Florida's Springs

Strategies for
Protection & Restoration

Prepared for

David B. Struhs, Secretary
Florida Department of Environmental Protection

and the
Citizens of the State of Florida

The Florida Springs Task Force
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Cover photos: left, Silver Springs (the Florida Photographic Collection, Florida State Archives); right, Ponce de Leon Spring (Jim Stevenson)

TABLE OF CONTENTS

A Note to Readers

For simplicity, the term spring recharge basin is used in this report to denote what might be more accurately called the "area of contribution" for a spring's supply of groundwater. Spring recharge basins encompass land areas that contribute surface water and rainwater to the spring flow. The boundaries of this three-dimensional area are determined from hydrologic studies of the groundwater flow, which can then be delineated on the land surface. Within the spring recharge basin, large volumes of groundwater are contained within microscopic spaces in the limestone; however, groundwater movement is generally dominated by the flow of water through water filled caves, and fractures in the limestone aquifer.

Acronyms and Abbreviations

ASR – aquifer storage and recharge
AWTP – advanced wastewater treatment plant
BMP – best management practice
DACS –Department of Agriculture and Consumer Services (Florida)
DCA –Department of Community Affairs (Florida)
DEP – Department of Environmental Protection (Florida)
DOH – Department of Health (Florida)
DOT – Department of Transportation (Florida)
DRI – Development of Regional Impact
EPA – Environmental Protection Agency (United States)
ERP – Environmental Resource Permit
FAC – Florida Administrative Code
FGS – Florida Geological Survey
FS – Florida Statutes
GIS – Geographic Information System
IFAS – Institute of Food and Agricultural Sciences (University of Florida)
IPMP – Integrated Pest Management Plan
MFL – Minimum Flows and Levels
mg/l – milligrams per liter, sometimes referred to as parts per million (ppm)
NWFWMD – Northwest Florida Water Management District
OFW – Outstanding Florida Water
OSTDS – Onsite Sewage Treatment and Disposal System (septic tank system)
RIB – Rapid Infiltration Basin
RPC – Regional Planning Council
SJRWMD – St. Johns River Water Management District
SPRTF – Springs Protection and Restoration Trust Fund (a proposed vehicle for funding the strategies in this report)
SRPP – Strategic Regional Policy Plans
SRWMD – Suwannee River Water Management District
SWFWMD – Southwest Florida Water Management District
USGS – United States Geological Survey
WMD – Water Management District

Beneath the surface at Silver Glen Springs in the Ocala National Forest. From SJRWMD

Executive Summary

Springs are among Florida's natural wonders…
Geologists estimate that there are nearly 600 springs in the state of Florida, representing what may be the largest concentration of freshwater springs on Earth. Archaeological evidence indicates that humans have been attracted to Florida's life-giving springs for thousands of years. Florida springs continue to draw awed and grateful visitors today – our twelve state parks that are named for springs attracted over two million visitors in 1999. Private spring attractions and parks are a multi-million dollar tourist industry.[1,2]

But our springs are in serious jeopardy…
Between 1950 and 1990, Florida's human population more than quadrupled, and our population continues to increase. With growth has come an unavoidable rise in water use, as well as extensive land use changes. During the twentieth century, flow discharge reductions have been noted in many of Florida's springs. Since the 1970s, scientists have documented a decline in water quality in most Florida springs, particularly in regard to nutrients such as nitrate.[3,4]

An initiative to protect and restore our springs…
David Struhs, Secretary of the Florida Department of Environmental Protection, directed the formation of a multi-agency Florida Springs Task Force to recommend strategies for the protection and restoration of Florida's springs. The Task Force, a group of sixteen scientists, planners, and other citizens, met monthly from September 1999 to September 2000.[*] They discussed the environmental, social, and economic interests that exist in all of Florida's spring basins.

"Must do" strategies…
With an approach that includes outreach, information, management and funding, we can protect and restore our springs. The Task Force has developed the following strategies for the preservation and restoration of Florida's rich treasury of springs:

Outreach Strategies

- **When citizens understand, they'll help:** Educate students, citizens, and local leaders about the values, function, and protection needs of springs. This strategy will spread awareness of the impact that citizens living in spring recharge basins can have on spring water quality (see page 23).

- **Landowners, citizens and government working as a team can make a difference:** Form and support Spring Basin Working Groups to engage citizens and agencies in the protection and restoration of spring water quality and quantity (see page 24).

Information Strategies

- **We have to monitor to know what's happening:** Implement Springs Monitoring Programs to detect and document long-term trends in water quality and quantity, to support research efforts, and to confirm the effectiveness of springs protection efforts. The information gained from monitoring will help citizens and state and local governments understand the impacts of our decisions on springs (see page 26).

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[*] Meetings were noticed in Florida Administrative Weekly.

- **Good science supports good decision-making:** Conduct research that will allow cause-and-effect relationships to be established between land use and water management activities and resulting changes in spring water quality and quantity. Good science will support sustainable resource planning and management (see page 29).

Management Strategies

- **Protection begins with local land use planning and ordinances:** Implement coordinated land use planning and ordinances that protect spring recharge basins. Land use practices within spring recharge basins determine the future of springs. Coordinated land use planning can protect the quality and quantity of spring water (see page 32).

- **Give Florida's Landowners the Resources to Protect Springs:** Fund and implement best management practices (BMPs) to protect spring water quality and quantity. Recommended BMPs address the following activities: landscape fertilization, agriculture, silviculture, stormwater management, and golf course design and management. BMPs, when properly implemented, may provide effective protection without the need to implement new regulations (see page 36).

- **Acquisition is the Most Effective Way to Protect Spring Recharge Basins:** Purchase spring recharge basins to protect springs from land use practices that reduce water quality and quantity (see page 41).

- **Proper Management for Recreation is Easy and Effective:** Uncontrolled public access to springs often leads to serious ecological damage, including bank erosion, trampling of vegetation, littering and dumping. Management actions can protect springs from damage associated with recreational use (see page 42).

Regulation Strategies

- **Realistically, regulations are necessary:** Regulations to protect springs must be strengthened and enforced. Waters that interact, as Florida's groundwater and surface waters do, should be protected across the boundary between the two, and for all uses. Florida's water quality rules do not provide for protection that takes into account the unique interaction that naturally occurs between groundwater and surface water at springs. Existing regulations should be amended and better enforced to offer protection to spring water (see page 44).

- **Spring flow can be protected with existing law:** Protect spring flow (discharge) from further significant reductions. Spring flow is reduced when aquifer levels are lowered by groundwater withdrawals for public and private water supply. Spring flow reductions affect recreational use and the ecological integrity of spring systems. The Task Force has identified five strategies for protecting spring flow (see page 44).

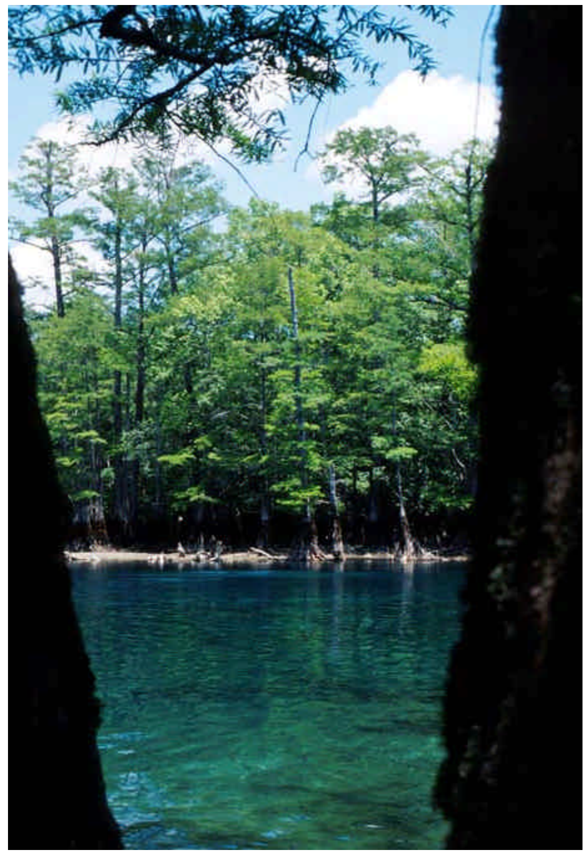
- **Rare and unique plants and animals of Florida's springs need protection:** Protect rare, threatened, and endangered species that are dependent on spring systems for habitat. Florida's springs and related karst communities are habitat for several state- and federally-listed species, some of which are extremely rare. Solutions for the problems that face these species may be complex or simple (see page 48).

Funding Strategy

- **We won't save Florida's springs without additional funding:** We must fund the strategies. Many of the strategies can be implemented with existing resources, but some of the strategies will affect agencies and citizens without resources to implement them. The Task Force proposes a funding source and an allocation strategy for springs protection and restoration (see page 51).

Our message to you, the reader…

The timely and efficient funding and implementation of each strategy and its action steps are essential to the restoration and preservation of the world-class springs that are part of Florida's unique natural heritage and economy. Let's take the bold steps necessary to ensure the protection of Florida's springs for our children's grandchildren!



Morrison Spring, Walton County
Photo: Jim Stevenson

Introduction

The bank was dense with magnolia and loblolly bay, sweet gum and gray-barked ash. He went down to the spring in the cool darkness of their shadows. A sharp pleasure came over him. This was a secret and a lovely place. - Marjory Kinnan Rawlings, *The Yearling*, 1938

Florida's springs provide immeasurable natural, recreational and economic values for residents and visitors. The mere mention of springs evokes, in most people, something magical, mysterious, pure, and visceral. Geologists estimate that there are nearly 600 springs in the State of Florida, representing perhaps the largest concentration of freshwater springs on Earth. Archaeological evidence indicates that humans have been attracted to Florida's life-giving springs for thousands of years. Florida springs continue to draw awed and grateful visitors today – our twelve state parks that are named for springs attracted over two million visitors in 1999.[1,2,3]

Springs are bowls of liquid light.
– Marjory Stoneman Douglas

Florida's springs have provided a major contribution to the state's economy for over a century. Health resorts at several Florida springs attracted thousands of tourists to the state around 1900. Springs became Florida's first major tourist attractions and Silver Springs and Weeki Wachee Spring continue in that role today. Ginnie Springs is the most popular freshwater diving location in the world and many other private springs are important recreation areas. The twelve state parks named for springs collect over $7 million in revenue annually. Ichetucknee Springs State Park generates an estimated $4.5 million to the local economy each year. Available information indicates that private parks featuring springs contribute millions of dollars to Florida's economy per year, making springs important contributors to Florida's tourist economy.

Between 1950 and 1990, Florida's human population more than quadrupled. With population growth has come an unavoidable increase in water use, as well as extensive land use changes. During the twentieth century, a number of once-popular springs, such as Kissengen Spring in Polk County, stopped flowing, and discharge measurements indicate flow reductions in other springs. Since the 1970s, scientists have documented a decline in water quality in most Florida springs, particularly with regard to nutrients.[4,5]

David Struhs, Secretary of the Florida Department of Environmental Protection, directed the formation of a multi-agency Florida Springs Task Force to provide recommended strategies for the protection and restoration of Florida's springs.

The Task Force, consisting of sixteen Floridians who represent one federal and three state agencies, four water management districts, a state university, a regional planning council, the business community, and private citizens, met monthly from September 1999 to September 2000*. These scientists, planners, and other citizens exchanged information on the many factors that impact the viability of Florida's springs and the ecosystems that the springs support. They listened to guest speakers with expertise in topics relating to spring health. They discussed the conflicting environmental, social, and economic interests that exist in all of Florida's spring basins. The Task Force members participated in the February 2000 Florida Springs Conference,

* Meetings were noticed in Florida Administrative Weekly.

Natural Gems – Troubled Waters, attended by over 300 people, including scientists, business owners, representatives of environmental groups, and residents from all over Florida.

During the months that the Task Force met, they developed recommendations for the preservation and restoration of Florida's rich treasury of springs. The implementation of the recommendations contained in this report will help ensure that Florida's "bowls of liquid light" will sparkle for the grandchildren of the children who play in Florida's springs today.

Wekiwa Springs, 1910. Source Unknown.

A Short History Of Florida Springs

Springs add a melody to the land. – Al Burt

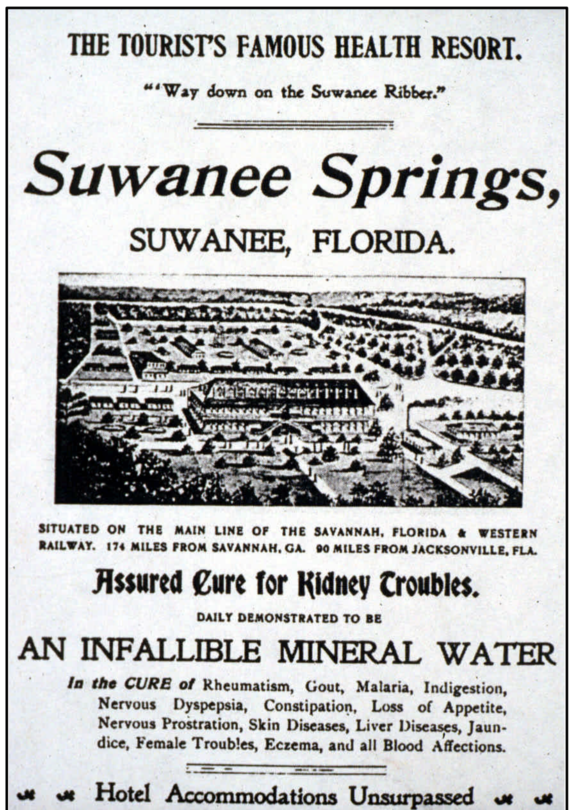
Archaeologists tell us that people have been drawn to Florida's springs for thousands of years. Twelve-thousand-year-old bones, tools, and weapons have been recovered from Wakulla Springs and from Little Salt Spring in Sarasota County. Numerous prehistoric spear points have been recovered from the beds of the Wacissa, the Ichetucknee, and other spring-fed rivers in north and central Florida.[2,3]

In 1513, a Spanish explorer, Juan Ponce de Leon, invaded Florida in search of land and riches. Legend holds that he was searching for a spring that would rejuvenate old men.[7]

Later, Florida's springs served as locations for Spanish missions, steamboat landings, gristmills, and post offices. They were used for baptisms by local churches, as sources of drinking water for homesteads, and as reservoirs for irrigating crops.

In the middle to late 1800s many of Florida's springs served as magnets for development, attracting settlers, tourists, and even railroads. A few springs gave birth to towns, including Silver Springs in Marion County, Green Cove Spring in Clay County, and De Leon Springs in Volusia County.

Some of Florida's springs have been valued for their perceived therapeutic qualities. People once flocked to White Springs, in Hamilton County, seeking the benefits of its healing powers. Panacea Mineral Springs in Wakulla County was the site of the 125-guest Panacea Hotel in the early 1900s. Worthington Springs, in Union County, now completely dry, once drew visitors seeking to drink from and bathe in its healing waters. Warm Mineral Springs, in Sarasota County, still attracts visitors to its year-round 87-degree waters.[12,13,14]



From the Florida Photographic Collection, Florida State Archives, Florida Department of State.

Many Florida springs have provided recreational opportunities for swimmers, boaters, wildlife watchers, and cave divers. Some, such as Kissengen Springs and White Springs, were once popular swimming holes but have diminished to a trickle. Sulphur Spring, in Tampa, has been closed to public use due to poor water quality. However, other springs and spring runs that were once damaged by overuse have been restored through good stewardship. Among these are Blue Spring (Madison County), Ichetucknee Springs (Columbia County) and Blue Spring (Volusia County).

Springs have supplied drinking water to Floridians for thousands of years. The groundwater that flows from most of Florida's springs originates from the same Floridan Aquifer that is tapped for most municipal supplies and private wells in the state. Boulware Spring, in Gainesville, once provided water to the city of Gainesville. Today it is a city park and a National Historic Landmark.

The bottled water industry is inspiring a renewed interest in spring water. Still, as the 21st century dawns, Florida's springs serve more often as windows to the mysteries of the Floridan Aquifer than as drinking water supplies. At the same time, many of Florida's diverse wildlife communities depend on our careful stewardship of Florida springs over the coming decades. The challenge lies in preserving the values of Florida's springs while balancing the pressing and seemingly conflicting needs of the state's many water users.

Green Cove Spring, Clay County, 1880's. From Florida State Archives.

