

ICHETUCKNEE SPRINGS RESTORATION PLAN



Beth Zavoyksi ENV 6932
Spring Ecosystems

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Section 1: Executive Summary/Introduction

Ichetucknee Springs and River are considered an “Outstanding Florida Water” body. The springs and river when combined have the flow of a 316 cfs (cubic feet per second), which classifies the system as a 1st magnitude spring. It attracts approximately 200,000 visitors/year and provides about \$22 million to the local economy on an annual basis. Despite this designation and the economic benefit that the springs generate, certain water quality attributes of the springs have been degrading over time. Nitrate concentrations in the springs have increased in the past several decades. Algal concentrations in the springs/river have also increased in recent years. The nitrate and algal phenomenon can be attributed to land use within the springshed. Fertilizer use drastically increased in the past few decades, which has aided the nitrate and algal problems within the springs. In addition to this, animal wastes from pastures and the spraying of wastewater from the nearby Lake City wastewater treatment plant have contributed to the nitrate problem. Ichetucknee Springs have also seen a decline in discharge in the recent years. This could be attributed to increasing water withdrawals in both the springshed and within areas that the springs receive groundwater flow from, like the Jacksonville area of Northeast Florida. While Ichetucknee Springs and River are not considered impaired from a regulatory standpoint, they are degraded from the natural background concentration of nitrate in Florida springs which is 0.05 mg/L. If Ichetucknee Springs is to be restored to near background conditions, changes in land use, or more specifically, changes in fertilizer use and wastewater remediation would be necessary. Some of the ways that restoration could occur would be to institute fertilizer ordinances at the city or county level within the springshed. Also, the cessation of wastewater sprayfields would be advantageous along with the retrofitting of standard septic tanks to advanced septic tanks within the springshed. Water use within the Ichetucknee springshed as well as in areas further away from the springs that provide groundwater flow to the springs must be made more sustainable through water conservation. This could allow the discharge of the springs and springfed river to be maintained and would prevent additional declines.

Section 2: Description of Springs Area

Ichetucknee Springs consists of nine named springs or spring groups and many other unnamed springs. The named springs include Ichetucknee Headspring, Cedar Headspring, Blue Hole Spring, Roaring Spring and Singing Spring (which make up the Mission Springs Group), Devil's Eye (also known as Boiling Spring), Grassy Hole Spring, Mill Pond Spring, and Coffee Spring (Rosenau et al., 1977; Skiles, Hayes, and Butt, 1991; Figure 1-2).

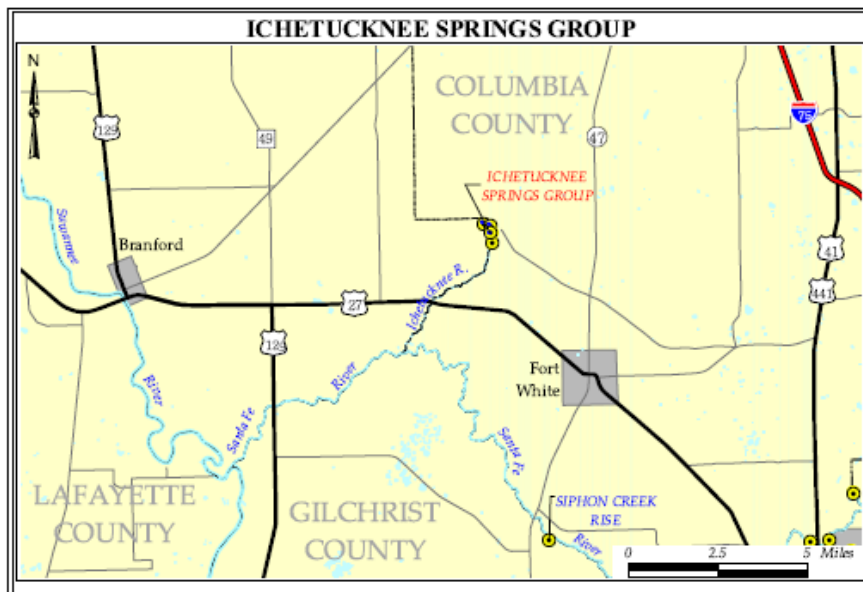


Figure 1: Location of Ichetucknee Springs.

Source: Scott, Thomas M., Guy H. Means, Ryan C. Means, and Rebecca P. Meegan. 2002. First Magnitude Springs of Florida. Florida Geological Survey. Open File Report No. 85.

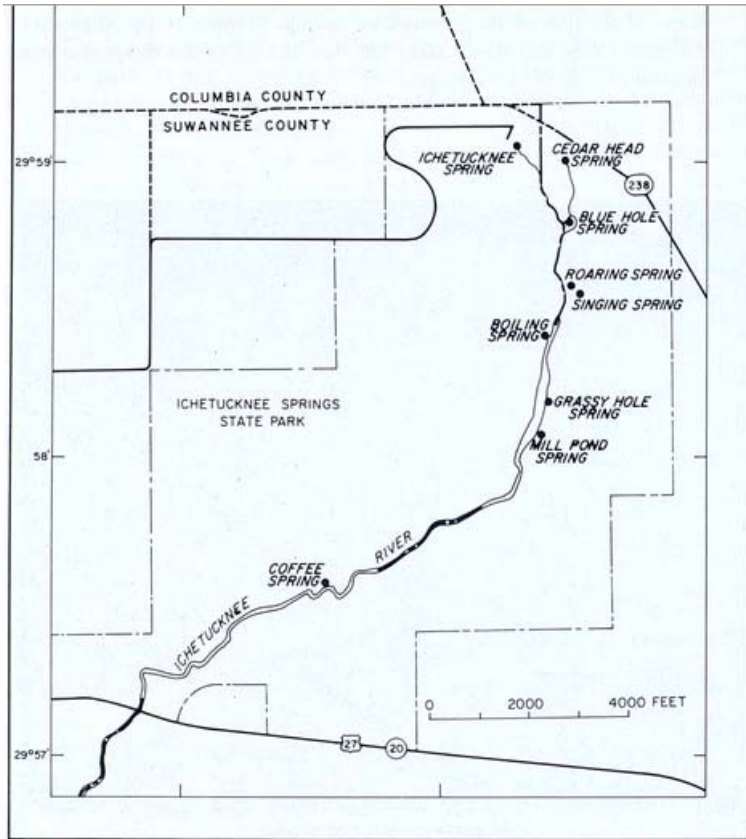


Figure 2: The Nine Named Springs Located along the Ichetucknee River

Source: Rosenau, Jack C., Glen L. Faulkner, Charles W. Hendry, and Robert W. Hull. 1977. Springs of Florida. United States Geological Survey. Bulletin no. 31 (revised).

The distance between the headspring and Coffee Spring is approximately 2.5 miles. The springs all discharge into the Ichetucknee River. The Ichetucknee River discharges into the Santa Fe River. The total distance between Ichetucknee headspring to the Santa Fe River is approximately 6.5 miles (Scott et al., 2004).

Ichetucknee Springs and River are considered special water bodies and have been designated an “Outstanding Florida Water” (Wetland Solutions, Inc., 2006). This designation is stated in the Florida Administrative Code (F.A.C.) Chapter 62-302 and it is intended to give extra protection to the springs. It is considered an outstanding water in the F.A.C. because of its “natural attributes” and because it is located in a state park.

The water quality of outstanding water is meant to be “protected under all circumstances.” Ichetucknee Springs also have the designation of a “State Natural Feature Site” and “National Natural Landmark” (DEP, 2000).

All of the springs, with the exception of Ichetucknee Headspring, are located in Columbia County. The headspring is located in Suwannee County (Scott et al., 2002). The Ichetucknee springshed (Figure 3) encompasses 44% of the total land area of Columbia County and the springshed is located almost entirely within Columbia County (Katz, Sepulveda, and Verdi, 2009).

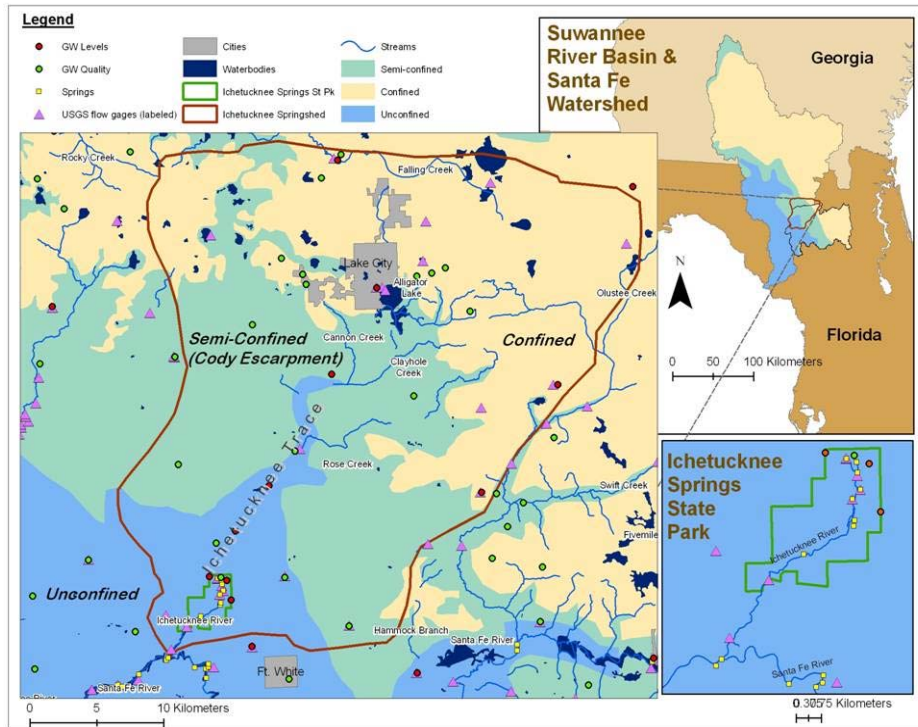


Figure 3: Ichetucknee Springshed (outlined in red)

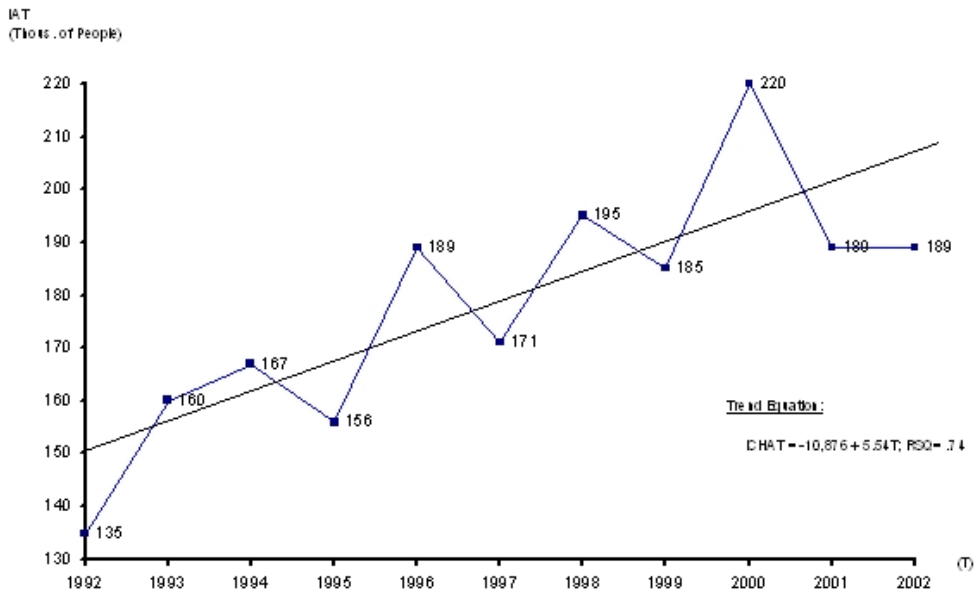
Source: <http://suwanneehydro.ifas.ufl.edu/datasets-ichetuck.htm>

The Ichetucknee springshed is 960 km² (approximately 237,220 acres) (Katz, Sepulveda, and Verdi, 2009). The springs are all located within the boundaries of Ichetucknee Springs State Park, a 2,241 acre park, about 10 miles northeast of the city of Branford (Herring and Judd, 1995; Scott et al., 2002). The springs and the state park are located in the southern portion of the springshed.

