Acknowledgments

The Howard T. Odum Florida Springs Institute (FSI) acknowledges the efforts of numerous springs scientists and recreationalists who have devoted their life energies to understanding Florida’s springs and working for their long-term restoration and protection. The information summarized in this document incorporates the work of professionals from nearly every environmental institution and agency in Florida, including the Florida Department of Environmental Protection, the state’s five water management districts, the Florida Fish and Wildlife Conservation Commission, the U.S. Geological Survey, the U.S. Fish and Wildlife Service, and multiple state universities and colleges. The Florida Springs Conservation Plan was prepared with financial support from the Fish and Wildlife Foundation of Florida, Inc. “Protect Florida Springs” Tag Grant PFS 1819-03 and the Jelks Family Foundation.

Principal authors of this report include Robert Knight, Executive Director of the Howard T. Odum Florida Springs Institute, and Heather Vick, FSI volunteer and professional hydrogeologist with Washington Department of Ecology. Publication design was provided by Emma Gersper, formerly with the Florida Springs Institute. Cover photo of striped bass at the Natural Well at Silver Glen Springs is by John Moran. The Florida Springs Conservation Plan was prepared in response to the 2016 Florida Springs Restoration Summit hosted by the Florida Springs Council. FSI accepts full responsibility for any errors or omissions in this Springs Conservation Plan.

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Taking Action to Conserve Florida’s Springs

Background

For more than a century, the State of Florida has attracted new residents because of its moderate winter climate and natural beauty. This inviting environment has propelled urban and commercial development to support a rapidly increasing population. In addition, agriculture has taken advantage of Florida’s temperate climate and generous water resources to develop land for food and forage production, including citrus, row crops, livestock, and dairy products. Increasing economic development has resulted in inevitable stresses on Florida’s natural environment as humans continue to alter the landscape to suit their needs. While Florida’s beaches, estuaries, rivers, and springs are what attracted many people to the state in the first place, the negative effects and resulting environmental ‘footprint’ of increasing human and livestock populations have taken their toll on the state’s imperiled natural resources.

North Florida is home to more than 1,000 artesian springs that are dependent on groundwater from the Floridan Aquifer System, creating the largest concentration of first magnitude springs in the world. While Florida’s artesian springs vary in many ways, including flow rate, mineral content, location (rural versus populated areas), geography (coastal versus inland), and plant and animal species, nearly all of Florida’s springs are suffering from a combination of anthropogenic impacts that include declining flows and increasing pollution due to accelerated human development.

The total area of Florida that has the potential to negatively affect the Floridan Aquifer and the state’s 1,000+ artesian springs is about 42,460 mi² and encompasses all or parts of 53 counties. This “Florida Springs Region” includes all areas in Florida where freshwater is primarily withdrawn from the Floridan Aquifer and where surface nitrogen sources at the land surface have the potential to contaminate the underlying aquifer. Florida’s Springs Region encompasses about 65% of the state’s land and water area, including an estimated 2018 resident population of 11.6 million as well as an even larger non-resident tourist population.
Spring Threats

The two greatest impacts to Florida’s springs over the past half-century are the decreased availability of clear flowing groundwater for discharge from the springs and the rise in concentrations of nitrate-nitrogen in the upper Floridan aquifer. There is compelling evidence that these stresses are the direct or indirect result of human activities rather than to natural variation in climate and regional ecology. As documented throughout the past 60-years of scientific study, starting with the seminal work of Howard T. Odum at Silver Springs, and summarized recently by the Florida Springs Institute, declining long-term aquifer levels and spring flows are due to increased groundwater pumping, and elevated/rising nitrate-nitrogen concentrations in the Floridan Aquifer and springs are due to fertilizer and waste inputs. These principal stresses, in combination with structural changes such as dams and seawalls, invasive plant management using herbicides, and increasing recreational impacts, have severely degraded many of Florida’s springs.

Responding to the last 20+ years of documented springs health declines, the Florida Springs Council, with technical support from the Florida Springs Institute, is focused on reversing this trend and to restore and protect springs in Florida. This mission and the impetus for the Florida Springs Conservation Plan is summarized next.
Vision
Restore Florida’s springs to their former healthy ecological condition consistent with observations prior to the 1960s. Then preserve and protect the restored springs for future generations of humans and wildlife to enjoy and prosper.

Goals
- 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 loading to springsheds from fertilizer and human/animal wastewater disposal by 50 to 90 percent as needed to consistently achieve Florida’s springs nitrate numerical nutrient standard of 0.35 mg/L;
- Eliminate or mitigate structural alterations affecting springs health;
- Curtail the widespread use of herbicides for aquatic plant control in springs and spring run ecosystems, and
- Determine and enforce human carrying capacities for publicly-owned springs and reduce recreational impacts as needed to maintain springs ecological health.
**Actions**

- Florida needs to use groundwater more efficiently and cut back significantly on pumping from the Floridan Aquifer, with a shift to increased reliance on surface water supplies for all non-potable uses. Mandatory monitoring of groundwater extractions accompanied by a reasonable fee for all non-potable groundwater uses will help accomplish this goal. A recommended preliminary target is to cut back to pre-1990 groundwater pumping rates within the next decade. These cuts need to be across the board in all counties that overlap springsheds. Once it is demonstrated that flows at sentinel springs rebound, it may be necessary to cut pumping back further. A permanent cap on Florida’s groundwater use must be established.

- Use of nitrogen-containing fertilizers in the Springs Region needs to be severely limited to achieve the desired nitrate reduction goal in Florida’s springs. A mandatory fee on the nitrogen content of fertilizer will help to accomplish this goal. All central wastewater facilities in the Florida’s Springs Region should be required to achieve advanced nitrogen removal standards. Nitrogen loading to the environment from septic tanks and animal waste disposal systems need to be taxed and no new septic tanks should be permitted on land parcels in Florida’s springs region less than five acres.

- Dams blocking spring outflows and downstream runs should be removed to allow free passage of migratory springs fauna and unimpeded springs discharges.

- Aquatic plant control in springs and spring runs should be restricted to mechanical methods and limited to the smallest areal extent needed to allow navigation.

- Recreational use in all publicly-owned Florida springs should be evaluated for environmental impacts and limited by designated human carrying capacities based on standard criteria.

- The ecological health of representative “sentinel springs” should be continually monitored and annually evaluated/reported to guide effective management and protection of this valuable natural resource.

**Did you know?**

Although many of the most significant stressors to Florida’s springs are large-scale withdrawals and nitrate pollution, there are still a multitude of actions individuals can take to be good springs stewards:

- **Vote!** Exercising your right to vote is a great opportunity to let your voice be heard and help shape environmental legislation.

- **Educate!** Knowledge is power and the more people know about springs impairments, the more involved people will become in the efforts for restoration.
Left: Ponce de Leon in Florida in 1517 (detail from a painting by Thomas Moran 1878)

Below: Jacksonville, Florida skyline and fountains symbolize the excessive use of a finite groundwater supply. All potable water used in this large city comes from the Floridan Aquifer with minimal efforts to recycle purified water back to the source.

**Significant Spring Landscapes**

**Historical Perspective**

Long before Walt Disney World, the State of Florida was a place of natural wonders and indigenous creations. From the coral reefs of the Florida Keys to the Panhandle’s ‘sugar sand’ beaches, from the Apalachicola to the St. Johns rivers, and from the Everglades to North Florida’s artesian springs, Florida’s original natural environments were a priceless gift to humans and the wild animals that occupied this land. These natural wonders have made tourism the largest economic driver in Florida today. The Magic Kingdom, Sea World, Universal Studios, and thousands of other human creations also attract many visitors to Florida. Although beaches are one of Florida’s signature natural tourist attractions, many Floridians as well as savvy travelers from around the world enjoy a less-publicized endemic tourist attraction – Florida’s 1,000-plus artesian springs.

Photo by Mark E. Park, TrekEarth.
Not surprisingly, Florida’s artesian springs have been degraded due to excessive agricultural, urban, and industrial development. The resulting impacts of a permanent statewide population of over 21 million, and more than 100 million tourists each year, have negatively affected the quantity and quality of water discharging from Florida’s springs with cascading impacts through the aquatic food web of dependent plants and animals. These undesirable changes have been widely noted and intensively studied over the past 20 years, resulting in a variety of state and local efforts to protect springs from additional harm and to restore them to some semblance of their previous health and grandeur.

**Springs Restoration Areas**

For restoration and management purposes, the Howard T. Odum Florida Springs Institute has divided Florida’s Springs Region into four principal Springs Restoration Areas. Encompassed within those four broad areas are 12 Springs Focus Areas that each include one or more major springs and their springsheds. This geographical grouping is used as a framework that accounts for regional variation in springs forcing functions, including climate, land use, recreation, and administrative authority.

The table to the right lists each Springs Restoration Area/Focus Area location, land area, and major springs.
<table>
<thead>
<tr>
<th>Springs Restoration Area/Focus Area</th>
<th>Description</th>
<th>Counties</th>
<th>Surface Area (miles²)</th>
<th>Major Springs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – Panhandle Springs Restoration Area – 12,611 square miles</td>
<td></td>
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<tr>
<td>1.1 – Northwest Coast Focus Area</td>
<td>Apalachicola River to Escambia River</td>
<td>Bay, Calhoun, Holmes, Jackson, Walton, Washington</td>
<td>7,718</td>
<td>Cypress, Jackson Blue, Gainer Group</td>
</tr>
<tr>
<td>1.2 – Nature Coast Focus Area</td>
<td>Apalachicola N.F. east to Wacissa River</td>
<td>Gadsden, Jefferson, Leon, Wakulla</td>
<td>4,892</td>
<td>Wakulla, St. Marks Rise, Wacissa</td>
</tr>
<tr>
<td>2 – Suwannee Springs Restoration Area – 5,664 square miles</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1 – Upper Suwannee Focus Area</td>
<td>Upper Suwannee, North Withlacoochee</td>
<td>Columbia, Madison, Hamilton</td>
<td>1,219</td>
<td>Alapaha River Rise, Holton Creek Rise, Madison Blue, Suwannee</td>
</tr>
<tr>
<td>2.2 - Middle Suwannee Focus Area</td>
<td>Middle Suwannee from Withlacoochee to Santa Fe</td>
<td>Lafayette, Suwannee</td>
<td>959</td>
<td>Falmouth, Peacock, Lafayette Blue, Troy</td>
</tr>
<tr>
<td>2.3 - Lower Suwannee Focus Area</td>
<td>Lower Suwannee from Santa Fe to Gulf</td>
<td>Alachua, Dixie, Gilchrist, Levy</td>
<td>1,229</td>
<td>Manatee, Fanning</td>
</tr>
<tr>
<td>2.4 – Santa Fe Focus Area</td>
<td>Santa Fe and Ichetucknee rivers</td>
<td>Alachua, Baker, Bradford, Columbia, Gilchrist, Union</td>
<td>2,256</td>
<td>Santa Fe, River Rise, Treehouse, Hornsby, Poe, Gilchrist Blue, Ginnie, Devils, Blue Hole, Ichetucknee Head</td>
</tr>
<tr>
<td>3 – Gulf Coast Springs Restoration Area – 9,060 square miles</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>3.1 - Rainbow Focus Area</td>
<td>Rainbow, South Withlacoochee</td>
<td>Alachua, Levy, Marion</td>
<td>1,567</td>
<td>Rainbow, Gum Slough, Sumter Blue</td>
</tr>
<tr>
<td>3.2 - Springs Coast Focus Area</td>
<td>Crystal River, Homosassa River, Chassahowitzka River, Weeki Wachee River</td>
<td>Citrus, Hernando, Pasco, Sumter</td>
<td>2,171</td>
<td>Kings Bay/Crystal River Group, Chassahowitzka, Homosassa, Weeki Wachee</td>
</tr>
<tr>
<td>3.3 - Southwest Coast Focus Area</td>
<td>Tampa Bay, Hillsborough River, Alafia River, Peace River</td>
<td>Pinellas, Hillsborough, Sarasota</td>
<td>5,323</td>
<td>Sulfur, Lithia, Eureka, Crystal, Buckhorn, Kissingen, Zolfo, Warm Mineral</td>
</tr>
<tr>
<td>4 – St. Johns Springs Restoration Area – 15,132 square miles</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.1 – Upper St. Johns River Focus Area</td>
<td>East Florida from Indian River county to confluence with Wekiva River</td>
<td>Okeechobee, St. Lucie, Indian River, Osceola, Brevard, Orange, Lake, Seminole, Volusia</td>
<td>7,881</td>
<td>Green, Gemini, Wekiwa, Black Creek</td>
</tr>
<tr>
<td>4.2 – Lower St. Johns River Focus Area</td>
<td>From Wekiva River confluence to Mayport</td>
<td>Clay, Duval, Flagler, Lake, Marion, Nassau, Putnam, St. Johns, Sumter, Volusia</td>
<td>5,221</td>
<td>Volusia Blue, Alexander, Juniper, Silver Glen, Salt, Green Cove, Croaker Hole</td>
</tr>
<tr>
<td>4.3 - Silver Springs Focus Area</td>
<td>Silver River, Ocklawaha River</td>
<td>Alachua, Lake, Marion, Putnam, Sumter</td>
<td>2,030</td>
<td>Silver Group, Ocklawaha Lost Springs</td>
</tr>
</tbody>
</table>
Florida Springs Conservation Plan

The purpose of the Florida Springs Conservation Plan is to present a realistic, systematic, and holistic approach to restore all of Florida’s springs to their natural condition and to protect them and their intrinsic ecologic values for the enjoyment of future generations. This Plan presents a comprehensive synopsis of the status of 12 Florida Spring Restoration Areas/Focus Areas that contain the majority of Florida’s existing springs. The Plan documents current and future threats to each regional spring complex and proposes practicable actions and achievable goals that will reverse their current progressive ecological degradation and preserve them into the foreseeable future.

This Plan is not intended as a technical reference on springs ecology. Nor does this Plan provide detailed discussion of monitoring efforts proposed for individual spring systems and their associated species. A bibliography of relevant publications is provided at the end of this Plan for readers who wish to delve more deeply into those technical aspects of Florida springs ecology and management.

Three Sisters Springs are part of the vast spring complex feeding the Crystal River in Kings Bay. The U.S. Fish and Wildlife Service is striving to find a balance between human access and the 700+ manatees whose lives depend on this warm-water refuge during Florida’s winters. Photo by John Moran.
Determining the Health of Florida’s Springs

Springs in Florida have evolved over thousands or even millions of years with highly-organized plant and animal assemblages that colonized the springs long before human development. Like other natural aquatic ecosystems, springs have adapted to maximizing the transformation of solar and water energies into foodchain productivity based on optimal species diversity and numbers. Compared to other fresh water ecosystems, springs benefit from relatively constant inflows, have higher water clarity, and more consistent chemistry and water temperature because they are fed by groundwater inflows.

This combination of near optimal physical and chemical properties equates to high ecological efficiency and wildlife habitat in Florida’s springs and spring runs. Stable environmental conditions in healthy springs promote the evolution of complex, adapted plant and animal communities. The effective utilization of available light by spring ecosystems translates into a natural abundance of fish and other wildlife. In addition to the importance of spring runs for the support of productive warm-water fisheries and other fresh water fauna such as turtles and water dependent birds, they are critical for the life history of other large and economically important migratory wildlife such as striped mullet, striped bass, Atlantic eels, and West Indian manatees.

All ecosystems, including Florida’s springs, have attributes that define their structure and function. Three general attribute classes for springs include: Physical Attributes such as light and water inputs; Chemical Attributes that include gases, salts, and nutrients dissolved in the groundwater inflow; and Biological Attributes that include plants, animals, and ecosystem metabolism. This section describes the methodology used to assess the health status of Florida’s springs based on these attributes and how progress towards effective conservation of Florida’s springs can be measured.

“The bubbling spring would rise forever from the earth, its current is endless.” – The Yearling by Marjory Kinnan Rawlings (1938)
Key Attributes and Selected Indicators for Assessing Ecological Health of Florida Springs

Identifying key ecological attributes is the first step for assessing the health of Florida’s springs. Key ecological attributes were identified and classified as either physical, chemical, or biological. For each key ecological attribute, one or more measurable indicators are identified. Indicators for the ecological attributes used to assess Florida’s springs are listed below.

<table>
<thead>
<tr>
<th>Attribute Class</th>
<th>Key Ecological Attributes</th>
<th>Selected Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical</td>
<td>Flow volume</td>
<td>Discharge (volume over time)</td>
</tr>
<tr>
<td></td>
<td>Temperature variation</td>
<td>Consistency (allowable change)</td>
</tr>
<tr>
<td></td>
<td>Water clarity</td>
<td>Feet of visibility; light transmittance</td>
</tr>
<tr>
<td>Chemical</td>
<td>Dissolved oxygen</td>
<td>Percent saturation (%)</td>
</tr>
<tr>
<td></td>
<td>Specific conductance</td>
<td>Micro-siemens per centimeter (uS/cm)</td>
</tr>
<tr>
<td></td>
<td>Dissolved nitrate-nitrogen</td>
<td>Concentration (mass over volume)</td>
</tr>
<tr>
<td>Biological</td>
<td>Ecological productivity</td>
<td>Photosynthetic efficiency (primary productivity /incident sunlight)</td>
</tr>
<tr>
<td></td>
<td>Plant community composition</td>
<td>Species diversity; biomass; percent cover</td>
</tr>
<tr>
<td></td>
<td>Faunal populations</td>
<td>Species diversity; biomass; density</td>
</tr>
</tbody>
</table>

Providing some clarity

Humans have been fascinated by and drawn to water throughout history. As a basic element crucial for survival, clean water has always played a key role in societies. Therefore, it comes as no surprise that society needs to keep track of water quality and look for ways to improve it.

Photo by Margaret Tolbert.
Physical Spring Ecological Attributes and Selected Indicators

Flow Volume

Discharge (flow volume) is the volume of water flowing from a river or spring run per unit of time, commonly expressed in cubic feet per second (cfs) or million gallons per day (MGD). In general, discharge is computed by multiplying the area of water in a channel cross-section by the average velocity of the water in that cross section: $\text{Discharge} = \text{Width} \times \text{Depth} \times \text{Velocity}$ (1 cfs = 0.646 MGD).

In the schematic diagram to the right, the cross-sectional area and average water velocity of each subsection are multiplied and then summed to obtain the segment discharge. Spring discharge is a direct function of water levels (pressure) in the Floridan Aquifer. Those levels are controlled by rainfall, recharge, pumping through wells, and springs outflows. When the combined groundwater outflows to springs and wells exceed inputs from rainfall/recharge, then aquifer levels/pressures fall, and spring flows decline.

Temperature

Temperature ($T$) is a measure of the degree or intensity of heat present in a substance or object, especially as expressed according to a comparative scale and shown by a thermometer or perceived by touch. Temperature is commonly reported as degrees Fahrenheit ($^\circ F$) or Centigrade ($^\circ C$) where $T(\circ C) = (T(\circ F) - 32)/1.8$.

Relatively constant water temperature in springs is the result of their groundwater source. Subterranean temperatures are very constant and near the ground surface generally mirror the annual average air temperature. In Florida, this artesian spring temperature ranges from about 68°F in the Panhandle springs to 75°F in the Central Florida springs. Depending on spring flow, water temperature may remain relatively constant at considerable distances downstream in the spring run. Water temperature in springs is a Physical Attribute that affects all chemical and biological functions.
Most of Florida’s artesian springs are fed by groundwater that originates as rainfall recharge through sandy soils and limestone bedrock. This method of aquifer recharge produces water purified of nearly all particulate matter and containing few dissolved salts. Pure water in the absence of particulates and dissolved organics has naturally high clarity. This combination of chemical properties imparts a bluish color to very pure spring water since visible blue wavelengths are the last to be absorbed. One rapid indicator of spring water clarity is use of a Secchi disk and tape measure to estimate visible distance. A second indicator is measurement of photosynthetically-active radiation (PAR) using a submersible photo cell.

Even pure water absorbs light—about 50% within a depth of 3.2 feet. The highest clarity or visibility reported in Florida springs is over 300 feet. Clear spring water allows maximum light penetration to underwater plant and algal communities. Factors known to reduce water clarity include concentrations of dissolved organic plant compounds such as tannic acids, particulates including microscopic planktonic algae, and suspended solids such as clay and sand particles. Water clarity may also be lowered by anthropogenic impacts associated with reduced discharge, increased nutrients, and recreation. Water clarity exceeds water depth in most springs. For that reason, in springs Secchi readings are taken horizontally rather than vertically through the water column.
Chemical Ecological Attributes and Selected Indicators

Dissolved Oxygen

Dissolved oxygen (DO) refers to the concentration of free, non-bound oxygen dissolved in water. The saturated concentration of DO in water is a function of temperature and biological activity, with less oxygen dissolved at higher temperatures and more oxygen present due to plant productivity. Dissolved oxygen is generally reported as both concentration in parts per million (PPM) or milligrams per liter (mg/L), and as a percent of saturation. Analytical meters are most commonly used for estimating the DO in spring waters.

