Exam 4
Springs Ecosystems
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Introduction
The purpose of this exam is to evaluate and understand the components necessary to develop and implement a springs restoration plan through the evaluation of student-developed plans from 2010. Restoration planning has become increasingly relevant as we seek to preserve, protect, and enhance natural resources. Given that many springs in Florida and throughout the country have been altered by human use (both directly and indirectly), these unique ecosystems no longer have the same value and function they once did. The implications of this impairment can be varied and significant, ranging from the relatively minor – a visit is no longer as enjoyable due to overcrowding, to the extreme – the spring is completely dry.

Restoration plans generally contain several major components: an evaluation of the resource (information about the geology, ecology, and human uses of the spring) a description of the problem(s) and impairments, a strategy for addressing the problems including assignment of responsibilities, engaging stakeholders as a part of the solution, and monitoring and benchmarking to know when to make adjustments and to track progress. An inclusive plan addressing the multitude of factors that influence the spring and its value and function is necessary for success.

For the purposes of this exam, the following spring restoration plans have been selected, each of which demonstrating a thorough approach:

- Rainbow Springs Restoration Plan by Derek Anthony Gregory
- Wakulla Springs Restoration Plan by Melissa “Katie” Hallas
- Ichetucknee Springs Restoration Plan by Beth Zavoyski

Role of Agencies
Numerous state and local agencies have the responsibility for successful implementation of springs restoration plans. These public entities were created to provide services to the citizens within their jurisdictions, as well as to provide protection of the resources that have no voice of their own. Together, and working toward a common goal, these agencies and affected stakeholders, have ultimate accountability for healthy springs systems. These government agencies have a regulatory role, a community engagement role, and a technical advisory role to varying degrees.

Table 1. Agencies Responsible for Water Quality and Quantity, Rainbow Springs

Rainbow Springs		
Affiliation	*Agency*	*Responsibility*
Local	Alachua County Government	Land use planning, public utilities, conservation measures
Local	City of Dunnellon	Land use planning, public utilities, conservation measures
Local	City of Williston	Land use planning, public utilities, conservation measures
State	FL Dept. of Environmental Protection	Development of TMDLs and BMAP, FL Springs Initiative (defunct), scientific research, water quality and biological monitoring, education and outreach, landowner assistance projects, and springs restoration

Table 1 continued. Agencies Responsible for Water Quality and Quantity, Rainbow Springs

Affiliation	*Agency*	*Responsibility*
State	FL Dept. of Health	Water quality monitoring, residential well and septic system permit review
State	FL Dept. of Transportation	Transportation/land use planning, transportation development
State	FL Fish and Wildlife Conservation Commission	Wildlife conservation, education and outreach, fish and game management
State	FL Geological Survey	Provides research, data and necessary institutional memory to support the need for geology-related information
State	FL Park Service	Managing the Rainbow Springs State Park - maintaining safe public recreational resources, balanced with the needs of environmental systems
Local	Levy County Government	Land use planning, public utilities, conservation measures
Local	Levy County Soil and Water Conservation District	Promote soil and water conservation through quality technical services, education and outreach
Local	Marion County Government	Land use planning, public utilities, conservation measures
Local	Marion County Soil and Water Conservation District	Promote soil and water conservation through quality technical services, education and outreach
State	Suwannee River Water Management District	Consumptive use permitting, development of MFLs, springs technical reports, conservation measures, education and outreach, data collection and analysis
State	Southwest Florida Water Management District	Consumptive use permitting, development of MFLs, springs technical reports, conservation measures, education and outreach, data collection and analysis
Federal	United States Geological Survey	Technical support to other agencies, data collection and analysis
State/ Regional	Withlacoochee Regional Planning Council	Regional land use planning technical guidance, comprehensive planning assistance

Sources:
http://www.dep.state.fl.us/geology/
http://www.dep.state.fl.us/springs/
http://myswcd.org/?cat=20
http://marionsoilandwater.com/
http://flregionalcouncils.org/

Table 2. Agencies Responsible for Water Quality and Quantity, Wakulla Springs

Wakulla Springs		
Affiliation	*Agency*	*Responsibility*
Local	Leon County Government	Land use planning, public utilities, conservation measures
Local	City of Tallahassee	Land use planning, public utilities, conservation measures
Local	City of Crawfordville	Land use planning, public utilities, conservation measures

Table 2 continued. Agencies Responsible for Water Quality and Quantity, Wakulla Springs

Affiliation	*Agency*	*Responsibility*
Local	City of Woodville	Land use planning, public utilities, conservation measures
State	FL Dept. of Environmental Protection	Development of TMDLs and BMAP, FL Springs Initiative (defunct), scientific research, water quality and biological monitoring, education and outreach, landowner assistance projects, and springs restoration
State	FL Dept. of Health	Water quality monitoring, residential well and septic system permit review
State	FL Dept. of Transportation	Transportation/land use planning, transportation development
State	FL Fish and Wildlife Conservation Commission	Wildlife conservation, education and outreach, fish and game management
State	FL Geological Survey	Provides research, data and necessary institutional memory to support the need for geology-related information
State	FL Park Service	Managing the Wakulla Springs State Park - maintaining safe public recreational resources, balanced with the needs of environmental systems
State	Northwest Florida Water Management District	Consumptive use permitting, development of MFLs, springs technical reports, conservation measures, education and outreach, data collection and analysis
Federal	United States Geological Survey	Technical support to other agencies, data collection and analysis
State/ Regional	Apalachee Regional Planning Council	Regional land use planning technical guidance, comprehensive planning assistance