Section 3: Ichetucknee Attendance/Economic Importance

Ichetucknee Springs is an extremely popular recreation area. Over 150,000 visitors came to the state park in 2008 making it the 5th most visited springs out of the 12 analyzed by Wetland Solutions, Inc (2010). The park saw a 41% increase in visitor

attendance between the years 1992-2001. Attendance has increased by approximately 5,500 per year since 1992 (Figure 4; Bonn and Bell, 2003).



Source: Division of Recreation and Parks, Florida Department of Environmental Protection, Unpublished Data.

Figure 4: Annual Attendance of Ichetucknee Springs State Park 1992-2002

Source: Bonn, Mark A. and Frederick W. Bell. 2003. Economic Impact of Selected Florida Springs on Surrounding Local Areas

Ichetucknee Springs provides a huge economic benefit to the surrounding area. It provided approximately \$23 million in visitor spending in 2002 alone. Each visitor spends around \$34/day. Ichetucknee Springs has also created 311 jobs in Columbia and Suwannee counties. Some of these are jobs directly within the park, but the majority of employment is outside of the park in restaurants, stores, lodging, and gas stations (Bonn and Bell, 2003).

Section 4: Physical Description and Discharge of Individual Springs

Ichetucknee Headspring is the northernmost spring in the Ichetucknee Springs system. It has a long term average discharge of 34 cfs (cubic feet per second) (Wetland Solutions, Inc., 2006), which makes it a 2nd magnitude spring (Meinzer, 1927). The headspring basin is 102ft by 87ft with a depth of 17 ft (Scott et al., 2002). The Division of Recreation and Parks state that the depth was increased to 30 after the removal of trash, rubble, and concrete in 1999 (2000). There is minimal aquatic vegetation on the spring bottom (Scott et al., 2002).

Cedar Headspring is about 1000 ft south of Ichetucknee Headspring and has a long-term average discharge of 6.34 cfs (Rosenau, et al. 1977; Wetland Solutions, Inc., 2006). This discharge classifies the spring as 3rd magnitude (Meinzer, 1927). The spring pool measures 30 ft by 60 ft and flows south through a 1,100 foot springrun (Rosenau, et al. 1977). Maximum depth is 6 ft (Scott, et al. 2002).

Blue Hole Spring (also known as Jug Spring) has a long-term average discharge of 107 cfs (Wetland Solutions, Inc., 2006), which makes it a 1st magnitude spring (Meinzer, 1927). The spring is located in the spring run of Cedar Headspring and measures 87 ft by 117 ft with a maximum depth of 32-37 ft (Scott, et al. 2002, Skiles, Hayes, and Butt, 1991). This is a heavily utilized swimming area. In 2004, Scott et al. said it had “abundant aquatic grass and some algae.”

Mission Springs are approximately 1,500 feet south of Blue Hole. The Mission Springs group includes Singing Spring and Roaring Spring. Mission Springs had a combined long-term average discharge of 87.2 cfs (Wetland Solutions, Inc., 2006), making it a 2nd magnitude spring (Meinzer, 1927). Singing Spring has a discharge that was said to be a “trickle” by Rosenau (1977). Singing Spring has two small spring runs. Roaring Spring is located in the northwest run of Singing Spring and “discharges forcefully” from a pool that measures 10 ft by 15 ft. Maximum depth is 3 ft. The bottom of Roaring Spring has algae covered aquatic grass (Scott et al., 2002).

Devil’s Eye is also called Boiling Spring (Skiles, Hayes, and Butt, 1991). It is located about 850 ft southwest of Mission Springs and has a pool size of 60 ft by 120 ft. It has a spring run of 30 ft (Rosenau, 1977). The long-term average discharge of Devil’s Eye is 47.2 cfs (Wetland Solutions, Inc., 2006), which classifies it as 2nd magnitude (Meinzer, 1927). Grassy Hole Spring is 1,350 ft south of Devil’s Eye and contains many small vents (Rosenau, 1977). Long-term average discharge is 6.5 cfs (Wetland Solutions, Inc., 2006), which makes the spring a 3rd magnitude spring (Meinzer, 1927). Mill Pond spring is 800 ft from Grassy Hole and has a spring pool size of 50 by 100 ft and a spring run of about 500 ft. (Rosenau, 1977). The long-term average discharge of Mill Pond is 25 cfs (Wetland Solutions, Inc., 2006), making it a 2nd magnitude spring (Meinzer, 1927). Coffee Spring is the smallest spring in the Ichetucknee Springs system in terms of discharge. It averages 2.92 cfs (Wetland Solutions, Inc., 2006), is a 3rd magnitude spring (Meinzer,

1927) and is one mile southwest of Mill Pond Spring. Coffee Spring has many small vents that discharge into a 30 ft by 40 ft “rectangular pond” (Rosenau, 1977).

When the total long term average discharge of the individual springs within Ichetucknee Springs are added up, they total about 316 cfs. The discharge of the Ichetucknee River by US Highway 27 is 289 cfs (Wetland Solutions Inc, 2006). This classifies the combined flow of the springs as a very large 1st magnitude group of springs, since the discharge is greater than 100 cfs (Meinzer, 1927). Discharge measurements for the Ichetucknee date back to 1898 when it was 403 second-feet (Meinzer, 1927). Total Discharge averaged 360 cfs between the years of 1917-1975 (Figure 5).

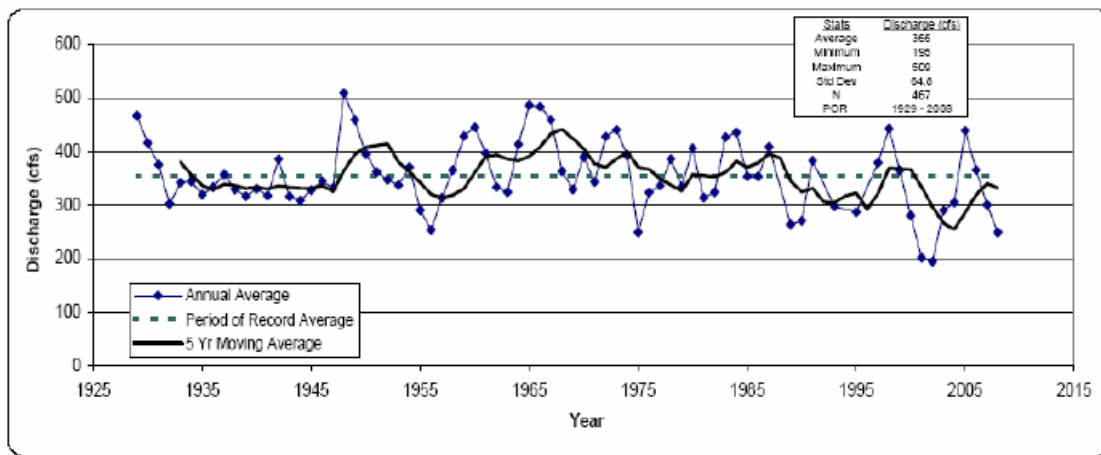


Figure 5: Discharge of Ichetucknee River (US 27) 1929-2008:

Source: Wetland Solutions, Inc. 2008. Ichetucknee Springs and River Environmental Health – 2008 Report Card.

During 1917-1975 maximum discharge was 578 cfs and minimum discharge was 360 cfs (Rosenau, 1977). During the years 2002-2009, annual mean discharge was 323 cfs at US 27 (Wetland Solutions Inc., 2010). Discharge of the Ichetucknee River at US 27 has declined since 1900. Trey Grubbs of the U.S. Geological Survey (USGS) says that flow has decreased by 25% and most of the decline has occurred since 1965. Grubbs believes that pumping from the Jacksonville area is the main reason for the decrease in flow (2010).

Section 5: Water Quality

Parameters (D.O. % saturation, D.O. mg/L, nitrate as NOx N, total phosphorus, color, pH, Secchi disc depth, specific conductivity, total dissolved solids, and temperature of water quality between for the years 1980, 1990, and the period of record average

(POR) are shown in Table 1. The period of record average shows that dissolved oxygen concentrations decrease downstream from Ichetucknee headspring to Mission Spring (4.260 mg/L and 0.459 mg/L), then slightly increase at Devil's Eye (0.543 mg/L), slightly decrease at Grassy Hole (0.486), and then start an increasing trend from Mill Pond to the river in US 27 (0.574 mg/L and 5.880 mg/L). Total phosphorus concentrations for all sites have decreased slightly from 1990-2000 with the exception of US 27. Only the Ichetucknee Headspring boil and US 27 have color data from 1990 and 2000. At both of these sites color has declined. In 1990 color was 5.00 CPU at Ichetucknee Headspring. By 2000 it had decreased about 50% to 2.61 CPU. At US 27 it was 16.10 CPU in 1990 and in 2000 it had decreased about 65% to 5.50 CPU. pH is relatively constant throughout time and space. Secchi disc depth is greatest at Blue Hole (9.49 m POR average) and lowest at Mill Pond (1.07 m POR average). All of the springs with the exception of Blue Hole have a Secchi disc POR average of less than 3 meters. Specific conductivity POR average is highest at Mill Pond (362 $\mu\text{S}/\text{cm}$) and Grassy Hole (359 $\mu\text{S}/\text{cm}$). Specific conductivity is low at Cedar Head, Blue Hole, Mission, and US 27 (309 $\mu\text{S}/\text{cm}$, 304 $\mu\text{S}/\text{cm}$, 306 $\mu\text{S}/\text{cm}$, and 310 $\mu\text{S}/\text{cm}$). Total dissolved solids POR average for all springs except Devil's Eye, Grassy Hole, and Mill Pond are below 200 mg/L. Temperature is constant throughout time and space.