Hydrogeology Of Florida Springs

Florida is young, freshly washed from the ocean in a recurring series of Ice Age fluctuations that has reconfigured its soft coastline as sea-born escarpments. – Bill Belleville, from an essay in *The Wild Heart of Florida*, 1999

Florida is underlain with limestone. Rainwater, made slightly acidic by the carbon dioxide it picks up from the atmosphere, enters the rock and slowly dissolves channels and caves as it works its way through the limestone and forms an underground drainage system. Where the water creates larger cavities, the overlying rock sometimes collapses, forming a sinkhole or spring.[15]

A portion of Florida's rainfall infiltrates the ground to replenish the aquifers that are the source of most of Florida's fresh water supply. This is the water that keeps Florida's springs flowing. Drought, major development, or mining within a spring's recharge basin, and excessive groundwater withdrawals from supply wells can reduce or even stop a spring's flow.[13]

In 1995 Floridians used 7.2 billion gallons of fresh water per day, more than any other state east of the Mississippi River. Florida's water use is expected to increase to 9 billion gallons per day by the year 2020. Sixty percent of Florida's drinking water supply comes from aquifers. One hundred percent of spring discharge comes from these same aquifers.[16,17]

Three different aquifer systems can be found in the parts of Florida where springs are common. They are the shallow Surficial Aquifer, the Intermediate Aquifer, and the limestone Floridan Aquifer. In some areas, all three aquifers may exist in sequence, separated by impermeable layers. In other places, only the Floridan Aquifer may be present, and it may be exposed to the surface by sinkholes and other karst features.

Karst: a limestone region with underground drainage and many cavities and passages caused by the dissolution of the rock.
– The Oxford American Dictionary of Current

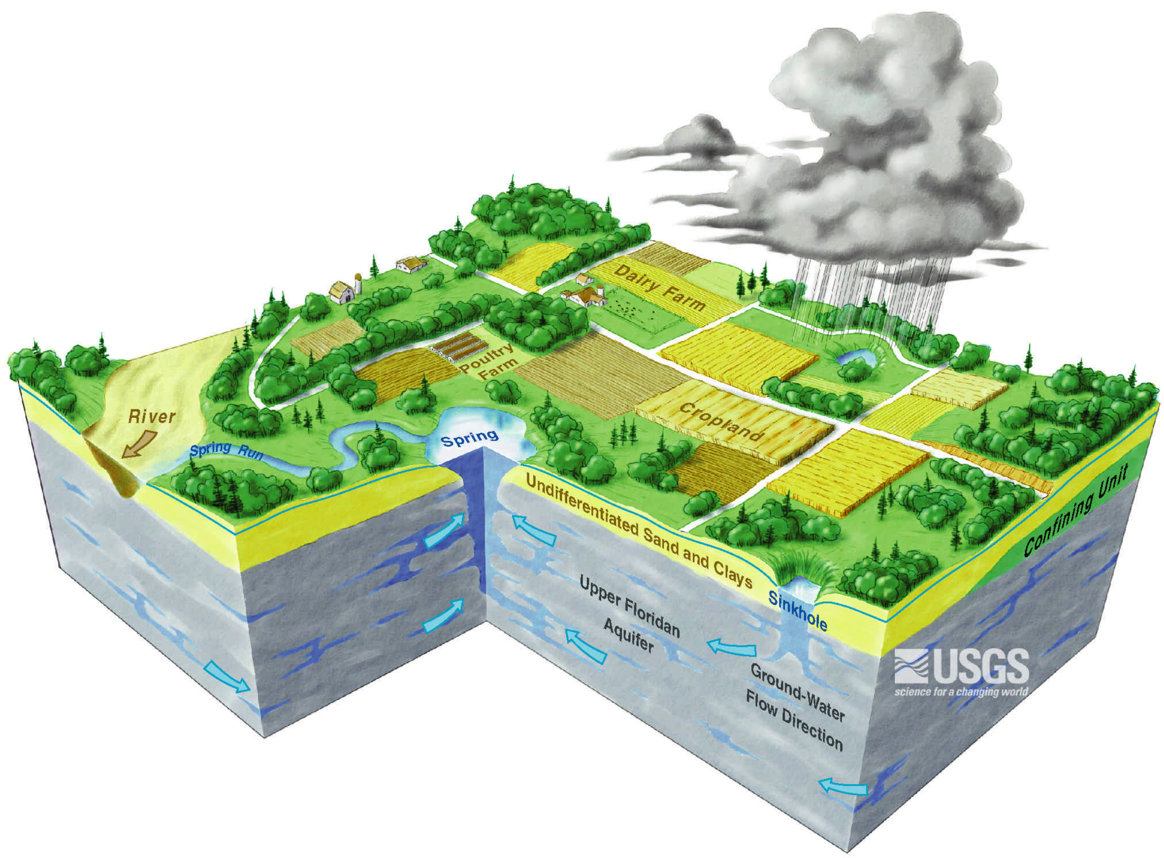
Most Florida springs occur where the limestone of the Floridan Aquifer is exposed at the land surface. Springs drain large amounts of groundwater from the Floridan Aquifer. These springs contribute to the relatively constant temperature and steady flow rate of many of Florida's spring-run rivers. In addition, numerous submarine springs exist along Florida's Atlantic and Gulf coasts. Spring Creek Springs, on the Wakulla County coast, is thought to be the nation's largest spring in terms of average flow: about 1.3 billion gallons per day.[13]

Springs are classified by rate of discharge. First magnitude springs produce the greatest amount of water. Following is a summary of spring classification by magnitude.

Magnitude	**Average Flow (Discharge)**	
1	100 cfs or more	(64.6mgd or more)
2	10 to 100 cfs	(6.46 to 64.6 mgd)
3	1 to 10 cfs	(0.646 to 6.46 mgd)
4	100 gpm to 1 cfs	(448 gpm)
5	10 to 100 gpm	
6	1 to 10 gpm	
7	1 pint to 1 gpm	
8	Less than 1 pint/min	

Cfs	=	cubic feet per second
Mgd	=	million gallons per day
Gpm	=	gallons per minute
pint/min	=	pints per minute

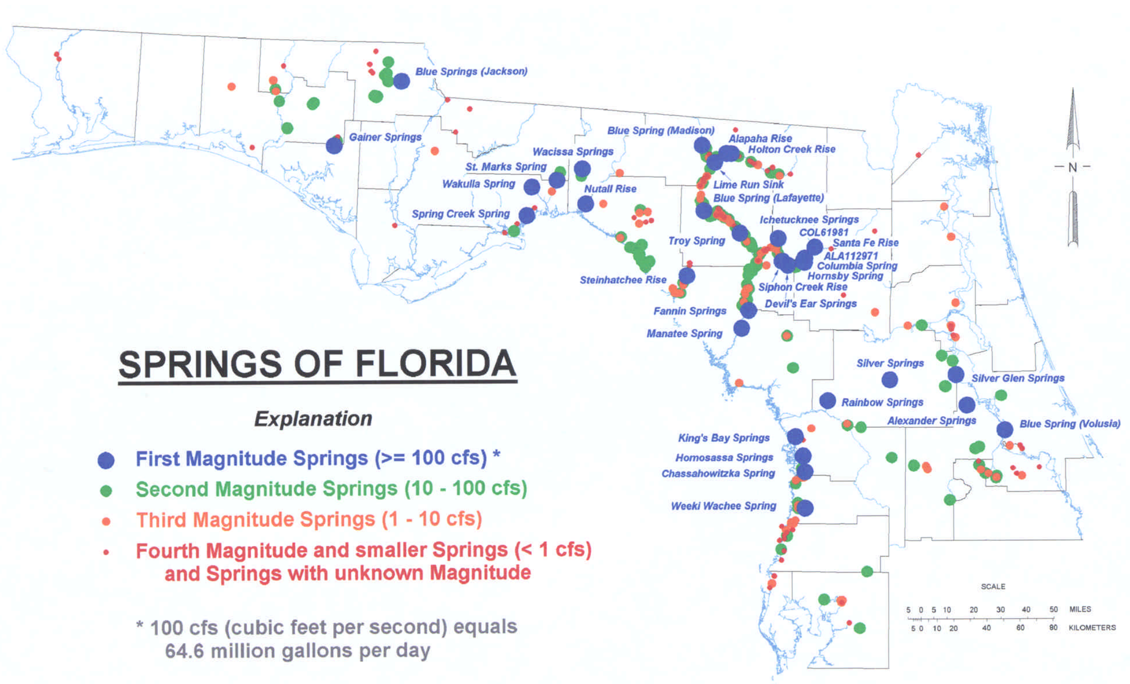
From *Geological Bulletin No. 31, revised, Springs of Florida,* *Florida Geological Survey, 1977*



Some of the rain that falls on Florida soaks into the ground to replenish the Floridan Aquifer, which supplies most of Florida's drinking water supplies and feeds most of Florida's springs. The Karst topography that is common in many parts of Florida leaves the aquifer vulnerable to contamination from activities on the land surface. (From the USGS)

Florida boasts 33 first magnitude springs, including six river rises. A river rise is the place where a sinking stream reappears. Most Florida river rises discharge water that resembles that of a nearby sinking stream or river. Examples of this phenomenon can be found at the Santa Fe River Rise and at Nutall Rise on the Aucilla River. Many if not most of Florida's dark-water springs or tannic springs are actually river rises.[1,18]

Springs are vitally important to many Florida rivers. Some springs, such as Wakulla Spring and Silver Springs, give rise to entire rivers. Some rivers receive significant portions of their flow from seeps (water table springs that issue from riverbanks). A map of springs of the northern peninsula reveals a series of Floridan Aquifer springs that define the shape of the Suwannee River.



The quantity and quality of spring discharge are vulnerable to the effects of activities that occur within spring recharge basins. The nature and magnitude of the threats varies according to land use practices and geology within each spring recharge basin.

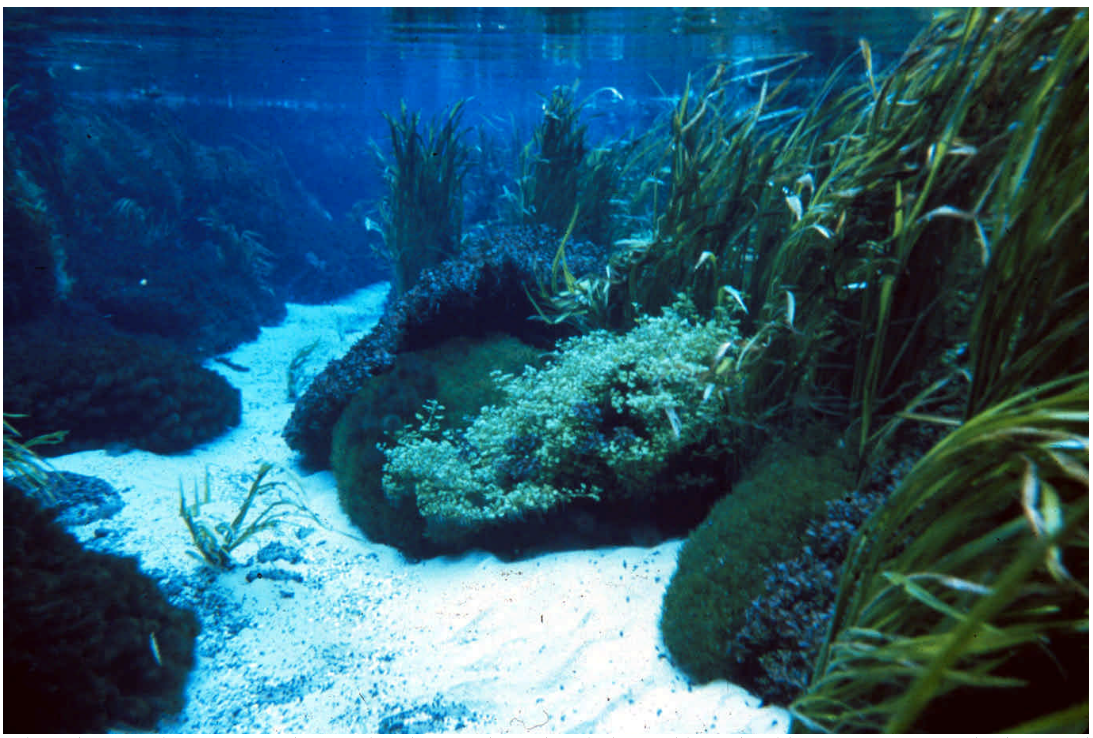
Contamination is a major threat to Florida springs. Water can carry contaminants from the land surface into springs. Stormwater runoff can carry oil, fertilizer, pesticides, and bacteria. Septic tanks and underground storage tanks can contribute nutrients, bacteria, and chemicals via seepage. Contaminants in groundwater travel toward spring openings through pores and fractures in the rock. Water moving through small pore spaces travels slowly, on a scale of years, while water that travels through caves can move fairly rapidly, on a scale of days or weeks. In spring recharge basins where surface water enters the aquifer through direct connections such as sinkholes and sinking streams, springs are especially vulnerable to contamination.[19,20,21]

Biological Systems: Expressions of Spring Health

Each spring is different from all the others; but in the intensity of its grace and color each is a little ecologic jewel in which geology and biology have created a masterwork of natural art. – Archie Carr*, A Celebration of Eden, 1994.*

The numbers and diversity of the plants and animals that live in a spring-fed stream paint a picture of a spring's health. Water quality, habitat quality, and biological health all contribute to the ecological integrity of Florida's spring-fed streams. Spring-fed streams are distinguished from other Florida streams by the following characteristics: more constant flow, higher pH, more submerged aquatic vegetation, naturally low dissolved oxygen and nutrients, high calcium levels, and remarkable clarity. The plants and animals that make up spring biological communities are adapted to these conditions.[22,23]

A spring is only as healthy as its recharge basin… The groundwater that feeds springs is recharged by seepage from the surface and through direct conduits such as sinkholes. Because of this, the health of spring systems is directly influenced by activities and land uses within the spring recharge basin. [22,23]



Ichetucknee Springs State Park, a National Natural Landmark, located in Columbia County. From Charles Dutoit.

Elevated nitrates are a common and growing problem in Florida springs. A steady rise in nitrate levels has been observed in most Florida springs over the past thirty years or so. Nitrate, an essential plant nutrient, was once a very minor constituent of Florida spring water. Typical nitrate concentrations were less than 0.2 milligrams per liter (mg/l). Today many Florida springs discharge water that has more than 1.0 mg/l of nitrate. Springs with recharge basins that have been left in a fairly natural state have maintained low nitrate levels. The Ocala National Forest boasts several such pristine springs.[5]

Anecdotal evidence and field observations suggest nitrate levels of less than 1 mg/l cause a significant shift in the balance of spring ecological communities, leading to intensified degradation of biological systems. More research is needed to document the exact concentration that causes impairment. Nitrates currently within aquifers that feed springs will continue to issue from spring vents for many years to come.

