Pilot Project
Nitrogen Sourcing for
Convict and Royal Springs

Convict Spring -FGS Photo

Royal
Spring

Convict Spring

Royal Spring - FGS Photo

Prepared for the:
Division of Environmental
Assessment and Restoration

STATE OF FLORIDA

DEPARTMENT OF ENVIRONMENTAL PROTECTION
Herschel T. Vinyard Jr., *Secretary*

LAND AND RECREATION
Bob B. Ballard, *Deputy Secretary*

FLORIDA GEOLOGICAL SURVEY
Jonathan D. Arthur, *State Geologist and Director*

Pilot Project
Nitrogen Sourcing for Convict and Royal Springs

By

Tom Greenhalgh, P.G. No. 1277

Prepared for the Division of Environmental Assessment and Restoration

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Caitlin Cerame, Environmental Specialist I

Autumn Dooies, Environmental Specialist I

Jake Mast, Environmental Specialist I

James McClean, Government Analyst

Melinda Spall, Environmental Specialist I

Eric Thomas, Environmental Specialist I

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EXECUTIVE SUMMARY

An on-going project to study the springs of the Middle Suwannee River area was revised to focus on Convict Spring, in Lafayette County, and Royal Spring, in Suwannee County. It is believed that excess nutrients, present in the groundwater discharging from springs, are promoting undesirable ecological changes in the river and its springs. This has led the Florida Department of Environmental Protection (DEP) to set stringent nutrient targets for waters of the Lower Suwannee River Hydrologic Unit Code (which includes the Middle Suwannee where Convict and Royal Spring are located. The purpose of this project was: 1) to delineate the areal extent of the groundwater basins that are contributing water to the springs, i.e. the springshed boundaries, and 2) to identify the sources of the nutrients that are adversely impacting these springs and if possible estimate their magnitudes.

A well network was established for the collection of water quality and water level data. Water levels were obtained over a seven month period. From these data, potentiometric surface maps were created, which were used to approximate the locations of the springshed boundaries. Although there are limitations to this approach, it was nonetheless possible to infer seasonal changes in the springshed boundaries, on the basis of changes in the potentiometric surface and the Suwannee River stage. Previous observations have shown that when head pressure in the river exceeds that at the spring vents, spring discharge may cease or even reverse flow, forcing groundwater to discharge elsewhere. This occurred during the study period, in February and March of 2010.

Nitrate concentrations in the springs and the distribution of groundwater nitrate in the springsheds were determined by water quality samples taken from the springs and a network of monitoring and private drinking water wells. Water quality samples were collected during four sampling events, beginning in March, 2010, and extending through June, 2010. In addition to routine nutrient analyses, several samples were analyzed for nitrogen ($\delta^{15}N$) and oxygen ($\delta^{18}O$) isotopes, which are indicators of nitrate sources.

Nitrate concentrations in the groundwater samples ranged from below the detection limit of 0.004 mg/L to as high as 21 mg/L. Results for four private wells exceeded drinking water standard of 10 mg/L, and were duly reported to the DEP Water Supply and Restoration Program for remediation. The nitrate concentration at Convict Spring ranged from 9.7 to 14.8 mg/L. The concentrations were lower at Royal Spring, ranging from 2.3 to 3.4 mg/L, but a downstream spring, SUW 725971, showed nitrate concentrations ranging from 15.0 to 20.0 mg/L. For comparison, the target concentration for Convict and Royal Spring is 0.35 mg/L (FAC 62-304.405, Nov 16, 2008).

The $\delta^{15}N$ and $\delta^{18}O$ results indicated that the main source of nitrogen to most wells in both springsheds is inorganic fertilizer (e.g., ammonium nitrate). Isotopic data from Royal Spring indicated a similar source (after fractionation by denitrification was taken into account) with some organic component. In contrast, results for Convict Spring indicated that the high levels of nitrate found there are being derived from a mix of inorganic and organic sources. These inferences are in broad agreement with the land use evaluation and nitrogen source loading estimates for the individual springsheds.

Nitrate concentrations have been increasing at both springs over the last decade. Long term changes in loads are not readily apparent, partially due to a paucity of discharge measurements over the time period. Nitrate loads in the spring discharges were measured during this study, and were found to be 840 pounds of nitrogen per day at Convict Spring and 220 pounds of nitrogen per day at Royal Spring. These loads were either similar to or higher than those measured previously, indicating that nutrient management efforts over the last decade have not yet yielded significant load reductions.

Approximately 50 percent of the land use by area in both springsheds is classified as upland forest, primarily planted pine on lands that were once used for row crop production and pastures. The second largest land use is agricultural, accounting for over 30 percent of the land area in both springsheds. Hay fields, improved pastures, and field crops are the major agricultural land uses. Dairy and poultry production are also significant land use activities in both springsheds, though they account for relatively minor acreage.

Granting several assumptions, the total load of inorganic fertilizer to the groundwater in both of the springsheds was estimated at approximately 1.3 million pounds of nitrogen per year. Calculated nitrogen loads from animal waste are of a similar magnitude (0.9 million pounds of nitrogen per year, based on estimates for 2011). Although the total loads for the two springsheds are similar, there are differences between the two basins; the estimated ratio of inorganic to organic nitrogen loading in the Convict springshed is approximately 0.3, while for Royal it is about 3. It must be emphasized that both of these numbers have large (and unknown) uncertainties, because the relevant information is not being carefully tracked.

Soil leachability ratings, developed by the University of Florida Institute of Food and Agricultural Sciences using the Soil Environmental and Agricultural Management Systems (SEAMS) model, were used as a proxy indicator of groundwater vulnerability to nitrate loading. Virtually all of the agricultural land use in the Convict Spring springshed occurs on “high” vulnerability soils, while most of the agricultural land use within the Royal Spring springshed occurs on “medium” vulnerability soils.

INTRODUCTION

In November, 2008, culminating several years of effort, the Department of Environmental Protection (DEP) established a Total Maximum Daily Load (TMDL) for nitrate in the Lower Suwannee River Hydrologic Unit Code and its estuary (FAC 62-304.405). The TMDL also included seven springs bordering the river (Branford, Falmouth, Royal, Ruth, Troy, Fanning and Manatee), based on studies that indicated excess nutrient concentrations were contributing to ecological imbalances (e.g. algal mats). The TMDL set a monthly average water quality target for nitrate of 0.35 mg/L (expressed as nitrogen). However, these springs, and most of the other 92 springs within the watershed that have been sampled, frequently show nitrate concentrations in excess of this target, and occasionally even exceed the Maximum Contaminant Level (MCL) of 10 mg/L, set by the U.S. Environmental Protection Agency for the protection of drinking water.

To achieve the nitrate target of 0.35 mg/L, the DEP is developing a Basin Management Action Plan (BMAP) for the Suwannee and Santa Fe River Basin, through which load allocations will be assigned to various contributors of the pollutant of concern. Previous studies have indicated that spring discharge accounts for the majority of the Lower Suwannee River's inflow (Hornsby and Ceryak, 1998) and is also the principal source of nitrate to the river (Hornsby and Mattson, 1997). In turn, the elevated nitrate concentrations in the springs are believed to derive primarily from agricultural nonpoint sources located within the springsheds (Katz and Hornsby, 1998; Katz et al., 1999).

In December, 2008, funded by the DEP Division of Environmental Assessment and Restoration (DEAR) Springs Initiative, the Florida Geological Survey (FGS) began a multi-year springshed delineation project that focused initially on the 63 springs of the Middle Suwannee River, a study area of about 2,400 square miles. Previously delineated springsheds were identified, water chemistry and discharge data were compiled, and wells available for sampling were identified. Written permission was obtained from land owners to provide sampling access, or where necessary, to install wells where none existed. A detailed summary of this work is provided in the Appendix A. Middle Suwannee Springshed Delineation Project Update FY '08-'09.

Changing priorities led DEAR and the Springs Initiative to suggest revisions to this project in January, 2010. The revised project consisted of similar tasks but was of narrower scope, and focused on two specific springs within in the Middle Suwannee, Convict and Royal Springs.

Project Description

The new project, entitled *Pilot Project - Nitrogen Sourcing of Convict and Royal Springs*, had two primary objectives: 1) to delineate the springshed boundaries; and 2) to identify the sources of nitrate impacting the two springs. Secondary objectives were to devise a system to rank groundwater vulnerability to various nitrate sources, and to develop methods to identify high transmissivity zones, including conduits.

Study Area and Springs

The pilot project study area encompasses approximately 90 square miles in Lafayette and Suwannee counties in North Central Florida (Figure 1), and is commonly referred to as the Middle Suwannee. The Suwannee River forms the border between the two counties and numerous springs are located on or immediately adjacent to the river.