| Parameter | Year | Ichetucknee Headspring boil | Cedar Head | Blue Hole | Mission | Devil's Eye | Grassy Hole | Mill Pond | Coffee | US 27 |
|--------------------------------------|-------------------------|-----------------------------------|------------|-----------|---------|-------------|----------------|-----------|--------|----------|
| DO (% saturation) | | | | | | | | | | |
| | 2000/POR Average | 58.7 | 36.4 | | 8 | 16.8 | 12 | 11.3 | 32.4 | 83.6 |
| DO (mg/L) | | | | | | | | | | |
| | 1980 | | | | | | | | | 5.070 |
| | 1990 | 4.470 | | 2.410 | 0.325 | 0.531 | 1.600 | 0.433 | 3.600 | 5.350 |
| | 2000 | 4.190 | 3.250 | 1.770 | 0.526 | 0.556 | 0.404 | 0.641 | 1.770 | 6.430 |
| | POR Average | 4.260 | 3.250 | 1.950 | 0.459 | 0.543 | 0.489 | 0.574 | 1.900 | 5.880 |
| NOx N (mg/L) | | | | | | | | | | |
| | 1990 | 0.760 | | 0.656 | 0.500 | 0.533 | 0.500 | 0.355 | 0.710 | 0.496 |
| | 2000 | 0.781 | 0.796 | 0.670 | 0.523 | 0.448 | 0.403 | 0.390 | 0.506 | 0.488 |
| | POR Average | 0.777 | 0.796 | 0.668 | 0.517 | 0.491 | 0.410 | 0.380 | 0.521 | 0.492 |
| Total Phosphorus (mg/L) | | | | | | | | | | |
| | 1990 | 0.031 | | 0.059 | 0.088 | 0.088 | | 0.090 | | 0.066 |
| | 2000 | 0.026 | 0.034 | 0.050 | 0.058 | 0.062 | 0.060 | 0.058 | 0.028 | 1.570 |
| | POR Average | 0.027 | 0.034 | 0.051 | 0.065 | 0.074 | 0.060 | 0.066 | 0.028 | 0.021 |
| Color (CPU) | | | | | | | | | | |
| | 1990 | 5.00 | | | | | | | | 16.10 |
| | 2000 | 2.61 | 3.64 | 2.17 | 3.23 | 5.00 | 5.00 | 2.81 | 4.81 | 5.50 |
| | POR Average | 2.85 | 3.64 | 2.17 | 3.23 | 5.00 | 5.00 | 2.81 | 4.81 | 9.96 |
| pH | | | | | | | | | | |
| | 1980 | | | | | | | | | 7.34 |
| | 1990 | 7.34 | | 7.48 | 7.49 | 7.48 | 7.63 | 7.51 | 7.13 | 7.49 |
| | 2000 | 7.45 | 7.49 | 7.47 | 7.43 | 7.46 | 7.48 | 7.42 | 7.57 | 7.64 |
| | POR Average | 7.43 | 7.49 | 7.47 | 7.45 | 7.47 | 7.49 | 7.45 | 7.54 | 7.56 |
| Secchi disc (m) | | | | | | | | | | |
| | 1980 | | | | | | | | | 0.908 |
| | 1990 | 1.2 | | 2.2 | 1.53 | 1.14 | | 0.517 | | 1.31 |
| | 2000 | 3.08 | 2.01 | 11.1 | 1.29 | | | 1.21 | | 1.16 |
| | POR Average | 2.91 | 2.01 | 9.49 | 1.35 | 1.14 | | 1.07 | | 1.22 |
| Specific conductivity (µS/cm) | | | | | | | | | | |
| | 1980 | | | | | | | | | 288 |
| | 1990 | 319 | | 293 | 292 | 310 | 313 | 347 | 241 | 309 |
| | 2000 | 325 | 309 | 309 | 313 | 349 | 363 | 370 | 296 | 312 |
| | POR Average | 323 | 309 | 304 | 306 | 329 | 359 | 362 | 292 | 310 |
| Total Dissolved Solids (mg/L) | | | | | | | | | | |
| | 1990 | 170 | | | | | | | | 180 |
| | 2000 | 183 | 172 | 174 | 178 | 213 | 233 | 219 | 174 | 191 |
| | POR Average | 182 | 172 | 174 | 178 | 213 | 233 | 219 | 174 | 196 |
| Temperature, °C | | | | | | | | | | |
| | 1980 | | | | | | | | | 21.4 |
| | 1990 | 21.3 | | 21.1 | 21.3 | 21.4 | 21.6 | 21.5 | 21.7 | 21.5 |
| | 2000 | 21.8 | 21.7 | 21.7 | 22 | 21.7 | 21.7 | 21.9 | 21.7 | 21.7 |
| | POR Average | 21.7 | 21.7 | 21.6 | 21.8 | 21.5 | 21.7 | 21.7 | 21.7 | 21.6 |

Table 1: Water Quality of Ichetucknee Springs, 1980, 1990, Period of Record (POR) average
Source: Wetland Solutions, Inc., 2010. An Ecosystem-Level Study of Florida's Springs. Appendix Q, Ichetucknee Springs.

Section 6: Nitrate

An increasing trend of nitrate is difficult to see from the POR for the years of 1990s-2000s in Table 1. One can see from Table 1 that nitrate increases downstream in Ichetucknee Springs. At the boil of Ichetucknee Headspring, the POR average is 0.777 mg/L. Blue Hole has a nitrate concentration of 0.668 mg/L, Devil's Eye concentration is 0.491 mg/L and Mill Pond is 0.380 mg/L. The trend is broken at Coffee Spring where nitrate is 0.521 mg/L. At US 27 nitrate again decreases to 0.492 mg/L. If the POR is extended beyond 1990, an increasing trend over time can be seen in all of the Ichetucknee springs. The concentration of nitrate in all of the springs of Ichetucknee is elevated with respect to the background concentration. The background concentration of nitrate in Florida springs is 0.05 mg/L (Upchurch, Chen, and Cain, 2007). A "safe level" of nitrate in Ichetucknee springs is said to be 0.30 mg/L. In 1946 nitrate concentration in Ichetucknee was 0.22 mg/L (Katz, 2004). In 1975 nitrate in Ichetucknee Headspring was 0.37 mg/L (Scott et al., 2004). By 1984 the nitrate concentration was about 0.70 mg/L. Nitrate concentrations began to exceed 0.80 mg/L in the 1990s and continued to fluctuate around this level in recent years (Figure 6; Hand, 2008).



Figure 6: Nitrate Concentrations in Ichetucknee Springs 1965-2008

Source: Hand, Joe. 2008. Algal Impairment of the Upper Ichetucknee River Springs.

When compared to other streams in the state, the nitrate concentrations in the spring fed Ichetucknee River are greater than the 95th percentile (FDEP, 2006). Out of

130 Florida springs analyzed for nitrate concentrations, Cedar Head Spring had the greatest nitrate concentration out of all of the Ichetucknee Springs at 0.87 mg/L. It has the 39th largest nitrate concentration out of all analyzed Florida springs. Ichetucknee Headspring had the second greatest nitrate concentration out of all Ichetucknee Springs, 0.77 mg/L. Blue Hole had the third greatest in Ichetucknee at 0.67 mg/L and Mission Springs had the lowest nitrate concentration in Ichetucknee, 0.48 mg/L (Wetland Solutions, Inc., 2010; Figure 7).

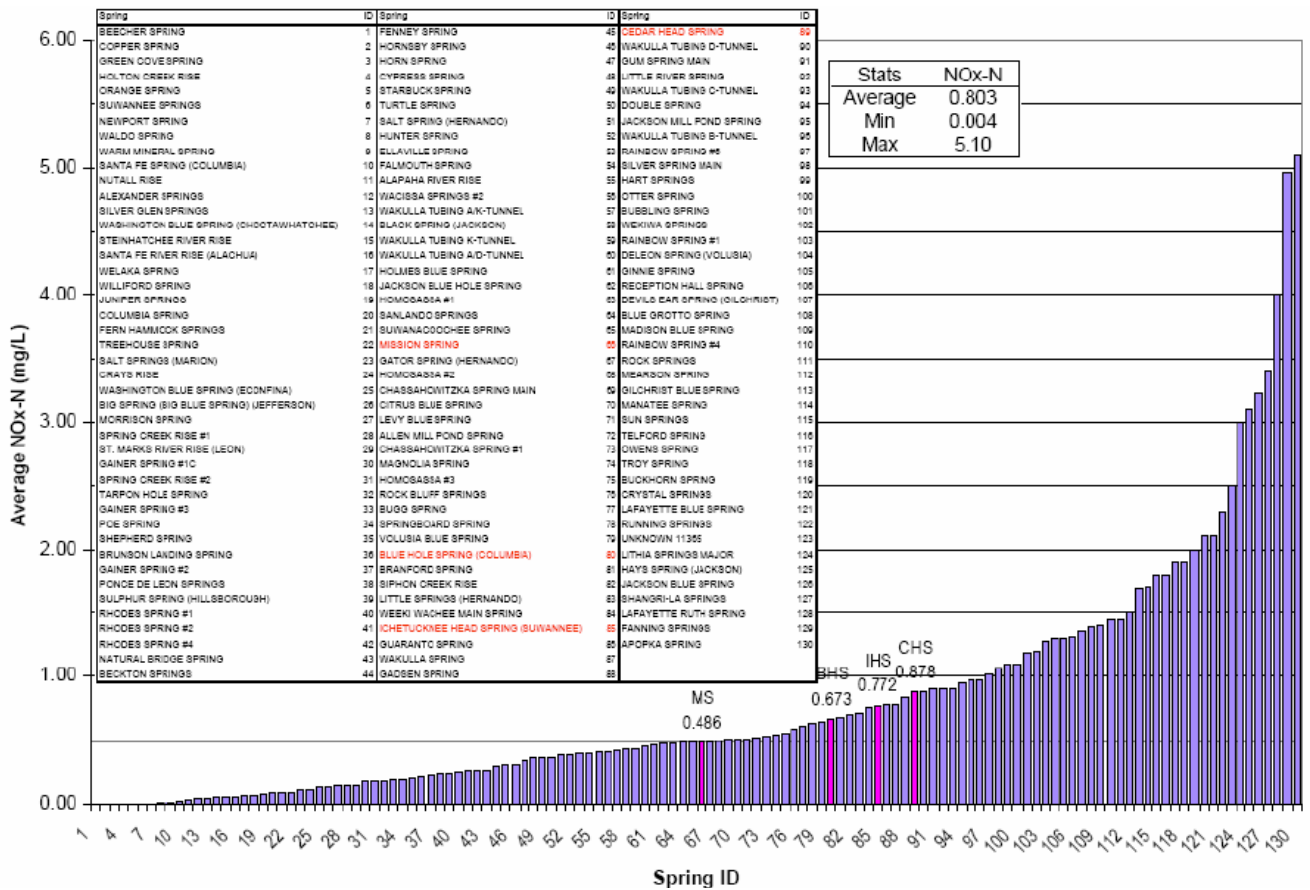


Figure 7: Nitrate Concentrations in Ichetucknee Springs
 Source: Wetland Solutions, Inc. 2010. An Ecosystem-Level Study of Florida's Springs.

The origin of nitrate in Ichetucknee springs varies depending upon where you are in the system.

Excess nitrate can fuel the growth of algae in springs. The greatest blue-green algae problem in Ichetucknee is located in the area below Mission Springs. Here the algal growth is due to both nitrate and low dissolved oxygen. D.O. value downstream of Mission Springs is 1.1 mg/L and nitrate is 0.61 mg/L. The chlorophyll *a* concentration in

this area is 537 mg/m² which is twice as great as the concentration upstream. A concentration greater than 150 mg/m² may constitute impairment (FDEP, 2006).