Current groundwater quality standards were developed to protect drinking water. The standards specify a maximum contaminant level of 10 mg/l for nitrate. Consumption of water with nitrate levels above this threshold concentration increases the likelihood of methemoglobinemia ("Blue Baby Syndrome") in infants. Studies have linked other human health problems to consumption of high levels of nitrate. The nitrate standard, established to protect human health, applies to groundwater because most Floridians drink groundwater. This standard does not address the fact that, in Florida, groundwater becomes surface water when it flows from springs. What is safe for human consumption is, in the case of nitrate, catastrophic for biological systems.[24]

Spring plants… Changes in a spring's plant community are an early indicator of elevated nitrates. Nuisance algal mats and exotic species of rooted aquatic plants such as hydrilla have become increasingly common in Florida springs as high nitrate levels have become widespread in spring-fed streams.[23]

Nuisance and exotic plants have caused adverse changes in many spring runs. These changes include the reduction of water flow, reduction in dissolved oxygen, and habitat changes. Monitoring is an important tool for distinguishing a natural spring-run plant community from one that has been affected by nitrate pollution.[23]

Little critters… Benthic macroinvertebrates are small animals without backbones that live on the bottoms of streambeds and within the plants that grow there. Many of them are juvenile forms of insects such as dragonflies and mayflies. Crayfish and other freshwater shellfish are also benthic macroinvertebrates. They are a critical link in the food web. These small animals do not respond directly to the nitrate enrichment so common in Florida's springs. They are, however, affected by changes in food quality, plant overgrowth, and decreased dissolved oxygen, all of which are caused by nitrate enrichment. They are also directly affected by pesticide contamination.[23]

Blind cave crayfish. Photo by Joe Kenner

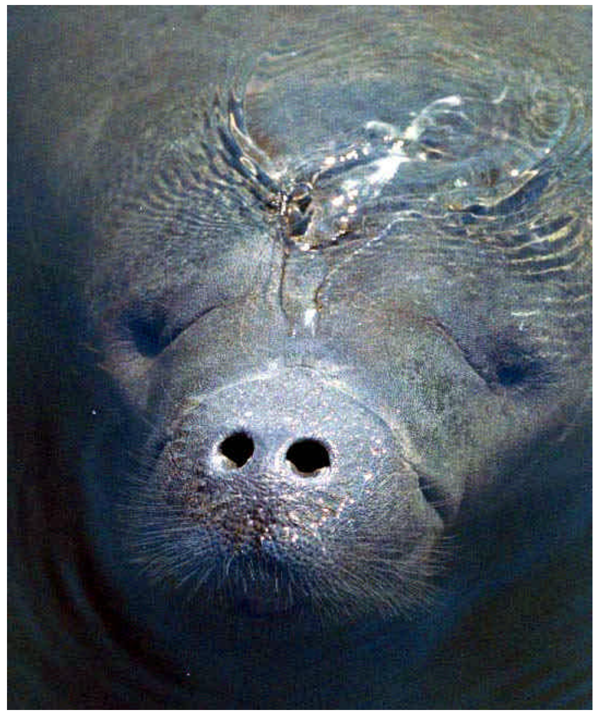
Spring and cave animals… Florida's spring caves harbor one of the richest underground aquatic faunas in North America. Many of Florida's spring and cave creatures are extremely rare. In fact, twenty-two Florida cave-dependent species are found nowhere else in the world. The Florida Committee on Rare and Endangered Plants and Animals has recognized that most Florida spring- and cave-dependent species merit state or federal protection. Currently only three species are legally protected.[26]

These populations of rare species are particularly vulnerable to changes in water quantity and quality, as well as to natural and manmade catastrophes. For instance, human-caused erosion will soon seal the entrance to the cave where the only known population of the Putnam County Cave Crayfish (*Procambarus morrisi*) is found, and may extinguish the species. The entire ranges of the Orlando Cave Crayfish (*P. acherontis*) and the Miami Cave Crayfish (*P. milleri*) lie within heavily urbanized areas that are at risk for groundwater pollution, and in Miami's case, salt water intrusion.[21]

The endangered West Indian Manatee (*Trichecus manatus latirostris*) depends on Florida springs as life-sustaining warm-water refuges in the wintertime. Currently, over 400 manatees regularly winter at Crystal River in Citrus County and Blue Spring in Volusia County. This represents about fifteen percent of the total Florida manatee population.[26]

The groundwater that feeds the springs that many of these animals depend upon is also increasingly in demand for drinking water supplies. Aquifer withdrawals for drinking water supplies can lead to reductions in spring discharge, threatening some of these essential thermal refuges. Land uses within the springs' recharge area can result in altered spring water quality, leading to a change in the type of plants growing at the springs. Manatees depend on aquatic plants for food.[26]

More information is needed to assess threats to the ecological communities that have evolved in Florida's springs and caves.



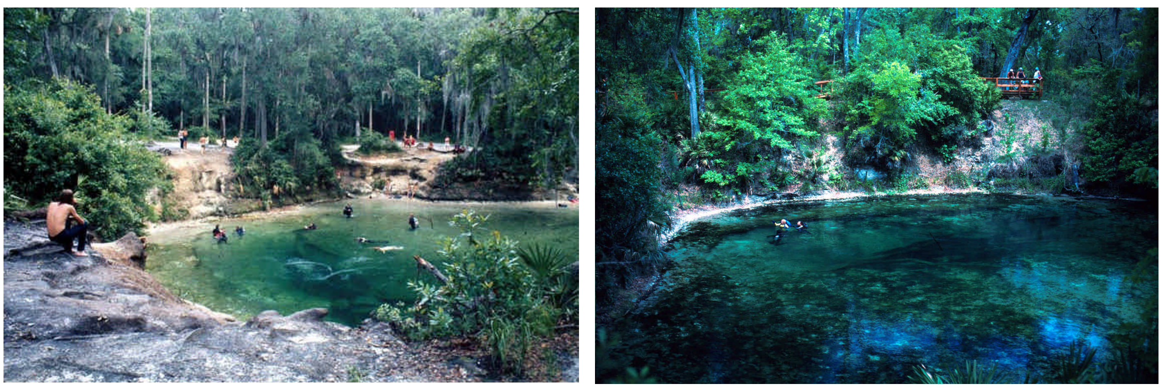
Curious manatee, Wakulla River, 2000. Photo by Tom Scott.

Stories That Illustrate The Values Of Florida Springs And The Issues That Threaten Them

Nearly 600 springs are known to exist in Florida. Each is a special place to someone, and each has a story. The following pages present five springs whose stories illustrate the range of values and issues that define Florida's springs. Today, four of these springs face threats from land uses within their recharge basins. Some protection strategies have been implemented for the four threatened springs, but more strategies are needed. The fates of these springs are dependent on continued efforts by state and local agencies, and private citizens who care. The fifth spring is located in the Ocala National Forest, where the recharge basin is protected from land uses that might affect water quality and quantity.

Blue Spring

A manatee refuge that is losing flow and gaining nitrates.



The photo to the left shows Blue Spring, Volusia County, in 1973, when purchased by the State. The photo to the right is of Blue Spring after the state purchased it, restricted foot traffic and re-established native plants on its banks. The spring provides essential habitat to the endangered West Indian Manatee. Photos by Jim Stevenson.

This first magnitude spring, the centerpiece of Blue Spring State Park in Volusia County, is the source of a quarter-mile-long spring run that flows to the St. Johns River. The spring and its run provide essential habitat for the endangered West Indian Manatee population of the St. Johns River and for two species of aquatic snails found nowhere else in the world. In 1766, naturalist John Bartram visited Blue Spring and described it in his journal.

Blue Spring was the site of a steamboat landing and post office at the turn of the twentieth century. The spring provides recreational, scenic, wildlife and historic values that attract 280,000 visitors annually.

Threats

The spring's recharge basin is being rapidly transformed into an urban/suburban landscape, with an associated increase in groundwater withdrawals. Water quality is steadily declining, with recent nitrate measurements as high as 0.60 mg/l. The spring was closed to recreation on Labor Day, 2000 due to the presence of coliform bacteria, indicative of sewage pollution. Spring discharge measurements show that the spring's flow rate has dropped below the historic, natural level. Flow may be further reduced as more groundwater is withdrawn for drinking water supplies and agriculture. Diminished spring flow represents a significant threat to the recovery and perhaps even the survival of the endangered West Indian Manatee population in the St. Johns River. Blue Spring's other values may be impacted by further flow reductions.

Strategies

Regulatory. The St Johns River Water Management District (SJRWMD) is developing a Minimum Flows and Levels (MFL) Rule for the discharge to Blue Spring, based on the habitat requirements of the manatee population. The Florida Park Service regulates public use of the spring and spring run to protect manatees and the scenic, recreational and biological values of Blue Spring State Park.

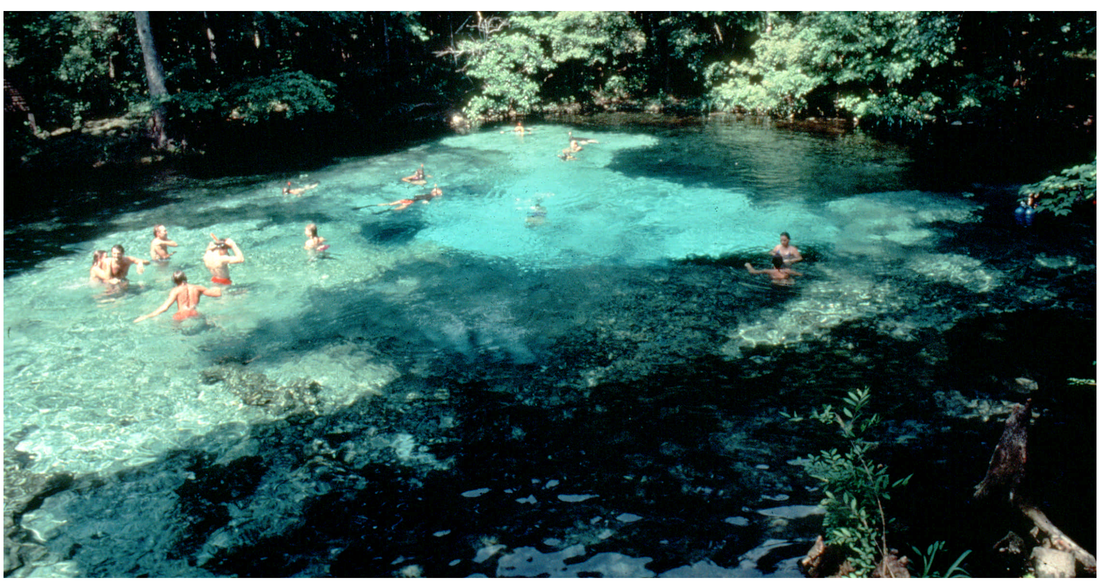
Research. The SJRWMD completed and published the results of a research project, Water Quality and Isotope Concentrations from Selected Springs in the St. Johns River Water Management District (Technical Publication SJ99-2), in 1999. Blue Spring was among those included in the study. The study results indicate that the spring is fed by the Floridan Aquifer, the source waters originate from a variety of depths, and the spring is affected by nitrate pollution.

Monitoring. The USGS has monitored water levels at Blue Spring since 1932. SJRWMD has monitored water quality since 1983. Volusia County is monitoring water quality. The Florida Museum of Natural History is monitoring the endemic Blue Spring Silt Snail population. The US Fish and Wildlife Service and park staff monitor the manatee population.

Stewardship. State park personnel have halted erosion and restored the spring slopes by building boardwalks to restrict foot traffic, and by re-establishing native plants.

Ginnie Springs

World-famous diving site and bottled-water source – but what about in ten years?



Ginnie Spring. Photo by Wes Skiles.

Ginnie Spring, named for a woman who once washed laundry there, is located in Gilchrist County, a sparsely populated county in north central Florida. Ginnie Spring is one of eleven springs with a combined total discharge of 260 million gallons per day.

The Ginnie Springs Group drains two different physiographic regions. The northern basin feeds four of the springs, including Devil's Ear and Devil's Eye. The southern basin feeds the other seven springs, including Ginnie and Dogwood. On average, the Ginnie Springs Group contributes approximately ten percent of the total flow of the Santa Fe River, which in turn flows into the Suwannee River.

Ginnie Spring is privately owned and managed as a recreation area. Ginnie Springs Resort is located seven miles west of the town of High Springs, and is the most popular freshwater and cave-diving site in the world. The spring is also the source for water bottled near the site by Danone International Brands.

Threats

The spring's water quality is affected by increasing nitrates, which have recently been measured at between 1.29 and 1.58 mg/l. Agricultural operations and residential and urban development within the spring recharge basin have probably contributed to this trend. This type of land use can have a serious impact on a spring's water quality. The growing popularity of the area's springs is leading to urban sprawl within the recharge basin.

Strategies

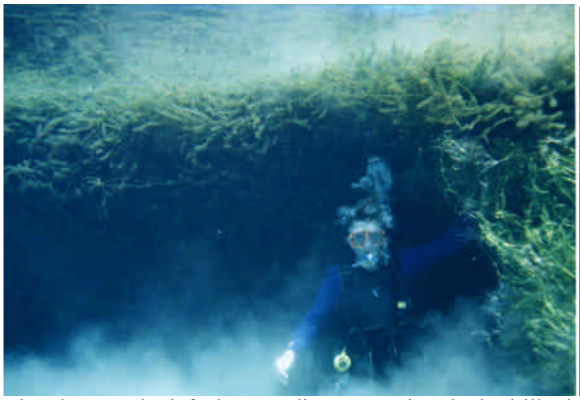
Working Group. The Santa Fe Springs Working Group was formed in 1998 to protect waters flowing to these springs.

Land Acquisition. Ginnie Springs Resort has purchased approximately 1,000 acres of the spring recharge basin, and Danone International Brands is pursuing the acquisition of additional acreage within the recharge basin.

Monitoring. A monitoring program, utilizing private home and commercial wells, has been established to monitor the quality of groundwater moving toward the Ginnie Springs Group.

Wakulla Spring

A wildlife paradise choking on hydrilla.



The photo to the left shows a diver removing the hydrilla that threatens to obscure visitors' view of the spring. Photo by Tom Kennedy, park volunteer. At right is one of the glass bottom boats that give Wakulla Springs State Park visitors a glimpse of the features of the spring bowl.

In 1837 John Lee Williams wrote, "Wakulla Spring is one of the finest springs in Florida or perhaps the world." It is one of the world's largest first magnitude springs, with a discharge of 252 million gallons per day. It is owned by the state of Florida and managed as a state park. The spring is the source of the Wakulla River. Cave divers have determined that Wakulla Spring flows from one of the longest underwater cave systems in the United States, and the spring bowl is one of the deepest in Florida. The spring has recreational, scenic, wildlife and historic values, and Wakulla Springs State Park is the third largest employer in Wakulla County. It is one of the foremost wildlife observation areas in Florida, attracting 200,000 visitors a year. The spring recharge basin encompasses much of Apalachicola National Forest, as well as a low-density residential area and the City of Tallahassee.

Threats

Water quality at Wakulla Spring is becoming increasingly degraded. Glass-bottom boat tours could not be provided for 303 days during 1995 due to dark water. Nitrate levels have increased to 1.0 mg/l and are feeding an explosive growth of the exotic aquatic weed hydrilla. First noted in early 1997, hydrilla is replacing native eelgrass and eliminating the open areas of the spring. Spirogyra, a native alga, is responding to the elevated nitrate levels by forming mats that smother the natural aquatic vegetation on the spring floor.

Strategies

Working Group. The Wakulla Springs Water Quality Working Group was formed in 1992 to protect the waters flowing to Wakulla Springs.

Education. Field trips and slide presentations have been provided to elected officials and the public. In 1998, the working group conducted a Scientific Symposium and a Public Awareness Day. That same year, WFSU-TV produced a documentary, *Below the Surface*, about threats to the spring.

Research. Researchers are attempting to determine the sources of nitrates flowing to the springs. Cave divers are continuing exploration of the cave system and are developing maps that will aid land-use planners.

Monitoring. The park biologist monitors water clarity daily and Northwest Florida Water Management District (NWFWMD) monitors spring discharge. Lakewatch volunteers collect samples monthly that are tested for a limited range of analytes. DEP has recently begun quarterly monitoring of biological health and monthly tests of water quality in conjunction with NWFWMD.

Regulation. In 1994, the Wakulla County Commission adopted a comprehensive land use ordinance (94-28, The Wakulla Springs Water Quality Protection Regulation). The ordinance established protective measures for a one-mile wide zone above the cave system, extending north to the county line. This step was taken in an effort to protect a highly vulnerable portion of the spring recharge basin. Leon County, Wakulla County's northern neighbor, is retrofitting stormwater management within the recharge basin.

Land Acquisition: The state has purchased 3,000 acres of the spring recharge basin and used eminent domain to stop the planned development of a 25-acre tract near the spring. DEP is pursuing the acquisition of additional tracts that overlie the cave system.

Stewardship. In 1997, divers and other volunteers conducted a cleanup of sinkholes in the Wakulla Springs recharge basin. They continue to assist in periodic manual removal of hydrilla from the spring. DEP's Division of Recreation and Parks spent $453,000 to relocate the park's wastewater treatment facility farther from the spring. A major landowner has restricted vehicle access to sinkholes connected to the cave system.

Sulphur Spring

Too much pollution…too late to cure?

Left, Sulphur Spring in 1925, when it was still a popular Tampa recreation area. Right, Sulphur Spring today, closed to the public due to coliform bacteria contamination. The spring also suffers from reduced flow and increased salinity. Hillsborough County, the City of Tampa, and SWFWMD are investigating ways to restore the spring.

Sulphur Spring is the largest of several springs that flow into the Hillsborough River within the City of Tampa. It is a second magnitude spring with a historic flow of 26 million gallons per day. The spring has been a popular recreation site since the late 1800s and was purchased in 1957 by the City of Tampa for public recreation and future water supply. Manatees use the spring waters as a warm water refuge during the winter months. One third of the flow of Sulphur Spring is pumped two miles to supplement Tampa's water supply reservoir. The spring's recharge basin is densely developed.