Table 3. Agencies Responsible for Water Quality and Quantity, Ichetucknee Springs

Ichetucknee Springs		
Affiliation	*Agency*	*Responsibility*
Local	City of Lake City	Land use planning, public utilities, conservation measures
Local	Town of Fort White	Land use planning, public utilities, conservation measures
Local	Columbia County	Land use planning, public utilities, conservation measures
State	FL Dept. of Environmental Protection	Development of TMDLs and BMAP, FL Springs Initiative (defunct), scientific research, water quality and biological monitoring, education and outreach, landowner assistance projects, and springs restoration
State	FL Dept. of Health	Water quality monitoring, residential well and septic system permit review
State	FL Dept. of Transportation	Transportation/land use planning, transportation development
State	FL Fish and Wildlife Conservation Commission	Wildlife conservation, education and outreach, fish and game management
State	FL Geological Survey	Provides research, data and necessary institutional memory to support the need for geology-related information

Table 3 continued. Agencies Responsible for Water Quality and Quantity, Ichetucknee Springs

Affiliation	*Agency*	*Responsibility*
State	FL Park Service	Managing the Ichetucknee Springs State Park and other state parks located within the springshed - maintaining safe public recreational resources, balanced with the needs of environmental systems
State	FL Dept. of Agriculture & Consumer Services	BMPs for agriculture
State/ Regional	Suwannee River Water Management District	Consumptive use permitting, development of MFLs, springs technical reports, conservation measures, education and outreach, data collection and analysis
	Santa Fe Soil and Water Conservation District	Promote soil and water conservation through quality technical services, education and outreach
Federal	United States Geological Survey	Technical support to other agencies, data collection and analysis
State/ Regional	North Central Florida Regional Planning Council	Regional land use planning technical guidance, comprehensive planning assistance

Role of Stakeholders

As with most causes and projects, success hinges on the involvement of stakeholders. Stakeholders, outside of the agencies discussed above, are often non-governmental organizations, citizen advocacy groups, business owners, and other parties vested in the outcome of the management or decision-making surrounding a specific topic or resource, like springs protection. In the case of springs, stakeholders are diverse including conservationists, recreational users (including consumptive and non-consumptive uses), vendors (such as kayak outfitters), local restaurants and businesses supported by tourism to the spring, property owners located within the springshed, educators and students, and others. Their input and buy-in to the development and implementation of a restoration plan is essential for success. They have the interest and capacity to influence policy-makers, to implement the plans, and to see them through to completion. Without an inclusive actively engaged stakeholder group, technical fixes implemented by government agencies will have only a minimal effect on addressing the problems. Stakeholders must be engaged, educated, and included in the development of the plan, its implementation, and long-term success.

The tables below represent the stakeholders identified by the student authors as well as other stakeholders identified through the review process. Several state or national-level stakeholders would be applicable to each of the springs discussed herein.

Table 4. Rainbow Springs Stakeholders

Stakeholder	*Interest/Stake*
Residents	Maintaining property rights, wise land use practice, BMPs, water conservation, enjoyment of natural areas
Businesses	Maintaining economic viability, role in conservation, best practice for their specific industry
Florida Thoroughbred Owners Association	Breeding and owning horses, agricultural BMPs
Friends of Rainbow Springs	Protection and enjoyment of the spring

Marion County Horseman's Association	Equine community advocacy, agricultural BMPs
The Nature Conservancy	Land and water conservation, advocacy, environmental planning and restoration

Sources: http://www.ftboa.com/about-us
http://www.nccentral.com/FORS/
http://www.mchainc.org/mcha/index.cfm
http://www.nature.org

Table 5. Wakulla Springs Stakeholders

Stakeholder	*Interest/Stake*
Residents	Maintaining property rights, wise land use practice, BMPs, water conservation, enjoyment of natural areas
Businesses	Maintaining economic viability, role in conservation, best practice for their specific industry
Friends of Wakulla Springs	Supporting the stewardship of natural and cultural resources through various means
Woodville Karst Plain Project	To explore, survey, connect and protect the flooded underwater cave systems of North Florida's Woodville Karst Plain
The Hydrogeology Consortium (HC)	To cooperatively provide scientific knowledge of ground and surface water resources and advocate for the effective application of that knowledge toward management, conservation and protection.
Area Educational Institutions	Education, outreach, activism, technical assistance
Apalachee Audubon Society	Environmental activism, conservation, education
Big Bend Sierra Club	Environmental activism, conservation, education
Florida Public Interest Research Group	Florida PIRG is a consumer group that stands up to powerful interests whenever they threaten our health and safety, our financial security or our right to fully participate in our democratic society.
Florida Trail Association-Apalachee Chapter	Building and maintaining safe hiking trails
Florida Water Environment Association	Preservation and enhancement of Florida's water environment
Florida Native Plant Society	Education, research, landscaping, native habitat protection
1000 Friends of Florida	Promotes healthy urban and natural places by wise management of growth and change.
Clean Water Network	Provides services to help accelerate the design, evolution and deployment of global water solutions.
Talquin Water and Wastewater, Inc.	Public water and wastewater utility
Hazlett-Kincaid, Inc.	Environmental science, engineering, and construction firm
Lake Watch	Volunteer water quality monitoring
McGlynn Laboratories, Inc.	Experienced in collecting and analyzing water and soil samples, and interpreting data to determine the environmental impact of various industrial and urban enterprises.
The Nature Conservancy	Land and water conservation, advocacy, environmental planning and restoration