Lafayette and Suwannee counties are extremely rural, with some of the lowest population densities found in the state. In 2009, the estimated populations were 7,949 and 40,149 persons for Lafayette and Suwannee counties, respectively. There are no cities or towns in the

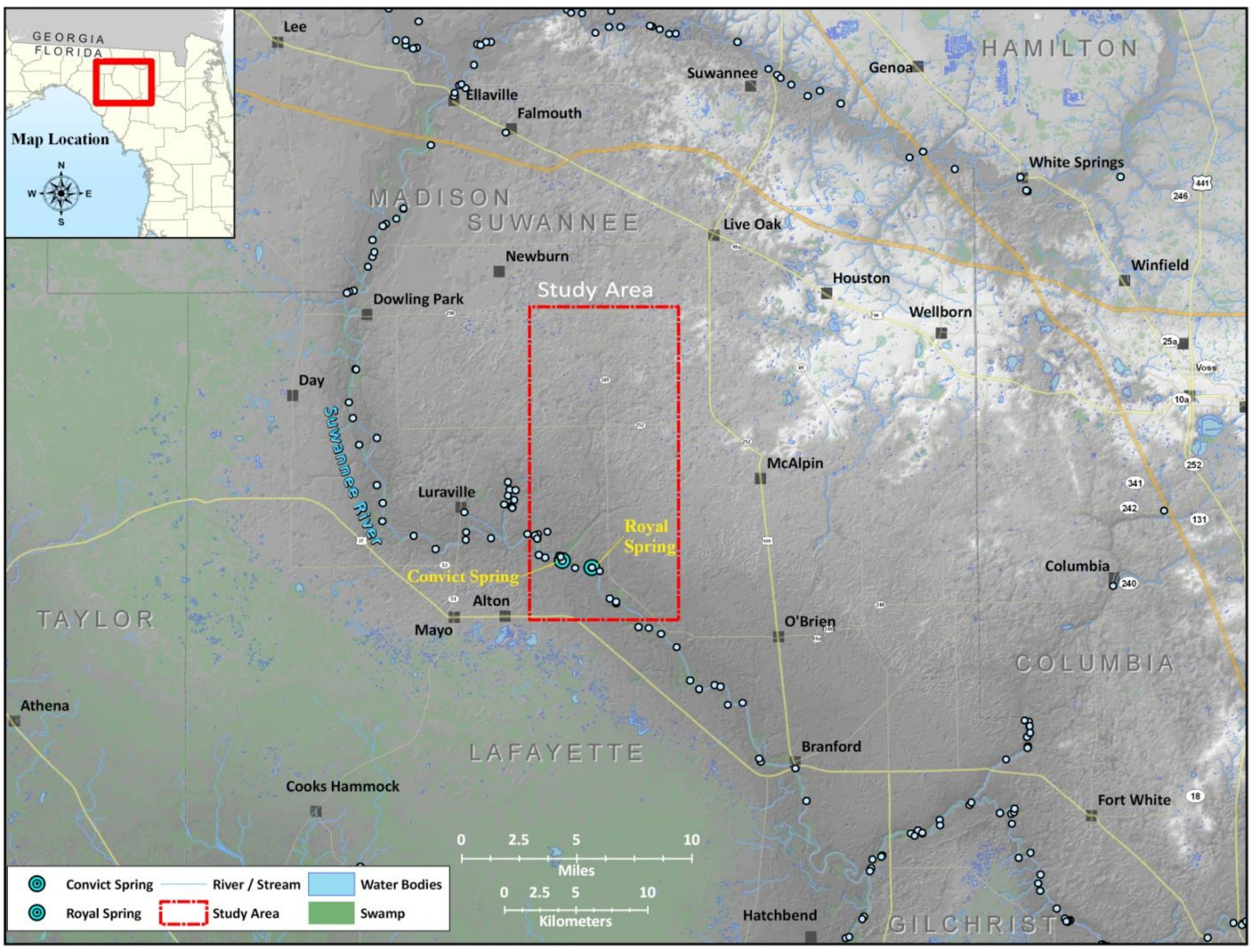

Figure 1. Study area.

study area and land use is predominantly upland forest (planted pines) and agriculture. The 2007 Census of Agriculture ranked Lafayette County second in the state in both broiler (chicken) and dairy production; Suwannee County was ranked first in broiler production, first in forage and corn silage acreage, and fifth in dairy production.

The groundwater in the study area is extremely vulnerable to contamination because the water table is near land surface, and permeable silica sands overlying karstic limestones allow recharge to move rapidly into the unconfined Floridan aquifer system, with little to no chemical or microbial attenuation of contaminants.

Convict Spring

Convict Spring is located in Lafayette County approximately five miles north east of the town of Mayo, Florida. The spring is classified as a third magnitude spring, and a cave system trending southwest into Lafayette County has been mapped by divers. It discharges into the Suwannee River via a spring run less than 100 feet long. The surrounding uplands have been developed into a camping area that includes campsites, rentals, and a store. The spring vent area has a poured concrete enclosure and a narrow walkway surrounds the spring (Figure 2). Over the last decade, nitrate concentrations in the spring have ranged from below detection to 15 mg/L (as N). In recent years, the spring has occasionally ceased to flow.

Figure 2. Convict Spring.

Royal Spring

Royal Spring (Figure 3) is located in Suwannee County approximately nine miles northwest of the town of O'Brien, Florida. The spring is classified as a second magnitude spring and discharges into the Suwannee River via a spring run that is approximately 200 feet in length. The spring frequently ceases to flow, sometimes for months. The spring occupies a large karst sink with a passable cave system that extends a very short distance to the east. The surrounding uplands are occupied by a county park which includes an observation platform, stair access to the spring, and a paved boat ramp to the Suwannee River. Previous nitrate concentrations in the spring have ranged from below detection to 3.5 mg/L.

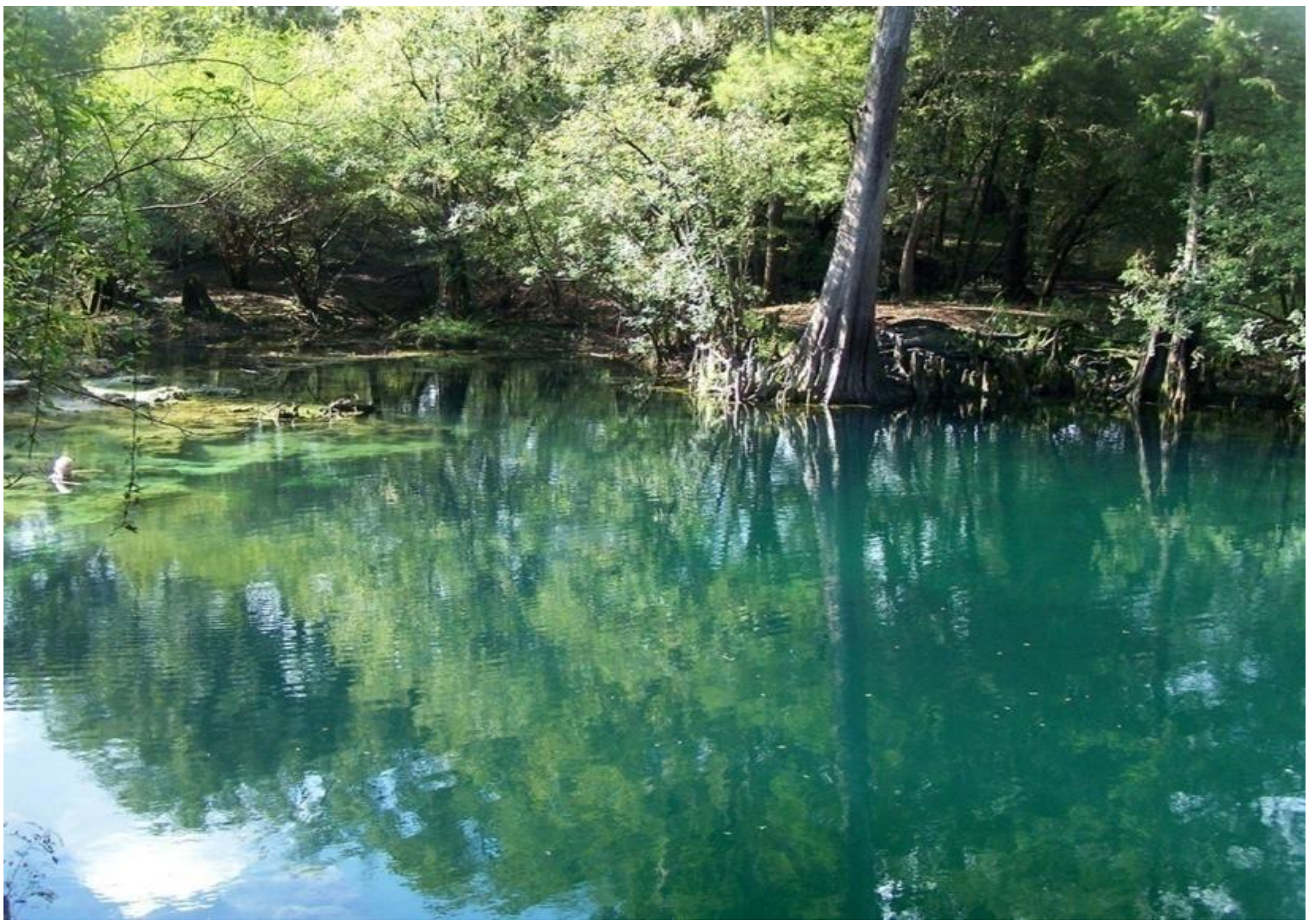

Figure 3. Royal Spring.

SPRINGSHED DELINEATION

Well Network

Using the Suwannee River Water Management District's permitted wells database, 218 wells were identified within the study area as possible sampling sites. This selection was refined by first considering only those wells with surveyed vertical elevations, and wells for which access could be obtained. However, other wells were considered in order to achieve the desired geographic coverage. Field crews visited each well to confirm construction information and to obtain written access permission from property owners. This effort continued for the duration of the project in order to achieve the maximum data density possible. As a result, the density of sampled wells was somewhat variable, but generally increased over the study period.

Twenty nine wells were surveyed to establish their elevation for use in the generation of the potentiometric surface maps. Surveys were done by Delta Land Surveyors Inc., of Monticello, Florida, with assistance from DEP field crews. All elevations were obtained to the nearest tenth of a foot, relative to the National Geodetic Vertical Datum of 1929. In addition to the well elevations, elevations were determined for benchmarks at Convict Spring and two points at Royal Spring. The final well network consisted of 95 wells (Figure 4, next page). Additional site information is given in Appendix B. Surveyed Locations.

Water Levels

Water level measurements were made during seven discrete sampling events, beginning in November, 2009, and ending in June, 2010 (data are found in Appendix C. Water Level Data). During each event, wells were sampled in the shortest time possible to minimize short-term variability in water levels.

Springsheds

Prior to delineating the springsheds on the potentiometric surface maps, the maximum upgradient extent of each springshed was established. The upgradient extent of the Convict Spring springshed was established at the approximate location of the boundary of Bear Bay and Mallory Swamp, where the semi-confined Floridan aquifer system transitions to unconfined and internally drained conditions. A 30-foot change in potentiometric surface occurs at this transition. In this zone, the sandy silts and clays that perch the swamp grade into very permeable sands. The dissolution of the limestone beneath the sands has lowered the land surface and has formed a series of ponds and small lakes at the margin of the swamp.