Threats

Sulphur Spring presents a prime 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. In an effort to manage its stormwater, the City of Tampa directed runoff into sinkholes. As many as fifteen of those sinkholes may be contributing stormwater runoff to the spring. Some of the sinks have since been filled. This action has resulted in reduced groundwater flow to the spring. The spring's discharge has been reduced forty-four percent 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.

Strategies

Watershed Planning. Hillsborough County has completed a stormwater plan for part of the Sulphur Spring recharge basin.

Regulation. The Southwest Florida Water Management District (SWFWMD) will establish an (MFL) rule to regulate spring discharge in 2001.

Monitoring. The US Geological Survey (USGS), in cooperation with the SWFWMD, is conducting continuous flow monitoring with three recorders. SWFWMD will conduct biological monitoring of the spring run and of manatee use in conjunction with the MFL study.

Research. Dye trace studies have confirmed the connection of certain sinks to the spring. Other studies have documented high coliform bacteria levels in the spring discharge several hours after major storm events. The City is conducting an assessment of the sinks to learn more about groundwater flow and water quality.

Restoration. The City of Tampa and SWFWMD are engaged in a project that will attempt to reopen a plugged sink that is connected to the spring. This project may result in increased groundwater flow to the spring and reduced salinity of spring discharge water.

Silver Glen Springs

A pristine spring

Silver Glen Spring. Photo by Jim Stevenson.

Silver Glen Springs includes a pair of vents that comprise a first magnitude spring, on the eastern edge of the Ocala National Forest in Marion County. The water quality of Silver Glen Springs is very good. The two major vents include a vertical cavity called the "Natural Well" adjacent to the main pool. The spring run conveys water from the vents eastward one half mile to Lake George.

A small stream feeding the spring run from the southwest also has numerous small spring boils in its bed. Silver Glen Springs was a private recreational area open to the public for a fee until 1989, when it was bought by the SJRWMD. The SJRWMD then re-sold it to the federal government in 1990 for incorporation into the Ocala National Forest. The spring recharge basin lies primarily in the Ocala National Forest.

Threats

Most of the spring recharge basin lies within a designated wilderness area. Only a small portion of the basin is privately owned. No threats are perceived at this time.

Strategies

Land Acquisition. Approximately three fourths of the spring recharge basin is in the Ocala National Forest. About half of this portion of the basin is in the Juniper Prairie Wilderness area. The remainder of the recharge basin is in private ownership. Acquisition of the private lands within the recharge basin would enhance long term protection of water quality.

Monitoring. The USGS monitored spring discharge intermittently from 1931 to 1984, and has monitored discharge twice a year since 1984. Water quality has been monitored intermittently since 1984. The SJRWMD has monitored discharge and water quality four times per year since 1983.

Stewardship. The Ocala National Forest has restricted foot traffic around the main pool, the "Natural Well", and the stream with the boils to halt erosion and allow reestablishment of vegetation. Access to the "Natural Well" has been restricted to prevent damage from swimmers. The US Forest Service is establishing controls on motorboat use in the spring run to reduce impacts to aquatic vegetation, water quality and manatees.

Findings

No one has the right to sit down and feel hopeless. There's too much work to do.
– Dorothy Day, journalist and activist

The five stories told in the previous section represent the range of problems facing springs throughout the state. The springs are located in different hydrogeologic settings, with a variety of land uses within their basins. Four of the five demonstrate elevated nitrate concentrations. Two of the four suffer from significant flow reductions. One of them has become too degraded for its traditional recreational uses. Another has rapidly changed to a weed-choked system that could face ecological collapse if no corrective action is taken. The most pristine springs in Florida are those found in the Ocala National Forest, with basins that encompass a limited range of land uses and few water supply wells. In general, Florida springs, whether found in urban or rural settings, public parks or private lands, are seriously threatened by actual and potential flow reductions and declining water quality.

In the past, local officials with responsibility for development decisions have not necessarily possessed sufficient information to make the best possible choices on behalf of spring health. Better information is now available to local governments, but the complexities of Florida's karst environments pose unanswered questions even to hydrogeologists. Florida's water supply managers face an ongoing struggle: to provide a plentiful supply of clean drinking water while maintaining spring discharge.

The mounting challenges of accommodating Florida's rapid population growth demand effective tactics to protect our world-renowned springs. The following pages present strategies for protecting the uniqueness and quality of our spring systems. The strategies are organized into five functional groups: Outreach (page 23), Information (page 26), Management (page 36), Regulation (page 43), and Funding (page 51). Recommended action steps to execute each strategy are provided. The parties with the authority and resources to implement each action step are identified. Task Force members agree that each strategy represents an essential part of an integrated plan to save our springs.

The Task Force has not prioritized specific springs for protection. The following criteria warrant consideration in any prioritization process:

- magnitude - first magnitude springs warrant priority attention;
- ecological significance;
- the public interest - state park and other publicly-owned springs warrant priority attention;
- economic value; and
- natural quality.

Outreach Strategies

Outreach Strategy 1: Education

Public sentiment is everything. With it nothing can fail. Without it nothing can succeed.
– Abraham *Lincoln*

Education is the most important spring protection strategy. Local officials cannot make informed decisions about land uses in spring recharge basins if they do not understand the relationship between land uses within spring basins and the quality and quantity of spring water. Homeowners, farmers, golf course managers, and public works officials will not reduce their use of fertilizers if they do not understand the impacts of their actions on the groundwater that feeds springs. The successful resolution of many other threats to springs is dependent on the actions of an educated populace.

The 461-page *Florida Geological Survey Bulletin No. 31, Springs of Florida* is the encyclopedia of Florida springs. It went out of print around 1983. Demand is so great that the Ocala National Forest Interpretive Association sells photocopies of the bulletin for $27 each. Since its publication, many new springs have been discovered.

Education can nurture appreciation of Florida's springs and bring about cooperation and voluntary compliance. Educational activities carried out on behalf of Wekiwa Springs, Silver Springs, and Ichetucknee Springs have resulted in substantial public support and increased protection. Education can build public support for land acquisition, restoration, and other protective actions for springs. In the absence of public support, lawmakers and policymakers are unlikely to provide funding that will benefit Florida's springs.

The public must be informed that Florida's springs are in trouble. A positive message of hope must be delivered – we *can* protect Florida's springs if we work together. Communication of a few fundamental concepts is an important goal of a coordinated educational program. The following three major concepts must form the foundation of every Florida Springs education program.

1. A spring is only as healthy as its recharge basin.
2. Activities within spring recharge basins can and do have adverse impacts upon the quality and quantity of groundwater, thereby affecting spring flow, water quality, and the health of spring-run ecosystems.
3. Protection of spring water must occur in the spring recharge basin before the water reaches the spring.

Action Steps for Outreach Strategy 1 (Education)

Florida Legislature

- Fund the production of a high-quality, made-for-television video to educate Floridians about the values, function and protection needs of their springs. Produce an updated version every five years.
- Fund the investigation, production and publishing costs to create an up-to-date database of water-quality parameters for Florida's more than six hundred springs and develop a revised inventory of springs. Compile and publish this database as an update to the 1977 Florida Geological Survey's *Geological Bulletin No. 31, Springs of Florida*.

DEP, WMDs

- Develop and conduct ongoing field trips and classroom presentations to educate school children about spring systems in coordination with DEP's *Water and You* environmental education program.
- Conduct periodic workshops on spring protection strategies for local government elected officials and staff in every county with springs.
- Provide and publicize user-friendly, online information about springs and the issues that threaten them.
- Conduct a biennial Florida Springs Conference.
- Educate the public about current and future water quality trends. Generate periodic "report cards" depicting relative water quality trends.
- Educate visitors to public springs about threats to springs and protection needs.

DEP

- Conduct the investigations necessary to create an up-to-date database of water-quality parameters for Florida's springs. Compile and publish the information as an update to the 1977 Florida Geological Survey's *Geological Bulletin No. 31, Springs of Florida.*
- Develop a booklet that provides land use planning guidance to local governments. The booklet should enable them to identify and plan for the protection and wise use of spring recharge basins.

Soil and Water Conservation Districts, in coordination with DEP & MWDs

- Erect signs at spring recharge basin boundaries with a message such as: "You are entering [name] Spring Recharge Basin."What you do on the land impacts the water below. Help keep our springs clean."

Outreach Strategy 2: Spring Basin Working Groups

Places need keepers – people who know how things are changing, whether from bad to good, or vice versa. People who have their eyes on the place and their hearts in it. The land itself needs people who know it, care about it, keep track of it, and work on its behalf. – Scott Russell Sanders, author and essayist

No single government agency has the authority or resources required to provide adequate protection for a spring. Participation by spring stakeholders is imperative for effective spring protection. A spring basin working group can conduct a vigorous, collaborative process for identification and resolution of spring problems. Effective working groups are composed of all federal, state and local government agencies having information or responsibilities concerning the function of the spring recharge basin. Other important stakeholders include agricultural and commercial interests, environmental organizations, and citizens. To be effective, a working group must have a capable leader.

The Wekiva River derives nearly all of its flow from springs. The Friends of the Wekiva (a member of the Wekiva River Basin Working Group) was the first group to successfully organize and effectively lobby for the enactment of protective measures for a spring or spring group. Every spring does not need a working group, but most major springs or spring groups with large recharge basins can benefit from this process. Ongoing working groups are also acting on behalf of Wakulla Spring, Ichetucknee Springs, Silver Springs, Homosassa Springs, and Santa Fe Springs.

Action Steps for Outreach Strategy 2 (Spring Basin Working Groups)

DEP, WMDs

- Form and support working groups to protect major springs and spring groups. Dedicate staff time to this effort.
- Provide technical assistance and training in support of the formation and facilitation of working groups.

Information Strategies

Information Strategy 1: Monitoring

Monitor: any of various persons or devices for checking or warning about a situation, operation, etc. – The Oxford American Dictionary of Current English, 1999

Information Strategy 1A: Springs Water Quality Monitoring. The collection and analysis of spring waters for potential contaminants is an important part of assessing the health of Florida's springs, and by extension, our drinking water. Recently, an alarming trend of increasing chemical contaminants within many springs has been noted. Nitrate concentrations, in particular, have increased dramatically, causing the growth of excess algae in springs and their runs, and contributing to the degradation of receiving waters. Concentrations of nitrate in some Florida springs exceed safe drinking water standards established by the EPA. Even if nitrate levels in springs were limited to one tenth of the drinking water standard, serious degradation of spring biological communities would occur. Low levels of pesticides and herbicides are also occasionally detected in Florida spring water.

The effects of chemical contamination on submerged cave life is not well known – much about the life cycles of these animals has yet to be learned. The known range of many of these species is limited to a few or only one spring system. Thus, entire species are highly vulnerable, with their survival totally dependent on a continuing supply of clean water.

The quality of Florida spring water is directly related to discharge rates, residence time of water within the aquifer, and land-use practices within the spring recharge basin.

Action Steps for Information Strategy 1A (Springs Water Quality Monitoring)

These action steps are presented in order of priority.

WMDs, DEP

- Delineate recharge basins for all of Florida's major springs. The implementation of this first step is essential to effective springs protection. Highest priority should be given to ecologically significant springs, including park springs and springs that are threatened.
- Determine the types and percentages of major land uses within each of the delineated spring recharge basins, with priority given to springs in state parks and on other conservation lands. Land uses that are near the spring may have a more immediate impact on water quality than those located further away.
- Design an analyte list for each spring, based on information generated by the survey of land uses within the spring recharge basin.
- Develop a water-quality monitoring plan for each spring to be sampled.
- Collect flow data whenever water quality sampling is performed, in order to determine loading of potential contaminants in receiving waters, and to correlate water quality with quantity (the two are usually intimately related to one another).
- Develop methods to address water quality problems detected through monitoring. These methods may vary considerably, based on each individual case.

Information Strategy 1B: Springs Discharge Monitoring. The protection of spring discharge, or flow, is essential to maintaining recreational, water quality, biological health, and aesthetic values. The State and WMDs have invested millions of dollars in the acquisition of springs and surrounding properties. These springs are managed as parks and conservation areas for the long-term use and enjoyment of the public.

A key challenge for the future is the preservation of natural discharge of all springs. Spring flow preservation is dependent on the wise use of water by the residents of Florida. Present groundwater withdrawals are reducing spring flows. This, combined with future increases in withdrawals, will negatively impact native plants and animals and reduce recreational opportunities. The preservation of spring discharge calls for the implementation of management and conservation practices that reduce groundwater withdrawals to the lowest level possible.

> *To permanently take away their water is Solomon-like; sliced in half for the price of reasonableness.*
> – Al Burt

Water flowing out of most springs comes from the Floridan Aquifer. The source of water to this aquifer is rainfall that has soaked into the ground in recharge basins. Spring flows are directly related to groundwater levels. If groundwater levels are maintained, then spring flows will also be maintained. When water is pumped from supply wells, it is removed from the aquifer and thus reduces spring flow. The greatest reductions in spring flow occur in areas with high well densities and high groundwater pumping rates. The impact is most noticeable on smaller springs.

Action Steps for Information Strategy 1B (Springs Discharge Monitoring)

DEP, WMDs, USGS Þ

- Establish stream flow gauging stations at a network of springs selected to represent most of the springs in the State. The gauging stations will provide baseline data that can be used to detect declines in long-term spring discharges.
- Establish a network of monitoring wells to measure water levels in the Floridan Aquifer. This will provide baseline data to determine if water levels are declining. Declining aquifer levels are a precursor to reduced spring flows.

Information Strategy 1C: Springs Biological Monitoring. To successfully manage an ecosystem, a basic understanding of the system's biological components is critical. The members of a biological system respond cumulatively to a wide variety of factors, both natural and of human origin. When human actions adversely affect a system, biological populations will change, leading to an impaired or imbalanced community. Pollution-sensitive species will disappear, food webs will be disrupted, diversity of species will decrease, and undesirable nuisance species may dominate the community. Protection of ecological integrity in springs requires four components: good water quality, natural discharge, appropriate habitat, and healthy biological communities.

Monitoring allows scientists to distinguish a spring run's natural plant community from one that is out of balance. A Floristic Quality Index for Florida is currently under development by DEP scientists.

Benthic macroinvertebrates are a critical link in the food web, and standardized methods for determining impairment exist and are in use in Florida. Invertebrates do not respond directly to the nitrate enrichment so common in springs, but are affected by associated changes in algal food quality, plant overgrowth, and the lower dissolved oxygen regimes that directly result from nutrient enrichment.

Large aquatic vertebrates, such as birds or fish, are the last group adversely affected by changes in spring water quality. However, their familiarity to casual observers and status at the top of the food web make this group worthy of limited monitoring efforts.

Action Steps for Information Strategy 1C (Springs Biological Monitoring)

DEP

- Conduct biological monitoring in spring systems, in cooperation with the water management districts and local environmental agencies. This monitoring should be part of DEP's "rotating basin approach", as well as a "stand alone" effort to gather this important information from selected springs, such as those associated with state parks.
- Include algae, aquatic plants, benthic macroinvertebrates, and appropriate vertebrate wildlife in the monitoring program. Give priority to the group of organisms best suited to determining potential problems. For example, algae and plant communities are most sensitive to nutrient enrichment, and invertebrates are most sensitive to insecticides.
- Monitor biota twice per year, at two locations in each spring run.
- Coordinate these monitoring efforts with research projects designed to establish cause-effect relationships between human land use activities and biological impairment.
- Coordinate with cave divers to receive observation reports on submerged cave biota. Post the reports on the DEP website.
- Request assistance from spring owners and managers in reporting observations of reduced flow, cloudy water, and other unusual events.

Information Strategy 1D: Integrated Springs Monitoring Protocol. The DEP is conducting a one-year pilot project at Wakulla Springs to determine how to monitor spring health by integrating biological, water quality, and discharge monitoring.

Action Steps for Information Strategy 1D (Integrated Springs Monitoring Protocol)

DEP

- Complete the monitoring pilot project at Wakulla Springs and develop a simple integrated monitoring protocol that can be used to determine spring health.
- Develop a training program on the implementation of this integrated monitoring protocol; make it available to all interested parties.

Information Strategy 1E: Springs Monitoring Data Management. DEP, the five WMDs, USGS, universities, and local governments all collect water quality, discharge and biological data. For scientists to be able to construct an overall view of the health of spring systems, the available data must be integrated into a common database. Reports, based on the interpretation of information stored in the database, must be provided to the public periodically.

Action Steps for Strategy 1E (Springs Monitoring Data Management)

DEP, WMDs, USGS, universities, local governments, others who collect water quality data

- Routinely enter all springs water quality, discharge and biological data into STORET, a water quality database administered by DEP and connected to a nationwide network.