Adequate concentrations of DO are required by almost all plants and animals living in springs and spring runs. Because of their groundwater source, many springs have naturally low DO in their inflows. The concentration of DO typically increases downstream due to a combination of natural reaeration from oxygen in the atmosphere and plant photosynthesis. Low oxygen springs generally have less diverse, naturally-depauperate plant and animal communities in their headwaters, with increasing biotic diversity with distance downstream.

Specific Conductance

Specific conductance or conductivity is a measure of the ability of water to conduct electricity. High specific conductance is a function of elevated concentrations of dissolved salts that ionize in water (separate into positive and negative components). Typical dissolved positive ions in Florida artesian groundwater include calcium (Ca+), magnesium (Mg+), and sodium (Na+). Negative ions include carbonate (CO3-), sulfate (SO4-), and chloride (Cl-). An electrical meter and probe are typically used to measure specific conductance which is reported in units of micro-siemens per centimeter (µS/cm).
The variability of the specific conductance of spring water is a function of the solubility of the soils and rocks the water is exposed to in the aquifer. For example, older and deeper groundwater typically has more dissolved ions and higher specific conductance than younger groundwater. The primary salt in seawater is sodium chloride (NaCl). Elevated NaCl and specific conductance in groundwater is sometimes an indication of relic seawater that formerly filled the limestone aquifer when the Florida peninsula was below prehistoric sea levels. Rising conductivity in many of Florida’s springs is an indication of possible upwelling or intrusion of saline water due to excessive groundwater pumping.

Dissolved Nitrate-nitrogen

Nitrate-nitrogen (NO$_3$-N) is naturally found at very low concentrations in Florida’s groundwater and springs. Dissolved nitrate in water is colorless, odorless, tasteless, and highly mobile. Nitrate concentrations are measured using sophisticated analytical laboratory procedures and are reported as mg/L (parts per million) as elemental nitrogen. A typical nitrate concentration in unpolluted groundwaters is less than 0.05 mg/L as nitrogen.

All groundwater and aquifer systems are susceptible to contamination from surface pollution sources. The magnitude of contamination from the sources increases in karst areas with sandy soils overlying porous, soluble carbonate rocks such as limestone. The Springs Region of North and Central Florida has a karst topography that makes the aquifer highly vulnerable to contamination from the land surface. Elevated nitrate concentrations found in spring water originate primarily from fertilizers and animal/human wastes that are deposited on or below the land surface in karst areas.

Nitrate, being a plant-growth nutrient, when concentrated by human activities can fuel excessive algal and aquatic plant growth in surface waters, including springs. The Florida Department of Environmental Protection (FDEP) adopted a numeric nutrient standard of 0.35 mg/L for nitrate-nitrogen in most springs. Approximately 80% of Florida’s springs currently have nitrate concentrations that exceed this standard.
Biological/Ecological Attributes and Selected Indicators

Ecological Productivity

Primary productivity is the conversion of carbon dioxide and other natural nutrients in air, soil, and water into organic compounds that comprise plants and algae. Through secondary productivity these plants provide food for the animals that live in springs. Extraction of the energy embodied in plant and animal foods through metabolism requires the availability of oxygen and results in the recycling of the carbon and other nutrients in the organic biomass. The productivity and metabolism of the entire springs ecosystem can be conveniently quantified and reported in terms of the oxygen or carbon fixed and released daily. Community or ecosystem metabolism is most commonly reported in units of grams of oxygen (O\textsubscript{2}) per square meter per day (gO\textsubscript{2}/m\textsuperscript{2}/d). Ecosystem metabolism is the most integrative measure of spring health. Changes in forcing functions such as sunlight, spring flow, and nutrient inputs change the ecosystem response. Under natural conditions springs have been found to have optimal ecological efficiency. The conversion of sunlight into plant biomass is called photosynthetic efficiency and provides a method of normalizing ecological productivity in response to variable day-to-day solar inputs.

Research in Florida’s springs has indicated that increasing human perturbations such as declining discharge due to excessive groundwater pumping, increasing nitrate-nitrogen concentrations from groundwater pollution, and other structural and recreation impacts tend to change the photosynthetic efficiency of springs. A subsidy-stress gradient has been observed for nitrate pollution with moderate nitrate increases resulting in increased productivity and higher concentrations reducing ecosystem metabolism. Photosynthetic efficiency is positively affected by spring discharge. Any reduction in spring discharge appears to reduce spring metabolism.
Plant Community Composition

The condition and types of vegetation occupying a spring and spring run is an important indicator of ecosystem health. Microscopic and macroscopic plants provide the principal basis of the aquatic food chain in spring ecosystems. Both micro- and macroalgae occur in springs; however, the microscopic forms (commonly diatoms growing on submerged plant leaves) are most characteristic of undisturbed springs. Excessive growth of filamentous algae is an indicator of ecological impairment in springs. Rooted submersed vascular aquatic macrophytes, such as eelgrass and strap-leaved sagittaria, are typically the most abundant plants in undisturbed springs on a weight and cover basis. Plant and algae biomass is typically reported as grams of dry weight per square meter (g/m²) or semi-quantitatively as percent cover. Plant and algae diversity is reported as species dominance.

Major plant community changes have been documented in springs throughout North and Central Florida. Some springs have seen a rise in the biomass accompanied by a decline in the diversity of submerged plants. More commonly, spring plant communities have shifted from a dominance by submersed macrophytes to a dominance by filamentous algae. FDEP has determined that an increasing prevalence of filamentous algae is an indicator of ecological impairment in springs. The combination of changed forcing functions leading to these biotic changes in springs is still under scientific investigation.

Faunal Populations

Many of the aquatic animals inhabiting springs are largely or completely dependent on local primary productivity for food and survival. These consumer organisms can be classified as primary (herbivores), secondary (feeding on primary consumers), and top consumers. Herbivorous spring fauna include various species of immature aquatic insects, snails, crayfish, and some turtles, fish, and mammals. Secondary and top consumers include a variety of specialized turtles, fish, reptiles, amphibians, mammals, and birds. Faunal populations are often quantified by density (numbers per area) or biomass (dry or live weight per area).

Springs research in Florida has documented declines in snail and fish density, biomass, and species diversity. In some cases, these changes have been linked to specific human impacts. For example, declining fish numbers and biomass at Silver Springs are strongly associated with the presence of a downstream dam. In some springs, declining primary productivity is linked to increased nitrogen pollution and declining populations of consumer organisms such as snails and fish.
Sentinel Springs

Data Availability

Relatively few of Florida’s 1,000+ springs have been intensively monitored. Some flow and water quality data have been reported from a few hundred springs, but for many springs monitoring has only occurred on one or a few widely-spaced occasions. A much smaller number of springs and spring groups, less than 40, have received more intensive scientific study. Relatively complete ecological evaluations have been conducted at some spring systems, but at most only a few times during the last century. Discharge data spanning more than 90 years exist for less than a dozen spring systems. Only Silver Springs, formerly the largest Florida spring in terms of long-term measured discharge, has been intensively studied multiple times over a period spanning more than sixty years.

Assessing the changing ecological health of Florida’s springs is limited by the availability of adequate data. No true pre-development baseline exists for most of Florida’s springs. In consideration of this limitation, this Plan relies on those springs with the most data to serve as sentinels of changes in ecological health for springs in each of the Florida Springs Restoration Areas. With increasing public and government focus on springs recovery and protection, the Florida Springs Institute and other non-governmental organizations have become increasingly important in collecting supplemental data to document shifting springs baseline health.

FSI Springs Report Cards

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<th>Clarity</th>
<th>Nitrate</th>
<th>Faunal Prod/SAV</th>
<th>Spring Cond. Index/Algae</th>
<th>Fish Biomass</th>
<th>Photo Eff.</th>
<th>Overall Grade</th>
</tr>
</thead>
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<tr>
<td>Ichetucknee (2016)</td>
<td>D</td>
<td>B-</td>
<td>D</td>
<td>F</td>
<td>n.d.</td>
<td>B</td>
<td>C</td>
<td>C-</td>
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<tr>
<td>Rainbow (2016)</td>
<td>F</td>
<td>B</td>
<td>F</td>
<td>C</td>
<td>n.d.</td>
<td>D</td>
<td>C+</td>
<td>C-</td>
</tr>
</tbody>
</table>
Universal Springs Ecological Health Assessment Protocol

With this Plan the Florida Springs Institute introduces an updated springs ecological health assessment protocol. Springs ecological health indicators described above are rated from Very Good to Failed and used to assign an associated letter grade. Grades are based on quantitative indicators of springs health and on the observed relationship between those indicators and springs ecology. Letter grades from A to F are associated with recommendations for appropriate springs intervention responses. These indicator ratings and grades are utilized in this Plan to evaluate the current condition of a total of 32 sentinel springs/spring groups with adequate data in Florida.

<table>
<thead>
<tr>
<th>Indicator Rating</th>
<th>Letter Grade</th>
<th>Recommended Intervention Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Good</td>
<td>A</td>
<td>Ecologically desirable status; requires minimal intervention for maintenance</td>
</tr>
<tr>
<td>Good</td>
<td>B</td>
<td>Multiple indicators within acceptable range of variation, but intervention needed to raise others</td>
</tr>
<tr>
<td>Fair</td>
<td>C</td>
<td>Outside acceptable range of variation; requires human intervention for multiple health indicators</td>
</tr>
<tr>
<td>Poor</td>
<td>D</td>
<td>Degraded with significant loss of ecological health; high priority for restoration; requires immediate intervention</td>
</tr>
<tr>
<td>Failed</td>
<td>F</td>
<td>Primary spring functions very low or absent; restoration increasingly difficult; may result in the extirpation of spring and/or associated species; requires immediate and holistic intervention</td>
</tr>
</tbody>
</table>

An overall ecological health evaluation of Florida’s springs has been proposed for the 32 sentinel springs for changing conditions through 2015. None of these springs received a rating above a B+. Half of the springs in all 12 Springs Restoration Focus Areas were rated D+ or lower, and 75% were below a B−, indicating an unacceptable level of existing harm and a need for significant restoration efforts. Some individual Springs Restoration Focus Areas are in worse shape than others. Springs located in East-central Florida, Southwest Florida, and along the Suwannee/Santa Fe rivers are most imperiled due to human activities. Many of these springs are prominent centerpieces within state and county parks. Clearly, public acquisition and management of springs does not insure protection of flows, water quality, and other biological indicators. A few notable springs outside these most affected areas, such as Jackson Blue in the Panhandle Springs Focus Area and Wekiwa in the Upper St. Johns Focus Area, are also severely impaired.
<table>
<thead>
<tr>
<th>Spring/System</th>
<th>Springs Focus Area</th>
<th>Overall Rating</th>
<th>Flow</th>
<th>Salinity</th>
<th>Nitrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silver</td>
<td>Silver</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>Silver Glen</td>
<td>Lower St. Johns</td>
<td>C+</td>
<td>D</td>
<td>C</td>
<td>A</td>
</tr>
<tr>
<td>Alexander</td>
<td>Lower St. Johns</td>
<td>B+</td>
<td>B</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>Volusia Blue</td>
<td>Lower St. Johns</td>
<td>C</td>
<td>B</td>
<td>D</td>
<td>C</td>
</tr>
<tr>
<td>De Leon</td>
<td>Lower St. Johns</td>
<td>B</td>
<td>A</td>
<td>A</td>
<td>D</td>
</tr>
<tr>
<td>Wekiwa</td>
<td>Upper St. Johns</td>
<td>D-</td>
<td>D</td>
<td>D</td>
<td>F</td>
</tr>
<tr>
<td>Madison Blue</td>
<td>Upper Suwannee</td>
<td>D</td>
<td>F</td>
<td>B</td>
<td>F</td>
</tr>
<tr>
<td>Suwannee</td>
<td>Upper Suwannee</td>
<td>B-</td>
<td>F</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Lafayette Blue</td>
<td>Middle Suwannee</td>
<td>D-</td>
<td>F</td>
<td>C</td>
<td>F</td>
</tr>
<tr>
<td>Troy</td>
<td>Middle Suwannee</td>
<td>D</td>
<td>F</td>
<td>B</td>
<td>F</td>
</tr>
<tr>
<td>Falmouth</td>
<td>Middle Suwannee</td>
<td>C</td>
<td>F</td>
<td>A</td>
<td>C</td>
</tr>
<tr>
<td>Manatee</td>
<td>Lower Suwannee</td>
<td>D-</td>
<td>F</td>
<td>C</td>
<td>F</td>
</tr>
<tr>
<td>Fanning</td>
<td>Lower Suwannee</td>
<td>F</td>
<td>F</td>
<td>D</td>
<td>F</td>
</tr>
<tr>
<td>Ichetucknee Blue Hole</td>
<td>Santa Fe</td>
<td>B-</td>
<td>A</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Poe</td>
<td>Santa Fe</td>
<td>C-</td>
<td>F</td>
<td>C</td>
<td>B</td>
</tr>
<tr>
<td>Ginnie</td>
<td>Santa Fe</td>
<td>D+</td>
<td>F</td>
<td>A</td>
<td>F</td>
</tr>
<tr>
<td>Gilchrist Blue</td>
<td>Santa Fe</td>
<td>C+</td>
<td>A</td>
<td>B</td>
<td>F</td>
</tr>
<tr>
<td>Ichetucknee Head</td>
<td>Santa Fe</td>
<td>C+</td>
<td>A</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>Rainbow</td>
<td>Rainbow/Withlacoochee</td>
<td>F</td>
<td>F</td>
<td>C</td>
<td>F</td>
</tr>
<tr>
<td>Gum Slough</td>
<td>Rainbow/Withlacoochee</td>
<td>D-</td>
<td>F</td>
<td>A</td>
<td>D</td>
</tr>
<tr>
<td>Kings Bay/Crystal River</td>
<td>Springs Coast</td>
<td>D</td>
<td>F</td>
<td>F</td>
<td>B</td>
</tr>
<tr>
<td>Homosassa</td>
<td>Springs Coast</td>
<td>D</td>
<td>F</td>
<td>D</td>
<td>C</td>
</tr>
<tr>
<td>Chassahowitzka</td>
<td>Springs Coast</td>
<td>D-</td>
<td>F</td>
<td>F</td>
<td>C</td>
</tr>
<tr>
<td>Weeki Wachee</td>
<td>Springs Coast</td>
<td>C-</td>
<td>D</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Crystal</td>
<td>Southwest Coast</td>
<td>F</td>
<td>F</td>
<td>D</td>
<td>F</td>
</tr>
<tr>
<td>Sulfur</td>
<td>Southwest Coast</td>
<td>D</td>
<td>F</td>
<td>F</td>
<td>B</td>
</tr>
<tr>
<td>Wakulla</td>
<td>Nature Coast</td>
<td>B-</td>
<td>A</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Wacissa</td>
<td>Nature Coast</td>
<td>B+</td>
<td>A</td>
<td>A</td>
<td>C</td>
</tr>
<tr>
<td>Jackson Blue</td>
<td>Northwest Coast</td>
<td>D-</td>
<td>F</td>
<td>C</td>
<td>F</td>
</tr>
<tr>
<td>Gainer</td>
<td>Northwest Coast</td>
<td>B+</td>
<td>B</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>Ponce DeLeon</td>
<td>Northwest Coast</td>
<td>C+</td>
<td>F</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>Washington Blue</td>
<td>Northwest Coast</td>
<td>B</td>
<td>C</td>
<td>B</td>
<td>A</td>
</tr>
</tbody>
</table>
What are the Concerns for the Future of Florida’s Springs?

Impacts to the health of Florida’s springs are assessed based on identifying the sources of environmental stresses that may affect one or more of their key ecological attributes. Five primary sources of impairment were identified that are historically and currently acting to stress Florida’s springs. These most widespread spring impacts include: excessive groundwater extraction, nitrate pollution, physical modifications, invasive species control, and excessive recreation. These sources of stress are also considered to have a high probability of contributing further harm to Florida’s springs in the future if they remain at current levels or increase in magnitude.

Excessive Groundwater Extraction

Florida’s springs are currently experiencing the inevitable effects of long-term declines in average water levels in the Floridan Aquifer. As development continues to increase and assuming average rainfall remains within historic ranges, the net effect of increasing groundwater withdrawals from the aquifer will continue to be an overall decline in Floridan Aquifer levels and a corresponding net reduction in total spring flows. Springs at higher land elevations located near the middle of the Florida peninsula, such as White Sulfur Springs, Worthington Springs, and Silver Springs, have already demonstrated that they are the first to lose part or all their flow when aquifer levels decline. Coastal springs such as those in Kings Bay, the Homosassa River, and the Chassahowitzka River become salty (lose the freshwater fraction of their historic flows) when aquifer levels decline.

In 1950, Kissingen Spring in Polk County ceased to flow. Kissingen Spring was the first known major (2nd magnitude) Florida spring to stop flowing due to anthropogenic groundwater withdrawals from wells. Kissingen Spring is in the Peace River drainage area in the Southwest Coast Springs Restoration Focus Area. A sampling of Florida springs (and their county) that have intermittently or permanently ceased flowing include:

<table>
<thead>
<tr>
<th>Springs with Intermittent or Permanent Flow Cessation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kissingen (Polk)</td>
</tr>
<tr>
<td>Poe (Alachua)</td>
</tr>
<tr>
<td>Springs Creek (Wakulla)</td>
</tr>
<tr>
<td>Suwannee (Suwannee)</td>
</tr>
<tr>
<td>Lafayette Blue (Lafayette)</td>
</tr>
<tr>
<td>Hampton (Taylor)</td>
</tr>
<tr>
<td>Worthington (Union)</td>
</tr>
<tr>
<td>Fanning (Levy)</td>
</tr>
<tr>
<td>Marion Blue (Marion)</td>
</tr>
<tr>
<td>Madison Blue (Madison)</td>
</tr>
<tr>
<td>Peacock (Suwannee)</td>
</tr>
<tr>
<td>Magnesia (Alachua)</td>
</tr>
<tr>
<td>White Sulfur (Hamilton)</td>
</tr>
<tr>
<td>Santa Fe (Union)</td>
</tr>
<tr>
<td>Cannon (Marion)</td>
</tr>
<tr>
<td>Troy (Lafayette)</td>
</tr>
<tr>
<td>Rum Island (Columbia)</td>
</tr>
<tr>
<td>Hornsby (Alachua)</td>
</tr>
</tbody>
</table>
Groundwater is the principal source of anthropogenic freshwater supply in Florida. Rainfall is the principal source of water that recharges Florida’s underground aquifers. Although there is considerable year-to-year rainfall variation in Florida, long-term rainfall trends for the state are steady. While some groundwater uses are measured and reported, many are not. For this reason, the U.S. Geological Survey has estimated all water uses in Florida and Georgia since 1950. Estimated total groundwater use from the Floridan Aquifer in Florida and Georgia increased by more than 400% between 1950 and 2010 from 630 million gallons per day (MGD) to 3,374 MGD. Average spring flows in Florida have declined by an estimated 32% (3,336 MGD) during the same period.

**Discharge Fluctuations:** Long-term discharge recorded at two of Florida’s largest spring groups – Silver and Rainbow in Marion County – has been steadily declining since the 1970s. The Florida Springs Institute has estimated that these spring flows have declined by 34% independent of rainfall for a combined total of more than 300 MGD. While average annual flows at Silver were always significantly higher than at Rainbow during the first 50 years of records, Silver lost supremacy of flows in the 1990s.
Minimum flows and levels (MFLs) refer to “the minimum flow for a watercourse or the minimum water level for groundwater in an aquifer or the minimum water level for a surface water body that is the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area”. Florida’s five WMD’s are required, under Section 373.042 (1)(a), Florida Statutes, to develop MFLs for springs to limit groundwater withdrawals that would cause significant harm to their water resources or ecology. The goal is to set a protective hydrologic regime that will maintain the range of surface water fluctuations required to ensure healthy water resources, including species composition, vegetative structure, and ecological functions.

“Any decline in aquifer levels translates into reduced spring flows. The number of Florida springs that have decreased or ceased flows increases every year.” - Silenced Springs: Moving From Tragedy to Hope by Robert L. Knight (2015)

MFLs have been set for about 30 Florida springs. Allowable average spring flow reductions in these MFLs range from zero to about 20%, with an average allowable flow decline due to human causes of about 5 to 10% being most typical. Based on actual spring flow data the Florida Springs Institute has determined that many of the numeric minimum average flow limits required by these MFLs have already been exceeded. In most cases the water management districts rely on computer modeling and simulation estimates to determine if MFLs are exceeded or if recovery is required. The need for flow recovery is acknowledged by the Suwannee River Water Management District for Ichetucknee Springs and the springs along the Santa Fe River, and for Volusia Blue Spring by the St. Johns River Water Management District. Model estimates of groundwater extraction impacts to spring flows are highly inconsistent with springs discharge data, resulting in a significant gap between actual spring flows and regulatory limits. Flow recovery is currently a clear priority at many of Florida’s MFL springs.
Nitrate Pollution

Nitrogen is a plant-growth nutrient that is ubiquitous in the environment. Even relatively low nitrogen concentrations can cause a shift in the balance of spring ecological communities, resulting in replacement of native plants by opportunistic invasive plants and nuisance algae. Nitrate, a common inorganic chemical, is the most oxidized form of nitrogen and is readily dissolved in water. It is also the dominant form of nitrogen in groundwater and spring discharges. Nitrate-nitrogen is the most prevalent chemical pollutant detected in the Floridan Aquifer, and thus in springs that are fed by the Floridan Aquifer. In karst areas springs are vulnerable to land applications of nitrogen and other contaminants because of direct recharge to permeable limestone units comprising the Floridan Aquifer that are at or near the ground surface.