Sources: http://wakullasprings.org/
http://www.globalunderwaterexplorers.org/Projects/WKPP
http://hydrogeologyconsortium.org/
http://www.floridapirg.org/page/flp/about-florida-pirg
http://apalachee.floridatrail.org/
http://www.fwea.org/
http://www.1000friendsofflorida.org/about/main.asp
http://www.cleanwaternet.com/
http://www.talquinelectric.com/
http://www.hgl.com/about/
http://lakewatch.ifas.ufl.edu/

Table 5. Ichetucknee Springs Stakeholders

Stakeholder	*Interest/Stake*
Residents	Maintaining property rights, wise land use practice, BMPs, water conservation, enjoyment of natural areas
Businesses	Maintaining economic viability, role in conservation, best practice for their specific industry
Save Our Suwannee	A group of people dedicated to protecting the water quality and quantity in the Suwannee Basin.
Four Rivers Audubon	Environmental activism, conservation, education
Florida Defenders of the Environment	To cooperatively provide scientific knowledge of ground and surface water resources and advocate for the effective application of that knowledge toward management, conservation and protection.
Three Rivers FNPC	Water resource, wetlands conservation and management
Current Problems	To preserve and protect the water resources of North Florida for the use and enjoyment of humans and wildlife through action, awareness and education.
Sierra Club	Environmental activism, conservation, education
1000 Friends of Florida	Promotes healthy urban and natural places by wise management of growth and change.
Fort White Chamber of Commerce	Represents companies and businesses
Lake City Chamber of Commerce	Public water and wastewater utility
NSS Cave Diving Section	Cave diving interests, and cave conservation
Friends of Ichetucknee Springs State Park	Supporting conservation and stewardship of the state park and its resources
The Nature Conservancy	Land and water conservation, advocacy, environmental planning and restoration

Sources:
http://www.saveoursuwannee.org/about-us/
https://www.fundraise.com/non-profit/online-fundraising-categories/environmental-quality-protection-and-beautification/water-resource-wetlands-conservation-and-management
http://www.currentproblems.org/
http://www.nsscds.org/

Springsheds

Springshed, or spring recharge basin, is defined as, "Those areas within ground- and surface-water basins that contribute to the discharge of the spring," (FGS 2003). A springshed is different from a watershed (an area of land that drains to a specific water body), in that springsheds are affected by confining layers, recharge areas, and ground elevation, whereas watersheds are based on ground elevation as water flows to the lowest point. A springshed is affected by a greater number of factors than a watershed, which in turn affect the spring that they supply.

Table 6. Springshed Comparison

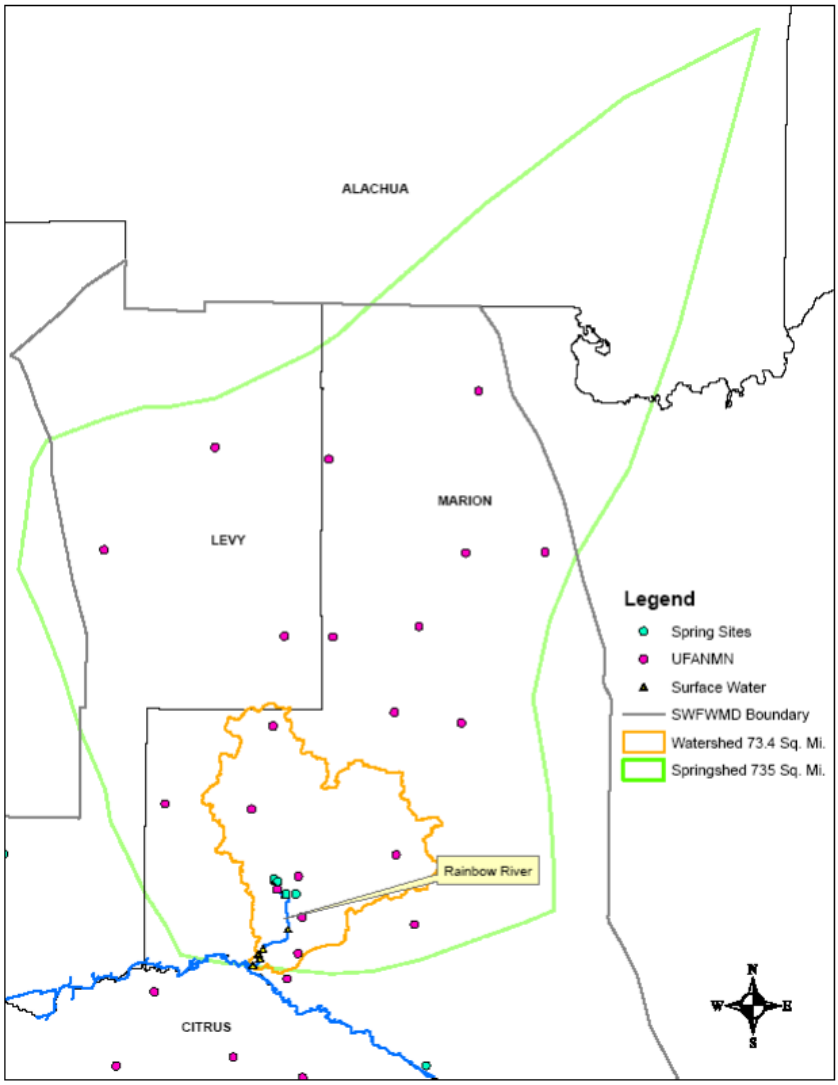
Spring	Size (sq. mi)	Dominant Land Uses (greatest to least)	Change in Last 50 Years
Rainbow	735	- Agricultural - Residential - Upland forest - Urban	Transition from native uplands to agriculture, residential and urban development (74% decline in forested habitats)
Wakulla	FL - 1,156 GA - 412	- Forested/rural - Wetland - Residential (high, med, low density combined)	Increasing urbanization, conversion of native land cover to urbanized uses
Ichetucknee	370	- Forest - Agricultural - Urban - Water and wetlands	While the dominant land use remains forested habitats, the percentage has declined and increased development has occurred. Percentages of agriculture have remained relatively constant