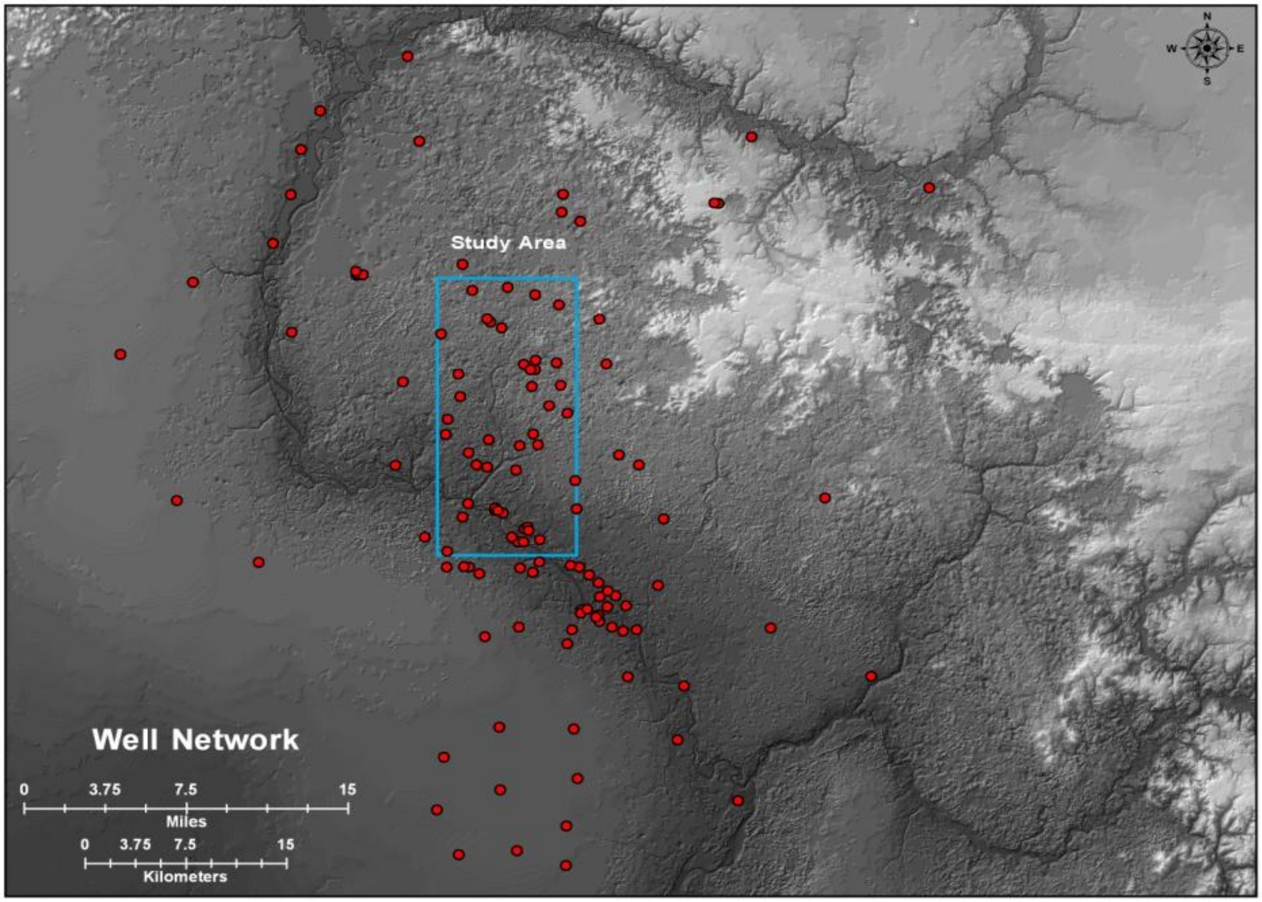

Figure 4. Well network.

Historically, surface runoff and surficial groundwater maintained these ponds and lakes. Now, recurring drought and the interception of surface runoff by canal systems to facilitate silviculture have lowered levels in the surficial aquifer system so much that these ponds and lakes remain dry, except during times of extremely high rainfall. It was assumed that under current hydrologic conditions the contributions to flow in Convict Spring from Bear Bay and Mallory Swamp are minimal; therefore, the springshed boundary was set at this location.

The upgradient extent of Royal Spring's springshed was established by estimating the location of the regional groundwater divide in the Floridan aquifer system under current hydrologic conditions. The western edge of the Royal Spring springshed was drawn to conform to the boundary of the Troy Spring springshed, as it is currently delineated by the Suwannee River Water Management District.

Potentiometric surface maps were then drawn for each of the seven time periods by hand-contouring the water level data using the boundaries established above, with a contour interval of five feet, as recommended by previous studies (e.g. Upchurch et al., 2001). These provide a time-series of the seasonal changes in the approximate configurations of the springsheds between November, 2009, and June, 2010 (Figures 5-11). For the Royal Spring springshed, these configurations were quite variable. The proximal cause for this variability appears to be the Suwannee River stage, which rose significantly in late January, 2010 (Figure 12). The high river stage evidently exceeded the potentiometric head of the Floridan aquifer system adjacent to the river corridor, slowing, stopping, or possibly even reversing discharge at Royal Spring. This is evident from the February potentiometric surface map, which shows little to no gradient (Figure 6), and was also evidenced by the dark color of the spring water during this sampling event. For this reason, the springshed for Royal Spring was not delineated for this sampling event. The springshed for Convict Spring was delineated because the potentiometric surface map indicated that the gradient was still toward the springs; however, the spring was dark at the time of sampling (i.e. the color of river water), suggesting substantial interaction with the river. Also, water quality data obtained from Lafayette County VISA Well #7, discussed elsewhere in this report, suggests that river water may have migrated into Convict Spring and out into its springshed. Normal flow began to be re-established by the time of the March sampling event (Figure 7), and the gradient was observed to increase over the remainder of the project (Figures 8-11). The data from all seven time periods were combined to draw composite springshed boundaries (Figure 12).

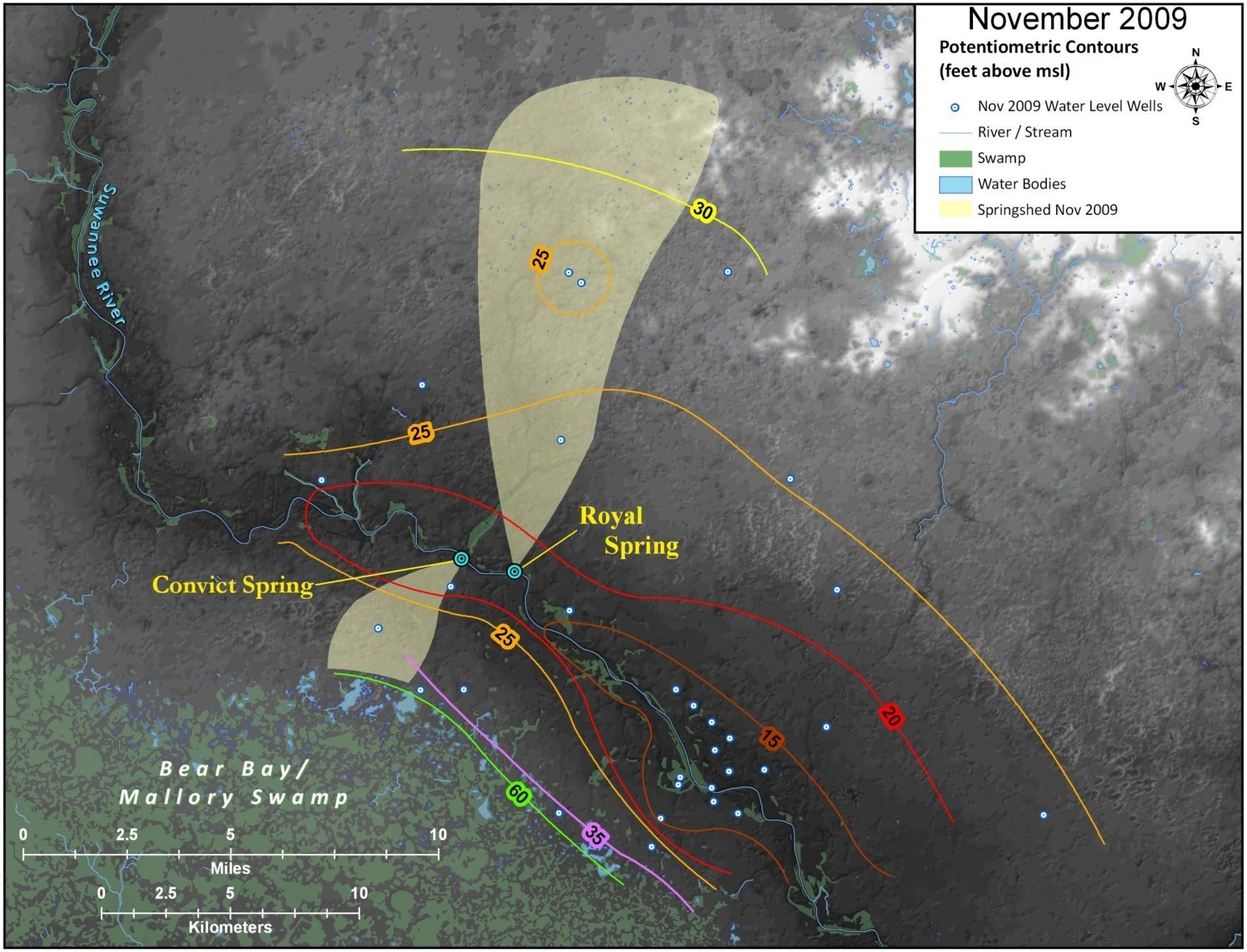

Figure 5. November 2009 springshed boundaries.