DEP

- Include data on the health of Florida's springs in the DEP's 305(b) report, which provides statewide water quality information to the US Congress on a biennial basis.
- Prepare and publish annual reports on the health of park springs.

Information Strategy 2: Research

The pursuit of truth shall set you free – even if you never catch up with it. – Clarence Darrow

Basic scientific research is important in order to understand existing conditions in Florida spring systems (including caves, springs, spring runs, and spring-fed estuaries). The information gained from such research will allow scientists to predict potential impacts to spring systems from activities within spring recharge basins. Although significant research has begun on Florida spring systems, many important questions remain unanswered. Three broadly defined research questions follow. They represent a general approach to the necessary research. The urgency of these three questions warrants immediate action. The pressing research questions are…

- What are the areas of contribution (from surface and subsurface) to Florida's spring systems?
- What is the capacity of groundwater systems to assimilate nitrogen in the vicinity of springs?
- What are the impacts of contaminants and excess nutrients on the ecology of spring systems?

The answers to these most pressing questions will enhance engineering designs, including BMPs, MFLs, stormwater management, and septic tank designs. The knowledge gained by investigating these questions will lead to improved land use practices within spring recharge basins. The answers may also lead to the development of efficient protection strategies for all of Florida's springs, as well as other water resources. Because these primary questions merely sketch a proposed approach to the unknown, the following text will focus on broad categories of spring research and expand the questions.

Geological and Hydrogeological Questions

Physical hydrogeology: What physical and geological characteristics control mixing of ground and surface water, and water contained in conduits, fractures, and pore spaces of matrix rocks in the subsurface? Is mixing heterogeneously distributed in the subsurface within the aquifer? How does mixing influence chemical composition and discharge of spring water?

Changing conditions: How can spring recharge basins be defined? Do spring recharge basins change with recharge? How do short and long term climatic events and rising sea level influence spring recharge basins and the quantity and quality of spring discharge?

Chemical Questions

Nutrients: What are the natural nutrient budgets, particularly for nitrogen, in spring water? What are the origins of nutrients (natural and anthropogenic) discharging from springs? What effects do excess nutrients have on ecosystems in spring systems? What is the upper limit of nitrogen that can be tolerated by spring ecosystems?

Contaminants: What are potential and existing pollutants in spring water? What are their current and potential sources? By what pathways do they enter spring water? What effects do contaminants have on spring ecosystems and what levels can be tolerated?

Biological Questions

Ecosystems: What are the natural biological and microbiological conditions of spring systems? What are the links between human actions and adverse biological responses? What are limiting nutrients (the nutrient that is available in the shortest supply; sometimes there is co-limitation of two nutrients) in these systems? What is the basis of the food web (for example, is it chemosynthetic or organic carbon delivered from the surface)?

Vulnerable Populations: What are the distributions of spring/cave/estuary fauna? What populations are so limited as to be considered threatened or endangered? What assessment tools (algal, macroinvertebrate, and macrophyte communities) can be used to determine adverse impacts from human activities? What assessment tools can be used to measure responses to attempts at restoration of ecological health? What are the most sensitive indicator species that can provide information on degradation of water quality in springs?

Engineering and Protection Questions

Engineering designs: What are the best engineering designs to protect springs from contamination (including septic tank design, maintenance, and inspection, control of stormwater runoff, best management practices, land use)? Do the current designs work? How do anthropogenic contaminants interact with aquifer rocks, confining units, and overburden?

Land use: What portions of spring recharge basins need to be protected, and how can they be protected? What land use practices are acceptable within spring recharge basins? What activities impact springs and in what way?

Action Steps for Information Strategy 2 (Research)

DEP, WMDs, USGS, other government agencies, and state universities

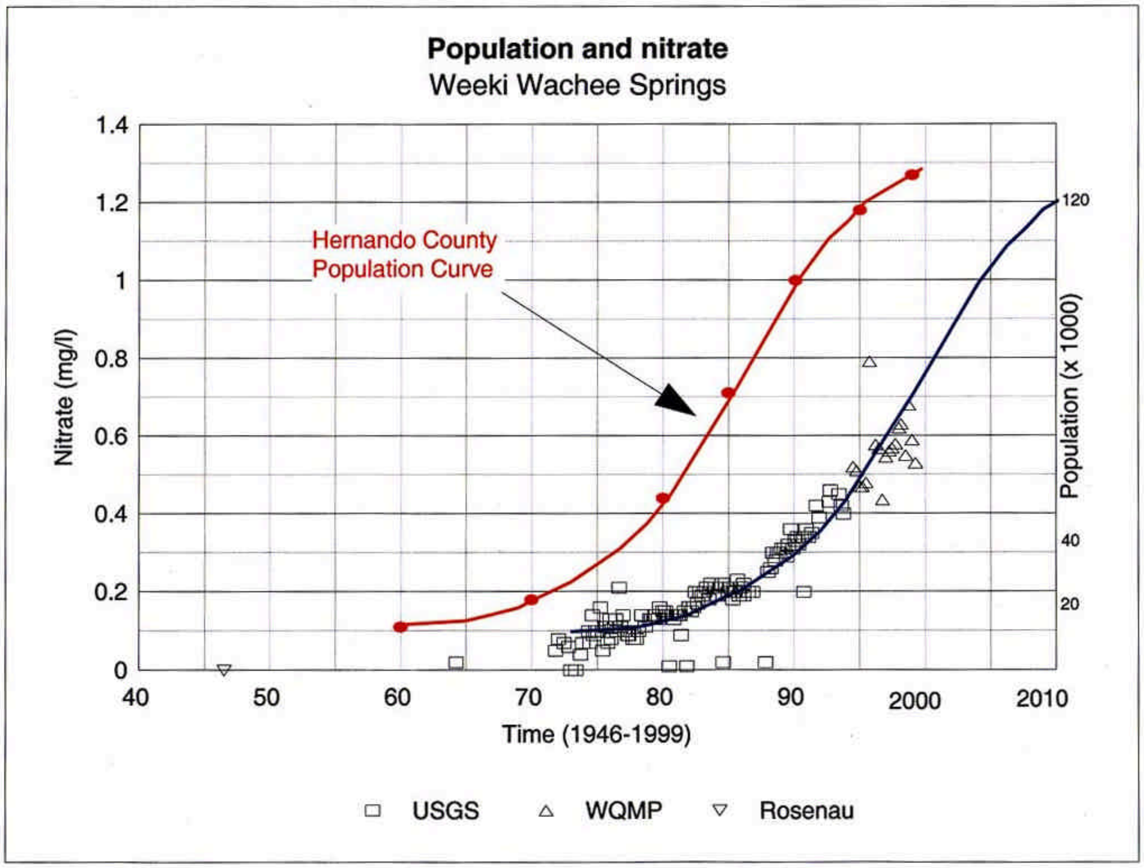
- Contribute personnel and support to the formation of a diverse group of scientists, engineers, and policymakers who can collaborate to develop specific research proposals to address these important research questions.

DEP, WMDs, DCA, DACS, USGS, NSF, EPA, municipal and county governments

- Provide funding to support the research projects. A conservative cost estimate to begin to address these questions is approximately 10 million dollars over a period of five years.

DEP, WMDs

- Encourage and support cave diver explorations and mapping of cave systems.



The black line traces the increase in nitrate levels in Weeki Wachee Springs since the 1940s. It mirrors the population increase for the spring recharge basin during those years. From SWFWMD.

Management Strategies

Management Strategy 1: Land Use Planning

An ounce of care is worth a pound of cure. – American proverb

Implementation Strategy 1A: Land Use Planning. Both the quality and quantity of spring discharges have declined notably in many of Florida's springs. Without effective remedial action, further declines can be expected. Activities such as urbanization and intensive agricultural practices on the land surface can and do have adverse impacts upon the quality and quantity of groundwater, thereby affecting spring flow, water quality, and spring-run ecosystems. Although certain land uses, such as landfills, are obviously unsuitable for sensitive karst areas and spring recharge basins, where to draw the line, short of leaving all land in its natural state, remains a question.

Land use planning is currently carried out within the following framework in Florida:

Local: Local governments have the primary responsibility to determine land use activities within their jurisdictions. Under the provisions of Chapters 163 and 380, Florida Statutes (FS), local governments also have the responsibility to provide for the conservation and enhancement of natural resources, including groundwater. Local government comprehensive plans include goals, objectives, and policies that address land use, natural resource protection, and other common considerations. All development undertaken or approved by a local government must be consistent with its comprehensive plan. A strong local government comprehensive plan that is effectively implemented can be a major force for protection and restoration of springs.

Although local governments can designate land for agricultural use, they have limited ability to regulate agricultural activities under the Right to Farm Act (Chapter 828, FS). Chapters 380 and 163, FS, exclude agriculture from land use regulation as development.

Regional: Regional planning councils (RPCs) and WMDs have review responsibility for land use and policy decisions of local governments. They exercise this responsibility through comprehensive plan review. Comprehensive plans must be consistent with RPC Strategic Regional Policy Plans (SRPPs). RPCs and WMDs provide technical assistance to local governments on comprehensive planning. In addition, WMDs (except for the NWFWMD) also exercise regulatory authority for individual projects through their review of stormwater management permits, water consumptive use permits, and environmental resource permits. However, WMDs do not have land use decision authority.

State: The Department of Community Affairs (DCA) has land use planning oversight responsibility as well as authority for the determination of local comprehensive plan compliance with state law. DCA also has review responsibility for large-scale developments and appeal authority (Developments of Regional Impact, Florida Quality Developments). The DEP and the Departments of Transportation (DOT) and Agriculture and Consumer Services (DACS) provide review and comment to the DCA on plans and plan amendments. DEP has regulatory authority for activities affecting submerged state lands, resource extraction, and water quality.

The following programs and activities that deal with land use planning are ongoing in Florida.

Comprehensive Plans

In general, when land uses are assigned to a particular location on a Future Land Use Map by local governments, they must demonstrate the suitability of those uses for that site considering soils, topography, natural resources, and other relevant factors under the provisions of Chapter 163, F.S. and Rule 9J-5.006, F.A.C.

A Natural Groundwater Aquifer Recharge Element is required in all comprehensive plans. It includes waste management, drainage, and aquifer recharge provisions. Local governments are required to depict any areas adopted or identified by water management districts as prime or high groundwater recharge areas for the Floridan and Biscayne aquifers and to give these areas special consideration when designating land uses (Section 163.3177, FS). Rule 9J-5.011, FAC, requires comprehensive plans to "address protecting the functions of natural groundwater recharge areas," and regulate land use and development to protect the functions of aquifer recharge areas.

A Conservation Element requires that comprehensive plans include policies to protect quality and quantity of water sources and to restrict activities and land uses known to adversely affect quality and quantity of water sources, including aquifer recharge areas (Section 163.3177, FS, and Rule 9J-5.013, FAC).

Development of Regional Impact Review

All development projects that, due to size and character, are likely to create regional impacts are required to undergo review (Chapter 380, FS, Rule 9J-2, FAC). The purpose of the review is to determine the nature and extent of possible impacts. Impact mitigation may be required as part of development order conditions. Under Chapter 380, FS, agriculture is excluded from consideration as development and is therefore not directly regulated under DRI or comprehensive planning programs.

It should be noted, however, that other programs do provide some measure of consideration for agricultural practices that relate to water quality. Section 403.0752, F.S., provides for Whole Farm Planning under the Department of Environmental Protection's Ecosystem Management efforts. In this program farming practices and agricultural BMPs are considered in a watershed context.

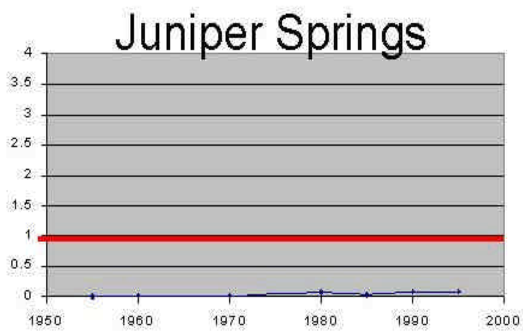
The Florida Yards and Neighborhoods program, supported by DEP, and the Audubon International standards for golf course design and maintenance help lessen development impacts to groundwater quality. In recent DRI reviews, DCA has been promoting the use of these programs by encouraging local governments to incorporate these practices into DRI development orders as development conditions.

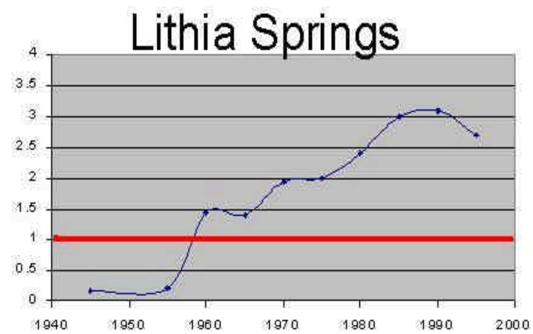
Regional Planning Councils (RPC) and Strategic Regional Policy Plans (SRPP)

SRPPs are a tool for coordinating protection of natural resources, such as spring recharge basins, that extend across governmental jurisdictions. SRPPs must provide goals and policies to address natural resources of regional significance (Section 186.507, FS). These goals and policies must be used to develop a coordinated program of regional actions directed at resolving identified problems and needs. SRPPs provide the basis for RPC review of comprehensive plans and DRIs.

SRPPs must identify natural resources of regional significance by specific geographic location and not by generic type.

RPCs, in their SRPPs, may recommend specific locations or activities in which a project, due to its character or location, should undergo DRI review.





The blue lines show nitrate concentrations (mg/l) in two Florida springs over forty-five to fifty years. Juniper Springs is located within the Ocala National Forest, with a recharge basin that is mainly in conservation lands. Land uses within the Lithia Springs recharge basin are mainly agricultural. Field observations indicate that as nitrate levels approach 1 mg/l (red line), spring biological communities become degraded by out-of control plant growth. The exact concentration that causes impairment is still not known.

Action Steps for Management Strategy 1A (Land Use Planning)

(*The steps that are marked* (*) *warrant priority attention and must be implemented prior to the other steps for maximum effectiveness.*)

DCA, WMDs, DEP, RPCs, local governments

- *Develop protocol for determining *suitability,* with respect to spring system protection, of a particular site for proposed land uses during review of land use change (comprehensive plan amendment).

- *Develop *land use screening protocol* that local governments can use in the development review process. Design this screening tool so that it can be used to evaluate proposed land use changes. Design it so that it may also be utilized in development approval reviews (for instance, plat reviews, site plan reviews). This tool will allow application of groundwater protective measures to projects of less than DRI scale.

WMDs

- *Identify the most vulnerable areas of spring recharge basins and assist local governments in creating zones of special consideration for land use planning or regulation. Protocol for the development of wellhead protection areas and groundwater capture zones may be used as a model.
- *Encourage the development and use of a Karst Procedure (subsection 40C-41.063(6), F.A.C.) similar to the one developed by SJRWMD. Include revisions that address stream-to-sink basins and direct discharge to sinkholes. Apply the procedure to all Environmental Resource Permits (ERP) projects in areas where springs are located.
- Establish a validation procedure for the SJRWMD Karst Procedure to determine its effectiveness at protecting groundwater (SJRWMD, with input from other WMDs, would take the lead on this initiative). Adjust the Karst Procedure, based on the results of the validation process.

Local governments, RPCs, DCA

- *Develop and implement zone of protection ordinances and land development regulations to protect spring recharge basins and areas that drain into sinkholes and other karst features.

Local governments, RPCs, DCA, WMDs

- Develop approaches and measures needed to protect and restore groundwater and springs through intergovernmental coordination elements of local government comprehensive plans.

DCA

- Identify and inform local governments of land uses that are known to adversely affect spring water quality.

DCA, WMDs

- *Provide assistance to local governments so that they may develop spring and spring system protection plans as part of adopted local comprehensive plans.

DCA, DEP, RPCs

- Use DRI review process to address regional impacts to groundwater resources not addressed by an existing permitting procedure for surface water management until the SJRWMD Karst Procedure is tested and karst rules are fully implemented in all other water management districts with karst geology. Groundwater protection BMPs should be recommended by all reviewing agencies for incorporation by local governments into all DRI development orders in karst areas in addition to implementation of a Karst Procedure for Management and Storage of Surface Water systems.

DACS, DEP, WMDs

- Develop, evaluate, and revise best development practices and BMPs for application in spring recharge basins.