Sources: http://www.swfwmd.state.fl.us/files/database/site_file_sets/34/rainbow_river-techsummary.pdf
Gregory, 2010
http://www.swfwmd.state.fl.us/files/database/site_file_sets/34/swim_project_status.pdf
http://www.floridasprings.org/protecting/featured/wakulla/
Zavoyski, 2010

Each of the springsheds described above faces different threats to the health of the down-gradient spring. For example, the Wakulla Springs springshed remains for the most part in an area dominated by native land cover. However, intensive application of treated human waste water by the City of Tallahassee has increased nitrate to the spring in amounts much greater than if that same amount of land were another land use, such as residential. Different land uses pose varying degrees of threat to the spring. More of one type of land use may demonstrate little effect, though small increases of another type may be significant. Understanding the ways in which the land use in totality contributes to the spring is necessary in identifying restoration opportunities and constraints.

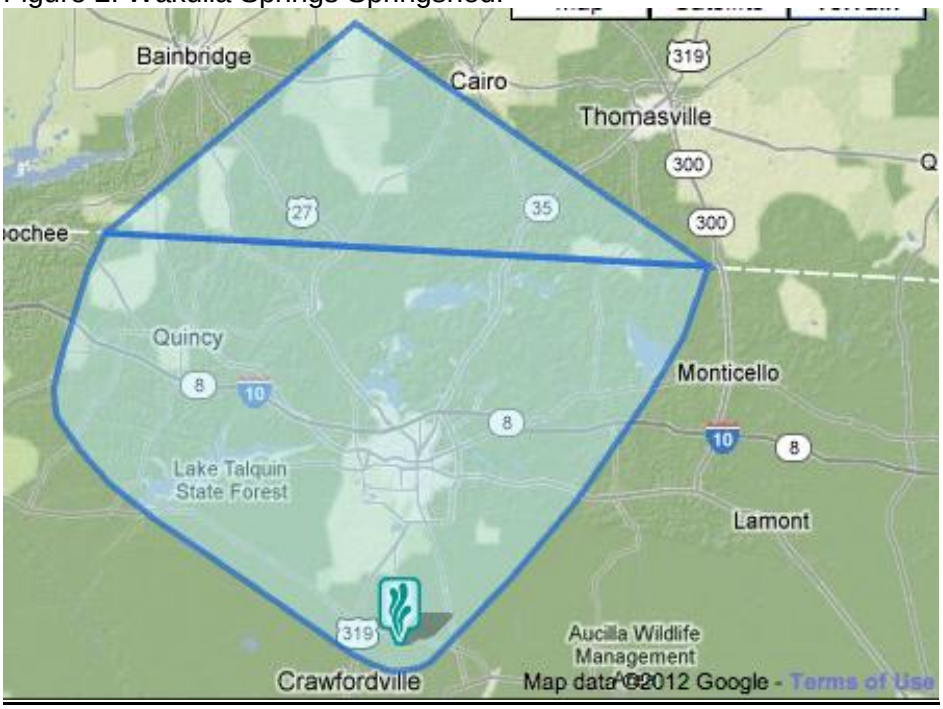
Another factor in considering restoration measures is the size of the springshed. With regard to the springs reviewed here, the Ichetucknee Springs springshed is less than 24% the size of the Wakulla Springs springshed. This presents opportunities and challenges for restoration of both springs. For Ichetucknee Springs, the smaller area presents the benefit of being able to concentrate restoration efforts in a geographically compact area. For Wakulla, maintaining native land uses becomes a priority, as does mitigating intensive uses that are degrading the value and function of the spring system.