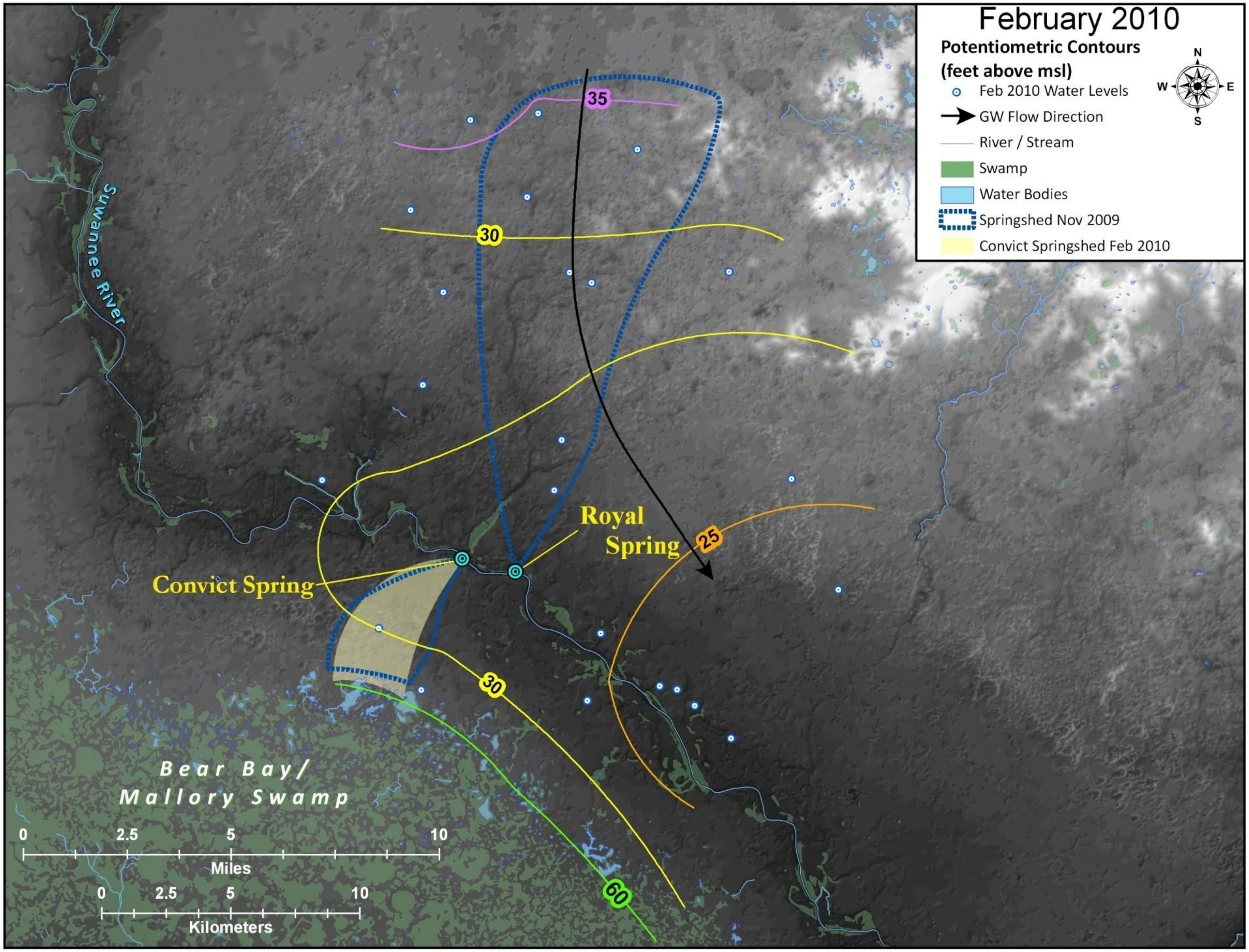

Figure 6. February 2010 springshed boundaries. Dotted lines represent previous boundaries.

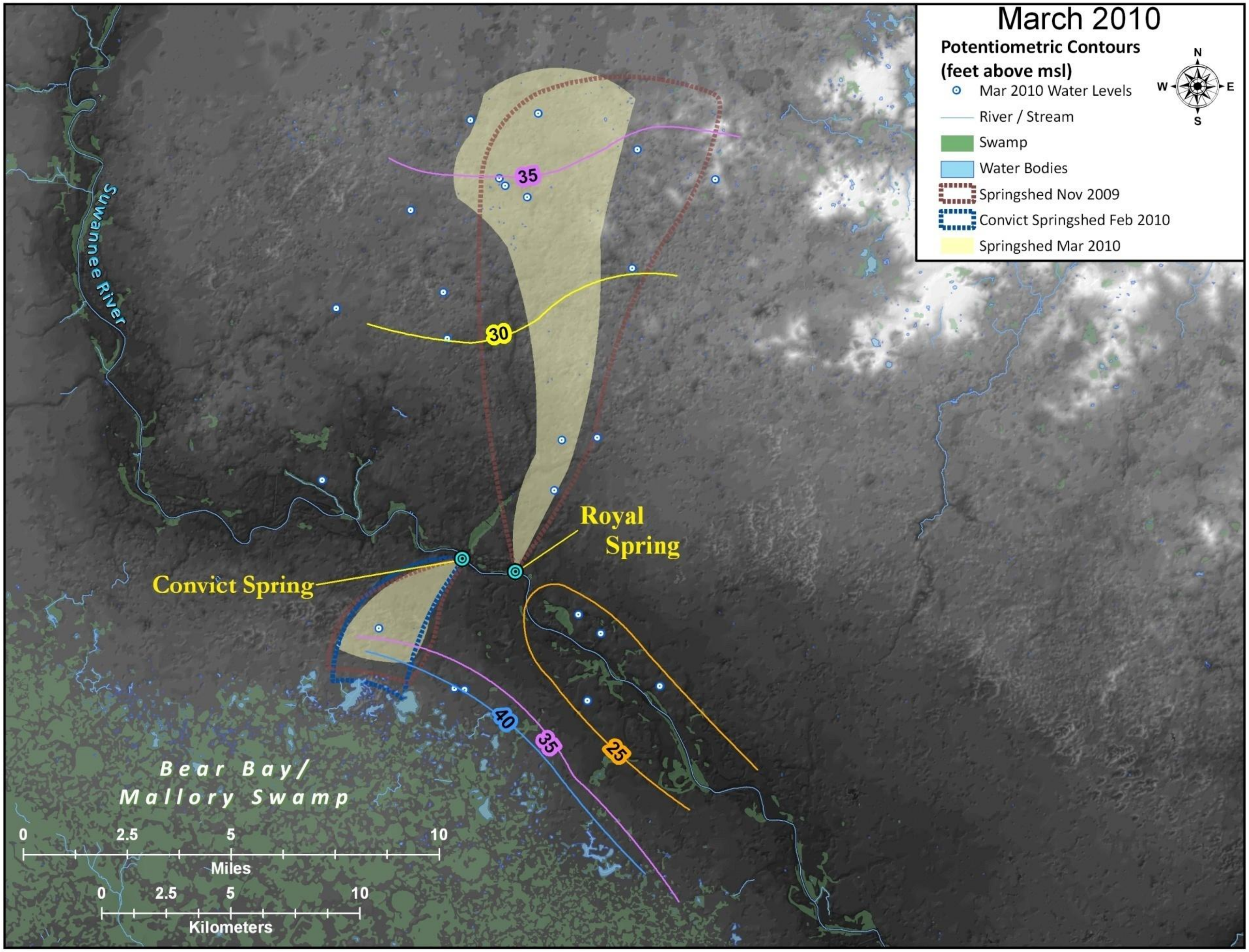

Figure 7. March 2010 springshed boundaries. Dotted lines represent previous boundaries.