RPCs

- Revise Regional Planning Council Strategic Regional Policy Plans to recognize groundwater aquifer(s) as natural resources of regional significance in all RPCs.

Florida Legislature

- Consider identifying groundwater aquifers as natural resources of regional significance in all Strategic Regional Policy Plans. Provide enhanced protection for these resources under that process.
- Consider the adoption of legislation to prohibit state agencies from issuing permits for proposed activities in spring recharge basins that are inconsistent with the applicable local government comprehensive plan and land development regulations.
- Consider requiring DRI review for certain projects that may have adverse impacts to groundwater, but which are not currently reviewed, such as landfills.

Management Strategy 1B: Better Onsite Sewage Treatment and Disposal Systems (OSTDS) Siting. Florida's continued population growth calls for careful infrastructure planning, including wastewater disposal that protects sensitive karst areas and spring recharge basins. Regulatory authority for the siting of OSTDS, commonly known as septic tanks, is shared by the Florida Department of Health (DOH) and DEP. Many local governments also regulate the siting of OSTDS.

Action Steps for Management Strategy 1B (Better OSTDS Siting)

Local governments, DOH

- Within the most vulnerable areas of spring recharge basins, permit only alternative OSTDS technologies, which are currently capable of removing up to 75 percent of nitrogen from OSTDS effluent. Provide incentives that will encourage the use of more efficient nitrogen-removal technologies as they become available.

Florida Legislature

- Consider the adoption of legislation that would make approval of large-scale developments within the most vulnerable parts of spring recharge basins contingent upon the construction of a centralized, advanced wastewater treatment plant (AWTP). Require a nitrogen management plan to prevent nitrogen in the AWTP effluent from impacting groundwater.
- Consider the adoption of legislation that would require OSTDS inspection and maintenance every five years or when property is sold.
- Fund the best available wastewater treatment technology for state parks with springs (or fund the connection to an off-site AWTP).

DOH

- Aggressively pursue a program for the continued development and refinement of OSTDS technologies that significantly reduce nitrogen and phosphorus levels.

Management Strategy 2: Best Management Practices (BMPs)

The values and benefits of a spring are found at *the spring – scenic beauty, recreation, and wildlife. They are dependent on water. Protection of the water must be applied* before *it reaches the spring – in the recharge basin*. – James A. Stevenson, DEP

Various land uses within spring recharge basins can contribute to the pollution of groundwater from nutrients, primarily phosphorous and nitrogen. BMPs for all land uses should be evaluated for effectiveness in groundwater protection. The Precautionary Principle should be observed when BMPs are developed and implemented.

"*When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically.*"
– from The 1998 Wingspread Statement on the Precautionary Principle

Management Strategy 2A: Landscape Fertilization BMPs. The importance of developing best management practices for residential turf fertilization is highlighted by the results of a study conducted by the SFWMD from 1995 to 1997. The study determined that nitrate levels in water discharging from the Weeki Wachee, Chassahowitzka, and Homosassa Springs had increased from < 0.1 mg/l in the 1960s to approximately 0.5 mg/l in the mid 1990s – a greater than five-fold increase. The study also determined that approximately 360 tons of nitrate was discharging from the springs annually into the Weeki Wachee, Chassahowitzka, and Homosassa Rivers. Furthermore, the study found that although there were a number of different nitrate sources related to human activity in the recharge basins of the springs, the principal source of nitrate in spring discharge was inorganic nitrogen fertilizers applied to lawns. At that time, 440 tons were being applied annually to residential turf in the portions of the recharge basins closest to the springs.

The study concluded that much of the fertilizer applied to residential turf was leaching through the soil into groundwater without being utilized by the turf. Strategies to increase the efficiency of fertilizer use, and to reduce the need for fertilizers, are essential to the survival of Florida's springs.

Action Steps for Management Strategy 2A (Landscape Fertilization BMPs)

Florida Yards and Neighborhoods program

- Educate large groups (garden clubs, retailers, lawn care services companies) on the importance of the use of slow-release fertilizers for residential lawns and gardens. Highlight the fact that, although the conventional, quick-release fertilizers that currently dominate the market are less expensive, slow-release fertilizers can last much longer and are much more likely to be used by the plant rather than leaching through to groundwater.

County Commissions

- Develop ordinances that require the preservation of as much native vegetation as possible when land is cleared for residential development. This can greatly reduce the landscape's need for water.
- Where native vegetation is not preserved, promote the use of plants that require a minimum of water.

DEP, DOT, DACS, WMDs, FWCC, and other state agencies Þ

- Limit or discontinue use of fertilizer in spring recharge basins.

Developers, Builders, Landscape Designers, and Homeowners

- Minimize turf areas in landscape design and in common areas within subdivisions, such as medians or buffer areas along sidewalks. Intersperse turf around large areas of native vegetation that is adapted to Florida soils and does not require fertilizer.

Developers, Builders, Homeowners Associations

- Investigate opportunities to revise deed restrictions, bank and homeowner association requirements, and builder packages that require a minimum square footage of turf in new development. The revisions should be designed to limit the area devoted to lawns (to reduce the need for fertilizer) and impervious surfaces (to reduce runoff).

County Extension Agents, Landscape Service Companies, Nurseries and Sod Companies

- Promote the use of turf grass varieties that require minimal amounts of fertilizer and water.

DEP, WMDs

- Provide small grants for implementation of residential landscape BMPs by landowners who cannot afford the cost.

All State Agencies

- Limit or discontinue fertilizer use on agency properties in vulnerable areas of spring recharge basins.

Management Strategy 2B: Agricultural Best Management Practices. Agricultural activities are known sources of nutrients from animal waste and from commercial (inorganic) fertilizers. Voluntary implementation of BMPs by owners of agricultural operations located within spring recharge basins is necessary for the protection of springs.

An example of such a nutrient reduction program directly linked to the water quality of springs is underway in the Middle Suwannee Region of North Florida, an area with more than 50 known springs, many of which have high levels of nitrates. The Suwannee River Partnership, which includes twenty-four agencies and private organizations, is cooperating to reduce nutrient loading to the waters of the Suwannee River watershed.

The success of nutrient reduction programs is dependent on ongoing financial and technical assistance from federal, state, and regional agencies. Nutrient reduction is necessarily a long-term effort. Farmers need financial assistance to offset the initial costs of implementing BMPs. Depending on the type of operation, BMPs used in a single spring recharge basin may cost hundreds of thousands of dollars, although some BMPs are less costly.

Action Steps for Management Strategy 2B (Agricultural BMPs)

WMDs, DEP, DACS

- Use a watershed planning and management approach to encourage and achieve nutrient reductions.
- Emphasize voluntary, incentive-based programs, such as those offered by the Natural Resources Conservation Service and DACS, as the preferred method for reducing nutrient loading in spring recharge basins.
- Where appropriate (regional plans may be adequate in certain areas), develop a nutrient-reduction plan specific to the recharge basin of the spring being targeted. The plan should include the following:
  - delineation of the planning area;
  - inventory of potential sources of nutrients;
  - monitoring to track the status of nutrients in groundwater and at spring sites;
  - monitoring to determine effectiveness of BMPs; and
  - targeted strategy for the reduction of nutrient loading from agricultural sources, including BMP cost-share programs and educational and technical assistance to implement proven BMPs.
- Form partnerships of farmers, private organizations, environmental groups, state and federal agencies, and local governments to provide policy and technical guidance for the planning process, and to guide the long-term implementation of an action plan.

Agricultural Interests

- Leave a 100-foot buffer around sinkholes and other karst features that are connected to spring conduits.

Management Strategy 2C: Silviculture Best Management Practices. Forestry is one of the most compatible land uses for a spring recharge basin. However, there is a concern that application of fertilizers and pesticides in karst areas and other vulnerable portions of spring recharge basins may affect spring water quality.

Action Steps for Management Strategy 2C (Silviculture BMPs)

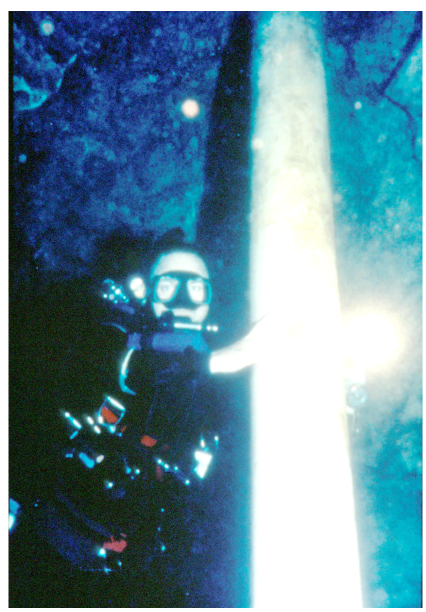
US Forest Service, DACS Division of Forestry, private foresters

- At a minimum, all forestry operations in spring recharge basins should adopt the practices outlined in the 1993 Silviculture BMP Manual produced by DACS.
- In addition, the following step is recommended:
  Evaluate the effectiveness of Silvicultural BMPs for groundwater protection, especially concerning application of fertilizer and pesticides in karst areas and near karst features. Based on scientific evidence, BMPs should be modified as necessary to achieve appropriate resource protection.

Management Strategy 2D: Stormwater Management in Sensitive Karst Areas. Throughout most of Florida, tens to hundreds of feet of sands, clays, and other material overlie the highly porous limestone that contains the Floridan Aquifer. This material acts as a buffer, providing the aquifer some protection from surface pollutants. However, in certain karst areas of the state, the limestone that contains the Floridan Aquifer is at or near the land surface, and can easily be contaminated.

The state of Florida first began regulating stormwater discharges in the 1980s because of flooding and water-quality impacts from stormwater. The stormwater rule required that new development include stormwater treatment systems, such as retention basins and detention ponds, to remove stormwater pollutants. The most common system utilized in karst areas is dry retention basins. Dry retention basins treat stormwater by percolating runoff into the ground beneath the basin. As the runoff passes through the soil, filtration, adsorption, and biological removal of contaminants occurs.

After a few years, it became apparent that special considerations were warranted when stormwater systems were sited in certain karst areas of the SJRWMD. There is concern in these areas is caused by the tendency of solution-pipe sinkholes to form in the bottom of some stormwater basins. When a solution pipe forms, it creates a direct connection between the bottom of the stormwater basin, where pollutants are concentrated, and the aquifer below. Runoff entering the aquifer by this route bypasses treatment. To address this problem, in 1991 the SJRWMD adopted more stringent criteria within the sensitive karst areas of western Alachua and Marion counties.



This cave diver, who entered the Floridan Aquifer at Little River Spring Cave, encountered someone's water supply well. Stormwater can enter the aquifer through similar openings.

Action Steps for Management Strategy 2D (Stormwater Management in Sensitive Karst Areas)

WMDs, DEP, counties, and municipal governments

- Adopt the SJRWMD's sensitive karst procedure, or equivalent, for the design and construction of stormwater management systems in karst areas.
- Provide pre-treatment, in the form of swales, berms, ponds, or dry basins, to runoff that currently discharges directly into sinkholes, solution pipes, or springs.
- In the most sensitive karst areas, consult DEP, IFAS, and DACS to review the use of agricultural chemicals to ensure that recommended application rates are protective of the water quality in areas where groundwater is particularly vulnerable.

Management Strategy 2E: Sinkhole Cleanup. Sinks have been called "go-away holes" for their utility in making undesirable objects disappear. In 1998, volunteers collected 3,000 pounds of trash and debris from Rose Sink, in Columbia County. Studies have shown that Rose Sink is directly connected to Ichetucknee Springs. Hazardous wastes in sinkholes threaten groundwater that contributes to spring flow. Some private landowners may need financial assistance to remove waste from sinkholes on their property.

Action Step for Management Strategy 2E (Sinkhole Cleanup)

DEP

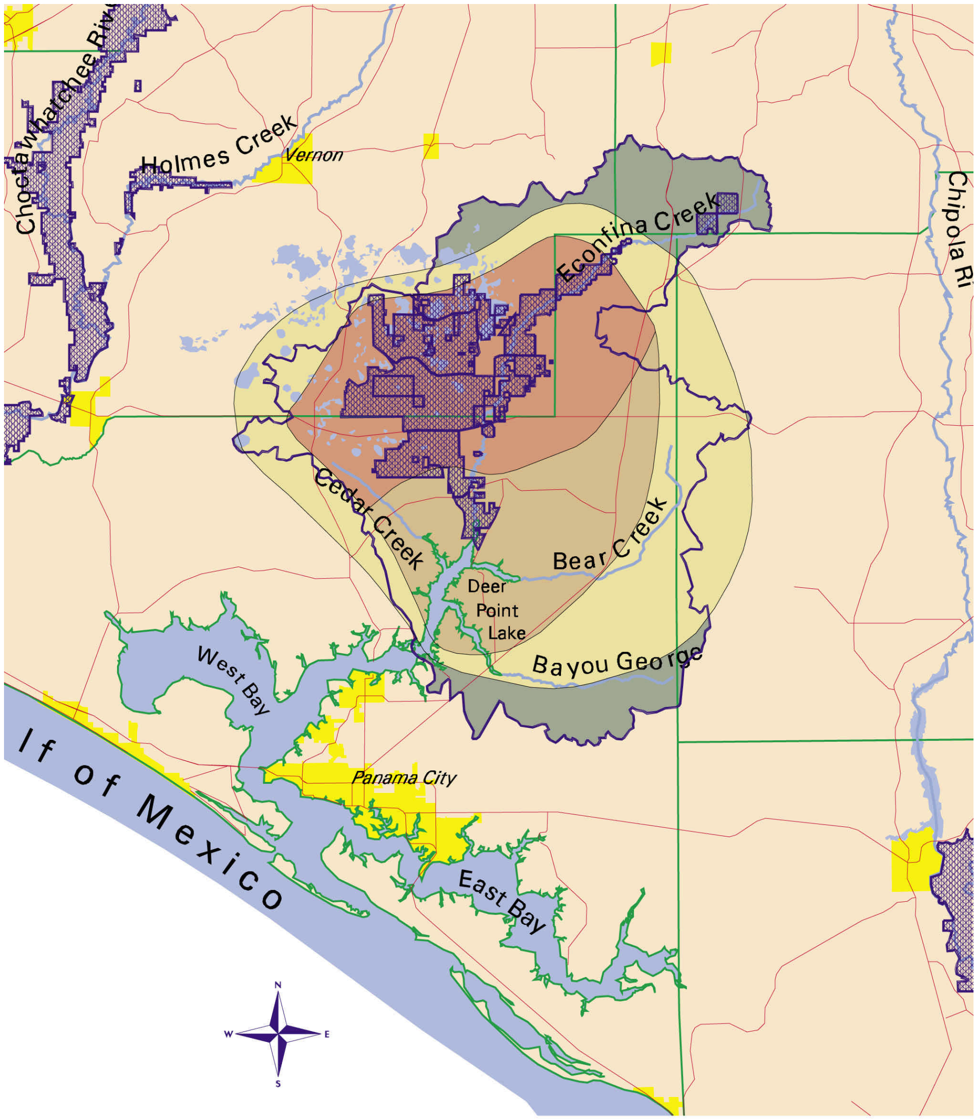
- Provide funding to assist private landowners with sinkhole cleanup (see Funding Strategy).

Management Strategy 2F: Golf Course Best Management Practices. With the increasing popularity of golf, and Florida's growing population, many new golf courses are being built in the State. Over 1500 golf courses, representing over 200,000 acres of land use, exist in Florida in the year 2000. Studies have shown that chemicals used on golf courses can contaminate groundwater and surface water resources. The use of BMPs in the operation and maintenance of golf courses can reduce the potential for negative impacts to water resources. An Integrated Pest Management Plan (IPMP) is the cornerstone of environmentally responsible golf course management. An IPMP guides golf course managers in the responsible storage, handling, and application of chemicals and in the use of native vegetation in golf course landscape plans. Ideally, IPMPs include water quality monitoring programs.

Action Step for Management Strategy 2F (Golf Course BMPs)

DEP

- Work with other state agencies to develop and adopt rules for required practices for golf course design, operation, and maintenance. Include a resource management plan, an IPMP, and a groundwater-monitoring plan as required BMPs for the operation of golf courses in Florida.