Figure 1. Rainbow Springs Springshed



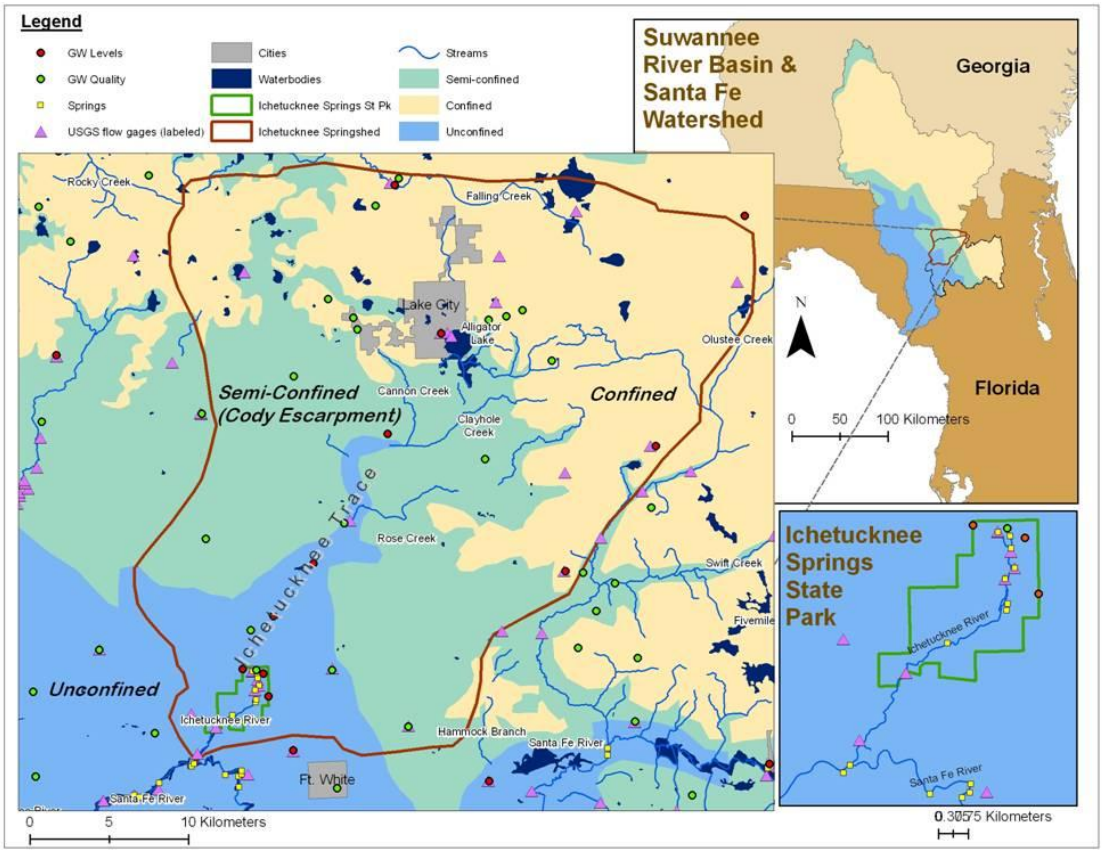
Source: http://www.swfwmd.state.fl.us/files/database/site_file_sets/34/rainbow_river-techsummary.pdf

Figure 2. Wakulla Springs Springshed.



Source: http://www.floridasprings.org/protecting/featured/wakulla/

Figure 3. Ichetucknee Springs Springshed.



Source: http://suwanneeho.ifas.ufl.edu/datasets-ichetuck.htm

Nitrate Loading and Associated Land Uses

Nitrate (NO_3^-) is a nitrogen-oxygen chemical that combines with various organic and inorganic compounds. Nitrates are found in fertilizer and when taken into the body (human/animal) is converted to nitrites. Nitrate can cause adverse health impacts if ingested in drinking water. According to the EPTA, "Infants below six months who drink water containing nitrate in excess of the maximum contaminant level (MCL) could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue baby syndrome."

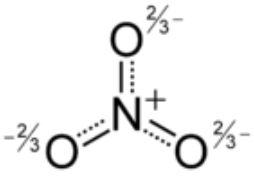


Figure 4. Nitrate Molecule

Within springs, there are many different sources of nitrate. Nitrogen is naturally deposited from the atmosphere. Nitrate may also be applied directly to the ground in fertilizer, through agricultural animal wastes, through application of wastewater and biosolids to the ground surface, or through seepage from septic systems. The land uses within a springshed determine which percentage of nitrate originates from the sources described above or from other sources. Land use changes through time have increased nitrate loading to springs, as the natural systems previously in balance with natural nitrogen sources have been converted for human use, brining more of this chemical into the system. These human uses contribute directly to increased nitrogen loads within spring systems.

Table 7. Spring Nitrate-Nitrite Comparison

Spring	Current Average N Conc.	Current Average Flow	Predevelopment N Conc.	Predevelopment Flow	Historic N Load (tons/yr)	Current N Load (tons/yr)
Rainbow	1.75 mg/L	613 cfs	.2 mg/L	763 cfs	152.6	1072
Wakulla*	1 mg/L	128.9 cfs	.2 mg/L	390 cfs	78	128.9
Ichetucknee	.777 mg/L	323 cfs at US 27 bridge	.22 mg/L in 1922	360 cfs	79.2	279.7

Note: Background concentration of nitrate is .05 mg/L for Florida springs
*Nitrate levels in Wakulla Springs have declined significantly from all time high levels in 1990 (Hand, 2012)

Sources: http://en.wikipedia.org/wiki/File:Nitrate-ion-resonance-hybrid-2D.png
http://water.epa.gov/drink/contaminants/basicinformation/nitrate.cfm
(Loper et al., 2005).
http://www.floridasprings.org/downloads/florida_122_tmj35ttp.pdf
Upchurch, Chen, and Cain, 2007

Sources of Nitrate within Springsheds

The sources of nitrate within a springshed are highly variable. The greatest percentage may come natural processes of atmospheric deposition in an undeveloped springshed, where as in a more urbanized or agricultural area it may come from wastewater or fertilizer.