It is important to know what the sources of nitrate are to Ichetucknee Springs if restorative efforts are to be made. There are two major sources of nitrate to springs. They include fertilizers and wastewaters. Major fertilizer inputs are applied to crops, pastures, and residential lawns. Major wastewater sources include animal wastes from feedlots and pastures, human wastes from septic tanks and municipal wastewater treatment. A minor source of nitrate is atmospheric deposition (Upchurch, Chen, and Cain, 2007).

Section 7: Ichetucknee Algal Problem

The plants in Ichetucknee Springs are being negatively impacted by algal mats. The springs are becoming more dominated by filamentous algae and cyanobacteria (Evans, 2007). A little under 50% of the biomass of Ichetucknee is covered by *Lyngbya wollei* mats (Stevenson et al., 2007). *Lyngbya wollei* algal mats at Blue Hole Spring are said to be “severe” by Joe Hand and it ranks “5% of 59 Florida Springs sampled by Stevenson in 2003” (2008). The growth of *Lyngbya wollei* increases with increasing nitrate concentrations (Stevenson et al., 2007; Albertin, 2009). Nitrate from inorganic fertilizers is responsible for algal growth in Ichetucknee Head Springs and Blue Hole Spring. If nitrate concentrations were reduced, the growth of *Lyngbya wollei* would decline. However, it would take some time to see the growth rates decline (Albertin, 2009). Nitrate concentrations of less than 0.230 mg/L are needed to “to slow growth of *Lyngbya wollei*” (Stevenson et al., 2007). Cowell and Dawes suggest that a nitrate concentration of 0.30 mg/L would prevent *Lyngbya wollei* growth (2003). This is the concentration that is said to be the “safe level” of nitrate in spring water. Epiphytic algae growth (*Oscillatoria*) at Mission Springs is due to phosphorus concentrations. The “safe” phosphorus level is 0.03 mg/L. At Mission Springs, the 1990-2007 average phosphorus concentration was 0.065 mg/L (Hand, 2008).

Section 8: Florida Rules on Nutrients

Impairment is a designation that means a water body is “not meeting applicable water quality standards, which is a broad term that includes designated uses, water quality criteria, the Florida anti-degradation policy, and moderating provisions” which

are “due in whole or in part to discharges of pollutants from point or nonpoint sources” (F.A.C. Ch. 62-303, 2006). Subsection 13 of Ch.62-303 of the Florida Administrative Code pertains to the anti-degradation policy. It states, among other things, that nutrients “constitute one of the most severe water quality problems.” This subsection intends to limit nutrients in water bodies that are either already high in nutrient concentration or are “sensitive to further nutrient loadings.” The current nutrient water quality standards for nutrients in Florida are narrative, not numeric. They state that nutrients should not “cause an imbalance in natural populations of aquatic flora or fauna” (F.A.C., 2008). Impairment for nutrients in streams can be made if “algal mats are present in sufficient quantities to pose a nuisance” (F.A.C., 2006). In fifteen months (Hiers, 2010), the DEP will have to regulate a springs nitrate nutrient concentration of 0.35 mg/L that was imposed by the EPA (Obreza, 2010).

These rules (the Outstanding Florida Water designation, the anti-degradation policy, and the water quality standards) in combination or alone should provide protection to Ichetucknee Springs from increasing nutrient concentrations. Unfortunately, this has not been the case until recently when the EPA imposed nutrient criteria for Florida. While Ichetucknee Springs has not been considered impaired from a legal standpoint, it appears to meet the criteria of impairment with respect to nutrients. It should be considered impaired from a legal standpoint in fifteen months when the nutrient criteria are implemented.

Section 9: Land use and water use within the Ichetucknee Springshed

The earliest land use records that were obtained from a literature search for the Ichetucknee springshed are from 1977. While a springshed map with land use was not attainable for this year, land use category percentages were available. During this year forested lands made up 60% of the land area in the springshed, agriculture comprised 26%, water/wetlands made up 10%, and urban was 3.4% of the total land area (Katz, 2004). By 1995 land use in the springshed was still dominated by forests, but the percentage declined to 52%. Agriculture remained relatively constant at 25% of the total area, water/wetlands declined to 8.8%, and urban lands increased to 12% (Figure 8; Katz and Griffin, 2008).

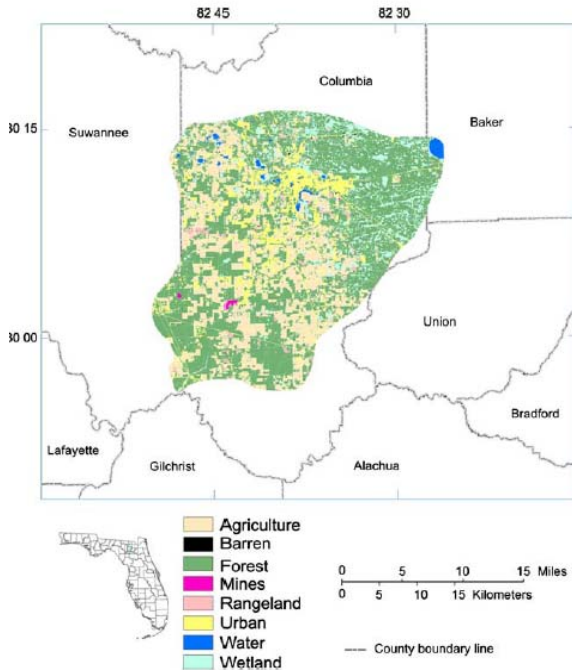


Figure 8: 1995 Land Use within the Ichetucknee Springshed

Source: Katz, Brian and Dale Griffin. 2008. Using chemical and microbiological indicators to track the impacts from the land application of treated municipal wastewater and other sources on groundwater quality in a karstic springs basin. *Environmental Geology* 55:801–821.

The main differences between these decades are that forested lands decreased by 8% and urban lands increased by 8.6%. It is likely that since the 1995 land use data was collected, forested land area has further declined while urban areas have continued to increase (Wetland Solutions, Inc., 2006). While agriculture has head relatively constant, the Ichetucknee springshed contains most of the agriculture land area in Columbia County. Approximately 66% of the entire agricultural area of the county is in the springshed (Katz, Sepulveda, and Verdi, 2009). Groundwater quality, or spring water quality since springs are fed by groundwater, have been said to be “controlled to a large extent by land use” (Lindsey et al., 2010). Land uses such as agriculture and urban areas are associated with high fertilizer use. Fertilizer used on the land surface within a springshed can elevate the nitrate concentration in springs (Katz, 2004). This is especially true if high fertilized areas in the same location as vulnerable recharge areas within the springshed. Within the Ichetucknee springshed, the land use of pasture and crop lands dominate the aquifer recharge areas (Hornsby, 2007). The recharge areas within the Ichetucknee springshed are mainly located where the Floridan aquifer is

unconfined (Figure 3). In addition to recharge areas, vulnerable areas include locations where sinkholes are present. Areas with both an agricultural land use category and high sinkhole density are considered the most vulnerable to nitrate contamination. However, areas with low sinkhole density and an agricultural land use were also found to be vulnerable (Lindsey et al., 2010).

Section 10: Physiographic Regions and Hydrogeology of the Ichetucknee Springshed

As shown in Figure 3, the Ichetucknee Springshed includes both confined, semi-confined, and unconfined areas of the Floridan aquifer. The aquifer is confined by the Hawthorne formation north of the springs in the physiographic area named the Northern Highlands (Figure 9). The Northern Highlands have a recharge of about 15-60 cm/year to the Upper Floridan Aquifer (Katz, Sepulveda, and Verdi, 2009).

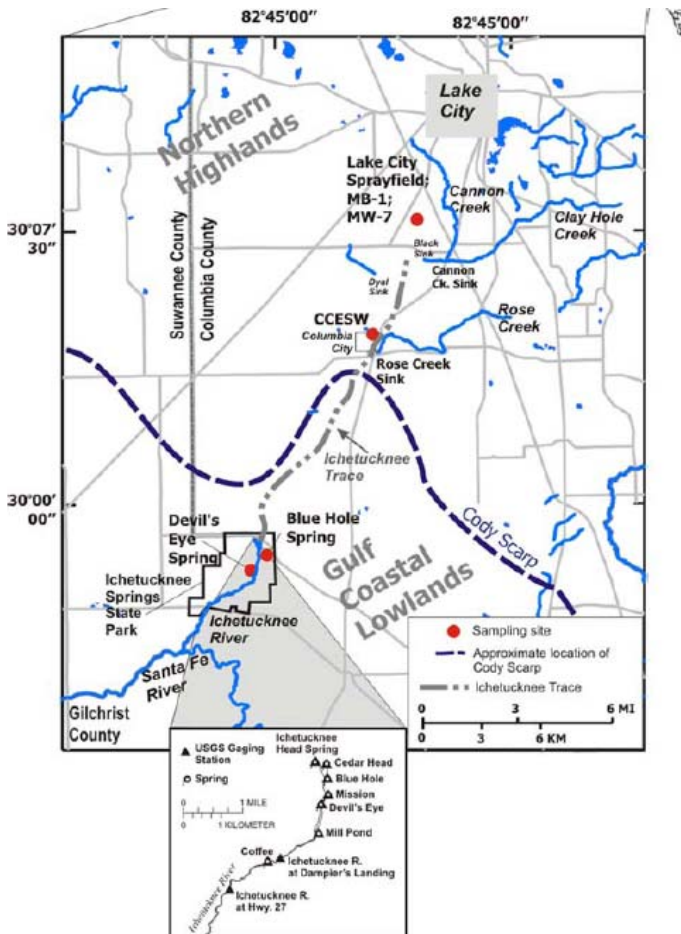


Figure 9: Physiographic Regions of the Ichetucknee Springshed

Source: Katz, Brian and Dale Griffin. 2008. Using chemical and microbiological indicators to track the impacts from the land application of treated municipal wastewater and other sources on groundwater quality in a karstic springs basin. Environmental Geology 55:801–821.

The springs are situated in the Gulf Coastal Lowlands. Here there are numerous small sinkholes and the aquifer is unconfined. The Gulf Coastal Lowlands are said to be “highly vulnerable” by Sam Upchurch. The unconfined lowlands recharge the Upper Floridan Aquifer 45-80 cm/year (Katz, Sepulveda, and Verdi, 2009). The Cody Scarp is where the springshed transitions from the Northern Highlands to the Gulf Coastal Lowlands. Here there are large sinkholes and sinking streams (Upchurch, 2007). The Ichetucknee Trace is a “dry river valley” (Katz, Sepulveda, and Verdi, 2009) that extends north of Rose Creek to Ichetucknee Springs. The trace has also been said to be highly vulnerable and is a significant recharge area in the springshed (Skiles, Hayes, and Butt, 1991).

Butt et al. conducted a dye trace study and found a hydrogeologic connection between the Rose Creek Swallet, which is just north of the Cody Scarp in the Northern Highlands and Mission Spring, Blue Hole Spring, Grassy Hole Spring, Millpond Spring, Devils Eye Spring, and Cedar Head Spring. There was no hydrogeologic connection between Rose Creek and Ichetucknee Headspring and Coffee Spring. The dye showed up in Mission Spring after 6 days and in the other springs between 12-18 days after it was released (1997). This provides evidence that contamination released around Rose Creek can end up in several springs within the Ichetucknee Springs system.