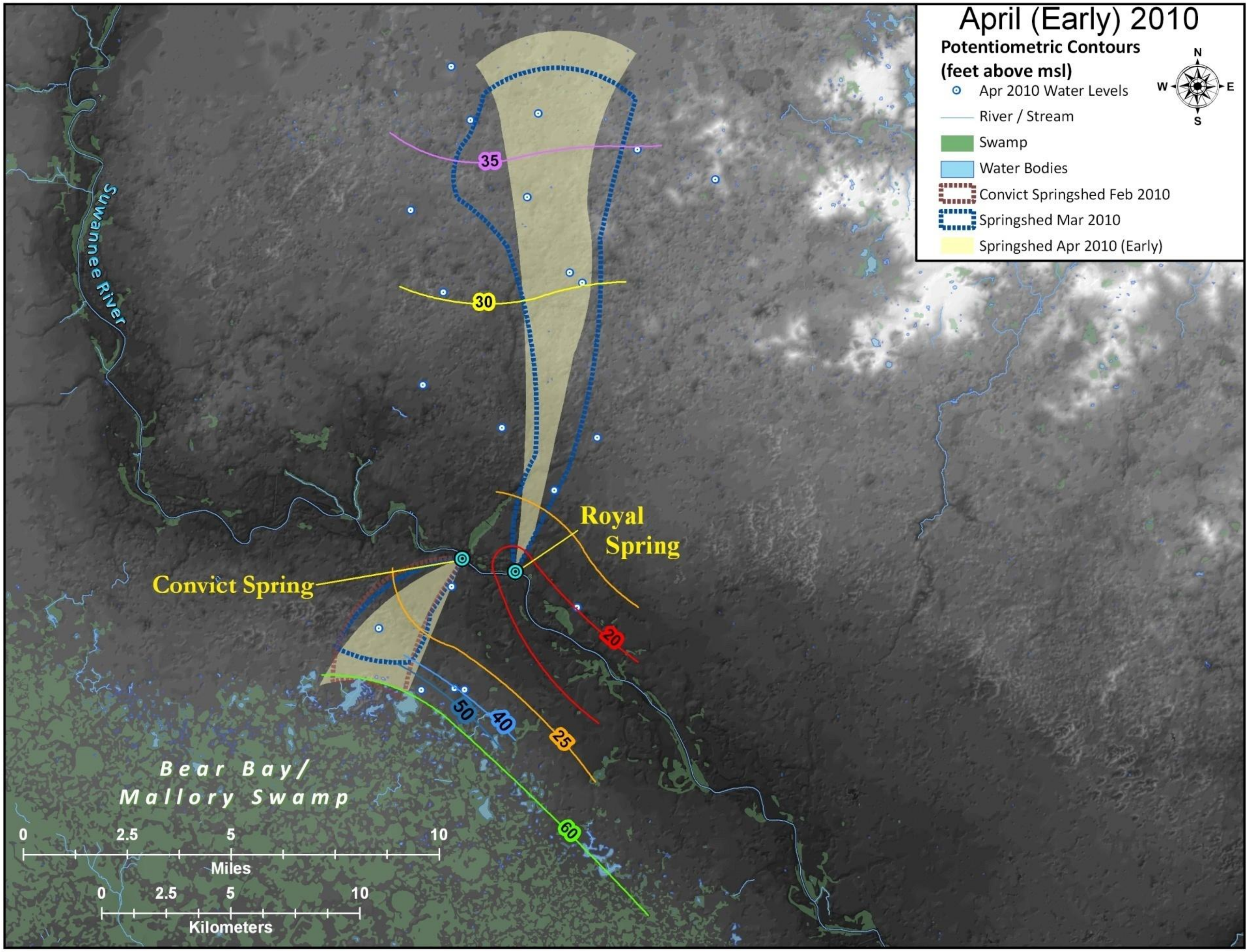

Figure 8. April (early) 2010 springshed boundaries. Dotted lines represent previous boundaries.

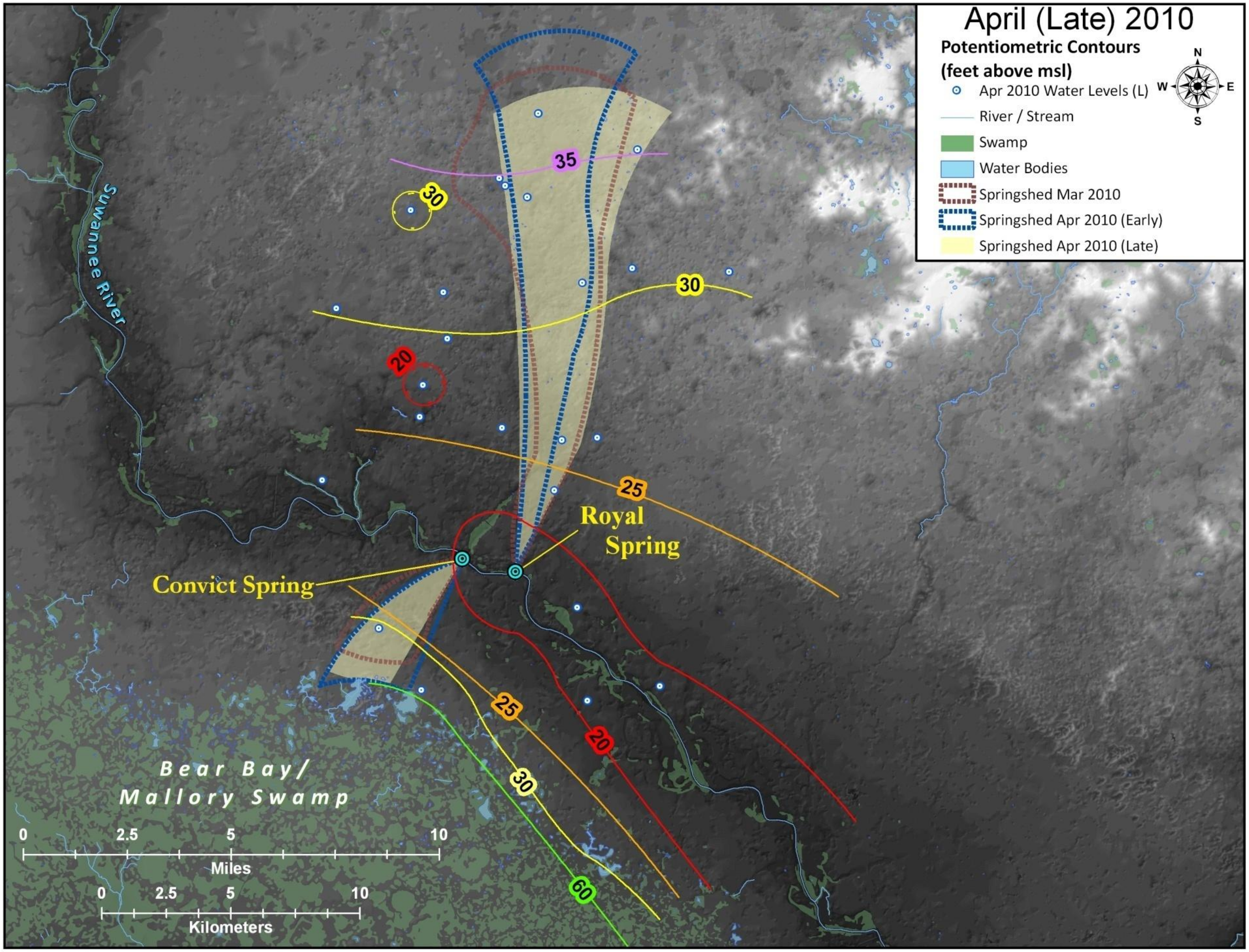

Figure 9. April (late) 2010 springshed boundaries. Dotted lines represent previous boundaries.

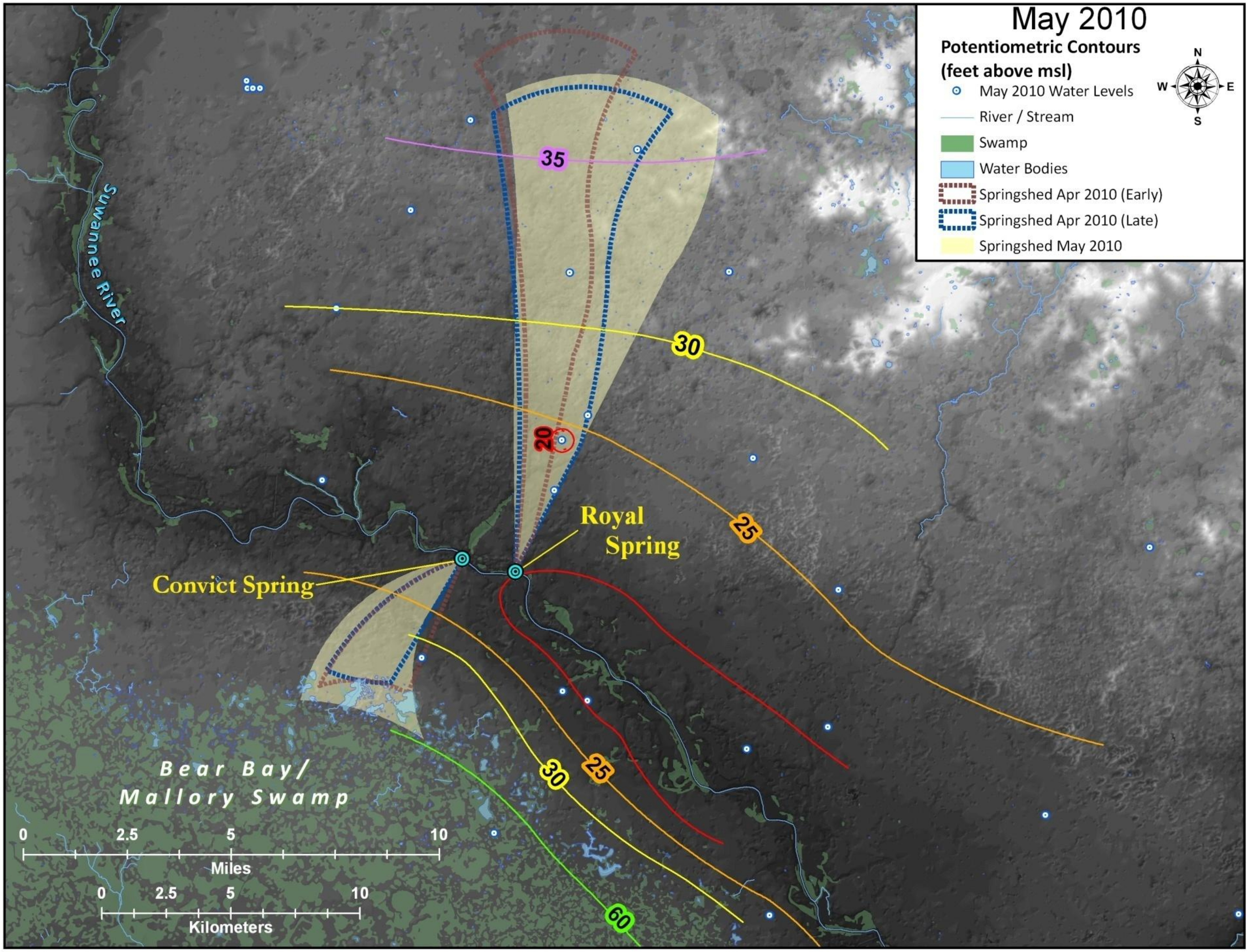

Figure 10. May 2010 springshed boundaries. Dotted lines represent previous boundaries.