The area shown in purple at the center of the map represents the portion of the Gainer Springs recharge basin that was acquired by NWFWMD in an effort to protect the water supply for much of Bay County. Such strategies can be used to protect the other values of springs, such as recreation and scenic beauty. From NWFWMD

Management Strategy 3: Land Acquisition

One of the regrets of my life is that I was always too poor to buy some of them [springs] *back in the days when they were still unspoiled and not worth much money. Their like existed nowhere else in the world.* – Archie Carr

Florida's springs are owned by public and private entities. In 1949, Manatee Springs was the first spring to be purchased by the State of Florida. Since then, dozens of springs have been purchased by federal, state, regional and local governments to provide protection for the springs while making them available for outdoor recreation. Although many private spring owners provide adequate stewardship, not all are able to do so and their springs have become abused by overuse and misuse.

The values and benefits of a spring are found at the spring. These values, including scenic beauty, recreation and wildlife, are dependent on the spring's water. Acquisition of a spring can ensure protection of the spring itself, but does not ensure protection of the water's quality or quantity. Protection of the water must occur in the spring recharge basin, before the water reaches the spring.

The most effective way to protect the quality and quantity of spring water is to acquire the spring recharge basin and manage it for that purpose. Since acquisition of an entire spring recharge basin is usually not feasible, acquisition of the most vulnerable portions of the recharge basin may provide substantial protection. Such areas will likely be near the spring and may include sinkholes and other karst features that are hydrologically connected to the spring.

The most successful spring recharge basin acquisition to date was achieved by the NWFWMD, which acquired 37,000 acres of the Gainer Springs recharge basin in Washington and Bay Counties.

Action Steps for Management Strategy 3 (Land Acquisition)

These action steps are presented in order of priority.

WMDs, DEP, Counties, The Nature Conservancy

- Identify and acquire the most vulnerable portions of spring recharge basins. Give these lands priority ranking in land acquisition programs.
- Give priority to the acquisition of springs that cannot be adequately protected and managed by the current owner, or are at risk of being developed.
- Ensure that springs acquired through environmental lands programs are managed by agencies experienced in the sensitive stewardship and use of springs.
- Acquire conservation easements to protect portions of recharge areas.

Management Strategy 4: Management of Recreational Use

The springs have been brutalized; but even they could be restored with careful tending. – Archie Carr

Springs have long been popular recreational sites. Too often, springs with uncontrolled public access become seriously damaged. In the absence of steps, fencing, directional signs, and on-site staff, considerable harm can befall the scenic and biological values of a spring. Typically, vegetation that stabilizes the slope and shoreline becomes trampled and uprooted, foot traffic and stormwater further erode the soils, and the spring begins to fill with sand and debris. Submerged aquatic plants in the spring and spring run become trampled. Vehicle traffic on the uplands around the spring also causes damage. Frequently, littering and dumping further degrade the site. Blue Spring (Volusia County) and the Ichetucknee Head Spring suffered from these problems until they were purchased by the state.

Action Steps for Implementation Strategy 4 (Management of Recreational Use)

Spring Owners/Managers

- Consult experienced spring managers for technical assistance on protection and management procedures.
- Educate users about the values of the spring and about sensitive user practices through exhibits, interpretive signs, leaflets and/or personal contacts with staff.

- Control foot and vehicle traffic, implement stormwater management and erosion control practices, and restore native plants.
- Provide a system for human waste disposal to protect the spring from contamination.
- When warranted by unique aesthetic, paleontological, archaeological, or biological values (or vulnerability to damage), protect certain springs from exposure to the impacts of active recreational use.

Any Spring Basin Stakeholders

- Organize an Adopt-A-Spring effort in cases where a spring owner cannot provide adequate control of public access and use.

Kissengen Spring. Left, in 1921 (from Florida State Archives) and right, in 2000 (from Charles Cook). The spring stopped flowing in 1950 because groundwater was withdrawn for phosphate mining within the spring recharge basin.

Regulation Strategies

Regulation Strategy 1: Regulations

I believe that every right implies a responsibility; every opportunity an obligation; every possession a duty. – John D. Rockefeller, Jr.

The State of Florida protects groundwater quality for potable (drinking water) use. Surface water standards are designed to protect potable water supplies, shellfish propagation, recreation and maintenance of fish and wildlife, agricultural water supplies, and navigation utility and industrial uses. When groundwater emerges to land surface at a spring, the water is classified as surface water. Even though it is the same water, as surface water it is protected for different uses. Waters that interact, as Florida's groundwater and surface waters do, should be protected across the boundary between the two, and for all uses. Florida's water quality rules do not provide for protection that takes into account the unique interaction that naturally occurs between groundwater and surface water at springs. The wellhead protection rule can be used to assign additional protection to a spring if the springhead supplies a public drinking water system. The drinking water standard of 10 mg/l for nitrate is inadequate to protect the ecology of spring systems.

Action Steps for Regulation Strategy 1 (Regulations)

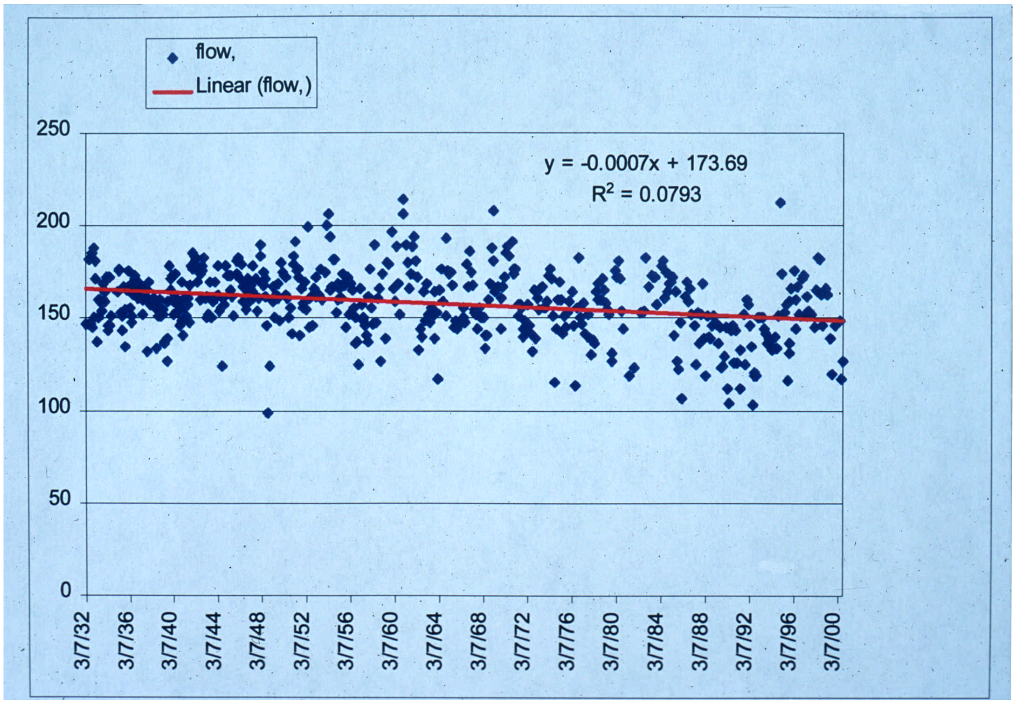
DEP

- Identify and enforce existing regulations that can be used to protect groundwater that flows to springs.
- Identify existing regulations that should be amended to protect groundwater flowing to springs.
- Identify pertinent existing groundwater standards that could be amended to increase protection of the surface water quality in springs.
- In priority spring recharge basins apply a nutrient management plan that includes water-quality-based BMPs.
- Extend Outstanding Florida Waters (OFW) designations to include streams and karst features that are known to have hydrologic connections to OFWs.
- Identify and designate additional springs as OFWs.
- Create a rule that specifically relates to springs and spring recharge basins and provides special protection and regulation.
- Establish and apply quantifiable groundwater quality standards for nutrients that protect the ecological quality and health of surface water systems.

Regulation Strategy 2: Spring Flow Protection

You never miss the water until the well runs dry. – American proverb

In 1995 Florida used 7.2 billion gallons of fresh water per day, more than any other state east of the Mississippi River. Water use is projected to increase to nine billion gallons per day by the year 2020. Currently, sixty percent of our water supply comes from aquifers. Consequently, flows from a number of springs have been significantly reduced or have ceased altogether. Kissengen Springs in Polk County, once a second magnitude spring and a popular recreational area, stopped flowing in the early 1950s in response to changes in local hydrogeology caused by phosphate mining. Flow from Blue Spring in Volusia County, an important winter refuge for manatees, is expected to be reduced by projected increases in groundwater consumption. Several Wekiva River springs in Orange County are projected to fall below minimum levels set for them unless alternative water supplies are developed. Several springs in southwest Florida have also experienced significant declines from their historic flows.



Blue Spring (Volusia County) 68 years of discharge data indicate a decline in spring flow (from USGS data).

In response to 1997 legislation concerning water supply planning (Chapter 373.036, FS), water sources are being identified and developed for public supply, agriculture, and industry for the next twenty years. Groundwater will continue to be an important source for meeting new demands. The combination of existing withdrawals and proposed withdrawals will likely have significant impacts on spring flow around the state, if steps are not taken to identify ways to protect springs from further decreases. Due to the complex nature of this problem, a set of related strategies has been developed to prevent further declines in spring flow. Such declines could cause significant harm to spring flow as well as to resources that are dependent on sufficient flow. Although the Task Force considers the first strategy (Establishment of Minimum Flows and Levels) to be the most urgent, implementation of each spring flow protection strategy is necessary to ensure the protection of spring flow and the biological communities dependent upon springs.

Save today, safe tomorrow

– American proverb

Regulation Strategy 2A: Establishment of Minimum Flows and Levels. The Water Resources Act (Chapter 373, FS) requires that minimum flow or minimum water levels be established for surface watercourses and aquifers that may be threatened by water withdrawals. The minimum flow is defined as "the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area" (Chapter 373.042(1), FS). Minimum flows define the minimum hydroperiod needed to sustain an ecosystem and thereby set a limit on water withdrawals. The minimum flow for a spring should be based on the protection of the spring resource(s) most sensitive to reductions in flow. If minimum flows are established and enforced for springs, they should provide protection. Unfortunately, minimum flows are currently established for only eight springs (five more are scheduled for establishment by 2001). If fully implemented, this provision of the statute would be a critical step in protecting minimum spring flows throughout the state.

Protection of Nonconsumptive Uses: In regard to the establishment of minimum flows, section 373.042(1), FS states that "The department [DEP] and the [WMD] governing board[s] shall also consider, and at their discretion may provide for the protection of nonconsumptive uses." Because of the high recreational value of many springs and spring runs, this provision may be used to protect spring flow.

Recovery of Flow: The Water Resources Act also provides for the recovery of spring flow if it has fallen below the established minimum flow. It states: "If the existing flow or level in a water body is below, or is projected to fall within 20 years below, the applicable minimum flow or level, the department [DEP] or governing board, as part of its regional water supply plan shall expeditiously implement a recovery or prevention strategy, which includes the development of additional water supplies and other actions" (section 373.0421(2) FS). Implementation of a prevention strategy or spring flow recovery strategy would require WMDs to limit aquifer withdrawals or develop alternative water sources.

Action Steps for Regulation Strategy 2A (Establishment of Minimum Flows and Levels)

Action steps are presented in order of priority.

WMDs and DEP

- Establish minimum flows for springs or minimum levels for aquifers threatened by groundwater withdrawals. WMDs shall prepare a schedule for establishing minimum flows for threatened springs and aquifers annually for DEP review as required by section 373.042, FS.
- Once the minimum flow for a spring has been established, implement a recovery or prevention strategy if needed to achieve the established flow or level.
- Protect nonconsumptive uses, such as recreation, through the establishment of minimum flows for threatened springs.
- In areas requiring a regional water supply plan, MFLs should be established for high priority springs or aquifers before next update of the plans so that spring flow may be protected from future water supply development.
- Evaluate consumptive use permits to ensure they do not violate established minimum flows and levels.
- Monitor spring flows to detect flow trends and verify the maintenance of minimum flows.
- Conduct hydrogeologic investigations to determine the relationships between groundwater levels and spring flows so that groundwater withdrawals can be managed to avoid impacts to spring flows.

Regulation Strategy 2B: Water Conservation. Water conservation is an important way to reduce aquifer withdrawals and help maintain spring flows. The water management districts generally implement conservation through their consumptive use permitting programs. Permit applicants may be required to implement one or more conservation measures before receiving a permit to withdraw water.

Currently, most resources are used for the investigation of new sources of water. Much more could be done to improve water use efficiency, and reduce per capita consumption. For example, nearly half of all water withdrawn for public supply in Florida is used to water lawns. More aggressive programs to encourage native landscaping around homes could make a major difference in water consumption. Irrigation consumes more water than any other use category in Florida. Micro-irrigation can cut crop water use in half compared to traditional irrigation techniques.[16]

Action Steps for Regulation Strategy 2B (Water Conservation)

WMDs, DEP, Utilities

- Conduct an aggressive public education program on the benefits of water conservation.

WMDs and DEP

- Promote greater research and implementation of conservation measures. Develop non-regulatory and incentive-based WMD programs to implement water conservation. Examples include: xeriscape-landscaping services, free mobile irrigation labs, and rebate programs for rain sensors, micro irrigation, water efficient plumbing fixtures and appliances. The cost and implementation of these programs could be shared with utilities, agricultural interests, and other water users.
- Review existing conservation requirements used in consumptive use permitting. Develop and implement improvements that will result in increased water-use efficiency. Examples include requiring public utilities to have a conservation rate structure, or implementing a xeriscaping ordinance.

Regulation Strategy 2C: Water Supply Planning. In response to Florida's rapidly expanding population, water supplies are being developed to meet the demand for public supply, golf course irrigation, commercial and industrial development. In addition, Florida's extensive agricultural and mining industries will continue to develop new water supplies.

Growing water demands and uncertain supplies led the legislature to amend the Water Resources Act in 1997. The amendment requires all WMDs to develop water supply plans for regions where water sources are deemed inadequate to meet projected demands. In these areas, the WMDs are required to identify potential sources of water to meet demands over a 20-year planning period while protecting water resources and the environment. Several of these regional water supply plans have been completed and those remaining are nearing completion. The plans must be updated every five years.

Spring flows may be protected in the water supply planning process by identifying alternative sources to groundwater such as stormwater and surface water, desalination, and reuse of reclaimed water. Additionally, the plans are supposed to develop conservation measures as a means of reducing demand. Alternative water sources can be more expensive and difficult to develop than traditional groundwater sources. However, the statute encourages utilities and local governments to develop these sources by providing water management district funding for these kinds of projects (sections 373.0831(4) and 373.1961 FS and the Florida Forever Act).

Spring flows should also be protected in the water supply planning process through the establishment of minimum flows for springs (see Strategy 6A).

Action Steps for Regulation Strategy 2C (Water Supply Planning)

WMDs and DEP

- In WMD Regional Water Supply Plans, maximize strategies for the development of alternative sources of water. This will ensure that spring flows are not further diminished while sufficient water supplies are available to meet future demand. Alternative sources include reclaimed water, surface water, storm water, brackish groundwater desalination, seawater desalination, and conservation. Each WMD Regional Water Supply Plan should be amended by the next update of the plans in 2005.

DEP, WMDs, Florida Legislature

- Evaluate and implement aquifer recharge and storage technologies such as rapid infiltration basins (RIBs) and Aquifer Storage and Recovery (ASR) as part of the WMD regional water supply plans. These strategies could potentially maximize the use of seasonally available alternative sources such as surface water, stormwater and reclaimed water. The Florida Legislature and DEP should assist the WMDs in the implementation of these alternative water management technologies.

Regulation Strategy 2D: Reservation of Water. WMDs may also reserve water from consumptive use to protect natural resources. Section 373.223(3), FS states that "The governing board or the department, by regulation, *may reserve* from use by permit applicants, *water* in such locations and quantities, and for such seasons of the year, as in its judgment may be required *for the protection of fish and wildlife* or the public health and safety" (emphasis added). Water reservations for Everglades National Park will be an important component of the Comprehensive Everglades Restoration Project now underway. While water reservations have seldom been used elsewhere in the state, this tool is available for the protection of spring flow.

Action Steps for Regulation Strategy 2D (Reservation of Water)

DEP, WMDs, Florida Legislature

- Use water reservations (Chapter 373.223(3), FS) to protect spring flow if the level of protection provided by minimum flows (Chapter 373.042, FS) is inadequate or untimely. This provision should be used to provide the highest level of protection for ecologically significant springs and springs that are threatened.

Regulation Strategy 3: Protection of Rare, Threatened and Endangered Species

Sometimes there is no leaving, no looking westward for another promised land. We have to nail our shoes to the kitchen floor and unload the burden of our heart. We have to set to the task of repairing the damage done by and to us. – Janisse Ray, *Ecology of a Cracker Childhood*, 1999

Florida's springs and related karst communities (aquatic caves, spring-fed streams, sinkholes) are critical habitat for several of Florida's state- and federally-listed species and endemic (found only in Florida) species. Some of these globally-imperiled species are found in only one spring system in the world.