Section 11: Nitrogen Loading in the Ichetucknee Springshed

Katz, Sepulveda, and Verdi estimated the nitrogen loading within the Ichetucknee Springshed. The inputs to the land surface include atmospheric deposition (402,230 kg/yr), fertilized crops which includes golf courses and pastures (707,470 kg/yr), fertilized yards (372,770 kg/yr), fertilized pine stands (266,280 kg/yr), the Lake City wastewater sprayfield (30,980 kg/yr), biosolids (13,250 kg/yr), animal wastes (706,340 kg/yr) and septic tanks (152,040 kg/yr). The inputs total 2,651,360 kg/yr. Anywhere from 5-70% of the loads actually reaches the groundwater. It is estimated that 261,554-1,343,626 kg/yr of the total inputs reach the groundwater (Table 2; 2009).

| Nitrogen Inputs to Groundwater | | | | |
|--|--|--|----------------------|----------------------|
| source | minimum percent % of total load | maximum percent % of total load | minimum kg/yr | maximum kg/yr |
| atmospheric deposition | 5 | 30 | 20,112 | 120,669 |
| fertilized crops, improved pasture, golf courses | 10 | 50 | 70,747 | 353,735 |
| fertilized yards | 10 | 50 | 37,277 | 186,385 |
| fertilized pine stands | 10 | 50 | 26,628 | 133,140 |
| sprayfield | 20 | 50 | 3,098 | 15,490 |
| biosolids | 20 | 30 | 2,650 | 3,975 |
| animal wastes | 10 | 60 | 70,634 | 423,804 |
| septic tanks | 20 | 70 | 30,408 | 106,428 |
| total | | | 261,554 | 1,343,626 |

Table 2: Nitrogen Inputs to Groundwater from Various Sources within the Ichetucknee Springshed

Source: Katz, Brian G., Alejandro Sepulveda, and Richard J. Verdi. 2009. Estimating Nitrogen Loading to Ground Water and Assessing Vulnerability to Nitrate Contamination in a Large Karstic Springs Basin, Florida. Journal of the American Water Resources Association 45(3):607-627.

Nitrogen losses can be calculated based on the percentage of the total load that leaches into the groundwater. Katz et al. named various nitrogen losses that included the retention by soils and vegetation, plant uptake, nitrogen volatilization, and denitrification, and the export of nitrogen from the springshed in by the spring water (Table 3).

| Nitrogen Losses | | | | |
|--|--------------------------------------|--------------------------------------|----------------------|----------------------|
| source | minimum percent of total load | maximum percent of total load | minimum kg/yr | maximum kg/yr |
| atmospheric deposition retained in soils | 70 | 95 | 281,561 | 382,118 |
| volatilization in fert from crops | 50 | 90 | 353,735 | 636,723 |
| volatilization in fert from lawns | 50 | 90 | 186,385 | 335,466 |
| volatilization in fert from pine stands | 50 | 90 | 133,140 | 239,652 |
| denitrification from septic tank drain field | 30 | 80 | 45,612 | 121,608 |
| removal (plant uptake, soils) from sprayfield | 50 | 80 | 15,490 | 24,784 |
| removal (plant uptake, soils) from biosolids | 70 | 80 | 9,275 | 10,600 |
| removal (plant uptake, soils) from animal wastes | 40 | 90 | 282,572 | 635,706 |
| Total | | | 1,307,770 | 2,386,657 |

calculation based on Katz et al. percentage inputs from each source

Table 3: Nitrogen Losses through Various Sources within the Ichetucknee Springshed

Calculations based on information provided in Katz, Brian G., Alejandro Sepulveda, and Richard J. Verdi. 2009. Estimating Nitrogen Loading to Ground Water and Assessing Vulnerability to Nitrate Contamination in a Large Karstic Springs Basin, Florida. Journal of the American Water Resources Association 45(3):607-627

Katz et al. found that minimal nitrogen leaching rates of 261,554 kg/yr closely approximate the total nitrogen removed from the springshed in the springwater, 266,260 kg/yr (2009). If you take the nitrogen loads to the surface, 2,651,360 kg/yr, and subtract the minimum of nitrogen losses, 1,307,770 kg/yr, you get the maximum nitrogen leaching to groundwater. Likewise, total nitrogen loads to the surface minus the maximum nitrogen losses, yields the minimum nitrogen leaching to groundwater.

If minimal nitrogen loading to groundwater is assumed, fertilizer is responsible for 51% of the total loads (sum of fertilizer used on crops, pasture, golf courses, yards, and pine stands) followed by animal wastes (27%), and septic tanks (11.6%) (Figure 10). If maximum loading to groundwater is assumed the sum of fertilized sources is responsible for 50% of the total loading, followed by 31.5% from animal wastes, and 9 percent from atmospheric deposition (Figure 11).

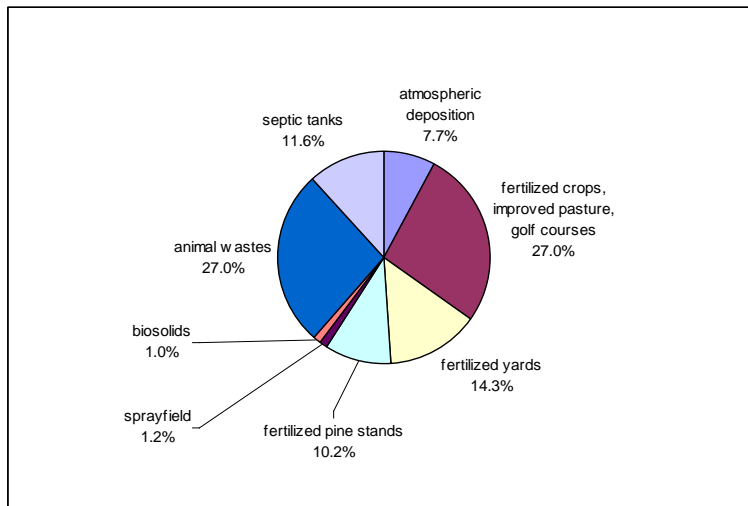


Figure 10: Minimum Nitrogen Loading to Groundwater within the Ichetucknee Springshed by Source

Compiled from data in Katz, Brian G., Alejandro Sepulveda, and Richard J. Verdi. 2009. Estimating Nitrogen Loading to Ground Water and Assessing Vulnerability to Nitrate Contamination in a Large Karstic Springs Basin, Florida. *Journal of the American Water Resources Association* 45(3):607-627

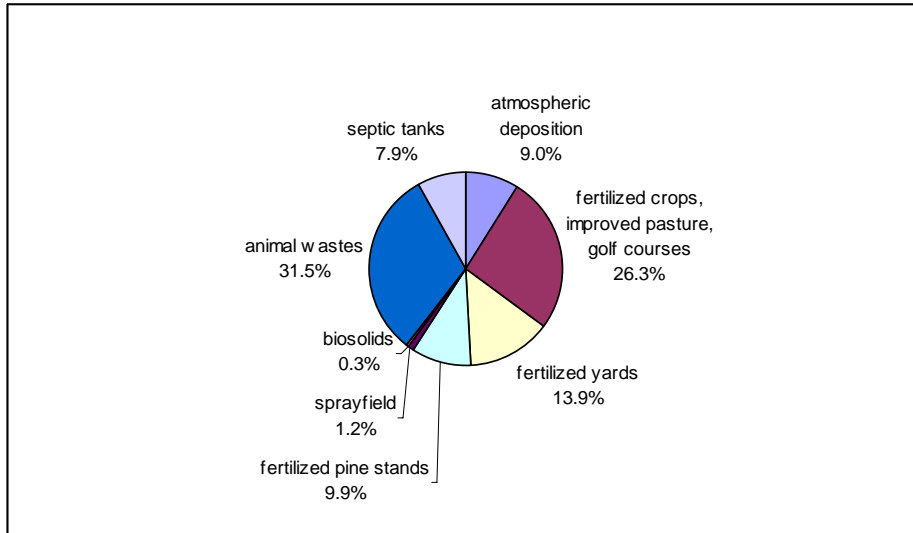


Figure 11: Maximum Nitrogen Loading to Groundwater within the Ichetucknee Springshed by Source

Compiled from data in Katz, Brian G., Alejandro Sepulveda, and Richard J. Verdi. 2009. Estimating Nitrogen Loading to Ground Water and Assessing Vulnerability to Nitrate Contamination in a Large Karstic Springs Basin, Florida. *Journal of the American Water Resources Association* 45(3):607-627

Section 12: Water use within the Ichetucknee Springshed

Since the majority of the springshed lies within Columbia County, estimates of population and water use for Columbia County are provided. The population of Columbia County in 2000 was 56,513 (SRWMD, 2004). For the year 2000, water withdrawals in the county totaled 10.5 mgd (million gallons/day) according to the SRWMD. 35% of the 10.5 mgd (or 3.675 mgd) was used for public supply, 30% (3.15 mgd) was used for agriculture, 28% (2.94 mgd) was used for domestic self-supply (for individuals with private household wells), 3% (0.315 mgd) was used for commercial/power generation (SRWMD, 2004). Ichetucknee Springshed makes up 44% of the total Columbia County land area. An approximation of population in the springshed is 24,865. An approximation of water use within the springshed based on total water use for the County yields, 1.617 mgd for public supply, 1.386 for agriculture, 1.294 for domestic self-supply, and 0.139 for commercial/power.

There are approximately 351 consumptive use permits in Columbia County which have a total final ADR, average daily rate of 24.13 mgd. Kevin Wright from the SRWMD explained that this number exceeds the total 2000 water withdrawals of 10.5 mgd because most permit holders never use their total allocations. Permit holders are

only using 40% of their allocation (2010). 154 of these permits are within the springshed if it is assumed that 44% of them are within the springshed area.

Water consumption has caused the potentiometric surface of the Floridan Aquifer within the springshed to decrease slightly over time. A predevelopment potentiometric surface map when looking at the southwest Columbia County where the Ichetucknee River is located shows elevations between 20-30 ft (Figure 12). A 2003 potentiometric surface map in the same general area shows elevations between 16-26 ft (Figure 13). Trey Grubbs of the USGS said that groundwater flow from the Jacksonville area (Duval and Nassau counties) used to flow towards the Suwannee River and the Ichetucknee River, but is now being diverted towards the Jacksonville area (2010). To see the bigger picture and to get an idea of the regional declines in the Upper Floridan Aquifer's potentiometric surface, one must look at the Duval and Nassau county area (Figure 14). Here, maximum declines are 40 feet in Duval County and 120 feet in Nassau County. The largest category of total water use in these counties, as in Columbia County, is for public supply. In 2000, Duval County withdrew 119.12 mgd of water just for public supply and the total amount of water used for all water categories was 154.33 mgd (Marella, 2004).