**MediNITRATE IN FLORIDA SPRINGS**
Monitored by the FDEP Florida Springs Initiative
2001-2010

**Nitrate Concentrations**: Median nitrate concentrations (2001-2010) in 58 springs monitored by the Florida Department of Environmental Protection. Nearly all of Florida’s artesian springs have nitrate concentrations higher than natural background and nearly 80% of them have median concentrations higher than Florida’s nitrate numeric nutrient criterion of 0.35 mg/L.
According to FDEP, a monthly maximum average nitrate-nitrogen concentration limit ranging from 0.22 to 0.35 mg/L (depending on individual spring characteristics) is sufficient to prevent a nutrient-imbalance in springs. In some springsheds, achieving this nitrogen target requires large reductions in nitrate-nitrogen inputs from a variety of sources that include fertilizer and human/animal wastes. As early as 1970, it was clear that Florida already had a serious groundwater and surface water nitrate pollution problem. Currently, average nitrate-nitrogen concentrations in Florida’s springs range from approximately 0.05 to more than 60 mg/L and nearly 80% of the springs tested contained nitrate-nitrogen at levels exceeding the 0.35 mg/L nitrate-nitrogen water quality standard.

Nitrate-nitrogen is known to cause acute and chronic health effects in aquatic flora and fauna. Caddisfly, mosquitofish, and aquatic frogs have known sensitivities to low concentrations of nitrate-nitrogen in laboratory studies. Nitrate readings above 0.4 mg/L have been observed to have toxic effects on macroinvertebrates. In human beings, elevated concentrations of nitrate-nitrogen in North and Central Florida’s drinking water supply, the Floridan Aquifer, increase the risk of certain cancers, birth defects, and methemoglobinemia (blue baby syndrome).

**Physical Modifications**

The physical condition of a spring may also be compromised by a variety of human alterations, including:

- Dams or seawalls
- Enclosed or enlarged man-made swimming areas
- Removal of native vegetation and replacement with landscaped and grass/lawn areas
- Beaches, ramps, steps, rails, docks, and diving platforms
- Adjacent visitor facilities (boardwalks/bridges, snack bars, restrooms, equipment sales/rentals, shuttles, etc.)
- Parking facilities
- Boat launching and beaching facilities

The visible effects of these structural modifications may include:

- Reduced spring flows
- Lost and degraded habitat area
- Elimination of natural wildlife migratory patterns
- Increased stormwater and groundwater pollution
Invasive Species

Florida is under an almost constant bombardment by newly-introduced non-indigenous plant and animal species. Springs are no exception to this invasion. Increasing cover by benthic, attached, and floating macroscopic algae is a recognized symptom of spring disturbance. Exotic macrophytic plants, both floating and submerged, have been noted in many springs and spring runs. Exotic animal species currently colonizing springs include a variety of invertebrates and fish. However, there is little information to indicate that invasive species are detrimental to the ecological health of Florida’s springs. In some cases, they may be Nature’s prescription for healing the other intentional and unintentional detrimental effects of human civilization. There is clear evidence that some methods of human control of invasive species, such as use of herbicides to eliminate floating and submerged aquatic plant species in springs and spring runs, are detrimental to springs health and should be reduced or eliminated.

Excessive Recreation

Human recreation takes a significant toll at many publicly and privately-owned and managed springs. Principal unintended consequences of increasing springs access and recreation include:

- Bank erosion due to human overuse and foot traffic
- Removal of natural submerged vegetation in overused areas
- Suspended sediments and lost water clarity in wadable areas
- Boat traffic
- Increased stormwater inputs including sediments, trash, and nutrients

Standard practice for managing the health of environmental systems is development of reasonable “carrying capacities” that prevent excessive impacts. Ichetucknee Springs State Park is a good example of a springs-based park with a protective visitor carrying capacity.
Now that springs recreation levels throughout Florida are at an all-time high, we have to find creative ways to protect these precious resources while also allowing the public to experience and understand the springs. The more people know about and appreciate them, the more they will be inspired to protect our springs.

Next Steps for Springs Conservation in Florida

Once considered the epitome of constancy in the broad spectrum of natural aquatic environments, it is now clear that Florida’s springs are changing rapidly. Average spring flows are declining, and dissolved nutrients/salts are increasing. Related ecological changes include reduced water clarity, proliferation of filamentous algae, loss of native aquatic plants, reduced primary and secondary productivity, additional structural manipulations, and increasing recreational use. The unhappy scientific prognosis is that we can expect to see increasingly unhealthy springs indefinitely into the future. The question now is not, “can springs recover?” but, “will society support and insure their recovery?”.

There are at least three necessary strategies that must be considered and pursued simultaneously to guarantee the recovery of Florida’s artesian springs. These include:

- Technical strategies
- Financial strategies, and
- Political and educational strategies.

Technical Strategies

Technical considerations for springs recovery include: (1) an ongoing assessment of springs condition/health through an integrated monitoring and assessment program; (2) immediate implementation of currently-available corrective measures, followed by an adaptive management approach to springs restoration as knowledge continues to grow; and (3) continuing applied research to better understand the complexity of springs structure and function to direct ongoing recovery actions.
Financial Strategies

As documented throughout this plan, springs restoration and recovery are in the public’s best interest. With that fact in mind, it is simple to conceive of a springs restoration effort that has minimal financial impact on the public’s pocket book. A basic amount of fresh groundwater uses and resulting nutrient waste production is an inevitable by-product of human life. Florida’s 2018 human population of 21 million residents and more than 100 million tourists is still rising and will by necessity place an impactful footprint on the environment, including the Floridan Aquifer and springs. However, most of existing springs impairments are the direct and indirect results of private businesses maximizing short-term profits while seeking to avoid long-term responsibility.

Commercial, urban, and intensive agricultural development in Florida all currently rely on the availability of abundant cheap/free groundwater and on the ability to dispose of waste by-products (pollutants) with minimal cost. This is a recipe for disaster that Florida has pursued over the past 50 years. The simplest and most cost-effective solution to these problems is the enactment of an Aquifer Protection Fee that charges users based on their Aquifer Footprint. Specifically, all groundwater uses should be monitored and standard fees applied, all fertilizer purchases should be tracked, and an Aquifer Protection Fee charged based on pounds of nitrogen applied.

A second, but less preferable, option for financing springs restoration is to try to buy our way out of the problems with public money rather than making the responsible parties pay. With this option, farmers might be paid to use less intensive agricultural production techniques, local and state governments might use public funds to implement technological fixes for dwindling and polluted groundwater supplies, and Florida might continue to invite businesses to the state by providing tax breaks and subsidized infrastructure. This option is not practical nor economically viable but appears to be the preference for many of Florida’s elected and appointed leaders.
Political Strategies and Educational Needs

The only power in politics stronger than money is a fully-informed and engaged electorate. When given a choice, Florida voters have consistently favored environmental protection over destructive development. The financially powerful corporate control of politics has greatly eroded the ability of voters to have an opportunity to express their innate environmentalism at the polls or in the courts. Correcting this situation and providing a more promising fate for Florida’s springs depends on engaged voters being able to distinguish between false political advertising and the reality of politician’s actions. This Florida Springs Conservation Plan and subsequent annual updates are intended to provide the thoughtful public with the factual scientific information they need to make political decisions that are in their own best interest.

There is no question that Florida’s springs can be healed. The only question is whether we, the current citizens and leaders of Florida, will be smart enough to restore and preserve them for future generations.
Appendix I - Description of Florida Springs

North Florida has over 1,000 naturally-flowing artesian springs that represent what may be the largest concentration of springs on Earth.

History

Florida’s springs were first discovered and used by indigenous people of the Americas (Amerindians) as early as 15,000 years before the present time (YBP). Based on archeological evidence from multiple sites, the earliest humans in Florida lived near streams and sinkholes. Florida’s climate was drier when the earliest human colonists arrived, so springs were flowing intermittently, and spring/sinkhole features were typically water-filled depressions connected by dry riverbeds. Sea levels were much lower during the end of the last North American (Wisconsin) glacial period, dictating a drier, more-continental climate.

By 5,000 to 8,000 YBP, later populations of Amerindians flourished in a subsequently wetter climate which in turn produced higher spring flows. The springs provided fresh drinking water and an abundance of food due to their highly productive natural aquatic ecosystems. Large quantities of freshwater snail and mussel shells have been found in Amerindian kitchen middens and mounds near springs along the St. Johns River and spring-fed rivers along the west coast of North Florida are often lined by coastal shell middens.

Selection of lithic artifacts recovered from Florida springs (courtesy of Coastal Plains Institute). Various artifact types are diagnostic of specific prehistoric time periods. From left to right in approximate calendar years before present – Clovis (Paleolithic >12,000), Bolen Bevel (Early Archaic >9,000), Kirk (Archaic 7,500), Newnan (Late Archaic 4,500), Citrus (Early Woodland 3,500), Tallahassee (Woodland 2,500), and Pinellas (Mississippian 1,000).
The discovery and exploration of Florida by the Spanish, French and English in the 1500’s brought disease and war that greatly diminished Amerindian populations. “La Florida” was not densely occupied until European colonization caused a rapid population expansion in the mid-1800s. Florida became a United States territory in 1821 and a state in 1845 at the end of the Second Seminole War. United States Army forts were situated on high ground near river transportation hubs such as Fort King in the 1830s in present-day Ocala just west of Silver Springs. The Silver River is completely groundwater-fed, and in turn is connected to the St. Johns River and the Atlantic Ocean via the Ocklawaha River, making it a natural commercial artery to the center of the developing state.

Ironically, the springs were critical to Florida’s development which has now progressed to the point of threatening their very health and future existence. Human commerce and regional transportation in Florida at that time were heavily reliant on spring runs and spring-fed rivers. River boats traveled extensively on clear-water rivers, including the St. Johns, the Suwannee, the Apalachicola, and their many tributaries. Steamboats departed Picolata, 44 miles south of Jacksonville and 18 miles west of St. Augustine traveling up the St. Johns River to Palatka, then upstream on the Ocklawaha River and eventually to Silver Springs. Similar use of surface water transport occurred on the west coast of Florida aided by spring-dominated rivers including the Hillsborough, Homosassa, Crystal, Withlacoochee (south), Wacasassa, Withlacoochee (north), Suwanee, Steinhatchee, St. Marks, Wakulla, and Apalachicola.

By 1900, Florida’s population was only half a million and was 44% African-American. By the beginning of the 20th century, many Florida springs (e.g., White Sulfur, Silver, Green Cove, Weeki Wachee, and Manatee) had become the state’s earliest tourist attractions.
Springs Terminology

A spring is broadly defined as a place where groundwater comes to or intersects the land surface. Groundwater is defined as any water that is stored and transmitted underground in soil, sediment, or rock. Groundwater that occurs in sufficient volume and availability to be used as a water supply for humans is termed an aquifer. Aquifers are either unconfined near the ground surface or confined at depth when they occur between relatively impervious layers of clay or rock which are referred to as an aquitard or an aquiclude. When a confined aquifer intersects the ground surface it does so under pressure, this condition is known as artesian. Groundwater reserves are sustained by the infiltration of rainfall or surface water in a process known as recharge, which is the downward migration of water through the unsaturated soil zone.

There are two general types of springs in Florida, seeps (water table springs) and artesian (karst) springs. The seeps flow from a shallow surficial aquifer. Artesian springs typically result from ground water in limestone formations that are confined or semi-confined.

Each spring has an area that contributes groundwater to the spring and includes both surface and subsurface basins. These areas are variable in size depending on rainfall patterns and resulting recharge and are called spring recharge basins. Also called a springshed, a spring recharge basin is defined as the area of land that contributes water and associated dissolved substances to the spring.

Generalized artesian springshed in Florida.
Source: Scott et al 2004
Spring Flows

Florida’s springs are generally classified by median flow rates, the average volume of the water they produce per unit of time, which is called discharge. The discharge of individual springs changes depending on rainfall, recharge, and the amount of groundwater withdrawals within their springshed. Many springs’ flows are measured regularly, while some have never been measured so the flow volume must be estimated. The U.S. Geological Survey devised a spring discharge classification system (shown below) that relates spring magnitudes to ranges of spring discharge. Discharge from Florida’s springs can range from less than 1 pint per minute to more than 1 billion gallons per day. The largest of Florida’s springs with the highest flows are called first-magnitude springs, defined as discharging at least 100 cubic feet of water per second (cfs) which is equal to 44,861 gallons per minute (gpm) or about 64.6 million gallons per day (MGD). The scale used for classifying spring flows is as follows:

<table>
<thead>
<tr>
<th>Magnitude</th>
<th>Flow/Discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Magnitude</td>
<td>Greater than 100 cubic feet per second (cfs)</td>
</tr>
<tr>
<td>2nd Magnitude</td>
<td>10 to 100 cfs</td>
</tr>
<tr>
<td>3rd Magnitude</td>
<td>1 to 10 cfs</td>
</tr>
<tr>
<td>4th Magnitude</td>
<td>1 cfs or 100 gallons per minute (gpm)</td>
</tr>
<tr>
<td>5th Magnitude</td>
<td>10 to 100 gpm</td>
</tr>
<tr>
<td>6th Magnitude</td>
<td>1 to 10 gpm</td>
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<td>7th Magnitude</td>
<td>1 pint to 1 gpm</td>
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</tr>
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Geology

Florida’s deep crystalline basement rocks were originally part of the African Tectonic Plate. A fragment of the African Plate left behind after the breakup of the supercontinent Pangaea about 200 million years ago provided the base for the development of large carbonate (primarily limestone) platforms in the western Atlantic which included the Bahama Platform and the Florida Platform.

Florida is the exposed, above-sea level portion of the broad Florida Platform, a thick (greater than 4,000 feet) sequence of limestone and dolostone overlying the older basement of igneous, metamorphic, and sedimentary rocks. These carbonate rocks are overlain in some parts of Florida by more recent and unconsolidated sediments of sand, silt, clay, limestone, and shells. Source: *Essentials of Geology*, Marshak.

The Florida Platform is generally considered to be part of a fairly-stable tectonic plate sitting on a passive margin of the North American plate. Even so, there are recognizable structural features that suggest that the Florida Platform has experienced and responded to plate tectonic forces in the recent geologic past, resulting in positive and negative structural features in Florida and the southeastern U.S. which correspond to linear highs and basins.

In west-central, north-central, and central panhandle portions of the Florida peninsula, the carbonate rocks occur at or very near the land surface. Away from these areas, the overlying sand, silt and clay, sequences are thicker. Source: U.S. Geological Survey.
Florida Springs Conservation Plan

Hydrogeology

Florida has an abundance of fresh groundwater due to high rainfall and generally low topographic relief. Rainfall in the area where most Florida springs occur ranges from about 50 to 60 inches per year. Due to the subtropical climate and the regional geologic setting, the source of all freshwater in Florida is precipitation.

Most of the water is either stored in or moving through surface water bodies and groundwater reservoirs originating from precipitation falling directly on the land surface within and north of the state’s boundaries. In addition, some surface water originates in Alabama and Georgia and moves southward into Florida via rivers, including the Apalachicola, Withlacoochee, and Suwannee.

Florida’s limestone geology and high rainfall have combined to create a karst landscape. Karst areas occur when underlying geology is soluble, forming underground void spaces, caves, and passages due to the action of water. Since rainwater is slightly acidic, it dissolves limestone over geologic time, forming the vast underground reservoir that is called the Floridan Aquifer System.
Aquifers

Occurrence and condition of aquifer systems in Florida are directly related to their position with respect to the geological and structural features described above. The combination of Florida physiographic setting and the geologic framework in turn controls the occurrence and distribution of artesian springs.

There are three major aquifer systems in north central Florida including the Surficial Aquifer, Intermediate Confining Unit, and Floridan Aquifer System. The Surficial Aquifer is the uppermost water-bearing zone and is generally comprised of sand, shell fragments, and some carbonate materials. The Surficial Aquifer materials are either thin or absent where springs are located. The Intermediate Confining Unit which consists primarily of limestone, sand, silt, and clay generally underlies the Surficial aquifer and overlies the Floridan aquifer. Although the thickness of the Intermediate Confining Unit is variable (0 to 180 feet), it is thin or breached at most springs. The Floridan Aquifer occurs within a thick sequence of permeable carbonate sediments (limestone and dolostone). The Floridan Aquifer system is in some regions divided vertically into three zones based on their ability to transmit water. In these limited areas, the Upper and Lower Floridan Aquifers are separated by a less permeable dolomitic limestone referred to as the Middle Semi-Confining Unit.

The diagram to the left shows a typical geological cross-section for the karst Florida Springs Region. The Surficial Aquifer is where the water table occurs above an impermeable sediment and is unconfined. Where the Intermediate Confining Unit is present and thicker than about 100 feet, the Upper Floridan Aquifer is confined. If the Intermediate Confining Unit is thin or absent, the Upper Floridan Aquifer is unconfined. The majority of north central Florida’s artesian springs issue from the Upper Floridan Aquifer in areas where the Upper Confining Unit is less than 100 feet thick or absent. This figure also illustrates recharge of rain and the locations of shallow and deep wells. Source: Florida Geological Survey.
The Cody Scarp approximates the transition area between the confined and unconfined Floridan Aquifer System. In the Northern Highlands, the Floridan Aquifer System is overlain by a thick layer of clay that greatly reduces recharge into the aquifer. To the south and the west of the Cody Scarp, the Floridan Aquifer System is generally unconfined in the Gulf Coastal Lowlands. This means that the clay units are generally absent (or very thin where present) in the Gulf Coastal Lowlands so recharge to the Floridan aquifer system is relatively high.

**Springs**

When sea level was higher, and the Cody Scarp area represented the western coastline of Florida, the clay confining layer was eroded away by wave action and ocean currents. When sea levels receded to the present-day shoreline, it helped to create the perfect geological conditions for a combination of headward erosion by streams as well as the dissolution of carbonate rocks by both streams and groundwater. This enabled the development of unique karst features including numerous springs, sink holes, swallets, karst windows and underground rivers. Some rivers that cross the Cody Scarp go underground and reemerge downstream as a spring. A prime example of this disappearance/resurgence is the Santa Fe River. At O’Leno State Park the entire Santa Fe River is swallowed up by a sinkhole (a.k.a. suck hole) as the river crosses the Cody Scarp, it then travels underground through a network of cave passages for over three miles before re-emerging at a first-magnitude spring in River Rise Preserve State Park.

Source: Florida Geological Survey.
Florida’s Hydrologic Cycle

Springs are an integral part of the hydrologic cycle in Florida. The hydrologic cycle begins with the evaporation of water from the surface of the Atlantic Ocean or the Gulf of Mexico. As the moist air is lifted, it cools and water vapor condenses to form clouds. Moisture is transported around the globe until it returns to the land surface as precipitation. Once the water reaches the ground, one of three processes may occur: 1) some of the water may evaporate back into the atmosphere or be transpired by plants, 2) the water is temporarily stored as surface water in uplands, wetlands, lakes, and eventually reaches streams and rivers that flow to the ocean, or 3) the water may penetrate the land surface and become groundwater recharge. Depending on the path that the groundwater travels, it may become part of the surficial aquifer or the Floridan Aquifer System. Groundwater from these aquifers either seeps its way into the oceans, rivers, springs, and streams, or is released back into the atmosphere through plant transpiration. Spring flows in turn provide important surface water to many of Florida’s rivers.

Springs are a rare but essential component of Florida’s fresh surface water systems. Occupying only about 10,000 acres or 0.03% of Florida’s surface area, springs and spring runs are probably the most endangered ecosystem in the state. Despite their relatively small contribution to the area of aquatic ecosystems, springs contribute an average of about 10 billion gallons per day (BDG) of inflows of freshwater to the state’s rivers, lakes, and estuaries. In fact, due to their consistency, springs provide the predominant baseflow to many of Florida’s rivers, which would otherwise be non-flowing and stagnant during extended droughts.

The physiography of the state and the geologic framework controls the distribution of many artesian springs. Areas where the Floridan Aquifer is poorly confined to thinly confined – generally corresponds to the location of Florida’s artesian springs. Source: Bush and Johnston 1988
Birth of Springs Science

In the early 1950’s, a young college professor, Dr. Howard T. Odum, graduated from Yale University and was hired by the Biology Department of the University of Florida in Gainesville. Dr. Odum had studied under G. Evelyn Hutchinson, the Father of Limnology (the study of lakes). From 1951 to 1955, Odum led a team of academic colleagues and students to conduct the first comprehensive ecological assessment of Silver Springs and the upper 0.75 miles of the Silver River ecosystem. This work was co-funded by the U.S. Office of Naval Research and the University of Florida. Although Dr. Odum and his colleagues studied the ecosystems and productivity of several of Florida’s springs, Silver Springs was the focus of the multi-year research project.