RAINBOW:

45% - Fertilized pasture
18% - Horse Farms
17% - Atmospheric deposition
15% - Cattle
5% - other (incl. septic, turf, sewage, row crops)

Source: Jones, et al. 1996

WAKULLA:

40% - Waste Water Treatment
26% - Atmospheric deposition
15% - Residuals disposal
7% - Commercial fertilizer
6% - OSDS
4% - Sinking streams
2% - Livestock

Source: Chelette, et al. 2002

ICHETUCKNEE:

37.5% - Improved pasture
33.9% - Atmospheric deposition
10.3% - Urban runoff
9.2% - Row crops
5.5% - WWTF Sprayfield
7.6% - OSTDS Drainfields

Source: Foster 2008

Spring Flow

Many factors influence flow coming from a spring vent, and associated volume and velocity. Several different factors contribute to the current velocity. Specifically, the head pressure, volume of water exiting the vent, and the porosity of the subsurface karst or dolostone will each affect current velocity. Velocity will increase with increased head pressure, large volume (based on the spring shed area at about 1cfs for every square mile), and porosity such that the water is funneled toward the vent, yet not impeded through excessive friction. Given that spring flow is driven also by rainfall, droughts and floods within a springshed will accordingly increase and decrease spring flow. Changes in land use, such as the conversion of native habitats to impervious urban uses reduces recharge and therefore can reduce flow.

A major culprit in reduced spring flows is groundwater pumping. This pumping has the direct result of taking water that would flow through springs and sending it to the homes, businesses, and farms that rely on groundwater. Conservation measures, alternative water supplies, and reuse are all necessary in consideration of how to maintain spring flows as a part of a restoration plan.

For each of the springs discussed here, a certain percentage of loss of flow may be attributed to a specific cause or use. That analysis is provided for each spring below.

RAINBOW: Flow at Rainbow has not dropped nearly as much as flow at other springs throughout the state. For the most part, lower flows are attributed to changes in rainfall.

- Change in rainfall – Lower than average in the last decade, possible migration of groundwater from the Silver Springs basin towards Rainbow Springs perhaps due to the fact that Rainbow Springs is at a lower elevation than Silver Springs by 10 feet.
- Changes in land use – combined with others as part of groundwater pumping
- Agricultural water uses – combined with others as part of groundwater pumping
- Urban water uses – combined with others as part of groundwater pumping
- Industrial/commercial – combined with others as part of groundwater pumping

The possible impact of the northwestern well field on flow from Rainbow Springs was modeled using the SWFWMD ND (Northern District) model and the result was a negligible impact of less than 0.2% of predevelopment discharge rates. However, overall greater than 15% in the decline of flow at Rainbow Springs can be attributed to groundwater pumping within the springshed associated with the above-listed land uses changes or water use demands.

Based on the chart below and statements found in sources, flow at Rainbow springs has remained relatively constant, with rainfall reductions accounting for recent low flow years.

Source: http://www.floridasprings.org/downloads/florida_149_eygeajyd.pdf

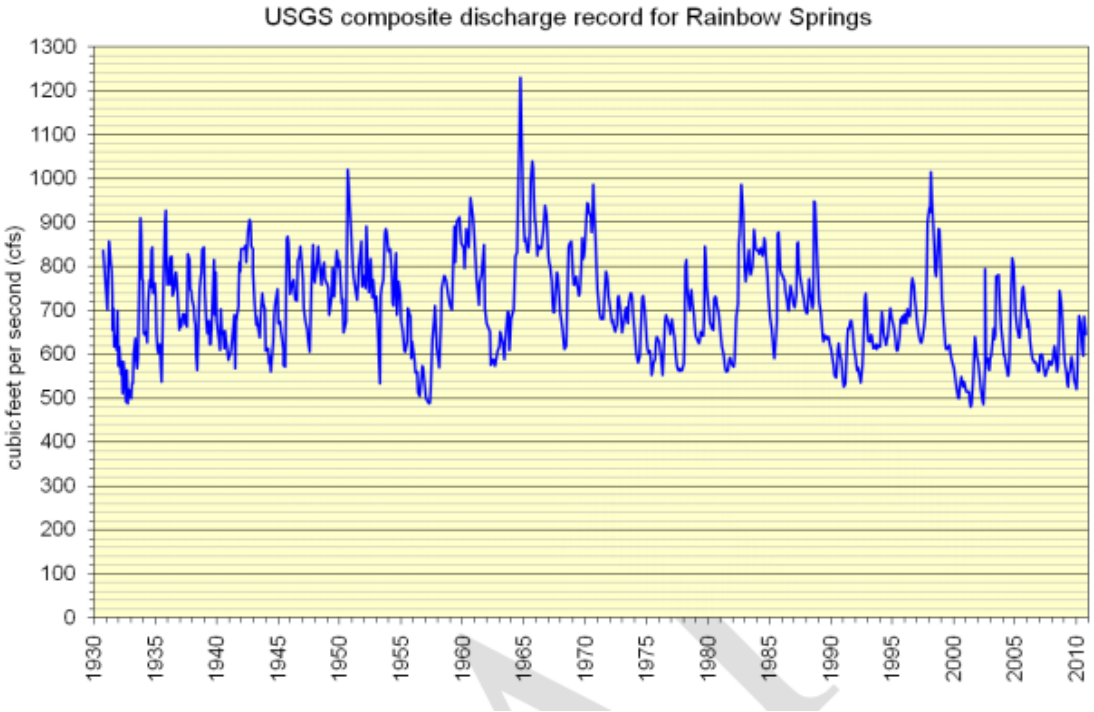


Figure 4. Composite discharge record for the Rainbow River from 1931 to 2010 (USGS Station #02313100).

