Suwannee, and Wekiva rivers, Silver Springs, Rainbow Springs, the Kings Bay/Crystal River springs, and Wakulla springs. The Volusia Blue Spring restoration plan is the final volume in this series of individual spring-group restoration plans. All FSI documents, including the full springs restoration plans and their executive summaries can be downloaded from www.floridaspringsinstitute.org.

The Florida Springs Institute is working to create a permanent research center focused on springs and aquatic ecology, and education at a major Florida spring. In the meantime, we are devoting our time and energy to developing restoration and management goals for as many springs as possible, and providing sound science for their protection and restoration.

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