“The geological formation of Florida gives rise to springs and fountains of such magnitude and beauty, that they deserve to be ranked with the great freshwater lakes, the falls of Niagara and the Mississippi River, as grand hydrographical features of the North American continent”. - Daniel Garrison Brinton (1856)

From his early work with Florida’s springs, Dr. Odum’s approach was that the entire spring ecosystem needed to be regarded as a ‘super-organism’ in addition to the conventional methodology of studying the individual species that comprised the total system. Dr. Odum’s work at Silver Springs was the beginning of a long and prolific career in which he was instrumental in establishing the scientific disciplines of systems ecology, radiation ecology, ecological engineering, and ecological economics. Eugene Odum, Dr. Odum’s older brother, was the author of a principal ecology textbook and the two brothers collaborated on some of their ecological studies. The Odum brothers are now credited with effectively incorporating ecosystem assessment as a principal component of most environmental studies. In 1987, the two Odum brothers were awarded the coveted Crafoord Prize presented by the King of Sweden for their accomplishments.
Springs Ecology

Florida’s artesian springs are the freshwater analog of tropical saltwater coral reef ecosystems. Like coral reefs and tropical forests in their biological diversity and complex energy flows, springs’ ecosystems are adapted to maximizing the transformation of solar and aquatic energies into species diversity and productivity. High solar energy inputs in subtropical Florida, combined with the stability of the water clarity, temperature, and chemistry in springs is what enables this high level of ecosystem efficiency, and in turn, supports their complex foodwebs.

Crystal-clear spring water allows maximum light energy to penetrate underwater to plant and algal communities. Due to their constant water chemistry, relatively abundant nutrient levels, and high flow rates, unimpaired springs have rates of primary productivity as high as coral reefs and coastal estuaries, fertilized intensive agriculture and even mature rain forests – the most productive ecosystems on earth. This high rate of primary production serves as the food for the secondary populations of aquatic fauna residing in springs. The springs’ fauna includes hundreds of species of micro- and macro-invertebrates, insects, fish, amphibians, reptiles, birds, and mammals. These organisms are distributed in a classic biomass pyramid of primary producers, primary consumers, secondary consumers, and top (tertiary) consumers.

“Unfortunately, it is now difficult or impossible to find an unaltered or truly natural spring in Florida” – Silenced Springs by Robert L. Knight (2015)

Annual measurements of whole ecosystem productivity of springs show relatively constant and efficient utilization of sunlight. In many springs, consumption approximately equals production, resulting in a stability that avoids the pitfalls of boom-or-bust economies.

Differing groundwater chemistries lead to natural variations in spring ecologies. Due to changes in regional geology, groundwater quality is variable in different parts of the Florida Springs Region. For example, springs in North-Central Florida along the Suwannee/Santa Fe drainage are high in dissolved carbonates and calcium but low in salts such as sodium and chloride. Many of the springs in the middle St. Johns River drainage, as well as some coastal springs, are characterized by elevated sodium and chloride salts resulting from relic saltwater lenses in the Floridan Aquifer. However, all of Florida’s springs are consistent in that each type of artesian spring in an unaltered state, has high water clarity with robust, well-balanced populations of flora and fauna and high ecosystem functionality.
Springs Protection Efforts

The 1972 Federal Clean Water Act (CWA) protects all the nation’s surface water bodies from the uncontrolled discharge of pollutants. The objective of the CWA is to restore and maintain the chemical, physical, and biological integrity of the nation’s waters by preventing point and non-point pollution. Florida has been delegated the authority to protect and preserve surface water quality under the CWA. Florida has classified natural waters based on intended uses and listed a total of 48 numerical standards for protection of surface waters from excessive pollution. Of importance to springs that receive groundwater inputs, Florida adopted a numeric standard for nitrate nitrogen in 2007 for springs of 0.35 mg/L. Currently, over 80% of Florida’s springs exceed that numeric nitrogen standard.

“It shall be the policy of the state to preserve and protect its natural resources and scenic beauty.” - Article II, Section 7(a), Florida Constitution

In Florida, the 1972 Florida legislature enacted the Water Resources Protection Act. The Water Resources Protection Act established five water management districts (WMD) which were given the responsibility to provide conservation and allocation of water supply, water quality protection, flood protection and natural systems management. One intent of the Water Resources Protection Act was to protect the state’s natural water systems from being over-exploited by human uses through the determination of Minimum Flows and Levels (MFLs). The MFLs are intended to ensure that there is enough surface and groundwater in the environment to protect the hydrological and ecological integrity of lakes, streams, and springs. Each WMD is required to develop recovery or prevention strategies in case a water body does not or will not meet an established MFL.

The four WMD’s that have springs in their jurisdiction and their MFL accomplishments since 1972 are listed below.

Nearly all of Florida’s springs have significant flow reductions. An overall Floridan Aquifer and springs water balance indicated an average spring flow reduction in Florida alone of 32% or about 3 billion gallons per day. It is important to note that rule making for spring MFLs can result in limits on the issuance of new and existing groundwater consumptive use permits, new prevention strategies, and/or new constraints affecting regional water supplies.

<table>
<thead>
<tr>
<th>Water Management District (WMD)</th>
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<td>Fanning, Little Fanning, Manatee (2007); Madison Blue (2014)</td>
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<td>St. Johns River WMD</td>
<td>Wekiva River springs (1992); Volusia Blue (2008); Silver, DeLeon (2017)</td>
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<tr>
<td>Southwest Florida WMD</td>
<td>Sulfur, Weeki Wachee, Homosassa, Chassahowitzka (2014); Rainbow, Kings Bay (2017)</td>
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</table>
Appendix 2 – Springs Restoration Areas and Significant Spring Systems

The following spring descriptions were incorporated or adapted from the Florida Geological Survey’s Bulletin 66, ‘Springs of Florida’.

Panhandle Springs Restoration Area

The Panhandle Springs Restoration Area includes 12,611 mi$^2$ of Florida’s panhandle and all or portions of 19 Florida counties (Bay, Calhoun, Dixie, Franklin, Gadsden, Gulf, Holmes, Jackson, Jefferson, Lafayette, Leon, Liberty, Madison, Okaloosa, Santa Rosa, Taylor, Wakulla, Walton, and Washington). Of the 1,090 recognized springs in Florida, 386 are located in the Panhandle Springs Restoration Area.

Upland forest, rangelands, and water/wetlands account for 64% of this area’s land use, while intensive agriculture occupies about 27% of the land area and urban/other is about 9% of the land area. The estimated human population in this springs restoration area is 1,107,960.

The Panhandle Springs Restoration Area includes the Dougherty Karst Plain, an area where the Marianna/Suwannee and Ocala Limestones are at or near the land surface due to folding and uplift associated with a structural feature – the Chattahoochee Anticline. In this region, the Floridan Aquifer is recharged through the overlying Intermediate System and discharges to streams and rivers. The Panhandle Springs Restoration Area is divided into the Northwest Coast Springs Focus Area and the Nature Coast Springs Focus Area separated by a north-to-south potentiometric divide through Gadsden, Liberty, and Franklin Counties.
Northwest Coast Springs Focus Area

The Northwest Coast Springs Focus Area includes about 7,718 mi$^2$, and 221 springs in the 12 most western Florida counties. Near the center of the Panhandle Springs Restoration Area several low to medium magnitude springs occur along the Apalachicola River. Jackson Blue Springs is a first magnitude spring that occurs furthest northeast. Other lower magnitude springs occur in Jackson County along the Chipola River which is fed by at least 63 springs in Jackson and northern Calhoun counties.

The Florida caverns located just north of Marianna formed in the Ocala Limestone approximately 38 million years ago when the limestone was submerged. Once the groundwater levels declined, the caves were exposed due to their elevation of approximately 145 feet above mean sea level. Florida Caverns State Park where the caverns are located was a project completed by the Civilian Conservation Corps in the late 1930s. The Florida Caverns State Park features the state’s only tour cave.

The natural bridge of the Chipola River is formed by the river’s sudden plunge into an underground passage at Florida Caverns State Park. The Chipola River sinks to about 90 feet below the surface to resurface just over a quarter-mile away.
Cypress Spring is located on Holmes Creek and currently is accessible by boat or canoe only. There used to be land access to it until a water bottling company bought the land surrounding the spring run and restricted public access.

Ponce De Leon Spring is a Florida State Park and was named for Juan Ponce de León, a Spanish conquistador and Governor of Cuba who led a well-armed Spanish expedition to Florida and the southeastern U.S. in 1534. The main spring discharges an average of about 14 million gallons of water daily into a crescent-shaped basin with depths averaging five feet but increasing to 16 feet over the vents. The bottom is sand and limestone and this popular swimming area has a light greenish blue appearance. The spring-run is approximately 350 feet in length and flows into Sandy Creek, a blackwater stream, which subsequently flows out of the park and into the Choctawhatchee River.

Morrison Spring is located south of Ponce de Leon Spring in Walton County and is a county park. In 2008 the county created a large parking lot, picnic pavilion, and public restrooms. They also constructed a boardwalk over the water. Local rains have a significant effect on conditions at Morrison Spring. Abundant rainfall in the basin increases tannic water input, reducing springs clarity.

Vortex Spring is a privately-owned spring that is open to cave divers. Depths in the open water portion of the spring average 20 feet with a maximum depth of 40 feet at the opening to the cavern. The owners have installed stairs and a floating dock. Vortex Spring discharge averages 28 MGD of clear water at a year-round temperature of 68 degrees. Depths in the spring basin range from about 50 feet for a cavern dive and up to 115 feet for a cave dive. The bottom of the spring bowl is sandy, with limestone near the vent. Vortex Spring discharges from the 225-foot-diameter spring pool to form Blue Creek, which flows more than a half-mile before entering the Choctawhatchee River.
Fish commonly seen at the spring include bluegills, channel catfish, American freshwater eels, gar, redhorse suckers, shadow bass, and exotic species such as koi and goldfish. Hydrilla proliferation is a significant environmental challenge at Vortex and other Panhandle springs.

**Jackson Blue Spring** is located in a county park near Marianna and feeds Merritt’s Mill pond, an artificial impoundment that discharges to the Chipola River and ultimately to the Apalachicola River and the Gulf of Mexico. Jackson Blue is a first magnitude spring and popular swimming and cave diving location.

**Gainer Springs Group**

At least five known springs associated with Gainer Springs Group are located along both sides of Econfina Creek. The uplands surrounding this group are high rolling sand hills that are forested with sand pine and patches of longleaf pine-turkey oak community. High ground adjoining the west side of the creek near Spring No. 2 and Spring No. 3 rises to 27 ft above the water surface and is densely forested with mixed hardwoods and pines. The creek floodplain is forested with cypress and hardwoods. Land on the west side of the Econfina Creek at Gainer Springs is privately owned. The east side of the creek is owned and managed by the Northwest Florida Water Management District.

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<th>Spring Name</th>
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<th>Mag.</th>
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<th>Specific Conductance (μS/cm)</th>
<th>Nitrate-N (mg/L)</th>
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Historic and recent water quantity and quality data from sentinel springs in the Northwest Coast Springs focus Area (WMD – Water Management District; Mag. – springs magnitude; cfs – cubic feet per second; mg/L – milligrams per liter).
Nature Coast Springs Focus Area

The Nature Coast Springs Focus Area includes about 4,892 mi$^2$ located from Liberty County on the west to Dixie County on the east and includes all of Jefferson, Leon and Wakulla Counties, most of Franklin, Gadsden and Taylor Counties, and portions of Dixie, Lafayette, Liberty, and Madison Counties.

The Gulf of Mexico borders the entire length of the Nature Coast Springs Focus Area. This region includes 165 recorded springs, with 16 first magnitude springs such as Wakulla, Springs Creek Rise, St. Marks River Rise, the Wacissa Springs Group, Nutall Rise, and Steinhatchee River Rise. All the Nature Coast springs are found along and near the central Gulf Coast as well as primarily along the lower sections of the Wakulla, Aucilla, and Steinhatchee Rivers where gently dipping beds of the Suwanee and the Ocala Limestones are exposed at or very near the ground surface.

The Nature Coast Springs Subregion’s Gulf of Mexico shoreline constitutes the northern third of Florida’s Big Bend Marsh Coast, a low-lying coastal area devoid of barrier islands. The Big Bend Marsh Coast is a drowned karst region covered with salt marshes, oyster reefs, marsh peninsulas, and extensive tidal creeks. Because of a very low topographic gradient on the exposed limestone bedrock surface, the coastline has very low wave energy and is starved of sand-sized sediment, as rivers draining the region all carry low sediment loads.

The first record of Paleo-Indians in the area between the Ochlocknee and Aucilla rivers (the Apalachee region) is dated to about 12,000 years ago. Sea level was lower (from 115 feet 12,000 years ago to 40 feet 8,000 years ago) at this time which resulted in Florida’s land area being close to twice its current size. Rainfall amounts were much less, and fresh water from spring flows was not as available because of lower water tables.

By the 1800s, European settlement of the region was underway, and the region was inhabited by Amerindians (Timucuans), the Spanish, and various tribes allied with the Seminoles. Numerous burial mounds, shell middens, and other remains of Amerindian habitation are still visible throughout the area. In the 1830s and early 1840s, the region was involved in the Second Seminole War. U.S. military personnel reported that the Seminoles and allied tribes used the swampy and thickly-forested parts of this area as cover during the conflict.
Most of the land in the Nature Coast Springs Focus Area is undeveloped with 86% covered by forest, wetlands, or water. About 8% is used for agriculture, rangeland, and other more intensive uses. Only 6% of the land use is urban with Perry and Tallahassee being the largest cities. Tallahassee, the state’s capital in Leon County was founded in 1824 on the site of earlier Amerindian and Spanish settlements. The city was planned specifically to serve as a center of government for the new Territory of Florida. Established cities St. Augustine and Pensacola were the capitals of the old Spanish colonies of East and West Florida respectively, but when the United States took over the region in 1821, the need for a capital "somewhere in the middle" became apparent. The site of the Creek/Seminole town of Tallahassee Talofa ("Old Field Town") was selected for the territory's new capital.

In the late 1800’s, cattle production became the area’s most lucrative industry. Ever since the Spanish brought the first cows to Florida, cattle had roamed the open range, feeding and procreating without much intervention. One of the area’s biggest attractions at that time was the Hampton Springs Hotel in Taylor County. This resort was built around a mineral spring feeding the Fenholloway River west of Perry. Visitors came from all over the United States, both to drink and to bathe in the cool sulphur-rich waters of this spring, which were said to have curative properties to heal ailments like rheumatism. The luxury hotel resort, a two-story structure with about 70 rooms eventually included elaborate fountains and gardens, a covered pool, golf and tennis courts, stables, a casino, ballroom, outdoor dance pavilion, and railroad depot. The hotel also had a water bottling plant, which shipped around the nation, and a private hunting and fishing lodge. After the hotel burned down in 1954, the area was largely abandoned. Ruins of the hotel, including the pool into which spring water still flows, are visible at the site.
Wakulla/St. Marks System

The Wakulla/St. Marks springs group is in Leon and Wakulla Counties in the central panhandle.

Wakulla Spring

Approximately 14 miles south of Tallahassee in Wakulla County, Wakulla Spring is one of the largest artesian springs in Florida. Wakulla Spring and three miles of the associated spring run are managed by the Florida State Park System as the Edward Ball Wakulla Spring State Park. The park is named after Edward Ball, a businessman who married into the Dupont family and in 1934 developed Wakulla Spring as a private resort and movie set location. Many movies were filmed on location there, most famously the monster film classic Creature from the Black Lagoon in 1954.

An extensive cave system underlying the Woodsville Karst Plain region containing ground water discharging to Wakulla Springs has been actively explored since the 1930s. The spring pool has been modified with a diving platform, swim platforms and a downstream boat maintenance facility. The Wakulla Spring Lodge opened in 1937. Because of its location near Tallahassee, the lodge and restaurant serve as an important meeting venue for Florida’s political elite.

The Wakulla/St. Marks springshed is underlain by marine sedimentary deposits including sand, clay, limestone, and dolostone. The northern portion of the springshed contains remnant deposits of clay and limestone of the Hawthorn Group. These isolated remnants are absent from the southern portion of the springshed which includes the Woodville Karst Plain. Groundwater recharge rates in the springshed are dependent on the presence/absence and thickness of the Hawthorn formation. The edge of the Hawthorn formation is a relic marine terrace, the Cody Scarp, south of which the Hawthorn is absent. That portion of the exposed Woodville Karst Plain is perforated by numerous sinkholes and swallets that allow recharge to the Floridan Aquifer from lakes, streams, and other surface watersheds.
Wakulla Springs is hydraulically connected to Springs Creek Springs on the Gulf Coast through water-filled caves. Careful analysis of flows and water quality, as well as direct cave exploration, has determined that Wakulla Spring is increasingly pirating flow from Springs Creek Springs due to shifting groundwater gradients. Increasing groundwater extractions in Leon County have lowered aquifer levels near Wakulla Springs while sea level rise has raised.

Recent studies at Wakulla Springs indicate a significant decline in the ecological health of this spring ecosystem and loss of aesthetic values. The Upper Wakulla River has been deemed impaired by FDEP due to high levels of nitrate-nitrogen and increased growth of hydrilla and filamentous algae. Plant community shifts from native submerged aquatic macrophytes to filamentous algae and loss of aquatic and wetland wildlife populations are indicators of this alarming trend.

Photos courtesy of Jim Stevenson.
Natural Bridge Spring 2

Natural Bridge Spring pool measures 66 feet north to south and 75 feet east to west and is situated in a conical depression. From the north bank spring depth is 33 feet. The water is clear and blue-greenish. There is considerable algae growing on the limestone substrate. The spring run is as wide as the spring pool, averaging about 6 feet deep and flows swiftly over a limestone and sand bottom. Most of the spring discharge flows southwest for approximately 0.25 miles, disappearing into a siphon approximately 300 feet east of Natural Bridge; however, nearly 200 feet downstream from the spring, a small channel splits off from the main spring run and travels westward approximately 1,000 feet into the St. Marks River. At Natural Bridge, the St. Marks River flows into a siphon. The river continues underground to the south. Its underground course is dotted with sinkholes and karst windows for approximately 0.6 miles until it re-emerges as St. Marks River Rise (or St. Marks Spring). Natural Bridge Spring flows into a siphon that is approximately 250 feet east of the St. Marks River siphon. It is suspected that Natural Bridge Spring and the St. Marks River merge underground near Natural Bridge. - Florida Geological Survey, Bulletin 66

St. Marks River Rise

St. Marks River Rise, a first magnitude spring accessible only by boat, flows from an elongated fracture in the limestone. The spring is the primary river rise of the St. Marks River and contains substantial flow from several nearby springs and upriver drainage. Water flows from beneath a large limestone shelf from a depth reported to be about 85 feet. The spring pool is over 100 feet in diameter, and water flows from the spring around an island. The river-rise pool diameter measures 315 feet east to west and 195 feet northwest to southeast. Just south of the vent, the St. Marks River widens to 420 feet.

Spring Creek Spring

Spring Creek No. 1 has a large boil that emanates from a 30 foot wide cavern in limestone against a seawall. The spring pool measures approximately 150 feet in diameter, with a depth of 43 feet over the vent. The bottom of the spring basin and spring run are sand and limestone, which were covered by algae and a small amount of silt when visited by the USGS in 2001. At low tide, the boil is strong, creating a swift current into the estuary.
Steinhatchee River Rise Spring

The Steinhatchee River Rise is the location where the Steinhatchee River re-emerges after flowing underground. Tannic water flows northwest from underneath a limestone shelf. The spring pool is approximately 70 by 30 feet and 12 feet deep.

Wacissa/Aucilla River and Springs

The Wacissa River rises in Jefferson County from a total of at least 12 documented springs, scattered along the upper 1.5 miles of the Wacissa River. Land to the east and west of the river is flat and swampy and surface elevations are little more than 3 feet above river level. The area immediately adjoining the river and springs is densely forested with cypress, oak, some pine, and generally moderate undergrowth. The average flow of the river in the 1970s was reported as 251 MGD.

The Wacissa River is known for its large concentration of aquatic birds, including egrets, herons, ibis, osprey, wood storks, limpkins, anhingas, kingfishers, barred owls and bald eagles. Aquatic animals are also abundant, including alligators, river otters, turtles, water snakes, and crayfish. The main species of fish are bass, mullet, catfish, red-breasted sunfish, stumpknocker and gar, although the warmouth perch, speckled perch, flier bream, and shellcracker may also found in the Wacissa.

Late in the nineteenth century, the Wacissa area was known to ornithologists because of ivory-billed woodpeckers which were then common. But by 1930 the entire Wacissa watershed was clear-cut by timber companies. When naturalist, Herbert Stoddard, Senior, visited the area in 1932 after the absence of some years, he reported the entire ecology of the lower river was "drastically changed." Instead of the shallow, clear stream he had once visited, he found it running high and dark in all seasons. Apple snails, which depend on clear, lime-laden water, survived only in the upper reaches of the river near the springs. Birds such as limpkins which feed on apple snails, had become as scarce as the snails.