WAKULLA: Wakulla Springs flow comes from two distinct sources – groundwater and surface water. Further, this system is tidally connected through the Spring Creek system and is influenced by changes in sea level. There is some uncertainty surrounding exactly what is affecting the discharge rates at Wakulla, but groundwater pumping is a major factor and here accounts for 70% of the reduction in spring flow.

- Change in rainfall – <10%
- Changes in land use – ~20%, area near Tallahassee continues to urbanize, decreasing recharge, but springshed remains dominated by natural land cover
- Agricultural water uses – combined with others as part of groundwater pumping
- Urban water uses – combined with others as part of groundwater pumping
- Industrial/commercial – combined with others as part of groundwater pumping

Pumping reduces groundwater levels in the north (aquifer pressure), gradient (slope of the water table) is getting shallower, it so shallow in the dry periods that high tide reverses the flow direction at Spring Creek.

Source:
http://www.floridasprings.org/downloads/florida_113_qg5bjxw6.pdf
http://wakullasprings.org/pdf/kincaid-BOCC.pdf

ICHETUCKNEE: The average flow in the Ichetucknee system has fallen by about 18%, about 92 cfs. The list below represents the source of that reduction.

- Change in rainfall – 35% (annual rainfall totals have been dropping since 1975)
- Changes in land use – minor given current land uses
- Agricultural water uses – combined with others as part of groundwater pumping
- Urban water uses – combined with others as part of groundwater pumping
- Industrial/commercial – combined with others as part of groundwater pumping

Groundwater pumping for the four combined above-listed purposes accounts for 65% of the reduction in flow coming from the Ichetucknee Springs group. Only 22% of that pumping is attributed to local sources. The remaining 78% is attributed to groundwater pumping from the Jacksonville area.

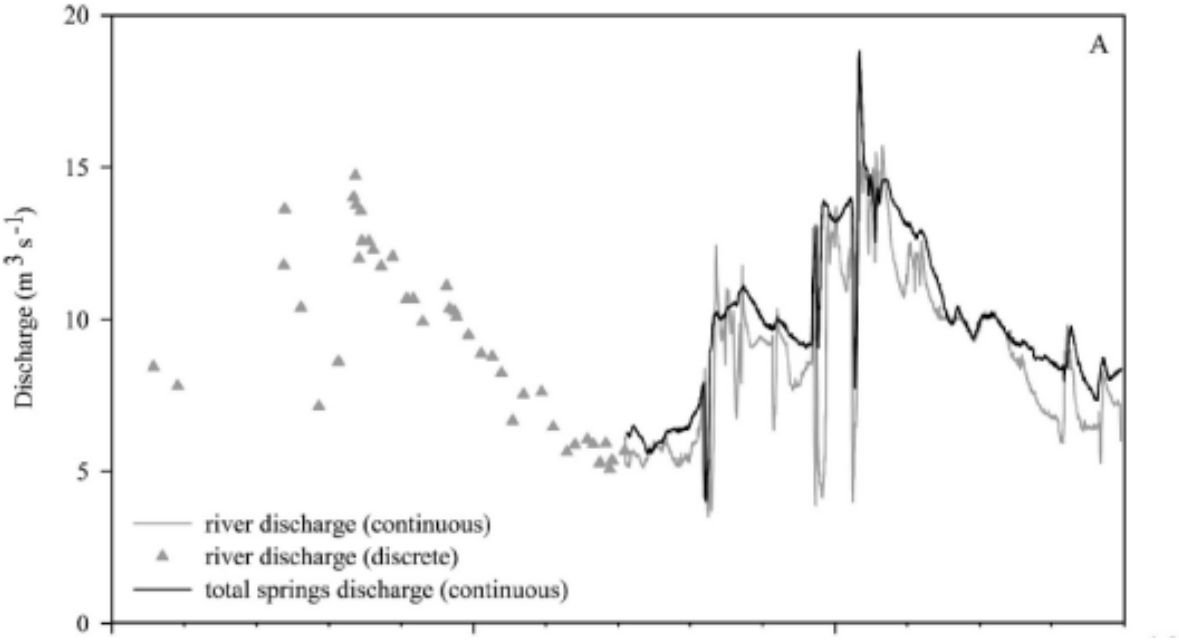


Figure 5. Ichetucknee River discharge at the US 27 bridge and total springs discharge from 1995 to 2009 (Heffernan et al. 2010)

Source: Trey Grubbs, USGS
Ichetucknee Springs and River Restoration Plan, HT Odum Springs Institute, 2012

Physical Alterations and Impairments

Through the years, many springs and their spring runs have been altered to facilitate human use of the spring system. Often, the perimeter of the spring pool is hardened to prevent erosion, board walks or fishing piers/observation decks are constructed, and in some cases, truckloads of sand are brought in to create a "beach". Other springs have also been dammed to control flow or to generate hydropower for a mill. These alterations have varying degrees of impact on the system. In many cases these changes inhibit the natural function of the system to some degree, however, they may also prevent degradation from recreational uses (ex: shoreline erosion from ingress/egress into spring pool). Given high levels of recreational uses for these systems, a physical alteration, like a boardwalk or restroom facility, is often a far better choice than allowing individual users to alter the system to gain access, blaze a new trail, or use the spring as a restroom.