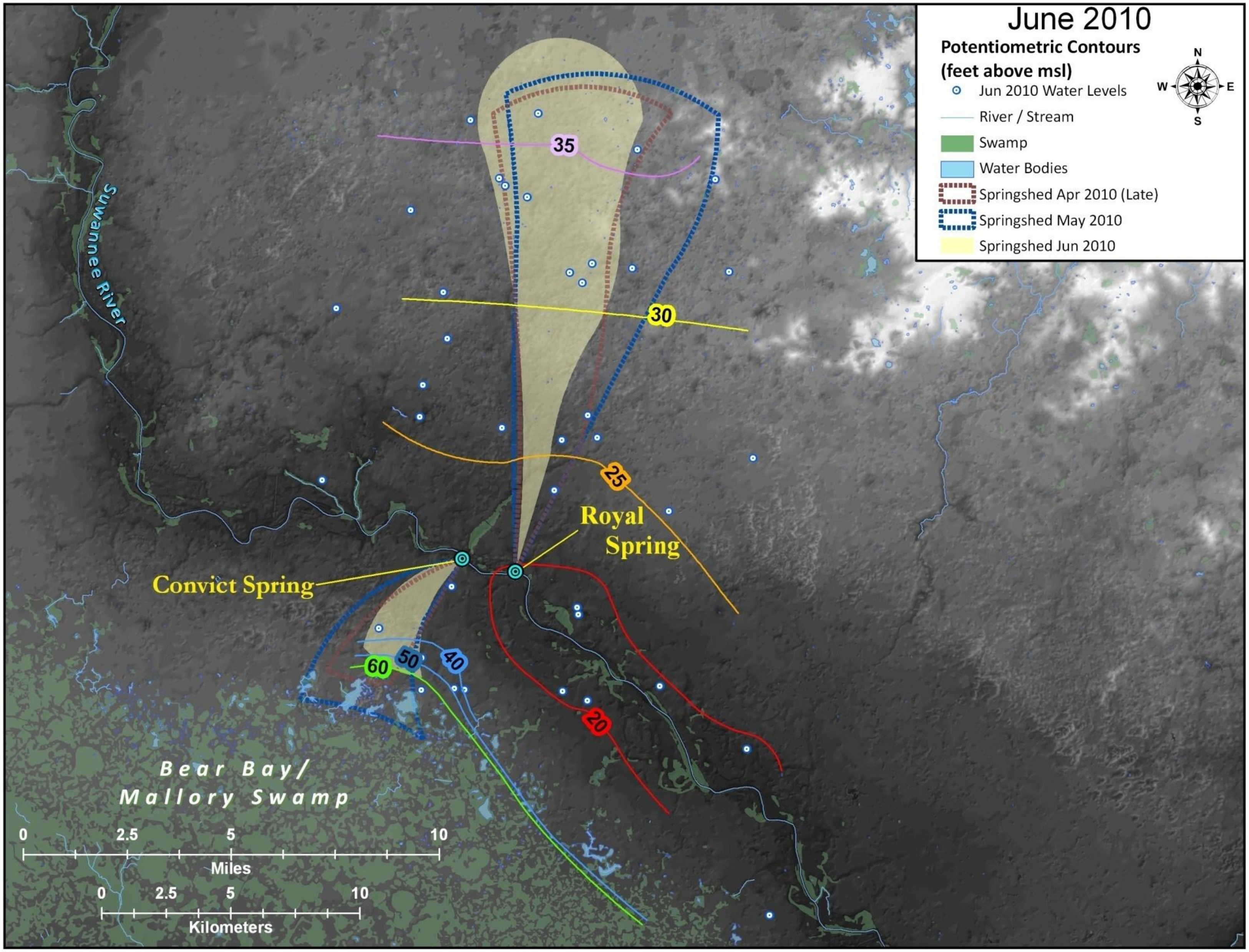

Figure 11. June 2010 springshed boundaries. Dotted lines represent previous boundaries.

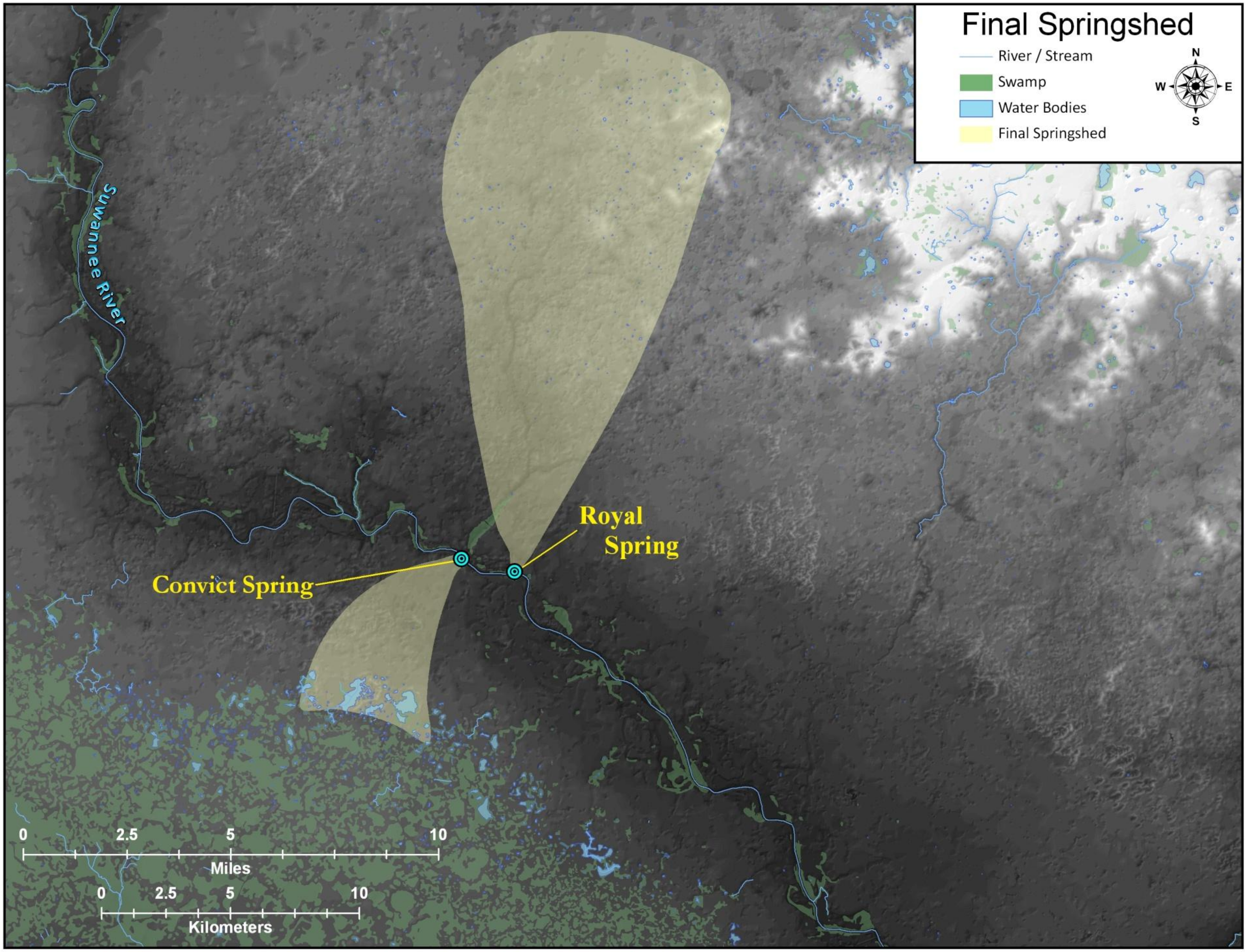

Figure 12. Composite springshed boundaries.

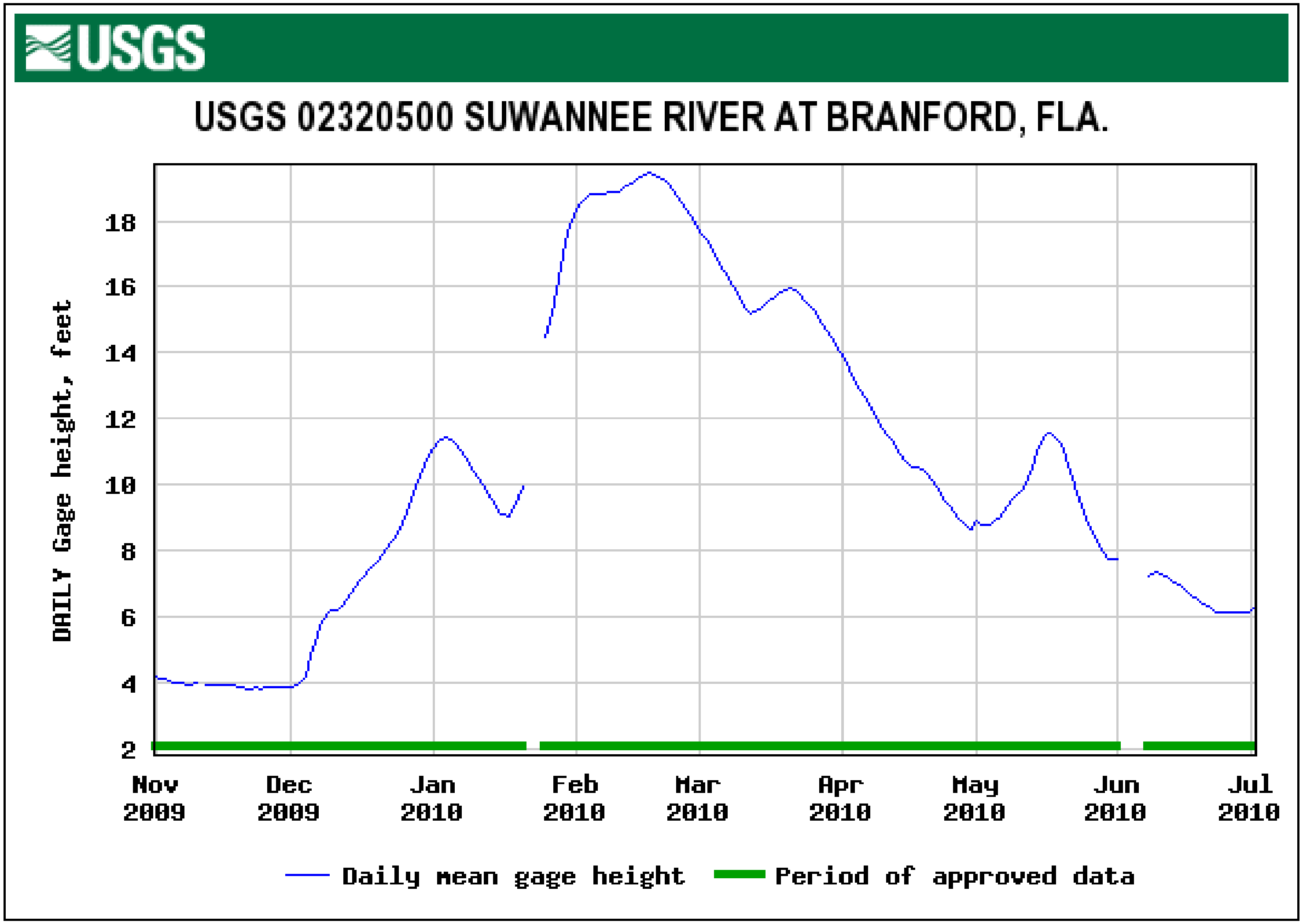

Figure 13. River stage at Branford during the study period.