Although much of the Wacissa forest is now some 85 years into recovery, logging activities are still common in the area. Large portions of the adjacent lands—though managed by the state of Florida—are owned by timber companies. Today, the water in the Wacissa springs and river is typically clear, dominated by native submerged aquatic vegetation, and used almost exclusively for recreational purposes, including swimming, boating, fishing, and birdwatching.
Nutall River Rise

Nutall Rise, a first magnitude spring, is where the Aucilla River issues from underground to flow toward the Gulf of Mexico. Before emerging at this spot, the Aucilla River can be seen flowing toward Nutall Rise through several sinkholes north of the rise. Tannic water flows from the spring, but can become clear during times of drought. The land surrounding the rise is relatively low-lying, with live oak and mixed hardwoods, and is surrounded by docks and houses. There is a large dolostone quarry located to the northeast. The Aucilla River is also the location of Half-Mile Rise, likely a former water-filled sinkhole that attracted early Amerindians and wildlife living in the area.

<table>
<thead>
<tr>
<th>Spring Name</th>
<th>WMD</th>
<th>County</th>
<th>Mag.</th>
<th>Discharge (cfs)</th>
<th>Specific Conductance (μS/cm)</th>
<th>Nitrate-N (mg/L)</th>
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Historic and recent water quantity and quality data from sentinel springs in the Nature Coast Springs Focus Area (WMD – Water Management District; Mag. – springs magnitude; cfs – cubic feet per second; mg/L – milligrams per liter).

Suwannee Springs Restoration Area

The Suwannee is a wild blackwater river with a historic mean flow of about 6.3 BGD. Two-thirds of the very large watershed (approximately 9,930 mi²) of the Suwannee River is in southeast Georgia and includes the Okefenokee Swamp where the river originates. The remaining one-third is in north Florida.

The Suwannee Springs Restoration Area includes a total of 5,664 mi², including all or portions of 13 counties (Alachua, Baker, Bradford, Columbia, Dixie, Gilchrist, Hamilton, Lafayette, Levy, Madison, Suwannee, Taylor, and Union). Upland forest, rangelands, and water/wetlands account for 55% of this region’s land use, while intensive agriculture occupies about 33% of the land area and urban/other is about 11% of the land area. The estimated human population in this springs region is 442,714.

Principal tributaries to the Suwannee River include the Alapaha, North Withlacoochee, and the Santa Fe Rivers, with the Santa Fe being the largest with an historic average flow of more than 1 BGD. The Suwannee River discharges to the Gulf of Mexico near the town of Suwannee, about 10 miles north of Cedar Key.
The upper portion of the Suwannee River Basin in Florida is underlain by the relatively impermeable Hawthorne Clay Formation. Streams in the upper portions of the Suwannee and Santa Fe river basins are characterized by black- or tea-colored water. In these areas of high surficial groundwater conditions, rainfall and resulting runoff pickup tannins that originate from decomposing leaves and peat in forested and marshy floodplain wetlands.

Spring flows strongly influence the middle and lower portions of the Suwannee River where the Hawthorn Clay Formation is absent or patchy. In this region the Suwannee River has cut into the underlying Suwannee and Ocala Limestone formations.

Some tertiary tributaries that are below (west of the Cody Scarp) such as the Ichetucknee River that is tributary to the Santa Fe are entirely spring-fed. The Suwannee River Water Management district estimated that more than 197 springs discharge an average groundwater inflow of 4,670 MGD for an average contribution of about 75% of the entire flow of the Suwannee River.

More recent information indicates that there are now a total of 312 springs recorded in the Suwannee Springs Restoration Area. This region is subdivided into four springs focus areas that include the Upper Suwannee Springs Focus Area with 76 known springs, the Middle Suwannee Springs Focus Area with 108 springs, the Lower Suwannee Springs Focus Area with 31 springs, and the Santa Fe Springs Focus Area with 97 recorded springs.
The Suwannee River was immortalized in Stephen Foster’s song ‘Old Folks at Home’. Written in 1851 as a minstrel song, it was adopted as the Florida state song in 1935. Photo from the Florida State Archives.

### Upper Suwannee Springs Focus Area

The Upper Suwannee Springs Focus Area includes 1,219 mi\(^2\) in North Florida, including portions of Baker, Columbia, Hamilton, Madison, and Suwannee counties. The estimated resident human population in this springs subregion is 49,780. Major inputs of groundwater to the Upper Suwannee Springs Focus Area include two large river rises – Alapaha River and Holton Creek, the first magnitude Madison Blue Spring that feeds the North Withlacoochee River, and many second magnitude and smaller springs, including Suwannee Springs, White Springs, and additional springs feeding the North Withlacoochee River.

#### Alapaha River Rise

Alapaha River Rise is the location of the Alapaha River’s re-emergence on the north bank of the Upper Suwannee River in Hamilton County, which is composed of a single vent at the head of a circular depression. This river rise is a first magnitude spring with a measured flow of about 512 MGD and flows south for about 1,500 feet before reaching the Suwannee River.
Holton Creek Rise is a first magnitude spring downstream of Alapaha River Rise in Hamilton County that discharges water that is dark and tannic. The rise discharges through Holton Creek, a run that meanders generally southeast approximately 1 mile to the Suwannee River. Reported flow is 107 MGD.

Lime Run Sink (Spring) is a first magnitude estuelle with a recorded flow of 112 MGD and located in Suwannee River State Park.

Suwannee Spring is enclosed in a stone wall on land currently owned by the Suwannee River WMD and was formerly the site of a hotel and bath house. Suwannee Spring is a second magnitude spring with a recorded historic flow of 9.1 MGD.

White (Sulfur) Spring is a second magnitude spring located on the north bank of the Upper Suwannee River in Stephen Foster State Park (Hamilton County) with a reported historic flow of 45 MGD. White Spring has stopped flowing during droughts since the 1970s.

North Withlacoochee River Springs

The North Withlacoochee River arises in Georgia near Valdosta and flows between Hamilton and Madison Counties in North Florida, just south of the Georgia-Florida border. The Withlacoochee River is fed by at least 14 named springs, including Madison Blue Springs, a 1st magnitude spring located on the west bank of the North Withlacoochee River about 10 miles east of Madison on NE State Road 6. Other named second magnitude springs downstream from Madison Blue include Pot, Tanner, Morgan, and Suwanacoochee. The groundwater springshed for these springs extends into South Georgia.

The historic flow at Madison Blue was more than 76 MGD and except for the two large river rises is the highest historic flow for any individual spring in the Upper Suwannee Springs Focus Area. The estimated groundwater basin for Madison Blue is about 100 mi². Madison Blue is an estuelle, with reverse flows common during periods of high stage in the North Withlacoochee River. Total historic average spring flow contributions to the North Withlacoochee River in Florida was 327 MGD or nearly one fourth of the average flow of the river.

<table>
<thead>
<tr>
<th>Spring Name</th>
<th>WMD</th>
<th>County</th>
<th>Mag.</th>
<th>Discharge (cfs)</th>
<th>Specific Conductance (uS/cm)</th>
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Historic and recent water quantity and quality data from sentinel springs in the Upper Suwannee Springs Focus Area (WMD – Water Management District; Mag – springs magnitude; cfs – cubic feet per second; mg/L – milligrams per liter).
Middle Suwannee Springs Focus Area

The Middle Suwannee River Springs and feeder springs are located along an approximate 54-mile reach from River Mile 74 at the confluence with the Santa Fe River south of Branford and extending upstream to River Mile 128 at the river’s confluence with the North Withlacoochee River. The estimated human population in the Middle Suwannee Springs Focus Area is 40,729.

The Middle Suwannee River is the location of eight springs-based state and county parks which are prominent recreational destinations. The Florida Suwannee River Wilderness Trail includes the entire Middle Suwannee River reach and offers public paddling and camping opportunities at three river camp sites including Dowling Park, Peacock Slough, and Adams Tract.

The geology underling the Middle Suwannee River Basin generally consists of marine sedimentary deposits including limestone, dolostone, sands, and clay. The confining clays and limestones of the younger Hawthorn Group overlie the northern portion of the springshed but are absent in the southern part, below the Cody Scarp.

The Middle Suwannee River is fed by inflows from a least 108 recorded springs, including three first magnitude springs: Falmouth, Troy, and Lafayette Blue.
Falmouth Spring is a karst window located 10 miles northwest of Live Oak. The pool measures 87 feet north to south and 81 feet east to west. The depth is 39 feet. The groundwater emanates from a conical depression. The bottom is sand and limestone, and was thickly covered with algae during a 2001 FGS visit. The water was fairly clear with tiny suspended algal particles during the same visit.

Lafayette Blue Spring is located 7 miles northwest of Mayo on the west side of the Suwannee River. Lafayette Blue Spring discharges from a single horizontal vent on the south side of the sink depression. The spring pool measures 57 feet north to south and 102 feet east to west. Spring depth measures 21 feet. The water is clear and light bluish green. Algae are very thick on limestone and sand substrates within the spring pool and run. The spring run flows east approximately 300 feet before reaching the Suwannee River.—Florida Geological Survey, Bulletin 66

Troy Spring is located within Troy Spring State Park, 5.5 miles northwest of Branford. Troy Spring issues from a depression with vertical limestone walls. The pool diameter measures 138 feet north to south and 118 feet east to west. The pool depth is 61 feet. The spring run is about 325 feet long and flows in a straight path eastward to the Suwannee River. A thick layer of dark green filamentous algae covers nearly all aquatic substrates. There is little to no aquatic or emergent vegetation. Water color is clear with a greenish hue.—Florida Geological Survey, Bulletin 66

<table>
<thead>
<tr>
<th>Spring Name</th>
<th>WMD</th>
<th>County</th>
<th>Mag.</th>
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<th>Specific Conductance (uS/cm)</th>
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Historic and recent water quantity and quality data from sentinel springs in the Middle Suwannee Springs Focus Area (WMD – Water Management District; Mag. – springs magnitude; cfs – cubic feet per second; mg/L – milligrams per liter).
Lower Suwannee Springs Focus Area

The Lower Suwannee River Springs and feeder springs are located along an approximate 74 mile reach from the Gulf of Mexico to the confluence with the Santa Fe River south of Branford. This springs focus area also includes the springs feeding the Wacasassa and Wekiva River in Levy County, south of the Suwannee River. The estimated human population in this focus area is 71,952.

There are 31 recorded springs in the Lower Suwannee River between its confluence with the Santa Fe River and its mouth at the Gulf of Mexico. These springs have an estimated combined historic average flow of about 700 MGD. A water budget indicates that another 800 MGD of additional groundwater historically entered this part of the Suwannee River through submarine springs and diffuse flow. The Lower Suwannee River also receives flow from the Upper and Middle Suwannee River and the Santa Fe River. The Lower Suwannee Springs Focus Area is entirely within the boundaries of the Suwannee River Water Management District and borders Alachua, Dixie, Gilchrist, Lafayette, and Levy counties. Two state parks bordering the Lower Suwannee River (Fanning Springs and Manatee Springs) are intended to protect the two largest springs from development and over-exploitation. Also, four of the smaller springs along the Lower Suwannee River are in county parks, and others are on land owned and managed by the Suwannee River WMD.

River stages and flows in the Lower Suwannee River are influenced by tides in the Gulf of Mexico to approximately 28 miles upstream of the river’s mouth. Thus, the Suwannee River Estuary consists of the lower reach of the river, two major branches (East and West passes), Suwannee Sound, numerous tidal creeks, and
the adjacent coastal waters from Horseshoe Beach to the Cedar Keys. Extensive tidal freshwater wetlands border the lower river and are included in the Lower Suwannee River National Wildlife Refuge.

Before the 1950s, the springs along the Lower Suwannee River were relatively unimpacted despite more than 10,000 years of human occupation. Impacts related to flow reductions and nutrient increases in many of these springs were not visibly evident as recently as the 1980s. However, in a period of less than 50 years, most of these springs have lost up to half of their historic flow, have nitrate concentrations elevated by 300 to 1,000 percent, have lost their native vegetation, and are now dominated by nuisance algae, and backflow tannic water into the aquifer each time levels in the Suwannee River rise due to rainfall in the watershed. These impairments have greatly reduced both the human and wildlife utilization of these springs for recreation and habitat.

Compared to other areas in Florida, the Lower Suwannee River Springshed is sparsely populated with most of the 71,952 people living in unincorporated areas. The largest incorporated town is Chiefland in Levy County. In 2011, the dominant land uses within the Lower Suwannee River Springs Restoration Area were commercial forestry (44%), agriculture and rangeland (27%), water and wetlands (18%), and urban/commercial (10%).

**Hart Springs** is a 2nd magnitude spring located in a Gilchrist County recreation area, 6.5 miles northwest of the town of Fanning Springs. Hart Springs Run is formed by three merging spring outlets and extends for about 850 feet before it joins the Suwannee River. The middle spring pool was measured as 51 by 45 feet or approximately 0.05 acres. The depth of this spring was reported as 20 feet. In 2002, the water was reported to be “greenish” with a prominent boil. This spring pool is enclosed by a metal retaining wall. That same year the north run was not flowing and flow from the south run was slight.

**Otter Springs** is a 2nd magnitude spring located in Gilchrist County about 4.5 miles north of the town of Fanning Springs in a park owned by the Suwannee River WMD and is operated by Gilchrist County. Otter Springs is nearly circular with a diameter of about 68 feet and an estimated area of 0.08 acres. The maximum depth over the spring vent was reported to be 27.5 feet. Otter Spring Run is about 0.8 miles in length before joining the Suwannee River.
**Rock Bluff Springs** is a 2nd magnitude spring located about 11 miles south of Branford. The spring pool measures about 250 by 171 feet or about one acre in surface area and has a greenish color. Numerous vents are reported to feed the spring pool. The spring run is reported to be about 750 feet in length before it reaches the Suwannee River. –Florida Geological Survey, Bulletin 66

**Sun Springs** is a 2nd magnitude spring located about 7.8 miles north of the town of Fanning Springs. This spring is entirely included in a private community and is not available for public access. The spring pool is reported to be 99 by 132 feet for an estimated surface area of 0.3 acres and a maximum depth of about 14 feet.

**Copper Spring** is a 2nd magnitude spring located in Dixie County one mile north of Old Town in Dixie County. Copper Spring includes three major vents and is surrounded by private property. The largest spring pool (Spring No. 2) is 126 by 84 feet for an estimated surface area of 0.24 acres, has a visible boil over a vent 5.3 feet deep, and has slightly turbid water with a blueish green tint. The spring run to the Suwannee River is about 500 feet in length. Spring No. 1 was reported to be about 34 feet in diameter with an estimated surface area of 0.02 acres and a maximum depth of about 28 feet.

**Guaranto Spring** is a 2nd magnitude spring located in a Dixie County park about 12.5 miles south of Branford. Guaranto Spring and spring run are impounded behind an earthen dike perforated by a metal culvert. The resulting impoundment is 240 by 87 feet for an estimated surface area of 0.48 acres. The water depth at the spring vent is 11.5 feet and the water had a slight boil and a greenish color in 2002.

**Fanning Springs** is a former 1st magnitude spring located in a Florida state park in the town of Fanning Springs. The spring pool measures 207 by 144 feet for an estimated surface area of 0.68 acres. The maximum depth over the spring vent is 18 feet deep, and the water was bluish when visited in 2002. The spring run to the Suwannee River is 450 feet long.

<table>
<thead>
<tr>
<th>Spring Name</th>
<th>WMD</th>
<th>County</th>
<th>Mag.</th>
<th>Discharge (cfs)</th>
<th>Specific Conductance (uS/cm)</th>
<th>Nitrate-N (mg/L)</th>
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</thead>
</table>

Historic and recent water quantity and quality data from sentinel springs in the Lower Suwannee Springs Focus Area (WMD – Water Management District; Mag. – springs magnitude; cfs – cubic feet per second; mg/L – milligrams per liter).
Turtle Spring is a 2nd magnitude spring located in Lafayette County on the west shore of the Suwannee River about 8 miles southeast of Branford. The spring pool is about 30 by 66 feet for an estimated surface area of 0.05 acres and has a maximum depth of 21.5 feet over the spring vent. The spring water was greenish when visited in 2002 by FGS. The spring run to the west side of the Suwannee River is about 90 feet long.

Manatee Springs is a 1st magnitude spring in Manatee Springs State Park and is located about 7 miles west of Chiefland in Levy County. The spring pool is about 60 by 75 feet for an estimated surface area of 0.1 acres. The depth of the spring pool was reported to be about 25 feet. During a 2002 visit by FGS, the spring water was sky blue with a very pronounced boil. The spring run is about 1,200 feet in length, flowing southward to the Suwannee River.

Santa Fe Springs Focus Area

The Santa Fe River, located in the springs heartland of north central Florida, is the discharge point for at least 97 recorded springs. The estimated human population in the Santa Fe Springs Focus Area is 280,253.

The Santa Fe River is a second order tributary that flows into the Suwannee River. The Santa Fe River is underlain by porous limestone formations that comprise the Floridan Aquifer system. Based on the depth to the Floridan Aquifer, the Santa Fe River is naturally divided into two sections: the upper segment extending from Lake Santa Fe downstream to O’Leno State Park; and lower segment extending from O’Leno State Park down to its confluence with the Suwannee River.
The watershed of the Upper Santa Fe River is underlain by up to 100 feet of fine-grained soils of the Hawthorne Formation which confine the Floridan Aquifer system below. The watershed of the Lower Santa Fe River is directly underlain by limestone at the surface, resulting in minimal confinement of the Floridan Aquifer, highly permeable soils, and generally drier plant communities at the land surface. The entire flow of the Santa Fe River goes underground at River Sink in O’Leno State Park. The water flows underground for approximately three miles through subterranean caves and returns to the surface at River Rise in O’Leno State Park. Groundwater from at least 90 recorded springs originating in the Floridan Aquifer (e.g., Poe, Gilchrist Blue, Ginnie, Rum Island, etc.) discharges into the Santa Fe River after the river emerges from underground. Further downstream, the Ichetucknee River—a predominantly spring-fed river—discharges into the Lower Santa Fe River. Karst features, comprised of sinkholes, springs, estavelles, suckholes, and swallets, illustrate the interdependence of surface and groundwater along the Lower Santa Fe River.

About 70 years ago, the Santa Fe River springshed is estimated to have been about 1,775 mi$^2$. By 2008, the Santa Fe River springshed had declined considerably to a current size of about 1,114 mi$^2$. These estimates indicate that there has been a 37% reduction in the size of the springshed that supplies water to the Santa Fe River Springs. The reduced springshed size is attributed to groundwater pumping from municipal wells, agricultural wells, and private wells which reduce the amount of spring discharge. It is these and other groundwater withdrawals that remove water from the Floridan Aquifer, lower the level of the aquifer, and diminish the flow of water that discharges at the Santa Fe River Springs.

Rainfall is the only significant input of water for the Santa Fe River. Based on a review of the available data, the estimated pre-development average flow in the Santa Fe River at the US 47 station was about 1,059 MGD. The current (2001-2010) estimated annual average flow at the US 47 station is about 672 MGD. While rainfall totals have declined about 20 percent over this period, average flows at US 441 and at US 47 in the Santa Fe River have declined between 40 and 60 percent. This discrepancy indicates that increasing regional groundwater withdrawals and not rainfall changes are the principle cause of flow reductions in the Santa Fe River Springs.
Worthington Spring is in Union County, north of the Santa Fe River, and about 16 miles north of Gainesville. Worthington Spring has a small circular pool 60 feet in diameter surrounded by an earthen berm. The east bank of the pool is a steep, man-made slope of limestone boulders. The north bank is grass with an asphalt parking lot at the top of the rise. The spring run averages 2 feet deep and flows 300 feet southwest into a backwater slough of the Santa Fe River. A picnic pavilion with a wooded hill behind is situated northeast of the spring pool. The spring is located within Chastain-Seay City Park and is developed with wooden walkways and picnic areas. Historically, the spring pool was enclosed by a 12-foot square concrete wall and the spring was a popular destination with a hotel, bathhouse, and swimming area. Worthington Spring has had only intermittent flows since the 1950s. –Florida Geological Survey, Bulletin 66

Santa Fe (Graham) Spring is an historic first magnitude spring on the west bank of the Santa Fe River in Columbia County, about 8 miles northeast of High Springs. This spring, formerly recorded as COL61981, is a large circular depression with steep sides. Spring pool diameter measures about 200 feet with a depth of 83 feet. The water color is typically clear to tannic. The spring run, which flows southeasterly into the Santa Fe River, is about 90 feet long. Some algae are present on limestone substrate in the spring run. No other aquatic vegetation could be seen through the dark water. Very little emergent vegetation is present.

Santa Fe River Rise is the first magnitude re-emergence of the underground Santa Fe River in Alachua County and is in River Rise Preserve State Park. The spring pool measures 175 feet east to west and 165 feet north to south. There is a vertical limestone ledge on the northeast side of the pool. The depth just south of the ledge measures 49 feet. The water color is typically that of the Santa Fe River, which may be tannic or clear depending mainly on the amount of recent rainfall. The river flows southward from the vent and is approximately as wide (east to west) as the spring pool. There is a narrow band of cypress growing around the pool perimeter. There are patches of duckweed and water hyacinth around the periphery of the pool, and no submerged aquatic vegetation are typically present. –Florida Geological Survey, Bulletin 66
**Hornsby Spring** is in Alachua County on private land (Camp Kulaqua) and is primarily used as a swimming recreation area. The pool is circular and measures 155 feet north to south and 147 feet east to west, with a depth of 34.5 feet. The water is clear to tannic. There is a limestone shelf submerged under a floating walkway. Algae patches were observed growing on limestone substrate by the Florida Geological Survey. The spring run is approximately 0.9 miles long, 15 feet wide and up to 5 feet deep. It flows generally westward into the Santa Fe River. Flows at Hornsby Spring are intermittent, depending on adequate rainfall and elevated aquifer levels. The underwater cave system at Hornsby has been mapped.