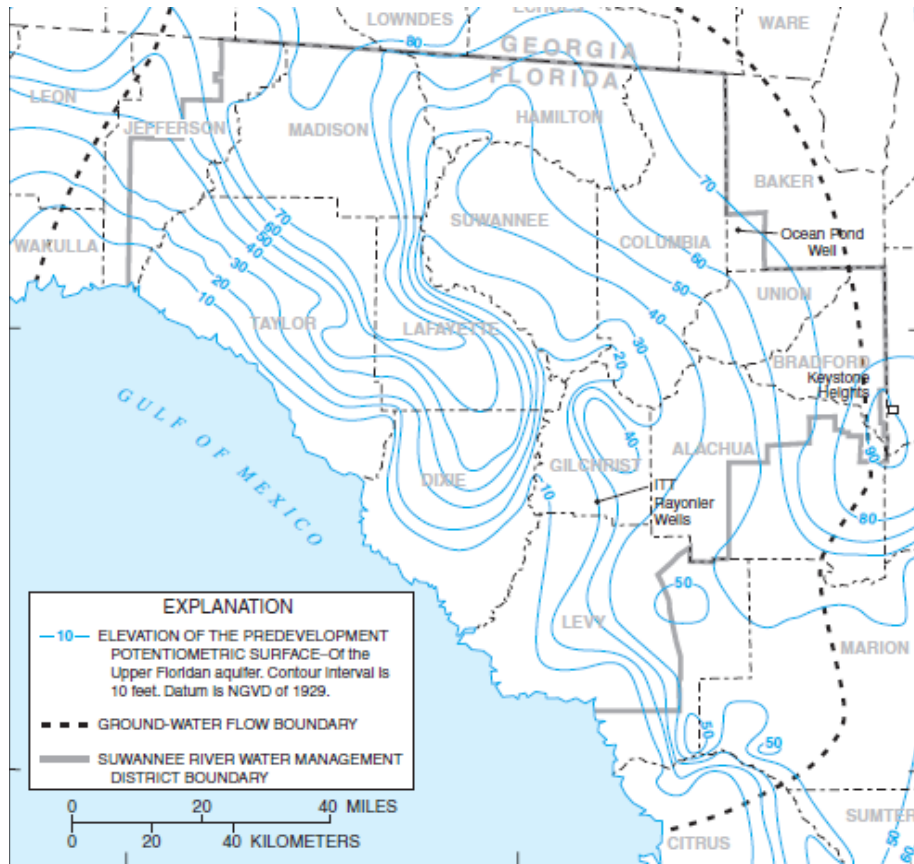


Figure 12: Predevelopment Potentiometric Surface Map of the Upper Floridan Aquifer
 Source: Planert, Michael. 2007. Simulation of Regional Ground-Water Flow in the Suwannee River Basin, Northern Florida and Southern Georgia. U.S. Geological Survey. Scientific Investigations Report 2007-5031

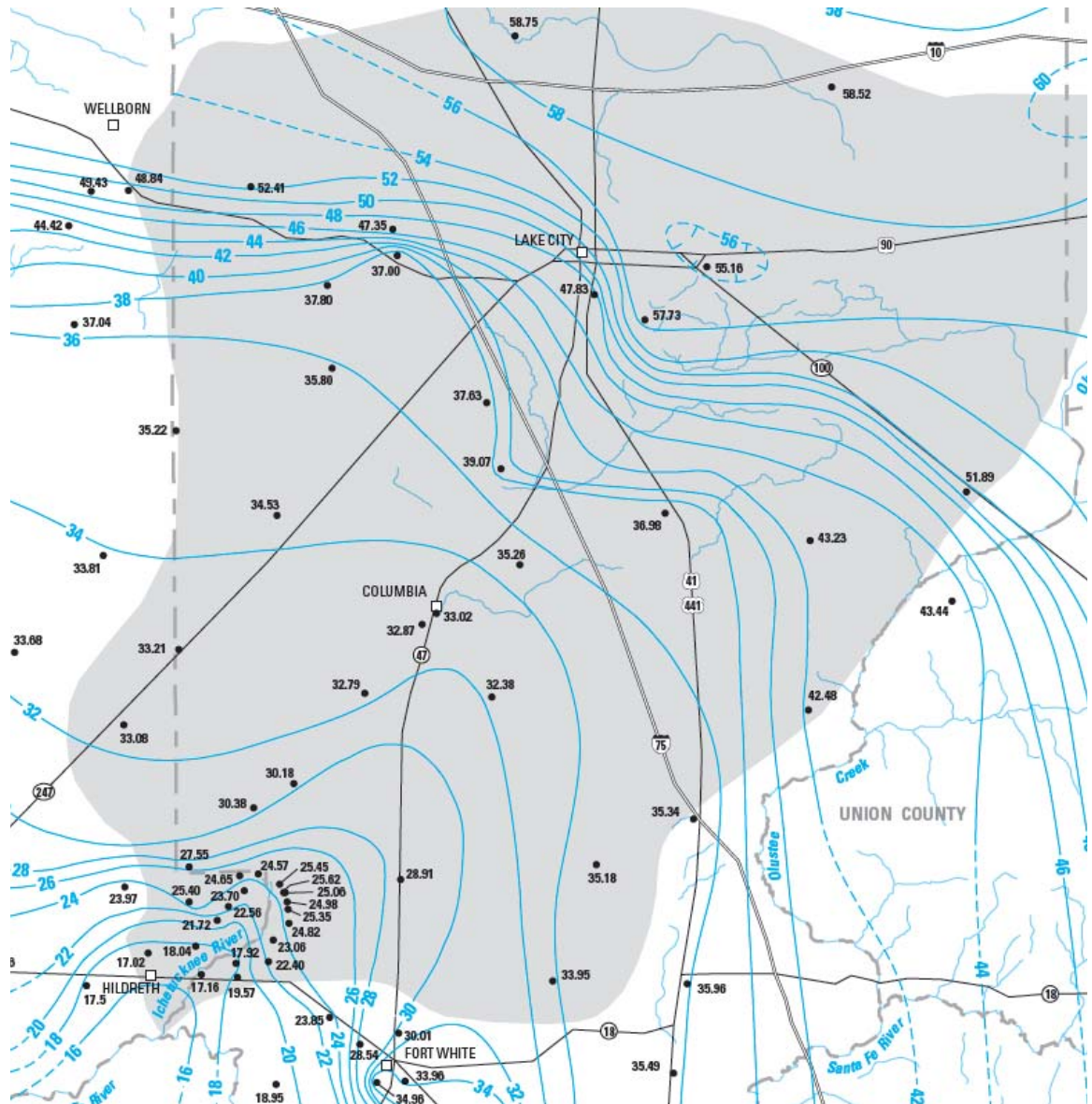


Figure 13: 2003 Potentiometric Surface of the Upper Floridan Aquifer in the Ichetucknee Springshed

Source: Sepúlveda, A.A. and others, 2006, Potentiometric Surface of the Upper Floridan Aquifer in the Ichetucknee Springshed and Vicinity, Northern Florida, September 2003. U.S. Geological Survey. Open-File Report 2006-1031.

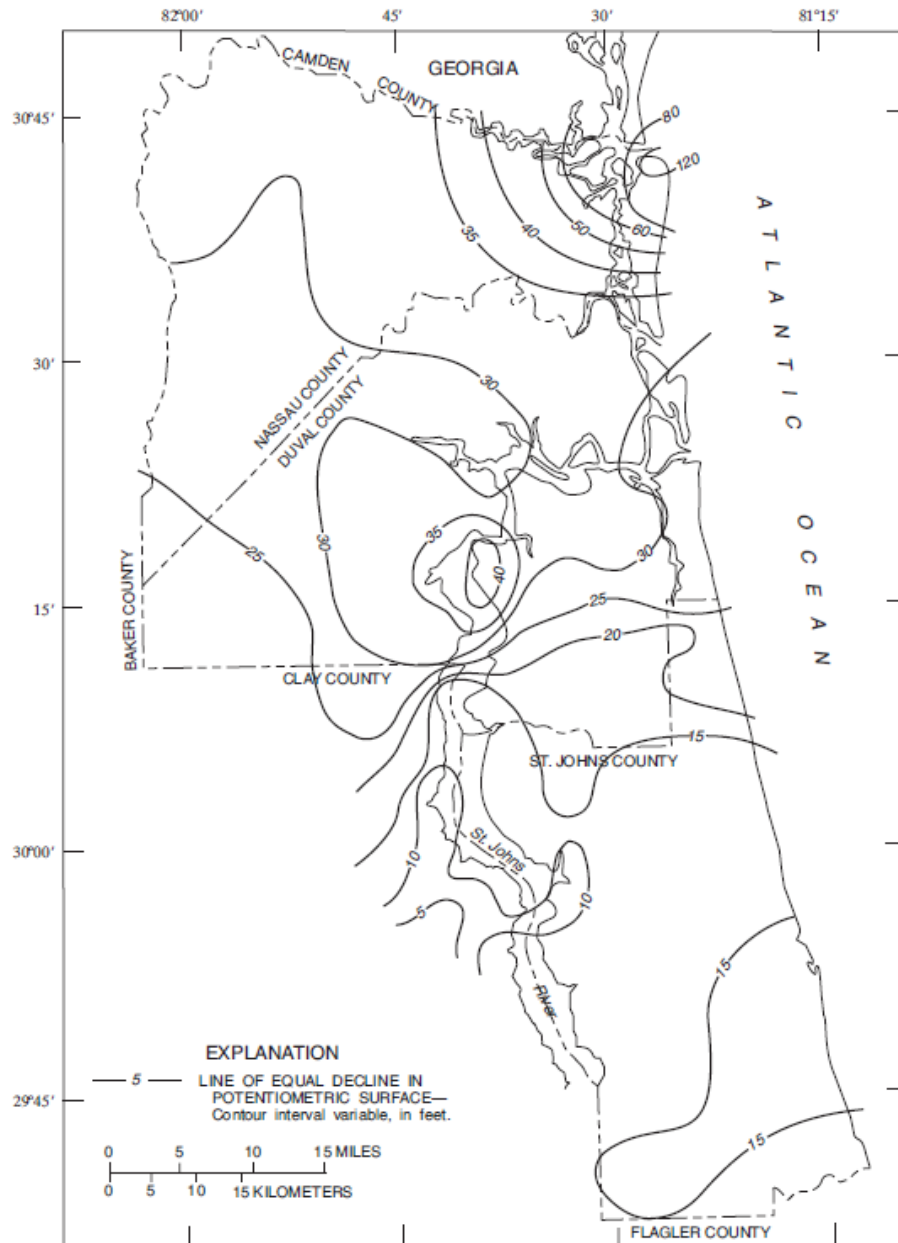


Figure 14: Potentiometric Surface Declines in the Floridan Aquifer in Northeast Florida from 1880-1989

Source: Spechler, Rick M. 1994. Saltwater Intrusion and Quality of Water in the Floridan Aquifer System, Northeastern Florida. U.S. Geological Survey: Water-Resources Investigations Report 92-4174.

Section 13: Vision for Ichetucknee Springs Restoration

The greatest problem in Ichetucknee Springs is nitrate and algae as indicated by a D+ and D- grade in the Report Card. Algal cover is >90% in Mission Springs and around 40% at Devil's Eye and Blue Hole Spring (Wetland Solutions, Inc., 2008). As stated in the introduction, restoration efforts should focus on decreasing nitrate

in the springs and river. They are elevated above background conditions and elevated above the “safe level.” A nitrate reduction to a concentration of 0.30 mg/L in Ichetucknee should be the target goal for restoration since this concentration will slow the growth of *Lyngbya wollei* and since this is considered the “safe level.” Cedar Head Spring has an average nitrate concentration of 0.87 mg/L, Blue Hole has 0.67 mg/L, and Mission Springs has 0.48 mg/L. A 65% reduction (a reduction of 0.57 mg/L) would be necessary at Cedar Head Springs to reach the 0.30 mg/L target. At Blue Hole, a 55% reduction is necessary (0.37 mg/L) and at Mission Springs, a 37% reduction is needed (0.18 mg/L) to meet the target.