NITROGEN SOURCES

A primary goal of this project was to identify the source(s) of the nitrogen that is adversely impacting Convict and Royal Springs. To accomplish this, water samples were collected from area wells and springs to determine the concentrations and distribution of nitrate. The isotopic composition of the nitrogen and oxygen present in the nitrate was also measured, to determine if the nitrate was derived from inorganic or organic sources. Finally, nitrate loadings attributable to animal (manure) and fertilizer sources were estimated for each of the springsheds, using the best available data.

Water Quality Sampling

Water quality samples were collected during March and April, 2010. The March event included 30 wells (25 drinking water and 5 monitoring wells); the April sampling event included 29 wells (22 drinking water and 7 monitoring wells) and four springs. In addition to nitrite/nitrate-nitrogen, all samples were analyzed for pH, temperature, specific conductance, dissolved oxygen, chloride, sulfate, alkalinity, total phosphorus, boron, calcium, magnesium, potassium, sodium, and apparent color (April only). To maintain consistency with previous and ongoing studies, springs samples were also analyzed for turbidity, total dissolved solids, ortho-phosphate (dissolved), color (true), ammonia, Kjeldahl nitrogen, organic carbon, and fecal coliform bacteria. All analytical work was performed by the DEP Chemistry and Biological Laboratories.

Water samples for isotopic analyses were collected during May and June, 2010. Eight private drinking water wells and three springs were sampled in May, with duplicate samples collected at two wells and one spring. The June sampling event included 14 wells, three springs, and two samples from the Suwannee River, one above and another below the study area. During this event, two of the sampled wells were specifically selected because previous samples had shown high nitrate levels, likely of organic origin. One of these wells is at a dairy, in an area that often has a high density of milk cows. The other well is located in a hayfield that has been fertilized exclusively with chicken litter. These wells were sampled to determine if the measured isotopic signatures correctly indicated organic sources (i.e. to provide additional confidence in the results). Isotopic analyses were performed by the Colorado Plateau Stable Isotope Laboratory (CPSIL) at Northern Arizona University, using methods developed by the US Geological Survey (Revesz and Casciotti, 2007)

An additional set of water samples was collected in May from monitoring wells installed in conjunction with the Middle Suwannee Springshed Delineation Project. These samples, obtained to establish a baseline for water quality in these wells, are unrelated to the present study. The samples were analyzed by the DEP Chemistry Laboratory; the resulting data for these wells are available upon request.

Water Quality Sampling Results

Analytical results from the March sampling event are shown in Table 1. As this project is focused on nutrients, only the concentrations for nitrate (N), potassium (K), phosphorus (P) and sulfate (SO_4) are shown.

Table 1. March 2010 water quality sampling results.

March 2010 Water Quality Sampling Results					
Site Name	Sample Date	N (mg/L)	K (mg/L)	P (mg/L)	SO_4 (mg/L)
SUWVW_KJ	3/10/10 4:10 PM	<0.004	<0.30	0.02	19.00
SUWVW_LCI	3/16/10 11:30 AM	0.01	<0.30	0.02	3.90
SUWVW_ WW 1	3/12/10 11:03 AM	0.01	<0.30	0.01	5.70
LAFAYETTE CO COMM - VISA 5	3/12/10 3:00 PM	0.02	0.32	0.09	5.80
LAFVW_HE	3/12/10 3:15 PM	0.03	1.00	0.07	5.90
LAFAYETTE CO COMM - VISA 7	3/9/10 12:31 PM	0.15	3.50	0.12	12.00
SUWVW_WH	3/9/10 2:30 PM	0.16	<0.30	0.01	5.70
SUWVW_MN	3/10/10 1:40 PM	0.22	<0.30	0.05	0.59
SUWVW_MJ	3/10/10 3:46 PM	0.32	<0.30	0.02	8.10
SUWVW_LJ	3/9/10 3:15 PM	0.33	<0.30	0.02	16.00
SRWMD - OWENS TRACT	3/12/10 1:22 PM	0.38	<0.30	0.03	8.70
SUWVW_CD 1	3/16/10 1:34 PM	0.42	<0.30	0.03	1.90
SRWMD - PEACOCK SLOUGH	3/12/10 11:14 AM	0.44	<0.30	0.03	8.60
SUWVW_HC	3/10/10 12:18 PM	0.46	<0.30	0.02	7.30
SUWXW_HP	3/16/10 2:14 PM	0.55	<0.30	0.03	5.90
SUWVW_BR	3/9/10 3:53 PM	0.58	<0.30	0.02	11.00
SUWVW_ST	3/9/10 3:40 PM	0.82	<0.30	0.01	8.40
SUWAW_TV	3/9/10 1:30 PM	1.20	<0.30	0.02	3.10
SUWAW_LD	3/10/10 4:46 PM	1.20	<0.30	0.03	6.00
SUWVW_CW	3/12/10 12:54 PM	1.40	<0.30	0.03	7.70
SUWVW_SD	3/12/10 11:58 AM	1.60	<0.30	0.02	9.50
SUWVW_SR	3/10/10 5:34 PM	1.70	0.49	0.01	9.80
SUWVW_JML	3/12/10 1:41 PM	2.50	0.77	0.03	12.00
SUWMW_ JS 19	3/10/10 5:56 PM	2.60	0.53	0.03	14.00
SUWVW_SW	3/16/10 2:51 PM	2.80	0.43	0.02	16.00
SUWVW_CJW	3/9/10 11:35 AM	2.90	<0.30	0.03	19.00
SUWVW_SRG	3/10/10 11:40 AM	4.10	<0.30	0.04	6.30
SUWAW_TD	3/10/10 1:10 PM	6.30	0.83	0.02	11.00
SUWVW_JR	3/9/10 2:51 PM	8.00	3.20	0.02	21.00
SUWVW_GA	3/8/10 4:40 PM	12.00	4.90	0.02	26.00

Nitrate concentrations in March ranged from below detection (<0.004 mg/L) to 12 mg/L. The drinking water wells SUWVW_JR and SUWVW_GA contained 8 mg/L and 12 mg/L nitrate, respectively. This information was forwarded to the DEP Water Supply and Restoration Program (WSRP) because drinking water wells that contain nitrate concentrations that exceed or are near the maximum contaminant level (MCL) of 10 mg/L are eligible for remediation or alternative sources of supply. Figure 14 shows the distribution and concentrations of nitrate found for this sample event.

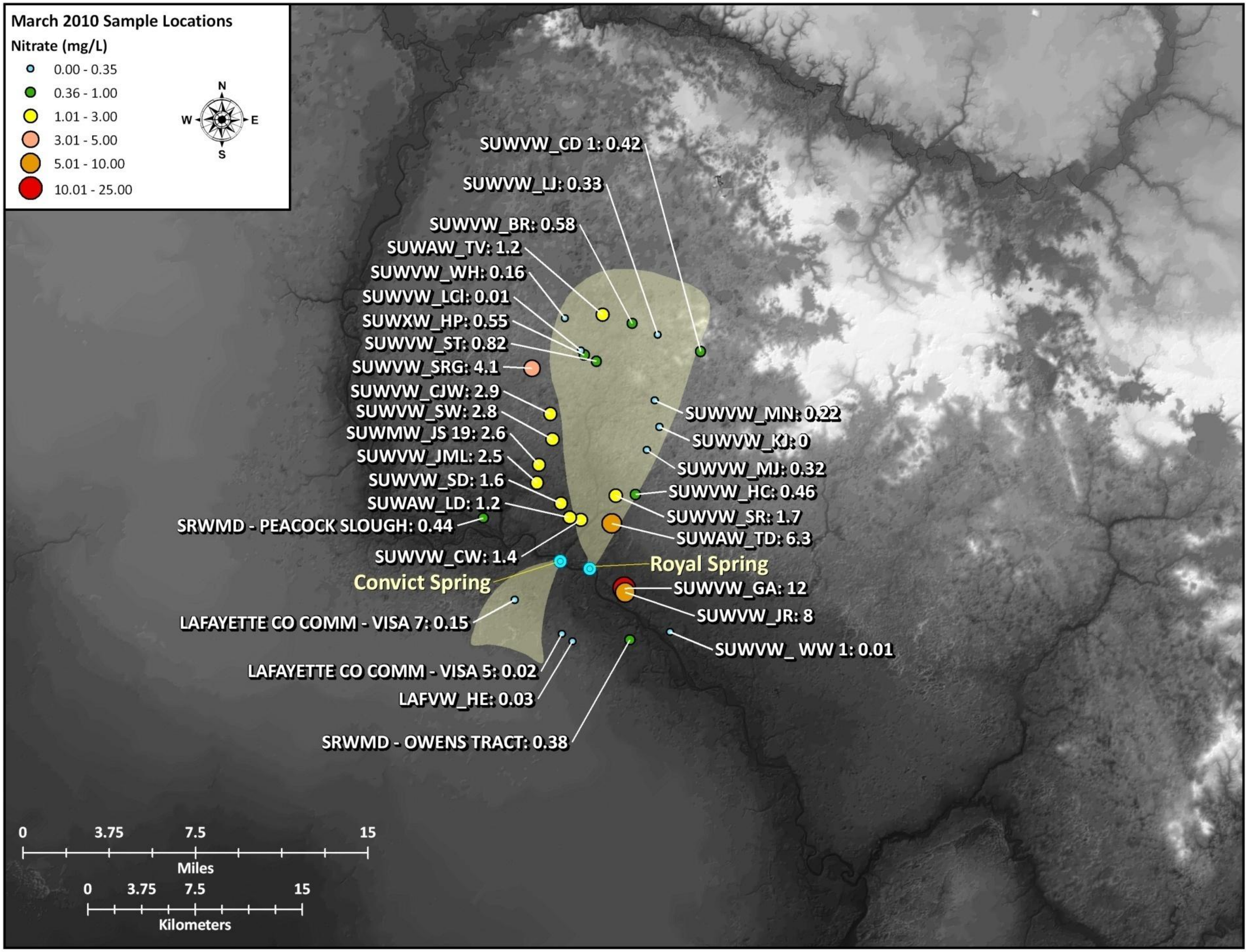

Figure 14. March 2010 nitrate concentrations.