**Poe Spring** is located within an Alachua County park. Structural modifications include a retaining wall around portions of the spring pool, a stone stairway, and a bath house. The spring pool is circular and about 120 feet in diameter. Several vents are on the south side of the pool at the bottom of a conical depression where there is exposed limestone. The depth measures almost 19 feet over the vent and a boil is occasionally visible on the spring surface. The water is clear to tannic with a yellow to green hue. The spring bottom is sand, native vegetation is absent, and during periods of low use the floor is covered by dense filamentous algae. A short, swift spring run flows approximately 75 feet northwest into the Santa Fe River. There is a wooden boardwalk on the south side of the pool, with low-lying river floodplain, surrounding the spring and mesic hardwood forest to the south and west of the spring.

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**ESTEVELLE: A spring that reverses flow direction**

Over the past decade, Poe Spring in Alachua County has reversed flow during each flood event in the adjacent Santa Fe River. Spring flow reversals occur when the pressure of water in the aquifer is less than the elevated head of water in the river. During a flow reversal, surface water from the Santa Fe River, evident by strong tannic color, low dissolved salts, and elevated coliform bacteria levels, penetrates the limestone caves and moves miles inland. When aquifer levels rise in response to increased seasonal rainfall and river levels fall due to a drought/pumping, spring discharge can return but the spring water is often tinted yellow or green for months or years due to the dissolved organic content from the river water. Photo by John Moran.
Poe Spring’s flow has been declining during the period-of-record with the first ever recorded cessation in May 2012. Flow reversals are increasingly common.

**Gilchrist Blue Spring** is in Gilchrist Blue Spring State Park and is about 6 miles southwest of High Springs. The spring pool is circular and measures 132 feet in diameter with a depth of about 20 feet at the vent. Water flows from a cave under a submerged limestone ledge on the northwest side of the spring pool and there is a wooden jumping platform directly overhead. The bottom near the vent is limestone, with the rest of the pool being shallow with a sandy bottom. The spring water is clear and blue. The pool is partially enclosed by a wooden retaining wall and is heavily used for wading, snorkeling, kayaking, and other surface recreational activities.

The spring run is approximately 1,100 feet in length and flows north to the Santa Fe River. The spring and spring run have been vegetated and unvegetated in recent history. Hydrilla and filamentous algae have dominated the spring pool during winter, low use periods. Native submerged species of sagittaria periodically colonize the spring run. Additionally, Little Blue Spring discharges from the west and Naked Spring and Johnson Spring discharge from the east into the run about 100 feet and 500 feet downstream from the spring pool. Gilchrist Blue Spring is adjacent to the south edge of the Santa Fe River floodplain.
The Ginnie Springs Group is in Ginnie Springs Outdoors, a privately-owned recreational camping resort located about 10 miles southwest of High Springs. The Ginnie Springs Group includes a total of seven named springs: Ginnie, Little Devil, Devil’s Eye, Devil’s Ear, Dogwood, Twin, and Deer.

The Ginnie Springs pool is roughly circular, measuring about 90 feet in diameter and 12 feet deep. The water is clear and blueish and flows from a cavernous vent underneath a limestone ledge on the pool’s east side. The spring has a sand and limestone bottom. Little to no aquatic vegetation occurs in the spring and its run. There are two scuba diving/swimming access platforms on the south side of the pool. The spring pool is surrounded by cypress and hardwood trees. The spring run has an approximate width of 35 feet, is 3 feet deep and flows east about 500 feet. The spring and run are situated within the river floodplain. A cave system that includes about 1,100 feet of known passages extends beyond the vent underneath the limestone ledge to the east and south. Cavern diving is popular in Ginnie Spring. The cave system is blocked with a gate to prevent divers from entering beyond the daylight zone.

The Devil’s Spring Group includes three major spring vents in and adjacent to a 375 feet long spring run that enters the Santa Fe River from the south side. The southern-most vent, Little Devil’s is most upstream, followed by Devil’s Eye near the end of the run. Devil’s Ear is the largest spring vent in terms of flow and is submarine in the floor of the Santa Fe River, about 30 feet offshore. It is an elongated limestone fissure that flows into the Santa Fe River. The spring pool is approximately 105 feet east to west and 60 feet north to south. The vent is oval shaped with steep sides and a depth of 34 feet. Dark, tannic water from the river mixes with clear, bluish water from the spring. Currently there is very little submerged aquatic vegetation in any of the Devil’s Springs Group. An underwater cave system connects the Devil’s Ear Springs Group vents.
Ichetucknee Springs

The Ichetucknee Springs Group is in Ichetucknee Springs State Park, about 10 miles south of Lake City in Columbia County, in north central Florida. The Ichetucknee River System is formed by cumulative ground water inflows from nine artesian springs including Ichetucknee, Cedar Head, Blue Hole (Jug), Mission Group (Roaring and Singing), Devil’s Eye, Grassy Hole, Mill Pond, and Coffee. The Ichetucknee River flows 5.5 miles before joining the Santa Fe River which in turn flows to join the Suwannee River on its way to the Gulf of Mexico.

The Ichetucknee Springs and River support a complex and diverse web of aquatic vegetation and fauna, including reptiles, amphibians, fish, mammals, insects, mollusks, and birds. Many insect larvae critical to the food chain occur in the Ichetucknee, including non-biting flies, stone flies and mayflies. Crustaceans include freshwater shrimp, amphipods and crayfish. Seven species of clams and mussels have been identified in the Ichetucknee River and aquatic snails are prolific. An endemic snail species, the Ichetucknee Silt Snail only occurs in Coffee Spring adjacent to the Ichetucknee River. A large number and variety of aquatic turtle species are also found in the Ichetucknee River.

Land uses in the Ichetucknee springshed are gradually changing from rural/agricultural to urban/residential. Filamentous algae cover much of the submerged aquatic vegetation in several of the springs feeding the Ichetucknee River. Species richness and total cover of submerged aquatic vegetation in the Ichetucknee River have shifted over time, apparently in response to a combination of declining spring flows, increasing nitrate pollution, and increasing recreation pressure.

Average percent cover and species diversity in the Ichetucknee River averaged over 24 stations located in the spring run within the Ichetucknee Springs State Park. FDEP data.
Ichetucknee Head Spring is the upstream-most spring in the Ichetucknee River Springs Group. The spring pool measures 102 feet east to west and 87 feet north to south. The depth measures 17 feet over the vent. Water is clear and light blue and issues from a fracture in the limestone forming a visible boil. A thin layer of algae carpets most of the bottom of the spring. The spring has sand and limestone bottom with little or no aquatic vegetation. The west shore is lined with rock walls and a concrete access area with steps and wheelchair access. This spring is accessed by a path and is a popular swimming hole. –Florida Geological Survey, Bulletin 66

Blue Hole (Jug) Spring is in the spring run channel of Cedar Head Spring, which is north of Blue Hole. The spring pool and outflow greatly widens the incoming spring run, and the combined run comprises a first magnitude spring and flows south a short distance to the Ichetucknee River. The spring pool measures 87 feet east to west and 117 feet north to south. The depth measured over the vent is 37 feet. The water is clear and light blue, and a boil is visible on the pool surface. Water issues from a cavern in limestone. The pool has a sand and limestone bottom with abundant aquatic grass and some algae. The land around the spring is heavily forested with mixed hardwoods and cabbage palms. The spring run is fenced off approximately 100 feet south of the vent. There is swimming access with a wooden boardwalk and overlook connected to the Ichetucknee Head Spring parking lot by a dirt foot path. –Florida Geological Survey, Bulletin 66

<table>
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Historic and recent water quantity and quality data from sentinel springs in the Santa Fe Springs Focus Area (WMD – Water Management District; Mag. – springs magnitude; cfs – cubic feet per second; mg/L – milligrams per liter).
Gulf Coast Springs Restoration Area

The Gulf Coast Springs Restoration Area includes 9,060 mi$^2$ in the central and western portion of the Florida peninsula and includes portions of 16 Florida counties (Alachua, Citrus, DeSoto, Hardee, Hernando, Highlands, Hillsborough, Lake, Levy, Manatee, Marion, Pasco, Pinellas, Polk, Sarasota, and Sumter). Of the 1,091 recorded springs in Florida, 245 are in the Gulf Coast Springs Restoration Area.

Upland forest, rangelands, and water/wetlands account for 41% of this area’s land use, while intensive agriculture occupies about 29% of the land area and urban/other is about 30% of the land area. The estimated human population in this springs region is 4,285,274.

The Gulf Coast Springs Region includes three springs focus areas: Rainbow/Withlacoochee Springs Focus Area (1,567 mi$^2$), the Springs Coast Springs Focus Area (2,171 mi$^2$), and the Southwest Coast Springs Focus Area (5,322 mi$^2$). Because of this area’s proximity to the Gulf of Mexico coastline, this region is a zone of ground water discharge through springs and more diffuse aquifer leakage which in turn feeds rivers, marshes and swamps bordering the coast. The Gulf Coast Springs Restoration Area is also characterized by numerous sinkholes, internal drainage and undulating topographic features that are typical of karst landscapes. The unconfined limestone comprising the Upper Floridan Aquifer in this area has been extensively and repeatedly subjected to chemical dissolution and deposition processes in response to sea-level fluctuations over a geologic timescale.
Rainbow/Withlacoochee Springs Focus Area

The Rainbow/Withlacoochee Springs Focus Area has an area of 1,567 mi², is located along the upper west coast of peninsular Florida, and includes portions of Alachua (8%), Citrus (14%), Levy (14%), Marion (32%), and Sumter (26%) counties. Upland forests, rangelands, and water/wetlands occupy about 48% of the land in this focus area, while intensive agriculture occupies about 35% and urban is about 18%. The estimated human population is 194,532.

Citrus Blue Spring has a roughly circular pool that measures 120 feet in diameter. The east side of the spring pool is partly enclosed by a man-made, five-foot high dike. The spring depression is relatively shallow and uniform except at the vent in the center where depth measures 22 feet. The color of the water is bluish-green, and the sand bottom has substantial submerged aquatic plant cover with sparse algae. Spring flow is directed northwestward through a 30 foot wide man-made canal, eventually discharging into the Withlacoochee River approximately 0.4 miles downstream. The canal has a sand bottom with abundant detritus as well as abundant aquatic vegetation. Before the dike was constructed, the spring discharged eastward approximately 150 feet into the river. The spring is within the forested Withlacoochee River floodplain. The spring has an extensive cavern system that opens southward to a depth of at least 180 feet below the land surface.

Gum Slough Springs is an isolated spring system surrounded by large, undeveloped public and private properties and partially protected from the pressures of modern urban development. This relatively isolated location provides a unique system that does not have the heavy recreational or developmental difficulties facing many of Florida’s springs. However, it does not make the spring system invulnerable to rising nutrient concentrations and declining flows.

Gum Slough Springs is made up of at least seven individual spring vents, some with their own short spring runs. The total length of the spring run is approximately 5 miles from its main spring boil to the junction with the Withlacoochee River. The stream is braided in many areas along its length with multiple channels and backwater areas. Gum Slough and Gum Springs Run were designated Outstanding Florida Waters (OFWs) in 1989. By law, no additional degradation of water quality is allowable in an OFW due to permitted wastewater discharges after it is designated.
Rainbow River System

The Rainbow River System is in southwest Marion County in west central Florida, approximately 4 miles north-northeast of Dunnellon and 19 miles west-southwest of Ocala. The Rainbow River originates at Rainbow Springs Group and flows about 6 miles south where it converges with the Withlacoochee River upstream of Lake Rousseau. The Withlacoochee River ultimately discharges to the Gulf of Mexico near Yankeetown, Florida.

The Rainbow Springs Group consists of twelve named vents and many lesser unnamed vents to create one of the largest first magnitude spring systems in the state and providing the principal water flow in the Rainbow River. Rainbow Springs has a long history of human usage. Amerindians used the area as early as 10,000 ago. During the 1880s, the area near the Rainbow River was logged and planted with citrus trees. Hard rock phosphate was discovered in the 1890s, and dozens of mines sprung up along the lower Rainbow River and the Withlacoochee River. Most of these mining operations closed at the start of World War I when pebble rock phosphate was discovered in Hillsborough and Polk Counties. By the 1920s, the springs were used by locals and tourists for recreation.

In the 1930s, Rainbow Springs was first developed as a private attraction featuring botanical gardens and glass-bottomed boat rides. The State of Florida purchased the property in 1990. The head springs and a large portion of the eastern bank of the Rainbow River are located within the 1,470-acre Rainbow River State Park, a major tourist attraction currently managed by the Florida Department of Environmental Protection.

The Rainbow Springs basin is underlain by the karstic Ocala Limestone and the Avon Park Formations. The Ocala Limestone forms the top of the Upper Floridan Aquifer which is largely unconfined in this area. The Upper Floridan Aquifer is about 600 feet thick in western Marion County; the greatest amount of recharge to the unit occurs at or near the ground surface entering the Ocala Limestone directly.

The geochemistry of groundwater discharging from Rainbow Springs indicates that the water moves relatively rapidly through a short, shallow flow system. Three prominent bedrock fracture traces pass through the Rainbow Springs area with one trending northeast and one trending northwest. Isotope studies at Rainbow Springs indicate an average groundwater age of no more than 16 years.
Along its eastern margin the Rainbow Springs’ springshed overlaps the Silver Springs springshed (Silver Springs Focus Area). The surface elevation of the Silver River near the spring vents is approximately 10 feet higher than the Rainbow River spring boil. Because of this difference and due to declining levels of water pressure in the Floridan Aquifer, it is hypothesized that springs in the Rainbow River are pirating flow from the Silver River springs.

The Rainbow Springs System has received numerous regulatory protections including recognition as a National Natural Landmark, designation as an Outstanding Florida Water, inclusion in a Florida Aquatic Preserve, and State Park status. Despite this recognition and regulation, the Rainbow Springs System has had significant degradation in the last 50 years due to agricultural, urban, and industrial development in the surrounding springshed. The effects of development include excessive ground water withdrawals, resulting in significant flow declines, and excessive use of nitrogen fertilizers and animal and human wastewater disposal, resulting in extremely elevated nitrate nitrogen pollution.

The declining spring flows no longer support the size and complexity of the Rainbow Springs Group ecosystem. Regional groundwater use in the area is over 1,100 MGD resulting in an estimated decline in the level of the Floridan Aquifer System in the Rainbow Springshead of about 8 to 15 feet compared with pre-development conditions. Flows from the Rainbow Springs System have declined by about 25% since the 1960s with an estimated 11% of the loss due to rainfall declines and the remaining 14% attributable to ground water extractions, both local and regional. Lowered spring flows have resulted in lower water velocity in the river and lower water levels.
Increasing concentrations of nitrate-nitrogen in the spring discharge, combined with lower average flows, are causing significant impairment in the Rainbow River, including algal proliferation and loss of native aquatic plants. Nitrate emerging from Rainbow Springs is primarily inorganic, indicating fertilizers as the dominant source. About 35% of the land use in the Rainbow Springs basin is agricultural. The Rainbow Springs Springshed is vulnerable to groundwater contamination by nitrogen from fertilizers and human/animal waste disposal practices resulting in an average load of about 1,000 tons of nitrogen per year discharging from the springs into the Rainbow River at a concentration of more than 2 mg/L as nitrate nitrogen. This means a reduction of nitrogen loading to the springshed area of approximately 82% is needed for compliance with state Numeric Nutrient Standard of 0.35 mg/L.

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<th>County</th>
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Historic and recent water quantity and quality data from sentinel springs in the Rainbow Springs Focus Area (WMD – Water Management District; Mag. – springs magnitude; cfs – cubic feet per second; mg/L – milligrams per liter).
Springs Coast Springs Focus Area

The Springs Coast Springs Focus Area has an area of 2,171 mi$^2$, is located along the upper west coast of peninsular Florida, and includes the majority of Hernando, Citrus, Pasco and Sumter counties and smaller portions of Hillsborough, Lake, Pinellas, and Polk counties.

Because of this area’s proximity to the Gulf coast, this area is a zone of ground water discharge to springs and more diffuse aquifer leakage which in turn feeds rivers, marshes and swamps bordering the coast. The Spring Coast Springs Subregion includes an estimated 135 documented springs and four first-magnitude spring groups.

The Springs Coast Springs Subregion is also characterized by numerous sinkholes, internal drainage and undulating topographic features that are typical of karst landscapes. The unconfined limestone comprising the Upper Floridan Aquifer in this area has been extensively and repeated subjected to chemical dissolution and deposition processes in response to sea-level fluctuations over a geologic timescale.

The Springs Coast Springs Focus Area is undergoing rapid growth and groundwater resources are being actively developed for regional and local water supplies. The estimated human population living in the Springs Coast Springs Subregion is 835,475. Of greatest concern is the quantity of spring flow that is being diverted for human uses, increasing contamination of

Springs Coast Focus Area estimated predevelopment springsheds (red dots indicate first magnitude springs and blue dots are second magnitude springs).
spring flows with nitrate-nitrogen derived from inorganic fertilizers and septic systems, and the environmental impacts resulting from flow and water quality reductions to the freshwater and estuarine resources of the area.

The principal rivers that drain the Springs Coast Springs Subregion are, from north to south, the Crystal, Homosassa, Chassahowitzka and Weeki Wachee Rivers. Each of these rivers originates from a spring or a group of springs that provide most of the freshwater flow in the rivers.

Kings Bay/Crystal River

The 600 ac Kings Bay embayment comprises a first-magnitude spring system that is the second largest spring system in Florida. Historic flows averaged nearly 600 MGD and accounted for approximately 99 percent of the freshwater exiting Kings Bay through the Crystal River. There are more than 70 artesian spring vents feeding groundwater to Kings Bay/Crystal River in Citrus County, Florida. Prior to the 1970s, Kings Bay was a fisherman’s and scuba diver’s paradise. Eelgrass (Vallisneria americana) covered the bottom of the bay like a lawn of waving grasses. Water clarity was so good that divers and fishermen could see the fish, manatees, and other aquatic wildlife hundreds of feet away.

The decline in water quality in Kings Bay/Crystal River began in the 1960s. As the City of Crystal River grew around Kings Bay, real estate development led to excavation of numerous finger canals, providing dry ground for housing development and boating access for many of the new residents. The city began discharging treated, municipal wastewater with high nutrient concentrations directly to Kings Bay in 1962. Spring flows were noticeably declining by the 1970s.
With dredged finger canals, developed shorelines, and the city’s wastewater inputs, increasing nutrient contamination led to proliferation of exotic aquatic weeds, including hydrilla (*Hydrilla verticillata*) and water hyacinths (*Eichhornia crassipes*). While Kings Bay’s water remained clear during this period, extreme measures, such as addition of copper herbicides and sulfuric acid, were applied to kill off the plants that were interfering with recreational boating.

By the 1980s and 1990s, poorly considered plant management measures had freed the bay from hyacinths and hydrilla dominance but had also largely led to the unintentional eradication of the desirable eelgrass. Spring flows continued to decline as Citrus County’s and southwest Florida’s population grew with increased reliance on groundwater for watering manicured landscapes and for farm irrigation and fertilization. The result of declining spring flows combined with the loss of much of the native aquatic vegetation in Kings Bay was the proliferation of undesirable planktonic and benthic algae and a marked increase in salinity in the springs and bay. With these physical and biological changes, water clarity in much of Kings Bay declined to less than 20 feet.

Whereas meaningful restoration of Kings Bay/Crystal River may appear to be complex, the causes of the impairment problems are well understood, and corrective actions are feasible to implement. In other words, today’s residents and tourists visiting Kings Bay/Crystal River could live to see a restored and vibrant ecosystem. Restoration can only result if everyone involved pulls together to make the relatively easy lifestyle changes that are needed to assure success in restoring Kings Bay/Crystal River.
Homosassa

Homosassa Springs Wildlife State Park is comprised of two physical properties located in the City of Homosassa Springs (Citrus County), approximately 75 miles north of Tampa and 90 miles northwest of Orlando. The visitor center, restaurant, gift shop, and administrative offices are adjacent to US19. The actual springs, as well as wildlife exhibits and underwater observatory (fish bowl) are located at the west portion of the park.

In 1963, the Chicago Cattle Feed Holding Company purchased virtually all the land surrounding Homosassa Springs. The new owner built pontoon boats for observation of the springs and river and created a 180-ton floating underwater observatory at the main spring for viewing fish and other aquatic life. In 1988, the state of Florida purchased the initial portion of the 197 acres that became Ellie Schiller Homosassa Springs State Wildlife Park.

Homosassa Springs is a popular destination for wildlife viewing, nature park programs, and general tourism. Homosassa Springs Wildlife State Park does not allow in-water recreation within park property. Swimming takes place outside the park, in the Homosassa River and in the limited spring run downstream of the park footbridge.