Another goal would be to prevent discharge from declining further. This goal could possibly be achieved through water conservation efforts both within the springshed and northeast of the springshed in Duval/Nassau counties. Efforts must be made in the northeast since the flow of groundwater to the springs is from this direction.

Some strategies that could help to achieve the nitrate reduction goal would be to decrease the use of fertilizer within the springshed. A geographic focus should be to reduce fertilizer in recharge areas, in both the Cody Scarp and the Gulf Coastal Lowlands. However, reductions should also be made in the Northern Highlands in areas that drain into the swallets that have been found to have connections with Ichetucknee Springs. Efforts to achieve this goal could include fertilizer ordinances for residents, best management practices for golf courses and agriculture, the upgrade of conventional septic tanks to performance based septic tanks (particularly in areas where septic tank density is high). Since fertilizer use contributes to at least 50% of the nitrogen loading to groundwater in the springshed, efforts to reduce its use should be a high priority. Another high priority would be for agriculture areas to implement best management practices that deal with animal wastes in areas with dense animal populations since animal waste contributes up to 30% of the nitrogen loading in groundwater. A medium priority would be to upgrade conventional septic tanks since they contribute to at most 11% of the total nitrogen groundwater loading. A low priority would be to end the spraying of wastewater from the Lake City wastewater treatment plant. This is responsible for 1.2% of the total nitrogen in groundwater in the springshed.

The stakeholders that would be impacted and should be consulted to implement any restoration goals have been identified by the Ichetucknee Springs Working Group. They include the citizens of the springshed and Columbia and Suwannee Counties, the City of Lake City/Fort White, Columbia County Health Department, Columbia County Tourist Development Council, Suwannee River Water Management District, North Central Florida Regional Planning Council, Santa Fe Soil & Water Conservation District, Department of Environmental Protection, Department of Agriculture & Consumer Services, Florida Department of Health, Fish & Wildlife Conservation Commission, the University of Florida, Save Our Suwannee, Sierra Club, Florida Defenders of the Environment, Karst Environmental Services, Wetland Solutions Inc., and S & S Food Stores (2006; for a complete list, see Appendix.)

Section 14: Nitrate Reduction Goal- Fertilizer Ordinances

Residential yards contribute 13.9-14.5% (37,277-186,385 kg/yr) of the total 51% of fertilizer inputs to nitrogen groundwater loading in the Ichetucknee springshed. Florida-friendly landscape practices should be made into an ordinance in Columbia County. Three of the nine principles of Florida-friendly landscaping would be beneficial to decrease fertilizer inputs to Ichetucknee. The first principle, Fertilize Appropriately, has obvious benefits. The principle says not to “exceed recommended amounts” of fertilizer, “use slow release fertilizers,” and do not fertilize during heavy rain. The second principle Reduce Storm water Runoff says to “sweep grass clippings, fertilizer and soil on to the lawn so they don’t get washed into storm drain.” The third principle Protect the Waterfront says to set a 10-30 ft. fertilizer-free zone along a water body and to “plant a buffer zone of low-maintenance plants between your lawn and shoreline to absorb nutrients” (FloridaYards.org).

When establishing the exact wording of the fertilizer ordinance, Columbia County should follow some of the Florida DEP’s Model Ordinance for Florida-Friendly Fertilizer Use on Urban Landscapes. This ordinance includes regulations on the timing of fertilizer application (2010). The ordinance for Columbia County may want to limit the use of fertilizer during the rainy season, June 1-September 30. As the DEP says, this would be controversial, but it is also necessary to protect the recharge areas within the springshed, both the unconfined areas and the karst sinkhole areas. The model DEP ordinance states

that the third principle of Florida-Friendly landscaping that would provide a 10-30 ft. buffer zone is “recommended, but not mandated” (2010). For increased The Columbia County ordinance would want to consider mandating this recommendation. The model ordinance also says regulates commercial fertilizer training and prohibits fertilizer use on impervious surfaces.

Section 15: Nitrate Reduction Goal- Golf Course Best Management Practices

Golf courses do not play a huge role in fertilizer inputs to the land surface (12,000 kg/yr; Katz Sepulveda, and Verdi, 2009) and groundwater within the Ichetucknee springshed, but they nonetheless still contribute to nitrate in the springs/river. Golf course managers should adhere to the best management practices outlined in the Florida DEP’s Best Management Practices for the Enhancement of Environmental Quality on Florida Golf Courses manual. The manual says that fertilizer on golf courses should be loaded into machinery away from water bodies and if any spill occurs that it must be cleaned up immediately. It also suggests calibrating the machinery in order to know the amounts of fertilizer being applied and to prevent excess unnecessary fertilizer inputs. Deflector shields should also be used to prevent the fertilizer applied through irrigation systems from reaching golf course water bodies. When golf courses are mowed, grass clippings should be left on the course (2007).

Section 16: Nitrate Reduction Goal- Agriculture Best Management Practices for Fertilizers

Agriculture contributes significantly to the nitrate inputs to groundwater in the Ichetucknee springshed. They contribute both through fertilizer inputs to crops and animal wastes. Fertilized cropland alone contributes between 70,747-353,735 kg/yr of the nitrogen load to groundwater. 66% of all of the cropland in Columbia County is within the Ichetucknee springshed. 49 row crop farms out of 76 total in the county are within the springshed and 533 farms with improved out of the 688 county total are within the springshed (Katz, Sepulveda, and Verdi, 2009). Plants only take up about 50-70% of the fertilizer that is applied.

Three general agricultural fertilizer best management practices have been identified by the Florida Department of Agriculture and Consumer Services (FDACS) and FL DEP: isolate fertilizer materials (know where they are stored and how they should

be stored), minimize fertilizer discharges, and conserve fertilizers. More specifically with the case of isolating fertilizers, it is important that they be stored in a place that avoids contact with rain. This can help to prevent the fertilizer from running off into a surface water body and percolating into the groundwater. Fertilizer discharges can be minimized by loading the material into equipment away from water bodies. If they are spilled, they must be cleaned up immediately (1998).

When applying fertilizers to crops, specific best management practices should be followed. However, some steps should be followed before any fertilizer is applied. Soils should be tested for pH and maintained around 6-6.5. Soil texture, organic matter and moisture content should be analyzed and with the aid of GPS, appropriate plots should be selected for planting that would yield the greatest crop return with the lowest fertilizer inputs. The crop nutrient requirement for the crop that will be planted must be known beforehand. Drip irrigation should be practiced to deliver fertilizer directly to the plants roots. “Double cropping” should be utilized since this eliminates the need of nitrogen fertilizer inputs after the first or previous crops are harvested. This practice uses “residual nutrients” instead of new inputs. Controlled release fertilizer is also recommended. (FDACS, 2005). Controlled release fertilizers prevent all but small amounts of the fertilizer from leaching and bypassing the root zone during dry periods and rain events (Oertli, 1980).

Section 17: Nitrate Reduction Goal- Agriculture Best Management Practices for Animal Waste

There are approximately 12,000 cows and 200,000 chickens within the Ichetucknee springshed (Katz, Sepulveda, and Verdi, 2009). Wastes from these animals contribute to the nutrient problem in the springs. A best management practice that could prevent animal waste from running off into surface water bodies that feed the springs and sinkholes are conservation buffers. The Florida Springs Task Force recommends a 100 foot vegetated conservation buffer (Figure 15; Florida Department of Community Affairs and FDEP, 2002).



Figure 15: Conservation Buffer around a Sinkhole

Source: FDCA and FDEP. 2002. Protecting Florida's Springs, Land Use Planning Strategies and Best Management Practices.

Another recommendation would be to remove any existing concentrated animal feedlots from the “primary” and “secondary” springshed protection areas. Primary areas include portions of the springshed that are recharge areas, the springs themselves, spring runs, surface waters that fed springs, and sinkholes. Secondary areas are those portions of the springshed outside of the primary protection areas that contribute water to the springs (Florida Department of Community Affairs and FDEP, 2002). Springshed protection areas for Ichetucknee include the Ichetucknee Trace and a ½ mile buffer around the trace, the springs area, Rose Creek and Swallet, Cannon and Clay Hole Sinks, areas around and near sinkholes, and areas with low potentiometric surface gradients (Figure 16; SDII Global Corporation, 2004).

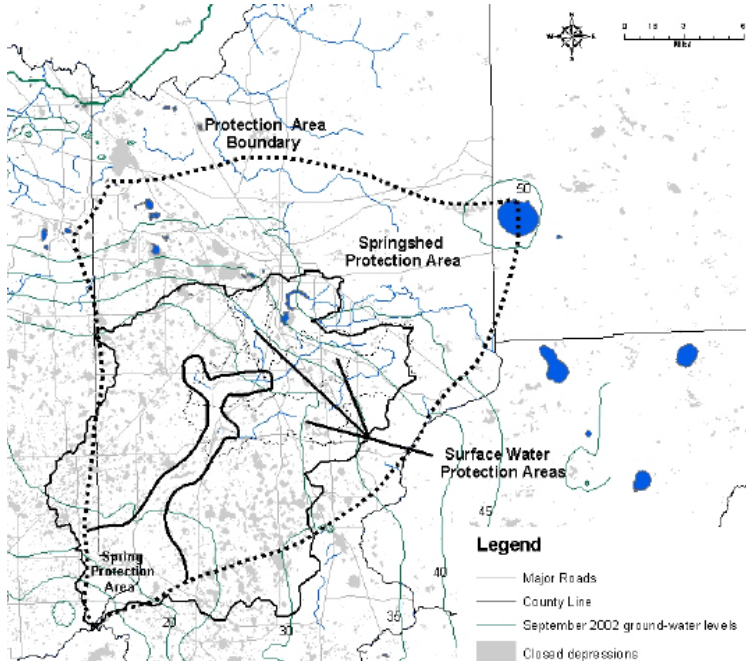


Figure 16: Ichetucknee Springshed Protection Areas

Source: SDII Global Corporation. 2004. DELINEATION OF SPRING PROTECTION AREAS AT FIVE, FIRST-MAGNITUDE SPRINGS IN NORTHCENTRAL FLORIDA.

The protection areas appear to encompass the entire springshed. Therefore, concentrated animal feedlots should be moved out of the springshed, if at all possible. If they remain within the springshed, they should be heavily buffered by conservation buffers. Berms should be constructed outside of the conservation buffers for added protection around sinkholes and water bodies. Shading/watering areas for cattle and other animals should be located away from water bodies (Florida Cattleman’s Association et al., 1997) that are known to feed the springs, and from sinkholes and other karst features.

Section 18: Nitrate Reduction Goal- Upgrade Areas with High Density Conventional Septic Tanks

67% (14,090) of Columbia County septic tanks are within the Ichetucknee springshed (Figure 17). They are responsible for 30,408-106,428 kg/yr of the nitrogen load to groundwater (Katz, Sepulveda, and Verdi, 2009).