Other human alterations may be less obvious, such as the introduction of nuisance/invasive plant or animal species. Often, the management or removal for these unwelcome guests may also impose a physical alteration (though perhaps of a shorter duration than structural ones). Management, though well intentioned, can have equally as destructive outcomes as a structural modification, when undertaken without consideration for entire system.

Removal of physical modifications or different approaches to management may be part of a restoration plan. This depends on the severity of impact in comparison to the benefit it provides for human use. Many structural changes will remain in place until recreation is eliminated from a particular area of a spring or within that spring entirely.

For each of the three springs under consideration, their respective alterations are described below.

Rainbow Springs

Alteration/Impairment	Effect
Parking Lot	Increased runoff
Swim dock	Shoreline alteration and shading of SAV
Hardened shoreline at head spring	Prevents erosion from visitor ingress egress, ecotone removed (between spring pool and surrounding uplands), decreased buffering from runoff
Canoe dock	Shoreline alteration and shading of SAV

Source: http://www.floridastateparks.org/rainbowsprings/
Gregory 2010

Wakulla Springs

Alteration/Impairment	Effect
Diving Platforms	Shading of SAV, resultant diving and swimming increases turbidity
Boat dock, boats	Shoreline alteration, shading of SAV
Wakulla Springs Lodge and parking lot	Conversion of native habitat to urban use, increased runoff
Hydrilla and associated management	Altered aquatic macrophyte community, management with Aquathol resulted in a severe crayfish kill, herbicide kills native plants, creation of anoxic sediments, loss of wildlife

Source: Hand, 2012
http://www.floridastateparks.org/wakullasprings/

Ichetucknee Springs

Alteration/Impairment	Effect
Hardened shoreline surrounding head spring	Prevents erosion from visitor ingress egress, ecotone removed (between spring pool and surrounding uplands), decreased buffering from runoff
Tube and Canoe Launch	Shoreline alteration, shading of SAV
Blue Hole Spring Boardwalk	Habitat alteration, some overland flow alteration
Midpoint Dock	Some shoreline alteration, shading of SAV
Dampiers Landing Dock	Some shoreline alteration, shading of SAV
US 27 Dock and Landing	Some shoreline alteration, shading of SAV, potential increased runoff given hardening

Source: http://www.floridastateparks.org/lib/img/park/parkmap/ich-map.jpg

Recreation

Many impacts made directly within a spring system are the result of recreational activities or enhancements to facilitate recreation (as described in the section above). Human use can take a heavy toll – increased turbidity, loss of vegetation, impacts to wildlife and birds, etc.. Therefore, it is critical to understand this impact in order to potentially lessen it. Several spring systems, like Ichetucknee, have capped entrance at the days of highest use in order to both provide some protection to the spring and preserve human enjoyment of the experience, which is often reduced with over crowding. Wakulla Springs allows no motorized boat access. It can be expected that with each additional type of recreation introduced, additional impacts will be realized. At the same time, the converse is also true, and the most impactful uses should be

evaluated for appropriateness, and possibly eliminated. The springs reviewed and discussed here experience their highest use during summer months when people flock to them to cool off during the heat of the day. Other springs, like Homosassa, experience their highest numbers of visitors in the winter, when people are attracted to the wintering manatees.

Maintaining access ensures that people are able to see first hand the splendor of Florida's springs. This access creates a springs fan club of sorts, with educated people willing to take a stand for maintaining the value and functions of these systems. Therefore, it essential that visitors understand how to minimize their impacts, both when spending time directly in the spring ecosystem and within the springshed. Education and outreach should be a major component of a springs restoration plan.

Spring	Number of Visitor/Yr	Peak Use	Impacts
Rainbow	220,000	Summer	Biomass of damaged plants are directly related to the number of boats, tubers, and total number of recreational users, increased turbidity, wildlife disturbance, litter
Wakulla	184,000	Summer	Increased turbidity, trampling of vegetation, wildlife disturbance, litter
Ichetucknee	189,000*	Summer	Increased turbidity, trampling of vegetation, wildlife disturbance, litter

Source: Bonn and Bell 2003, SWIM 2009, RRTS 2008.
Ichetucknee Springs and River Restoration Plan, HT Odum Springs Institute, 2012
http://www.floridasprings.org/downloads/florida_97_perkczcy.pdf

*Note: access capped at a maximum of 3,000 people per day during times of peak use and in order to reduce litter, only reusable containers are allowed on the river.

Conclusion

The process of reviewing springs restoration plans and the various impairments that have affected Florida's springs illustrates that these are complex systems affected by many different factors. Success in restoration depends on scientific understanding, an engaged stakeholder group, willingness to change behavior, and belief in the value of preserving these unique ecosystems. Existing patterns of conduct when visiting springs, land use, water use, fertilization, waste water disposal etc., cannot be maintained if the people of the state and its many visitors hope to be able to experience artesian springs in the years to come. Each of the aspects that impair springs must be evaluated and the impacts of those activities and uses mitigated. Only a comprehensive systems level approach toward restoration will accomplish meaningful progress.

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