The lands immediately surrounding the spring are hardwood/coastal wetland, but many portions have been extensively developed for residential and commercial use. The spring run is surrounded by a variety of park attractions and runs about 400 feet downstream to a footbridge. Below this footbridge there a metal barrier system which prevents human and manatee passage (manatees are kept in the spring pool/run for rehabilitation and education). Below the foot bridge the spring run feeds the Homosassa River, along with spring flow from nearby springs, and further downstream, surface drainage from the Halls River.

Historic and recent water quantity and quality data from sentinel springs in the Springs Coast Springs Focus Area (WMD – Water Management District; Mag. – springs magnitude; cfs – cubic feet per second; mg/L – milligrams per liter).
The hydrology of Homosassa Springs has been investigated using data from ground-water levels in the Upper Floridan aquifer, surface-water stage, spring flow, and specific conductance of spring water. Upper Floridan aquifer water levels control the magnitude of daily mean spring flow and tidal influences from the Gulf of Mexico, and impact the diel range and duration of spring pool stage (and instantaneous spring discharge). Seasonal and stochastic rainfall patterns and groundwater pumping strongly influence ground-water levels and resulting average spring discharge.

Homosassa Springs State Wildlife Park has an active manatee rehabilitation program which utilizes the spring pool and upper run to shelter and contain rescued manatees. Downstream of the park footbridge, wild manatees are known to congregate during the winter for the thermal refuge provided by the spring effluent. Concerns over the fencing (under the foot bridge) which precludes wild manatee access to the main spring pool have been raised in a review of Florida springs and their accessibility to manatees seeking thermal refuge.

Unique tourism opportunities at Homosassa State Wildlife Park include the ability to observe manatees year-round because of the rehabilitation facilities for these animals. This park does not have overnight usage and the annual attendance values represent day use only. Maximum annual attendance has exceeded 500,000 since 2007. Mean monthly attendance peaks in March, a probable consequence of winter tourism and the fact that the park does not allow swimming.


Chassahowitzka

The Chassahowitzka River is a 5.8 mile spring-fed river located in the Gulf Coast Springs Region, which includes the coastline extending from the Pithlachascotee River located north of Tampa Bay to the Waccasassa River area located south of the Suwannee River Basin. The river originates in Citrus County and enters the Gulf of Mexico at Chassahowitzka Bay. It was designated an “Outstanding Florida Water” by the Florida Department of Environmental Protection (FDEP) in 1979 and the lower half of the river is part of the 35,000+ acre Chassahowitzka National Wildlife Refuge established in 1943. Mean depth is approximately three feet. The upper reach of the Chassahowitzka is relatively narrow but broadens considerably (to over 500 feet) downstream.

The surface drainage area for the Chassahowitzka River is approximately 89 mi², but the springshed is significantly larger. Groundwater contribution is estimated to be from a 713 mi² area. The surface watershed is limited to Citrus and Hernando Counties while the historic springshed southeast extended through Pasco and Lake counties to the potentiometric high in Polk County.

The headwaters for the Chassahowitzka River are formed by the Chassahowitzka Main Spring, Chassahowitzka #1, Chassahowitzka #2, and several unnamed springs upstream. The main spring is located about 200 feet northeast of the boat ramp at the Citrus County Chassahowitzka River Campground (near the west end of County Road 480). Chassahowitzka #1 and #2 are located 350 feet upstream of the main spring in a short channel entering from the northeast. More than a dozen springs discharge additional flow into the Chassahowitzka River. The main pool is nearly circular and about 150 feet in diameter. The bottom slopes gently toward the vent in a crevice about 25 feet long and 1 to 2 feet wide. The depth of the spring vent is about 34.5 feet below water surface.

All groundwater discharging from the Chassahowitzka springs group is from the Upper Floridan aquifer. Tides in the area are semidiurnal and unequal, generally ranging from 2.0 to 4.6 feet. Tidal water level fluctuations inversely affect discharges. In common with other streams along the Florida Springs Coast, the Chassahowitzka River flows over and drains a predominantly karst landscape.
Weeki Wachee

Weeki Wachee Spring is in Hernando County 20 miles south of Homosassa or 5 miles north of Spring Hills, at the intersection of SR 50 and US HWY 19. This first magnitude spring has a long history as a tourist attraction due to the opportunity to view performers dressed as mermaids. The first mermaid show was performed in October 1947. Although the spring was purchased by the City of St. Petersburg as a potential source of drinking water in 1940, it was never utilized for this purpose. Ownership has changed several times in the intervening decades, and in 2001 the springs and surrounding lands were purchased by the Southwest Florida WMD with the tourist attraction continuing operation by private lease. Weeki Wachee Springs and the facilities became a state park administered by the FDEP/FPS in 2008.

The Weeki Wachee Springs State Park facilities are well developed and include large parking lots, staff housing, animal exhibits, gift shops, and food concessions. The primary recreational inducements to the spring are the underwater viewing chamber and associated mermaid show; a boat tour; and the water park- Buccaneer Bay, which has water slides, swimming, and beaches. Private boats can travel the Weeki Wachee River but are prohibited from entry into the headsprings pool.

Weeki Wachee Spring forms the headwaters of the Weeki Wachee River system which ultimately discharges into the Gulf of Mexico at Bayport, Florida. Approximately 0.6 miles downstream of the main spring, a smaller spring, Twin Dees Spring, contributes additional groundwater to the river system. The nearly circular Weeki Wachee spring pool is large at approximately 200 feet wide, with steeply sloping sides which form a conical vent at a depth of about 50 feet. The spring vent has rocky substrate revealing the region’s karst geology and is covered by quartz sands around the upper sides. A unique feature of Weeki Wachee Springs is the 400-seat underwater theater which allows viewing the spring vent through large submerged windows. Built to facilitate mermaid shows, this feature also allows spectators to appreciate the large spring vent and excellent water clarity.
The lands immediately surrounding the spring are mostly developed by various commercial ventures. The winding spring run is extensive but rarely wider than 50 feet and as a result, riparian canopy cover can be heavy. Sediments in the spring run are primarily coarse sands. The Weeki Wachee River travels westerly for about 7 miles, passing through sandy uplands, and then forested wetlands, and ultimately into a coastal salt marsh where it discharges into the Gulf of Mexico at Bayport. The shoreline of the spring run is relatively undeveloped in the upper portion and residential housing is widespread along the middle and lower reaches.

The Weeki Wachee Spring originates in the Weeki Wachee Dune Field, a relic dune system with typical elevations of 65 feet or less. Remaining terrestrial habitats are principally scrub and pine uplands. As the Weeki Wachee River travels west, it passes through the Coastal Strip, comprised of a limestone plain with elevations typically less than ten feet above sea level. Soils overlying the Coastal Strip are poorly drained, organic, and shallow.

The hydrogeological framework of the Weeki Wachee area includes a discontinuous, sandy surficial aquifer system, a discontinuous, sandy-clayey intermediate confining unit, and the thick, mostly limestone Upper Floridan aquifer. Although substantial saturated sandy deposits are found in the area, a hydraulically separated and regionally extensive surficial aquifer system does not exist; as the clay confining unit is breached by numerous sinkholes, allowing numerous hydraulic connections between the aquifers. Geologic units which form the freshwater part of the Upper Floridan aquifer are the Avon Park Formation and Ocala Limestone of Eocene age, and the Suwannee Limestone of Oligocene age.

Both the surface drainage area and the springshed for Weeki Wachee Spring have been delineated and are approximately 38 mi² or 24,320 acres and 295 mi² or 188,800 acres, respectively. While the watershed is solely contained within Hernando County, the springshed encompasses large portions of Hernando and Pasco Counties.
Land use for the Weeki Wachee springshed in 1999 was approximately 27% urbanized. Other major land use categories within the springshed include agriculture and upland forests. Land use continues to be transformed to urban areas, primarily through the conversion of rangeland and forest habitats and the current percentage of urban lands are greater.

Because of the urbanization of the Weeki Wachee springshed, nitrate-nitrogen concentrations have increased greatly over the past three decades. The trend of increasing nitrate concentrations closely follows human population growth in the springshed suggesting a linkage between these two variables. Research indicates that the origin of the nitrate discharged from this spring is most likely derived from an inorganic source of nitrate, such as inorganic fertilizers applied to residential and golf course turf grass within the springshed.

Historical discharge data for Weeki Wachee Springs through 1974 averaged 114 MGD. Recent analysis of the discharge record for Weeki Wachee Springs, as part of the minimum flows and levels (MFL) analysis, indicated that discharge averaged approximately 105 MGD for 1984-2004, the baseline period chosen for establishing the MFL. The reduction in average flow was determined to be the result of anthropogenic impacts, principally springshed ground water withdrawals. This reduction has resulted in an estimated 11 MGD or eight percent reduction in flow through 2004. The adopted minimum flow for the Weeki Wachee Spring system allows an 11% reduction in average flows.

Southwest Coast Focus Area

The Southwest Coast Springs Focus Area has an area of 5,320 mi², is located along the upper west coast of peninsular Florida, and includes all or the majority of Desoto, Hardee, Hillsborough, Manatee, Pinellas, and Sarasota counties, and lesser portions of Polk, Pasco, and Highlands counties. Uplands in this area are made up of an almost even mix of urban (35%) and agricultural land uses (31%), with forest/rangeland/wetlands occupying the remaining 34%. The estimated population in this subregion was nearly 3.3 million in 2018. A total of 52 artesian springs are documented in the Southwest Coast Springs Subregion. There are no first-magnitude springs recorded in this subregion but there are 15 second-magnitude and 6 third-magnitude springs.
Hillsborough River

Crystal Springs sits in a pool formed by a dam and is a major contributor to the baseflow of the Hillsborough River in Pasco County. The spring pool measures 135 feet north to south and 276 feet northwest to southeast. The depth is generally shallow, ranging from 4 to 10 feet. There are multiple vents and sand boils scattered about the pool. The main vent is in the southeastern portion of the spring pool and has a stainless-steel bottled spring water extraction pipe. The bottom of the spring pool is limestone and sand with abundant aquatic grass and algae. The water is clear and light blue. The pool edges are entirely enclosed by a sandbag retaining wall. An observation platform is on the southeast bank of the pool. The weir/dam on the northwest side of the pool has a boardwalk over it, and water discharges through a culvert into the adjacent Hillsborough River. The clear water from the spring contrasts sharply with the tannic water of the river. The river is approximately 100 feet wide at the confluence with Crystal Springs. To the southeast, the ground rises gently to approximately 8 feet above the spring, and the hillside is open and grassy. A residence is located a few hundred feet upslope. The lowlands along the river harbor an intact floodplain forest. Previously run as a private recreation area, the spring and surrounding property has been restored to more natural conditions and opened as Crystal Springs Preserve, a learning laboratory and environmental education facility. A portion of the spring flow is extracted by Zephyrhills water bottling company owned by Nestle Waters. –Florida Geological Survey, Bulletin 66
Sulphur Spring has been highly altered from its natural condition into a circular pool enclosed by concrete walls. The diameter of the pool is 90 feet. The pool is uniformly about 15 feet deep with a limestone and sand bottom and a maximum depth of 30 feet. The water is slightly murky and greenish colored. Algae are abundant in the pool. Spring outflow is southeast, cascading over a 7 foot-high weir. The falls continue for approximately 50 feet, and the rest of the run travels approximately 600 feet to the Hillsborough River. The spring run is sand-bottomed and algae-covered. A hydrogen sulfide odor is associated with the spring. There is a City of Tampa water pumping facility on the west side of the pool where a large metal pipe discharges water forcefully into the spring. The facility pumps a portion of the spring flow for municipal use, and the other portion is rerouted through the pipe into the pool. The spring itself is closed to swimming, but the surrounding area is developed into a swimming and recreation park with a large swimming pool just a few feet east of the spring pool. Park personnel report that the spring’s cave system has been explored by divers and heads northward under the city. Divers have connected the cave system to several nearby sinkholes. –Florida Geological Survey, Bulletin 66

Sulphur Spring presents an example of the serious degradation that can occur in the absence of planning and protection that is based on an understanding of the dynamics of the hydrogeologic system. To manage its stormwater, the City of Tampa directed runoff into sinkholes. As many as fifteen of those sinkholes contributed stormwater runoff to the spring and eventually some of the sinks were filled. This action resulted in reduced groundwater flow to the spring. The spring’s discharge has been reduced by more than 40% since the 1960s.

Septic tanks and domestic sewage systems may also contribute contaminants to the groundwater that feeds the spring. Nitrate measurements as high as 0.89 mg/l have been noted. By 1986, contamination by coliform bacteria forced the permanent closure of the spring to public recreation. Salinity of the spring water is increasing, a symptom of reduced freshwater inflow due to plugged sinkholes and pumping of the aquifer for water supply.
Alafia River

**Lithia Spring Major** is situated within a large, human-modified, spring pool. The pool measures 168 feet north to south and 180 feet east to west, and depth measured over the vent is 8.2 feet. The water is clear and blue-greenish. The pool bottom is sand with a limited exposure of limestone near the vent. The spring pool has steep retaining walls with several access stairways leading down into the water. The vent in the center of the pool is covered by a barred metal barricade to prevent entry. Spring water discharges through the bars and creates a visible boil. The clear, sandy spring run exits east and flows approximately 200 feet, then turns south flowing approximately 750 feet into the tannic Alafia River. There are some algae and other aquatic vegetation in the run. Land around Lithia Major is a developed county park. Lithia Spring Minor joins the Alafia River approximately 100 feet downstream from the mouth of Lithia Spring Major. –Florida Geological Survey, Bulletin 66

Peace River

**Kissengen Spring** is a former second-magnitude spring that fed fresh groundwater to the Peace River. Historic flows were approximately 19 MGD. Kissengen Spring stopped flowing regularly in February 1950. Throughout the first half of the twentieth century Kissengen Spring was a popular recreation spring. A commemorative marker was placed at the location of the former spring in 2012.
Myakka River

Warm Mineral Spring emerges from a large sinkhole that measures 252 ft north to south and 315 ft east to west. The bottom of the pool slopes gently to a depth of 17 ft at about 40 ft from the shore where it drops off precipitously. Spring depths are reported to reach 230 ft. The vent is at the base of the north wall of the sink. The spring has a debris cone of dolostone, limestone and sand on the bottom. The debris cone rises as much as 100 ft above the deepest part of the sinkhole. The water is yellow-greenish, slightly murky and often has a hydrogen sulfide odor. There is no boil on the water surface. Very little aquatic vegetation or algae live in the spring. A small, narrow spring run exits on the west side and flows southwest approximately 2.3 mi into the Myakka River. –Florida Geological Survey, Bulletin 66

In the 1960s, Warm Mineral Spring became a health spa and many still believe that the waters have amazing healing powers. Warm Mineral Spring is still a popular tourist destination. The spring is developed into a healing and wellness swimming park. A circular swimming rope on the spring surface keeps the interior deepest water demarcated. Grassy lawn and palm trees cover the surroundings, and there are abundant chairs and picnic tables. There is an underwater cave that has been explored and mapped.

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<th>Spring Name</th>
<th>WMD</th>
<th>County</th>
<th>Mag</th>
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Historic and recent water quantity and quality data from sentinel springs in the Southwest Coast Focus Area (WMD – Water Management District; Mag. – springs magnitude; cfs – cubic feet per second; mg/L – milligrams per liter).
St. Johns Springs

Restoration Area

The St. Johns Springs Restoration Area includes 15,121 mi² along the east coast of the Florida Peninsula and has an estimated 2018 population of 5.7 million. This springs region includes all or portions of 23 Florida counties (Alachua, Baker, Bradford, Brevard, Clay, Duval, Flagler, Hardee, Highlands, Indian River, Lake, Marion, Nassau, Putnam, Okeechobee, Orange, Osceola, Polk, Putnam, Seminole, St. Johns, St. Lucie, Sumter, and Volusia). Of the 1,091 recognized springs in Florida, 148 are located in the St. Johns Springs Restoration Area.

Upland forest, rangelands, and water/wetlands account for 49% of this region’s land use, while intensive agriculture occupies about 29% of the land area and urban/other is about 22% of the land area.

The St. Johns River, Florida's longest river, begins in a flood control basin west of Vero Beach and flows north for about 310 miles to join the Atlantic Ocean near Jacksonville. The St. Johns River was among Florida's first tourist attractions, with up to 300 paddle-wheel ferryboats transporting visitors to lavish hotels, rustic camps and rejuvenating artesian springs. Then came the railroad, and travelers headed south to warmer resorts leaving the St. Johns to amble through some of the state’s most uninhabited lands. In 1998, the St. Johns River was designated as an American Heritage River; by 2008, the river was on a list of America’s Ten Most Endangered Rivers.

The upstream reaches of the St. Johns River are dominated by blackwater flowing through swamps and marshes adjacent to the river that contain tannic acid. Clear groundwater inflows to the Upper St. Johns River from springs are for the most part north of Orlando and the Interstate 4 corridor. The Wekiva River Springs System is the largest contributor in the Upper St. Johns River. The Lower St. Johns River includes the reach from Orange City past the confluence with the Ocklawaha River near Welaka, all of the way to the river’s mouth at Mayport. Large spring inputs start with Volusia Blue and DeLeon springs and many of the springs in the Ocala National Forest.
The Ocklawaha River receives inflows from dozens of springs in the Harris Chain of Lakes and then joins the Silver River and the large groundwater flow from Silver Springs near Ocala. Below the confluence with Silver, the Ocklawaha River receives additional groundwater inputs from at least 20 other named springs that are currently depressed due to the pressure from the Rodman Pool, legacy of the ill-fated Cross Florida Barge Canal. The Lower St. Johns below the Ocklawaha confluence receives relatively minor spring inflows.

Upper St. Johns Springs Focus Area

The following springs descriptions are from the St. Johns River Water Management District.

The Upper St. Johns Springs Focus Area includes 7,881 mi², including portions or all of 13 counties. The estimated population of this region is about 3.3 million.

Wekiva River Springs

Located north of Orlando in south Lake County, the Wekiva River flows north and east to join the St. Johns River. The Wekiva River obtains more than half of its flow from at least 30 named springs. The largest spring in the group (in terms of average flow) is Wekiwa Spring in Wekiwa Springs State Park which was established in 1969. Wekiwa Spring feeds Wekiva Springs Run which is the headwaters of the Wekiva River. Flows from Wekiva Springs Run are joined by surface and ground water inflows from at least five smaller springs including Witherington, Barrell, Miami, Nova, and Island, as well as three major tributaries, Rock Springs Run, Little Wekiva River and Blackwater Creek. These waterways join to form the 17-mile Wekiva River that discharges into the St. Johns River near Debary, Florida.

Rock Springs Run originates at Rock Springs and receives additional flows from smaller springs Sulphur and Tram and from surface runoff via extensive floodplain wetlands. Rock Springs Run extends from Rock Springs to its confluence with the Wekiva River about 1 mile downstream from Wekiwa Spring.

Rock Springs is located within Kelly Park, a 200-acre facility owned by Orange County where outdoor activities such as swimming, picnicking, camping and nature study are all enjoyed. Rock Springs is one of the few areas in central Florida where limestone of the Hawthorn Formation is exposed. In this location, crevices and solution channels have developed in the Hawthorn, providing a spring outflow from the underlying upper Floridan Aquifer. The principal discharge from Rock Springs originates at the base of an exposed limestone bluff. A large public swimming area is located several hundred feet downstream from the spring discharge point where some of the flow has been diverted and partly retained by concrete walls. Rock Springs Run flows northward for about 1.5 miles, then turns southward where the floodplain is about three miles wide. Rock Springs Run meanders for a total of about nine miles before joining the Wekiwa Spring Run to form the Wekiva River.
Over the past 50 years the Wekiva River System has declined from a pristine landscape of clear water and wetland wilderness, to an increasingly impaired, depleted and altered watershed adjacent to one of the most highly developed areas in Florida. Despite a significant public and regulatory effort at holistic protection, the Wekiva River System’s ecological health continues to degrade, losing native plant and animal populations and aesthetic appeal to a growing population of recreationalists. Wekiwa and Rock Springs have each experienced about a 15% decline of long-term average flows. Rock Springs had a nitrate-nitrogen concentration of 0.07 mg/L in the 1940s, 1.1 mg/L in the 1970s and 1.3 mg/L in the 2000s. FDEP has set a nitrate nitrogen TMDL for Rock and Wekiwa springs and the river at 0.286 mg/L. Ground water use in Orange County which is primarily pumped from the Upper Floridan aquifer has increased substantially in the last 35 years. Most of the water is for public water supply which increased from 63 MGD in 1965 to 212 MGD in 2000. About 12% of the water withdrawn in Orange County is transferred to Brevard County for consumption. The large increase in public supply has been partially offset by a decline in agricultural use from 60 MGD in 1980 to 27 MGD in 2000 related to changes in land use.

<table>
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<th>Spring Name</th>
<th>WMD</th>
<th>County</th>
<th>Mag.</th>
<th>Discharge (cfs)</th>
<th>Specific Conductance (µS/cm)</th>
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Historic and recent water quantity and quality data from sentinel springs in the Upper St. Johns Springs Focus Area (WMD – Water Management District; Mag.– springs magnitude; cfs – cubic feet per second; mg/L – milligrams per liter).
Lower St. Johns Springs Subregion

The Lower St. Johns River Springs Subregion includes a land area of about 5,221 mi$^2$ and all or portions of eleven counties. The estimated 2018 population of this area is about 2 million. The Ocala National Forest includes a total of 673 mi$^2$ and occupies a significant portion of the land in the Lower St. Johns Springs Subregion. For this reason, impacts to springs flow and water quality are somewhat reduced compared to the other portions of Florida’s Springs Region.