Without the warm water provided by springs, a large number of manatees would be at risk of dying during the winter. Manatees' low metabolic rate and low thermal capacity require waters that are warmer than 68 degrees Fahrenheit to survive the cold season. When winter cold fronts threaten to push waters below this temperature, large numbers of manatees move into spring waters. This is especially true in North Florida where up to 20% of the state's manatee population use springs. Springs, with their lush aquatic vegetation, also provide important foraging habitat for manatees.

The numbers of manatees are declining, and some way or another if we don't do things better, we aren't going to have any wild manatees left.
– Fran Stallings, Save the Manatee Club

The use of regulatory means (including the Endangered Species Act, Marine Mammal Protection Act, Florida Manatee Sanctuary Act and others) to protect the threatened and endangered species who inhabit springs includes measures to protect their habitat. These regulations should be used in conjunction with other means to ensure the continued existence of these rare species.

Many species found in springs, including aquatic snails, are considered to be sensitive indicator species. That is, their status mirrors the health of their spring community. Healthy populations are reflective of viable communities. Declining populations can be indicative of springs that are in poor health. Solutions for these problems can be complex or simple. For example, the endemic Ichetucknee Siltsnail and its habitat in Ichetucknee Springs State Park are protected from trampling by a fence and through the use of an interpretive sign placed at Coffee Spring.

Action Steps for Regulation Strategy 3 (Protection of Rare, Threatened and Endangered Species)

Florida Museum of Natural History and Florida Natural Areas Inventory

- Identify and list spring systems inhabited by aquatic listed and endemic species.

U.S. Fish and Wildlife Service and Florida Fish and Wildlife Conservation Commission

- List the species identified in the previous step that are threatened or endangered.
- Identify threats to the spring-related habitats of these species. Develop and implement strategies to overcome the threats.

WMDs

- As soon as possible, establish minimum flows that will assist in the recovery of listed species inhabiting spring systems.
- Give priority attention to the implementation of the previous step at all spring systems that support heavy use by manatees as warm water refuges or seasonal residence locations. Heavy use is defined as use by more than twenty individuals at a time. The spring systems that should receive priority consideration for this action are, in order of priority: Crystal River Springs, Homosassa Springs, Blue Spring (Volusia County), Warm Mineral Spring, Manatee Spring, Weeki Wachee Springs, and St. Marks/Wakulla River System Springs.
- Use data on manatee behavior and use of springs to establish minimum flow criteria for spring systems with documented manatee use. Include projected growth of the manatee population in the establishment of minimum flow criteria.
- Conduct long-term discharge monitoring of all spring systems used by manatees.

DEP

- Consider designating spring systems with listed species as OFWs.

DEP, WMDs

- Continue to focus the efforts of state land acquisition programs on spring systems with manatee use.

Public and Private Owners and Managers of Springs

- Protect listed species from recreational or consumptive use impacts.
- Design aquatic plant management activities in springs so as to provide an abundant and historically diverse native aquatic plant community as a foraging resource to manatees.
- Avoid use of herbicides or mechanical means of nuisance aquatic plant control when manatees are present in spring systems.
- Do not permit any human activities that can cause manatees to alter their behavior, especially during the cold season in documented spring refuge sites.
- Develop and implement management plans for individual spring systems, and include consideration of manatee use in developed plans.
- Avoid the use of pesticides and fertilizers above known spring cave systems.

Funding Strategies

Funding Strategy: Funding of the Springs Protection and Restoration Strategies

The value in money lies in what we do with it. – American Proverb

The majority of the recommended strategies in this report can be implemented with existing staff and resources. However, a few of the recommendations will affect agencies that don't have the resources to implement them. Additional resources will be required to implement monitoring, research, education, and BMPs. Agencies will have to reprioritize activities in order to fund the other strategies. So that the delivery of quality public services can be maintained, it is strongly recommended that agencies not be asked to fund these new activities out of their existing funding sources. This new money could come from a Springs Protection and Restoration Trust Fund (SPRTF) built from a 25-cent increase in auto tags. This funding option would generate around 4.63 million dollars. The amount needed to fund the task force recommendations is 4.42 million dollars. Other possible funding sources include a portion of the documentary stamp tax, a fertilizer tax, a Florida Springs specialty license tag, or federal funding sources.

The following is a summary of the spring protection and restoration strategies that will require new funding for effective implementation.

Monitoring. One of the most critical places to begin monitoring spring water quality, discharges and biology is in state parks. The state has invested millions of dollars in acquiring springs and surrounding properties. These springs are managed as parks and conservation areas for the long-term use and enjoyment of the public. Loss of the use of these properties by the public would be extremely unfortunate and costly to the state.

The Florida Park Service currently does minimal monitoring of this kind in state park springs. It is anticipated that, with appropriate funding, the DEP Bureau of Laboratories can perform the water quality and biological monitoring. Spring discharge monitoring would be a new expense for the Division of Recreation and Parks. Discussions between the Division and the USGS indicate that the cost of flow monitoring per spring can range from $25,000 to determine real time flow to around $6,000 to develop a rating curve for discharge determination. The state would have to pay for half the cost of either proposal.

It is recommended that DEP be appropriated $225,000 to cover the costs associated with discharge monitoring. The DEP Bureau of Laboratory budget should be expanded by $75,000 to cover any additional costs for water quality and biological monitoring for state parks. The DEP Division of Recreation and Parks' budget should be expanded by $75,000 to cover state park costs for biological and water quality monitoring.

Research. Basic scientific research is vital to gaining an understanding of existing conditions in spring systems. Such knowledge will allow water managers and land use planners to foresee and prevent potential impacts to spring systems.

The use of springs for recreation and water bottling represent multi-million dollar businesses for Florida. Yet we do not have complete answers to basic questions about springs, such as…

- "What are the impacts of excess nutrients on the ecology of spring systems?"
- "What are the natural biological and microbiological conditions of spring systems?"
- "What are the best engineering designs to protect springs from contamination?"

Spring research could be supported by one million dollars per year from the Springs Protection and Restoration Trust Fund. This fund would support grant distributions to fund springs research efforts at universities and other research entities. The funds could be regionally distributed to institutions in the areas in which the work will be done. DEP would administer and allocate the fund.

Education. Education is the most important strategy for producing changes in the behavior and land use practices of millions of Floridians who are unwittingly polluting springs. Funds will be used to produce a video, develop elementary and secondary school curricula, prepare Geographic Information Systems (GIS) mapping information for local governments, and produce and publish an updated inventory and database of water-quality parameters for Florida's more than 600 springs. An estimated $600,000 is required to fund these actions.

BMPs. Within spring recharge basins, various land uses such as agricultural activities, septic tanks, golf courses, and silvicultural operations, along with stormwater runoff, all contribute to the pollution of groundwater. Most landowners are willing to make changes, but either do not know what to do or cannot afford the costs. The Task Force recommends that $2.5 million be appropriated and made available to landowners and businesses to cover the costs associated with implementing spring protection BMPs.

Action Steps for Funding of the Springs Protection and Restoration Strategies

Florida Legislature

- Create the Springs Protection and Restoration Trust Fund and finance it with a twenty-five cent increase in the cost of motor vehicle license tags. The trust fund would be administered by DEP. The Trust Fund would subsidize the following springs initiatives:
- Increase annual funding for DEP discharge monitoring by $225,000.
- Allot $75,000 per year to the DEP Division of Recreation and Parks to cover the cost of implementing biological and water quality monitoring at Florida State Park springs.
- Allot $75,000 per year to the DEP Bureau of Laboratories to cover the additional costs for water quality and biological monitoring for Florida State Park springs.
- Earmark one million dollars annually to a springs research grant program to support universities and other research entities undertaking springs research.
- Provide six hundred thousand dollars to fund springs educational programs, including $450,000 to carry out the field investigations, laboratory analyses, and writing and publishing costs required to create an up-to-date inventory and database of water-quality parameters for Florida's more than 600 springs.
- Provide $2.5 million annually to be administered by DEP and made available to landowners (public and private) and businesses to cover the costs of implementing BMPs and cleaning up sinkholes.

DEP

- Identify other funding sources and seek federal funding for the Restoration Trust Fund.

GLOSSARY OF TERMS

algae – nonflowering, stemless water plants. Analyses of types and abundance of algae provide indicators of aquatic ecosystem health.

analyte – one of the components for which a sample is analyzed. For example, one water sample may undergo laboratory analysis for dozens of different chemical constituents, or analytes.

anthropogenic – having a human origin.

aquifer – an underground geological formation that stores water; aquifers are the source of spring water and well water.

benthic macroinvertebrates – small animals without backbones, including insect larvae and worms, which live on the bottoms of lakes and streams and within the plants that grow there. A diversity of species and an abundance of individual animals is an indication of a healthy aquatic community.

coliforms – microorganisms found in the intestinal tract of humans and animals. Their presence in water indicates fecal pollution.

dissolved oxygen (DO) – the oxygen freely available in water, vital to fish and other aquatic life. DO levels are an important indicator of a water body's ability to support desirable aquatic life.

denitrification – the biological conversion of nitrate to nitrogen gas by natural or manmade processes.

ecology – the study of the relationships of organisms to one another and to their physical surroundings.

ecosystem – the interacting system of a biological community and its non-living environmental surroundings.

first magnitude spring – a spring with a flow rate of 100 cubic feet per second (64.6 million gallons per day) or more.

Floristic Quality Index – a data-interpretation system that uses the relative pollution tolerances of plants to score the health of a water body.

groundwater level – the measurement, in feet, of the elevation of the top of an aquifer, as measured in a network of groundwater monitoring wells and/or supply wells. The level can fluctuate in response to aquifer recharge and groundwater withdrawals.

groundwater withdrawal – the act of removing water from aquifers by pumping it from a well, whether it be a small domestic supply well or a large public supply well.

habitat – the place where a population, whether human, animal, plant, or microorganism, lives and its surroundings, both living and non-living.

hydrogeology – the study of subsurface waters in their geologic context.

hydroperiod – the pattern of water level rise and fall over time.

impermeable – not permitting the passage of fluids. In the case of geologic formations, an impermeable layer of earth is one through which groundwater cannot pass.

karst – a limestone region with underground drainage and many cavities and passages caused by the dissolution of the rock.

Lakewatch – a statewide network of over 1800 trained volunteers who monitor more than six hundred lakes in more than 40 Florida counties.

loading – the amount of pollutants entering a system (concentration times flow rate).

macrophyte – a non-woody plant.

nitrate – a compound containing nitrogen that can exist in the atmosphere or as a dissolved gas in water. Nitrates are essential plant nutrients, but in excess they can be dangerous to animals and ecosystems.

pH – an expression of the intensity of the basic or acid condition of a liquid. The pH may range from 0 to 14, with 0 the most acid, 7 neutral, and 14 the most basic. Natural waters generally have a pH between 6.5 and 8.5.

physiographic region – a region that is defined by its particular landforms or landscape.

pumpage – the act of pumping groundwater to the surface (via a well), or the amount of water pumped.

RUCK – an advanced septic system that is capable of removing up to 70 percent of nitrogen from household wastewater.

sinkhole – a hole in the earth that is formed when an underlying limestone cavity collapses.

spring recharge basin – see page iv.

stormwater – rainwater that flows overland after falling. In developed areas stormwater typically becomes polluted by materials it picks up from roofs, streets, parking lots, and other impermeable surfaces, and may deliver pollutants to surface water and groundwater.

transmissivity – the rate at which water travels through a specified area of an aquifer. Transmissivity is affected by many factors that vary from aquifer to aquifer and even from one part of an aquifer to another part of the same aquifer.

SJRWMD Karst Procedure – a set of protective measures applied to those portions of western Alachua and western Marion counties within the SJRWMD boundaries. The procedure was developed to protect the Floridan Aquifer from contamination by stormwater. The Floridan Aquifer is the source of drinking water for most of the population of the SJRWMD, and in this area, its limestones are at (or very close to) the land surface and are vulnerable to pollution. The design criteria can be found in subsection 40C-41.063(6), FAC.

spring run – a spring-fed stream.

watershed planning and management – water resource management that is organized on the basis of the natural boundaries formed by surface water basins or groundwater divides, which often overlap the borders of governmental jurisdictions.

withdrawal – see **groundwater withdrawal**.

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APPENDIX A – First Magnitude Springs of Florida

Spring	County	WMD	Type	Discharge Cfs	Nitrates mg/L	Cave Mapped	Monitoring Spr./Basin	Basin-Work Group	Basin Delineation	Owner
GAINER	Bay	NWF	G	159	No Data	No	No	No	Yes	P
JACKSON/BLUE	Jackson	NWF	SS	205	3.0	Yes	No	No	Yes	S/CM
ST MARKS	Leon	NWF	R/R	670	.16	No	No	No	No	PU
SPRING CREEK	Wakulla	NWF	G	2003	No Data	No	No	No	No	PU
WAKULLA	Wakulla	NWF	SS	390	1.0	Yes	Yes	Yes	Yes	S
ALA 112971	Alachua	SR	R/R	406	.41	No	Yes	No	No	P
HORNSBY	Alachua	SR	SS	352	.53	Yes	Yes	No	No	P
COLUMBIA	Columbia	SR	SS	306	.21	No	Yes	No	No	P
COL 61981	Columbia	SR	SS	150	.09	No	Yes	No	No	P
ICHETUCKNEE	Columbia	SR	G	361	.74	N/a	Yes/Yes	Yes	Yes	S
DEVILS EAR	Gilchrist	SR	G	117	1.55	Yes	No	No	No	P
SANTA FE RISE	Columbia	SR	R/R	442	.78	No	No	No	No	S
SIPHON CREEK RISE	Gilchrist	SR	R	370	1.38	No	No	No	No	P
ALAPAHA RISE	Hamilton	SR	R/R	608	.24	Yes	Yes	No	No	P
HOLTON CREEK RISE	Hamilton	SR	R/R	288	.40	No	No	No	No	WMD
LAFAYETTE/BLUE	Lafayette	SR	SS	162	1.41	Yes	Yes	No	No	C

Legend

R/R = River Rise
R = In the River
G = Spring Group
SS = Single Spring
PU = Private Uplands
CM = County Mgt.
PM = Private Mgt.
C = City or County
P = Private
S = State
F = Federal

Spring	County	WMD	Type	Discharge Cfs	Nitrates mg/L	Cave Mapped	Monitoring Spr./Basin	Basin-Work Group	Basin Delineation	Owner
TROY	Lafayette	SR	SS	166	2.13	N/a	Yes	No	No	S
FANNIN	Levy	SR	SS	103	4.20	N/a	Yes	No	No	S
MANATEE	Levy	SR	SS	160	1.67	Yes	Yes	No	No	S
MADISON/BLUE	Madison	SR	SS	115	1.72	Yes	No	No	No	S/CM
LIME RUN SINK	Suwannee	SR	SS	173	.70	Yes	No	No	No	P
WACISSA	Jefferson	SR	G	388	.38	N/a	Yes	No	No	P/S
NUTALL RISE	Jefferson	SR	R/R	500	.20	No	No	No	No	P
STEINHATCHEE RISE	Taylor	SR	R/R	400	.03	No	No	No	No	WMD
ALEXANDER	Lake	SJR	SS	120	.05	N/a	Yes	No	No	F
SILVER	Marion	SJR	SS	820	.90	Yes	Yes	Yes	Yes	S/PM
SILVER GLEN	Marion	SJR	G	112	.05	Yes	Yes	No	No	F
BLUE	Volusia	SJR	SS	162	.60	N/a	Yes	No	Yes	S
CHASSAHOWITSKA	Citrus	SWF	G	138	.45	N/a	Yes	No	Yes	S
KINGS BAY	Citrus	SWF	G	916	.24	N/a	Yes	No	Yes	S/PU
HOMOSASSA	Citrus	SWF	G	106	.46	Yes	Yes	Yes	Yes	S
WEEKI WACHEE	Hernando	SWF	SS	176	.55	?	Yes	No	Yes	C/PM
RAINBOW	Marion	SWF	G	760	1.10	N/a	Yes	No	Yes	S

Legend

R/R = River Rise
R = In the River
G = Spring Group
SS = Single Spring
PU = Private Uplands
CM = County Mgt.
PM = Private Mgt.
C = City or County
P = Private
S = State
F = Federal