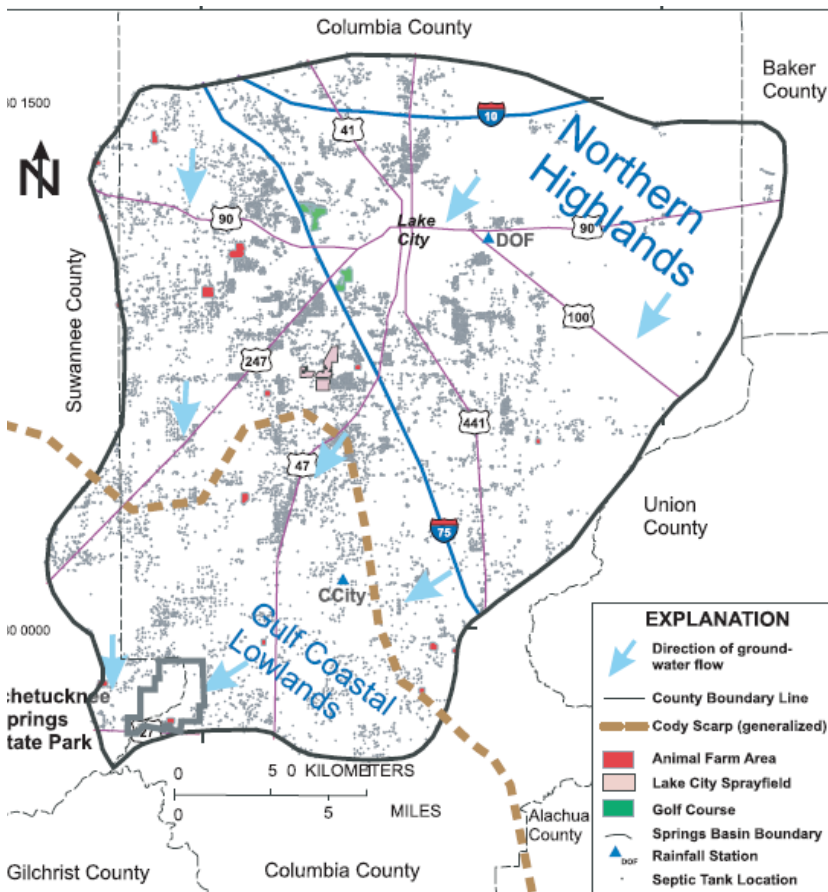


Figure 17: Location of Septic Tanks within the Ichetucknee Springshed
 Source: Katz, Sepulveda, and Verdi. 2009.

60% of all septic tanks are said to be faulty. The density of septic tanks is a “major concern” because high densities exceed the “natural ability of the subsurface environment to receive and purify system effluents prior to their movement into ground water” (Canter and Knox, 1985). The minimum lot size needed to have a properly functioning septic tank system is one acre (Cotteral and Norris, 1969 as cited in Canter and Knox, 1985).

A Wakulla County study found that conventional septic tank systems have effluent concentrations of 64 ± 13 mg-N/L while performance based septic tank systems have 29 ± 19 mg-N/L. The study showed that conventional systems are generally capable of reducing nitrogen by $9 \pm 19\%$ while performance based systems can reduce nitrogen by either $56.0 \pm 15.9\%$ or $58.9 \pm 28.5\%$ (Harden and Chanton, 2010). In 2006 Wakulla County passed Ordinance 2006-58 that required all failing septic tanks to be upgraded to performance based and all newly constructed homes be built with performance based septic tanks. The ordinance requires all septic tanks to be inspected every three years to determine if they are failing (Gilbert, 2010). Wakulla County wanted the performance systems to have effluents less than 10 mg/L, but at the present time, many of the systems are above this desired limit (Wakulla County Board of County Commissioners, 2010). Performance based septic tanks are more expensive than conventional tanks. They cost approximately \$9,433-10,283 for a 3-4 bedroom home whereas conventional tanks are \$2,666-3,200 (Leon County Government, 2009). Columbia County should implement a similar ordinance to protect Ichetucknee Springs. A priority should be to upgrade failing systems near the recharge areas of the springs. Even if the systems do not achieve 10 mg/L, they are still far superior than the 64 ± 13 mg-N/L effluent of conventional systems.

Section 19: Nitrate Reduction Goal- Eliminate the Spraying of Wastewater at Lake City

The Lake City wastewater treatment plant sprayfield contributes anywhere from 3,098-15,490 kg/yr of the nitrogen load to groundwater in the Ichetucknee springshed. The plant also contributes 2,650-3,975 kg/yr the nitrogen load to groundwater from biosolids (Katz, Sepulveda, and Verdi, 2009). Lake City should consider the conversion of the sprayfield to a wastewater treatment wetland. Treatment wetlands are less expensive to operate than sprayfields. They are also capable of reducing nitrogen loading

to the aquifer. Construction costs for a treatment wetland for Lake City are estimated to be \$4,212,660- 7,092,160 (Keller and Knight, 2006).

Section 20: Prevention of Discharge Reduction Goal- Water Conservation

Water conservation within the Ichetucknee springshed, Columbia County, and northeast of the springshed in the heavily populated Jacksonville area would be beneficial to preventing further declines in discharge of Ichetucknee Springs. Groundwater flow is in a southwest direction from the Jacksonville area towards the Ichetucknee Springs area. The Jacksonville area is part of the St. Johns River Water Management District and they are predicting an 118% increase in the public water supply category by 2030 (SJRWMD, 2009). The public supply category is expected to increase to 6.41 mgd by 2030 for Columbia County (SRWMD, 2010). This is more than a 70% increase from the public supply consumption of 2000.

To prevent these substantial increases in public supply, water conservation both inside and outside of the home is recommended as well as the use of price to reduce water demand. Outside conservation efforts, such as reducing lawn irrigation, may prove to be slightly more beneficial than indoor efforts since more than of 50% of water is used outdoors (SJRWMD, 2009). SJRWMD and SRWMD already have mandatory lawn irrigation restrictions. The problem with the restrictions is that they are not uniformly enforced. Enforcement of these restrictions is the key to reduce water demand. Water demand can be reduced from 15-22% if restrictions have high enforcement where violators are issued fines and if the informational/educational intensity to publicize these restrictions are high. (Halich and Stevenson, 2009). High publicity could include the use of newspapers, television, and mailings to make sure all homeowners are aware of the water restrictions.

Another method to reduce water demand could be the use of price. Water is currently priced too low. The demand for water is “inelastic at current prices” (Olmstead and Stavins, 2007). This means that an increase in price would have a small impact on demand. While many say that water is inelastic, they also consider the use of price as an “effective tool” (Whitcomb, 2005). The cost of water in Jacksonville for the first 1-6,000 gallons used is \$0.93/1,000 gallons. The next larger block for 7,000-20,000 has the cost

of \$1.45/1,000 gallons. The largest block is 20,000+ with the cost of \$4.96/1,000 gallons (JEA, 2009).

In Florida it was found that when price increases from \$1.50 to \$4/1,000 gallons, residential water consumption decreases with increasing home values up to a point. The wealthiest of homes did not follow the trend, but they were nevertheless still responsive to price increases. The majority of homes in the study reduced water consumption anywhere from 100-400 gallons/home/day (Whitcomb, 2005). This is evidence that prices should be increased to at least this \$4/1,000 gallons level.

Section 21: Success of Restoration Efforts

In order to know if these restoration efforts that reduce fertilizer, animal wastes, human wastes, and implement water conservation will be successful, nitrate concentrations in all springs of Ichetucknee and the river near US 27 should be continuously monitored on a monthly basis for several years. Discharge measurements at all sites should also be made for several years. It is important that stakeholders not grow impatient if the above goals are implemented and reductions in the nitrate concentration of the springs are not seen immediately. Katz, Sepulveda, and Verde said that a reduction in fertilizer inputs will reduce the nitrogen loading to groundwater “over time.” Patience is necessary since further nutrient inputs can occur from the subsurface even if all other inputs were to cease. Ongoing monitoring and measurements should be made for approximately a decade with a mid-term review after five years. After one year fertilizer ordinances could be put into place and publicized to citizens. Faulty septic tanks could be identified within two years after restoration efforts begin. One year after this, they should be required to be replaced with performance based septic tanks. After five years, restoration efforts should be reevaluated if nitrate is increasing or if reductions in discharge are occurring. If nitrate is increasing and/or if discharge is declining, additional restoration efforts or more stringent efforts and/or water conservation measures would be necessary at this time. If additional efforts are added, they should be put into place and monitored for the next five years until the decade of intensive monitoring comes to an end. After a decade, if nitrate levels have declined, the fertilizer best management practices should continue and be considered the standard operating procedure for homeowners, agriculture, and industry within the Ichetucknee springshed.

Likewise, if after a decade, discharge continues to stabilize/increase, the water conservation measures that were put into place should not come to an end. They should continue and be considered the new standard of water use within the springshed and within the impacted counties. Once the decade of restoration monitoring to determine overall success comes to an end, monitoring needs to continue to see if any new or additional threats to the springs arise.

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Appendix: Complete List of Stakeholders as identified by the Ichetucknee Springs Working Group

Citizens

City

City of Lake City (stormwater, wastewater)
 Town of Fort White

County

Columbia County (land use planning, stormwater)
 Columbia County Health Department (septic tanks, drinking water)
 Columbia County Tourist Development Council (economy)
 Fort White High School (education)

Regional

Suwannee River Water Management District (stormwater, research, monitoring)
 North Central Florida Regional Planning Council (land use planning)
 Santa Fe Soil & Water Conservation District

State

Department of Environmental Protection
 Florida Park Service
 Ichetucknee Springs State Park (management)
 Florida Geological Survey (research)
 Office of Water Policy (regulations)
 Office of Intergovernmental Programs (land use planning)
 Office of Greenways & Trails (former mine management)
 Office of Ecosystem Projects (funding, protection)
 Northeast District Office (permitting)
 Bureau of Invasive Plants (monitoring)

Department of Community Affairs (land use planning)

Department of Transportation (stormwater)

Department of Health (septic tanks, drinking water)

Department of Agriculture & Consumer Services (best management practices)

Fish & Wildlife Conservation Commission (fisheries management)

University of Florida

Geology Department (research)
IFAS/ Columbia County Extension (education)

Federal

U.S. Geological Survey (research)

Organizations:

Save Our Suwannee
Four Rivers Audubon
Florida Defenders of the Environment
Three Rivers FNPC
Current Problems
1000 Friends of Florida
Sierra Club
Fort White Chamber of Commerce
Lake City Chamber of Commerce
NSS Cave Diving Section
Friends of Ichetucknee Springs State Park

Business:

Karst Environmental Services (research)
Karst Environmental Productions (education)
Dive Rite (cave exploration)
S & S Food Stores
Columbia Livestock Market
Hunter the Printing Company
The Wheeler Agency
Wetland Solutions Inc. (research)
Sdii-Global (research)

Press

Lake City Reporter
Gainesville Sun
High Springs Observer
High Springs Herald
LakeCityJournal.com

Source: Ichetucknee Springs Working Group. 2006. Ichetucknee Springs Basin Working Group Stakeholders.
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