Prior to the 1500s when the first French and Spanish explorers arrived, Amerindians who occupied the Lower St. Johns River area were part of a larger group known as the Timucua Indians. Some lived near the mouth of the St. Johns River and on the nearby Sea Islands now named St. Simons, Jekyll, Cumberland, and Amelia. The first permanent European colony in North America was Fort Caroline founded in 1564 by the French near the mouth of the St. Johns River.

The Lower St. Johns River is tidally influenced with an extended estuary. The tidal range at the river’s mouth in Mayport is about 6 feet. The Atlantic Ocean’s tide heights are large compared to the gradient of the St. Johns River and can produce strong tidal currents and mixing in the northernmost portion of the river. During times of drought when little rainwater enters the system or extreme high tides, reversals in river flow direction can occur as far south as Lake Monroe, 160 miles upstream.

Volusia Blue Spring

Blue Spring is located about 2 miles west of Orange City. Blue Spring is a 1st magnitude spring with a nearly circular pool about 135 feet long from north to south and 100 feet from east to west. Steep banks 10 feet to 20 feet high surround the pool except to the south, where the spring opens to the spring run. The pool bottom is mostly limestone and sand; the spring vent is an elongated opening in the limestone about 15 feet from the north edge of the pool. From the limestone ledge, the vent slopes precipitously to about 40 feet in depth. A limited underwater cave system has been mapped at Blue Spring. From the pool, the spring run flows 0.2 mile to the south, then to the southwest for another 0.2 mile to join the St. Johns River. The run varies from 70 feet to 100 feet in width and is bounded by steep wooded slopes, except for the lower southeast bank where the terrain flattens considerably.
Blue Spring State Park is owned and operated by the State of Florida, providing a wide range of recreational activities, including swimming, diving, canoeing, fishing, hiking, and camping. Manatees commonly frequent the spring run during the winter months when the spring water is considerably warmer than the water of the St. Johns River. The difference between the minimum and maximum discharges is 85 MGD over the period-of-record. The maximum measured discharge of 141 MGD occurred in February 1983; the minimum discharge of 56 MGD occurred in November 2001. The mean and median discharges for the period from 1932 to 2005 are 101 and 102 MGD, respectively.

**Alexander Springs** is in the Ocala National Forest about 6 miles south of Astor Park. Alexander Springs is a 1st magnitude spring that flows from the large cavernous opening in the bottom of the central part of the pool. The large pool measures over 300 feet from north to south and 250 feet from east to west. The pool bottom near the beach is mostly sandy. Aquatic vegetation surrounds the area of the main spring vent, where the pool bottom falls away to reveal a large open area of exposed limestone rock and boulders to a depth of about 25 to 28 feet. Flow from the discharging water creates a large and powerful surface boil over the spring opening that is readily visible from the shore. A broad sand beach forms the southwest edge of the pool, with mixed hardwood and palm forests around the spring. The pool discharges to Alexander Springs Creek that flows approximately 10 river miles until reaching the St. Johns River. Forests and wetlands surround the spring area.

The spring area has been developed by the U.S. Forest Service into a multiple-use recreational facility open to the public. Activities include camping, swimming, snorkeling, scuba diving, hiking, fishing, bicycling, and canoeing.

Discharge at Alexander Springs has been measured since 1956. Discharge at the spring has varied greatly over the years. The difference between the minimum and maximum discharges is 94 MGD over the period. The maximum measured discharge of 130 MGD occurred in January 1984; the minimum discharge of 36 MGD occurred in May 1986. The lowest periods of discharge correspond to periods of below-normal rainfall in Florida. The mean and median discharges for the period from 1956 to 2005 are 67 and 66 MGD, respectively.
Silver Glen Springs is in the Silver Glen Springs Recreational Area of the Ocala National Forest, about 11 miles south of the town of Salt Springs. Silver Glen Springs is a 1st magnitude spring with a large, semicircular pool that measures 200 feet north to south and 175 feet east to west. Most of the strong flow emerges from two cavern openings in the rock at the bottom of the pool, with large boils at the water’s surface over the vents. The vertical cave opening called the Natural Well in the southwestern edge of the pool is about 12 to 15 feet in diameter and 40 feet deep. The vent in the east part of the pool is a conical depression about 18 feet deep. Most of the spring pool has sand and limestone on the pool bottom, with areas of aquatic grasses. Large fresh and salt water fish are common in the pool and around the vents. Additional flow is from sand boils in the bottom of the spring run downstream from the head of the springs. Water from the springs flows eastward down a run about 200 feet wide for 0.75 miles to Lake George. The recreation area is used for swimming, snorkeling, picnicking, fishing, and boating. Boating is not allowed in the spring pool, but the spring run is a popular spot for recreational boaters.

Silver Glen Springs. Photo by Tessa Skiles.

Discharge at Silver Glen Springs has been measured since 1931. The difference between the minimum and maximum discharges is 134 MGD over the period. The maximum measured discharge of 158 MGD occurred in April 1983; the minimum discharge of 25 MGD occurred in October 2004.
Salt Springs

Salt Springs is located at the Salt Springs Recreational Area within the Ocala National Forest. The recreation area is used for swimming, snorkeling, fishing, and boating. Salt Springs is a 2nd magnitude spring that derives its name from its saline waters. The spring pool measures about 190 feet by 130 feet, with spring flow emerging from four vents in the limestone rock floor of the pool. Prominent, gentle boils are usually observed at the water’s surface over the vents. Limestone and sand are on the pool bottom near the vents, with the rest of the bottom covered with aquatic grasses. The north, west, and south sides of the pool are surrounded by a concrete wall which rises about 5 feet above the surface of the pool. The wall is topped by a concrete railing and edged by a 4-foot-wide concrete walkway. From the pool, water flows southeast about 4 miles down a broad run to discharge into the northwest corner of Lake George. Discharge at Salt Springs has been measured since 1929 to 2002. The difference between the minimum and maximum discharges is 52 MGD over the period. The maximum measured discharge of 87 MGD occurred in January 1985; the minimum discharge of 35 MGD occurred in October 1935. The mean and median discharges for the period from 1929 to 2005 are 52 MGD.

Croaker Hole Spring is located about 3.5 miles southwest of Welaka in Little Lake George, which is part of the Lower St. Johns River. Croaker Hole is a relatively deep, small-diameter hole in the bottom of the St. Johns River. The river is generally about 5 feet to 9 feet deep in this area, except in the immediate vicinity of Croaker Hole, where it plunges to a depth of about 48 feet. Discharge at Croaker Hole Spring has been measured since 1981. The difference between the minimum and maximum discharges is 18 MGD over the period. The maximum measured discharge of 58 MGD occurred in November 1998; the minimum discharge of 40 MGD occurred in September 2001. The mean and median discharges for the period are both 49 MGD.
Green Cove Spring is a 3rd magnitude spring on the west bank of the St. Johns River. A 2-foot-high concrete railing with a diameter of about 15 feet encircles the main vent of the spring pool. The pool tapers downward in soft marl like an irregularly shaped funnel to a 2-foot diameter cavern opening in its bottom, approximately 30 feet below the pool surface. The 2-foot vent then opens into a cavern 25 feet wide, trending in a northeast direction toward the St. Johns River.

Discharge from the spring pool is through a 4-foot-wide weir opening on its northeast side to a 50-foot by 100-foot swimming pool. The swimming pool overflows through a weir on its east end to a spring run that flows about 450 feet eastward to the St. Johns River. Discharge at Green Cove Spring has been measured since 1929. The mean discharge for the period from 1929 to 2005 is 2 MGD.

Beecher Springs is located within the Welaka National Fish Hatchery, about 3 miles south of Welaka. Beecher Springs is a 3rd magnitude spring with a roughly oval-shaped spring pool about 150 feet long from east to west and 130 feet wide from north to south. A natural bank borders the pool to the east and a concrete walk and retaining wall border the north and west sides. Gentle surface boils are visible in the northwest part of the pool, with a depth to water about 10 to 15 feet over the limestone vent. Water flows south down a run for about 1.3 miles to discharge into the St. Johns River. Between the springs and the river, water is diverted into manmade holding ponds used as fish hatcheries by the U.S. Fish and Wildlife Services. The spring is not open to the public. Discharge at Beecher Springs has been measured since 1972. The mean discharge for the period is 5.9 MGD.

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<th>Spring Name</th>
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<th>Nitrate-N (mg/L)</th>
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Historic and recent water quantity and quality data from sentinel springs in the Lower St. Johns Springs Focus Area (WMD – Water Management District; Mag. – springs magnitude; cfs – cubic feet per second; mg/L – milligrams per liter).
Silver/Ocklawaha Springs Focus Area

The Silver/Ocklawaha Springs Focus Area encompasses 2,030 mi\(^2\) in north central Florida. The Silver Springs Group is a first magnitude collection of at least 25 spring vents located near the center of Marion County and forming the headwaters and the majority of the baseflow for the Silver River, largest tributary for the Ocklawaha River, which in turn is the largest contributor of water to the St. Johns River. Starting with Apopka Spring in Lake Apopka, there are a half-dozen smaller springs feeding the Upper Ocklawaha River located in the Harris Chain of Lakes. At least 20 drowned springs are located along the Lower Ocklawaha River. The estimated 2018 population of the Silver/Ocklawaha Springs Focus Area is about 439,000.

Apopka Spring is located at the southwest corner of Lake Apopka in the Gourd Neck, a narrow arm of Lake Apopka that curves northwestward from the southwest tip of the body of the lake. The spring is about 2 miles south of Monteverde and is accessible only by boat.

Apopka Spring is a 2nd magnitude spring that discharges from a bowl-shaped depression about 5 to 6 feet in diameter below the central part of the pool. The vent opening is about 40 to 45 feet below the water surface. An underground cave system has been recognized for Apopka Spring. The vent opening narrows vertically downward into the limestone for 16 feet, where it then slopes northward at about 45 degrees to a depth of 90 feet, making for dangerous diving conditions.

The circular spring pool above the vent is about 180 feet in diameter. When spring flow is high, the spring discharge pool is clean and clear, but when flow is low, murky lake water may cloud the pool. When the lake is still, a gentle boil can be seen at the pool surface over the vent. Emergent vegetation and an organic, mucky bottom surround the pool perimeter in the cove area. Gourd Neck is buffered by marsh and lowland swamp forests toward the west; the east side of Gourd Neck is bordered by sandhill pine trees.

Apopka Spring is a submerged spring, requiring divers to perform discharge measurements at the vent opening. The U.S. Geological Survey measured the spring discharge seven times over the period from 1971 to 1992. From 1997 to the present, St. Johns River Water Management District (SJRWMD) has measured discharge at least four times per year. The difference between the minimum and maximum discharges is 32 MGD over the period. The maximum discharge of 45 MGD was measured in November 1988; the minimum discharge of 13.5 MGD was measured in September 2001. The mean and median discharges for the period from 1971 to 2005 are 20 and 18 MGD.
Bugg Spring is located about 0.4 miles northwest of Okahumpka on private property and is not open to the public. The spring is leased to the U.S. Naval Research Laboratory for underwater sound research.

Bugg Spring is a 2nd magnitude spring with a deep, circular pool about 400 feet in diameter. Except on the western side, the side walls are almost vertical, reaching depths of 170 feet to 175 feet. There is no boil observed on the pool surface due to the depth of the spring opening. There is very little aquatic vegetation, but algae are present in the spring pool and run. The spring run flows north about 0.8 mile into the Helena Run outflow from Lake Denham. The low-lying areas around the spring are densely forested, with sandhills to the south.

Discharge at Bugg Spring was measured sporadically from 1943 to 1985. Seven discharge measurements by the U.S. Geological Survey during this time ranged from 11.4 MGD in 1943 decreasing to 5.6 MGD in 1985. From 1990 to the present, discharge has been measured by the landowner at least monthly, with more frequent measurements at times. The mean discharge for the period from 1943 to 2005 is 7.4 MGD.

Silver Springs

The Silver River system is located near the center of the Florida peninsula, about 5 miles east of Ocala in Marion County. Silver Springs is a group of at least 25 named artesian springs that together constitute a first magnitude spring group and form the headwaters of the Silver River. The largest spring in the Silver Springs group is Mammoth Spring (Silver Main Spring) which provides about half of the flow in the Silver River. Multiple smaller springs line the upper part of the Silver River for nearly a mile downstream of Mammoth Spring.

The Silver River flows east through a hardwood and cypress swamp before joining the Ocklawaha River approximately 5.5 miles downstream.

Once the largest spring in Florida in terms of recorded flows, Silver Springs today is one of the state’s most endangered large springs. A formerly abundant flow averaging 530 million gallons per day has declined by more than 30 percent. The crystal-clear waters viewed by millions of tourists through glass-bottomed boats over the past 100 years now contains concentrations of nitrate-nitrogen more than 3,000 percent higher than the natural background. The combination of reduced flow, increased nitrate pollution, and the downstream Rodman Dam that blocks fish migration has caused nuisance algal blooms, reduced fish and wildlife populations, and overall degradation of the former crown jewel spring of Florida.
The world first learned of Silver Springs in the 1850’s when steamboat lines were established on the Ocklawaha River that ran up the Silver River to Silver Springs. Quickly becoming the state’s premier tourist attraction, by 1880 a hotel had been established and by 1890 the first glass-bottomed boats were in use. In 1922, the land surrounding Silver Springs was leased and further developed as a tourist destination and movie setting. Starting in 1932, six Tarzan movies were filmed on location at Silver Springs. At least 31 movies and episodes of numerous television programs such as Sea Hunt were filmed using the clear-water, natural setting, and scenery of Silver Springs.

In 1949, prior to racial desegregation in the south, “Paradise Park” was established for African-American families and tourists on the Silver River downstream from the main spring and related attraction facilities. Paradise Park was closed in 1969.

In 1962, the original lease was sold, and Silver Springs was developed into the largest tourist attraction in Florida, eventually accommodating more than one million visitors per year. In 1992, the Silver Springs 242-acre attraction tract was donated to the University of Florida which leased it to various vendors as the Silver Springs Nature Theme Park. In 2013, Silver Springs was incorporated into the Silver River State Park to become Silver Springs State Park which is operated by the Florida Park Service.

The areal extent of the Silver Springshed has been estimated using groundwater potentiometric surface maps. The maximum extent of the Silver Springshed (approximately 1,360 square miles) includes all potential areas that may contribute flow and contaminants to Silver Springs. The geology of the Silver Springshed is comprised of shallow sands and clays overlying the Ocala Limestone. Much of the Silver Springshed has active sinkhole development and is a significant recharge area for the Floridan Aquifer. Groundwater from the Floridan Aquifer is used for most human water needs within the Silver Springshed. Most ground water extractions are not monitored or reported and methods of estimating flow volumes are not standardized. Estimated groundwater extraction in Marion County between 1965 and 2010 increased by an order of magnitude (28 MGD to 124 MGD).
Of Florida’s 1,700 rivers, the Silver River was designated in 1987 as one among only 41 which are recognized as Outstanding Florida Waters (OFW). The OFW designation recognizes diverse ecosystems and is meant to protect the water body from degradation of ambient water quality “under all circumstances”.

The first large-scale scientific study of Silver Springs was conducted in the early 1950s by Dr. Howard T. Odum and collaborators who documented the physical and chemical water quality, biological community, trophic (food chain) structure, energy flow, and ecosystem metabolism (primary productivity and community respiration).

Between 1949 and 2005, land use within the Silver Springshed transitioned from primarily undeveloped (forested and natural vegetative) to developed. For example, urban land use in that time increased from 3.3% to 37%. Land covered by agricultural uses and pastureland remained constant at approximately 10%. Nearly 90% of the Silver Springshed is considered vulnerable to contamination from pollutants that are introduced at the ground surface (such as nitrogen fertilizers) and dissolve in percolating rain water destined to recharge the Floridan Aquifer.

In the 1960s, the Rodman (Kirkpatrick) Dam was constructed across the Ocklawaha River during construction of the ill-fated Cross Florida Barge Canal. The dam prevents fish and manatee migration from the Atlantic Ocean and the St. Johns River up through the Silver River to Silver Springs. Emplacement of the dam caused a change in the dominant fish species from mullet and catfish to gizzard shad. At least 20 artesian springs feeding the Ocklawaha River were covered by the impounded waters of the Rodman Pool.

The chemistry of ground water from the Silver Springs group has been relatively consistent for the past 100 years with the exception of rapidly increasing nitrate-nitrogen concentrations, gradual increases in chloride concentrations and specific conductance, and decreases in water clarity and night-time dissolved oxygen concentrations. FDEP has determined that nitrate-nitrogen concentrations in the groundwater feeding Silver Springs need to be reduced by 79% to prevent algal blooms.
Faunal studies conducted at Silver Springs indicate that macroinvertebrate (aquatic insects, snails, and crayfish) communities, while abundant in numbers, are not diverse and are declining in productivity. Fish counts over the last 50 years indicate relatively high diversity but a substantial loss in fish numbers and biomass. While state regulatory programs are in place to restore Silver Springs, lax enforcement is contributing to a continuing decline in the health of this priceless natural ecosystem.

Ocklawaha River “Lost springs”

Wells Landing (Cannon Spring) is a 3rd magnitude spring that is normally submerged by the Rodman Reservoir. At times of drawdown, the spring pool and vent are more easily discernible. During periods of low water in the reservoir, the spring run discharges toward the northwest for approximately 0.75 mile to the Ocklawaha River. Discharge from Wells Landing Spring was measured by the U.S. Geological Survey in March 1999 and by SJRWMD in February 2002. The mean discharge was 5.9 MGD.

Tobacco Patch Landing Spring is located about 5 miles north of Eureka about 4 miles downriver from the Eureka Dam. Tobacco Patch Landing Spring is a 3rd magnitude spring that is submerged by 4 to 5 feet of water when the Rodman Reservoir is full. At times of drawdown, the spring pool and vent are easily discernible. The circular pool of the main spring is near the base of a hill and the vent is approximately 12 to 15 feet across, with a rock ledge visible on its northern side. Discharge from Tobacco Patch Landing Spring was measured from the spring pool by the U.S. Geological Survey at 1.8 MGD in March 1999. Discharge was measured on the spring run below the confluence with the nearby stream at 3.2 MGD in February 2002.

<table>
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<tr>
<th>Spring Name</th>
<th>WMD</th>
<th>County</th>
<th>Mag.</th>
<th>Discharge (cfs)</th>
<th>Specific Conductance (uS/cm)</th>
<th>Nitrate-N (mg/L)</th>
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Historic and recent water quantity and quality data from sentinel springs in the Silver Springs Focus Area (WMD – Water Management District; Mag. – springs magnitude; cfs – cubic feet per second; mg/L – milligrams per liter).
Appendix 3 – Reading for Additional Information about Florida’s Springs


Gao, X. 2008. TMDL Report: Nutrient TMDLs for the Wekiva River (WBIDs 2956, 2956A, and 2956C) and Rock Springs Run (WBID 2967). Florida Department of Environmental Protection, Tallahassee, FL.


Martin, R.A. 1969. Eternal Spring: Man’s 10,000 Years of History at Florida’s Silver Springs.


Florida Springs Conservation Plan

North Florida is home to more than 1,000 artesian springs dependent on groundwater from the Floridan Aquifer System, creating the largest concentration of first magnitude springs in the world. While Florida’s artesian springs vary in many ways, including flow rate, mineral content, location (rural versus populated areas), geography (coastal versus inland), and plant and animal species, nearly all of Florida’s springs are suffering from a combination of anthropogenic impacts that include declining flows and increasing pollution due to accelerated human development.

This Conservation Plan seeks to provide a comprehensive look at the factors surrounding the steady decline in health and quality of Florida’s many springs. There are clear causes and effects of the population growth combined with agricultural development that has taken place in Florida. The way the Florida environment is being handled is not sustainable if Floridians want to have pristine springs and clean drinking water in the future. This plan seeks to provide some insight into what is happening, why it is changing our environmental landscape, and what can be done to protect Florida’s springs and aquifer.

Aquatic Adventures: Florida’s Springs & Aquifer is an activity book developed by the Florida Springs Institute to inform young people from 8 to 80 about Florida’s priceless springs, groundwater, the Floridan Aquifer, and what they can do to protect their water future.

About the Florida Springs Institute

The Howard T. Odum Florida Springs Institute is a privately-funded, 501(c)(3) non-profit corporation that documents the ecological health of Florida’s springs and educates the public about their wise conservation and management. You can learn more about the Institute at www.FloridaSpringsInstitute.org.

About the Florida Springs Council

The Florida Springs Council is a coalition of 46 organizations who have pledged to protect and restore Florida’s springs. These organizations represent more than 360,000 members. The Florida Springs Council was organized to advocate for springs and to support and represent groups who focus on springs advocacy. Learn more at www.FloridaSpringsCouncil.org.

Photo by Tessa Skiles.