The analytical results from the April event are shown in Table 2 and in Figure 15. Nitrate concentrations in this sample set ranged from <0.004 to 21 mg/L.

Table 2. April 2010 water quality sampling results.

April 2010 Water Quality Sampling Results					
Site Name	Sample Date	N (mg/L)	K (mg/L)	P (mg/L)	SO_4 (mg/L)
SUWVW_KJ	4/15/10 1:30 PM	<0.004	<0.30	0.02	14.00
LAFAYETTE CO COMM - VISA 2	4/15/10 1:30 PM	0.01	0.43	0.05	3.10
LAFVW_HE	4/16/10 10:00 AM	0.01	1.10	0.07	4.00
LAFAYETTE CO COMM - VISA 6	4/15/10 5:50 PM	0.08	7.60	0.06	3.00
SUWVW_WH	4/14/10 2:30 PM	0.097	<0.30	0.013	5.4
LAFAYETTE CO COMM - VISA 5	4/15/10 4:04 PM	0.16	0.77	0.13	4.60
SUWVW_LJ	4/14/10 3:15 PM	0.17	<0.30	0.012	17
SUWANNEE CO - ROYAL SPRINGS WELL	4/20/10 11:05 AM	0.28	0.51	0.05	8.70
SUWVW_HC	4/14/10 12:18 PM	0.42	<0.30	0.014	7.3
SUWVW_SL	4/15/10 4:21 PM	0.71	0.39	0.05	5.40
SUWVW_ST	4/14/10 3:40 PM	0.72	<0.30	0.012	9
SUWVW_CD 1	4/14/10 1:34 PM	0.78	<0.30	0.025	2
FALMOUTH SPRING	4/21/10 10:20 AM	0.83	0.73	0.06	9.20
SUWVW_BS	4/15/10 2:20 PM	1.00	<0.30	0.02	4.90
SUWAW_TV	4/14/10 1:30 PM	1.00	<0.30	0.014	4.3
LAFVW_PC	4/15/10 5:36 PM	1.40	1.20	0.04	16.00
SUWVW_HD	4/15/10 1:01 PM	1.50	0.33	0.03	8.30
SUWAW_LD	4/14/10 4:46 PM	1.5	0.37	0.029	7.1
SUWVW_CW	4/14/10 12:54 PM	1.6	0.92	0.026	8
ROYAL SPRING	4/20/10 12:48 PM	2.30	1.10	0.03	11.00
SUWVW_RS	4/15/10 3:10 PM	2.50	0.62	0.02	8.00
SUWVW_CJW	4/14/10 11:35 AM	2.9	0.51	0.028	19
SUWMW_JS 19	4/15/10 12:19 PM	3.10	0.62	0.03	17.00
SUWVW_SRG	4/14/10 11:40 AM	3.2	0.46	0.036	5.8
SUWMW_EC 2	4/16/10 12:08 PM	3.30	0.69	0.05	13.00
SUWVW_AG	4/14/10 12:00 AM	4.1	2.5	0.037	13
SUWVW_JR	4/16/10 11:49 AM	8.00	3.00	0.02	23.00
CONVICT SPRING	4/20/10 2:40 PM	9.70	4.60	0.04	12.00
SUWAW_TD	4/14/10 1:10 PM	9.9	1.7	0.022	15
SUWVW_MB	4/16/10 12:17 PM	11.00	3.00	0.01	21.00
SPRING SUW 725971	4/21/10 11:54 AM	15.00	5.10	0.03	28.00
SUWVW_GA	4/16/10 11:18 AM	16.00	6.10	0.02	33.00
LAFAYETTE CO COMM - VISA 7	4/15/10 11:59 AM	21.00	10.10	0.20	21.00

Four drinking water wells were reported to the WSRP because of elevated nitrate concentrations, including SUWVW_ TD (9.9 mg/L), SUWVW_GA (16 mg/L), SUWVW_JR (8 mg/L) and SUWVW_MB (11 mg/L). The four sampled springs, Convict, Falmouth, Royal and SUW 725971, had nitrate concentrations of 9.7, 0.83, 2.3, and 15 mg/L respectively. Nitrate concentrations measured in April are shown in Figure 15. Variable nitrate concentrations, which were observed during both sampling events, show that the groundwater in the study area is not uniformly impacted.

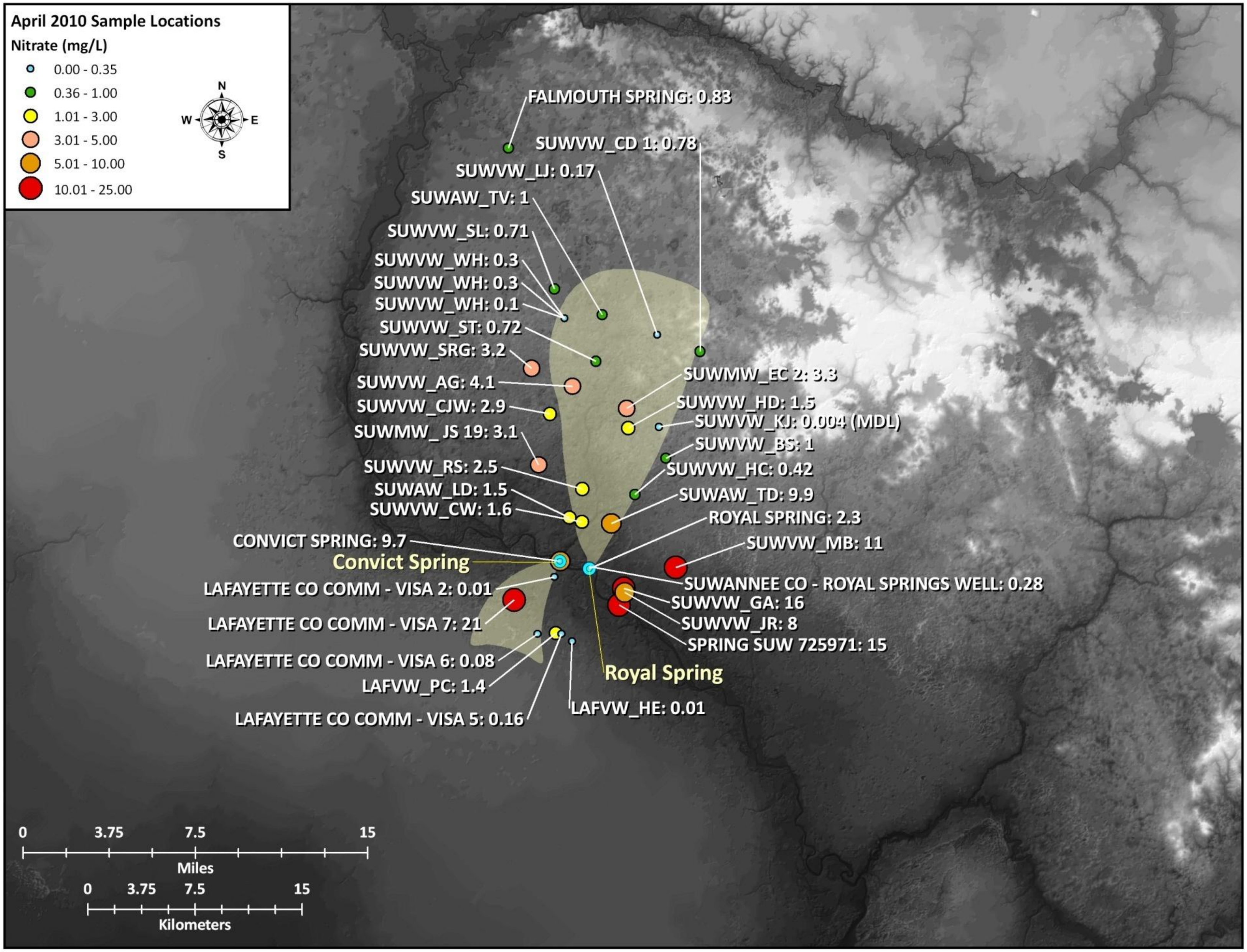

Figure 15. April 2010 nitrate concentrations.

Lafayette County VISA Well #7

The monitoring well "LAFAYETTE CO COMM – VISA 7" April sample contained 21 mg/L nitrate which was significantly elevated from its March sample which contained 0.15 mg/L nitrate. The marked change in nitrate concentration suggests the possibility that the well screen may intersect a cave conduit or an otherwise highly transmissive zone. Figure 16 shows the conduit system for Convict Spring, which trends in the direction of the well. Water quality data for this well and river stage data from the gage USGS 02320500 Suwannee River at Branford, Florida were obtained. Significant nitrate fluctuations (as well as potassium and sulfate) in the well over time appear to correlate with river fluctuations (data not shown). However, other explanations for the variable water quality, such as variable and localized loading, or other site-specific characteristics are possible. Further study would be necessary to verify a direct connection between this well and Convict Spring.

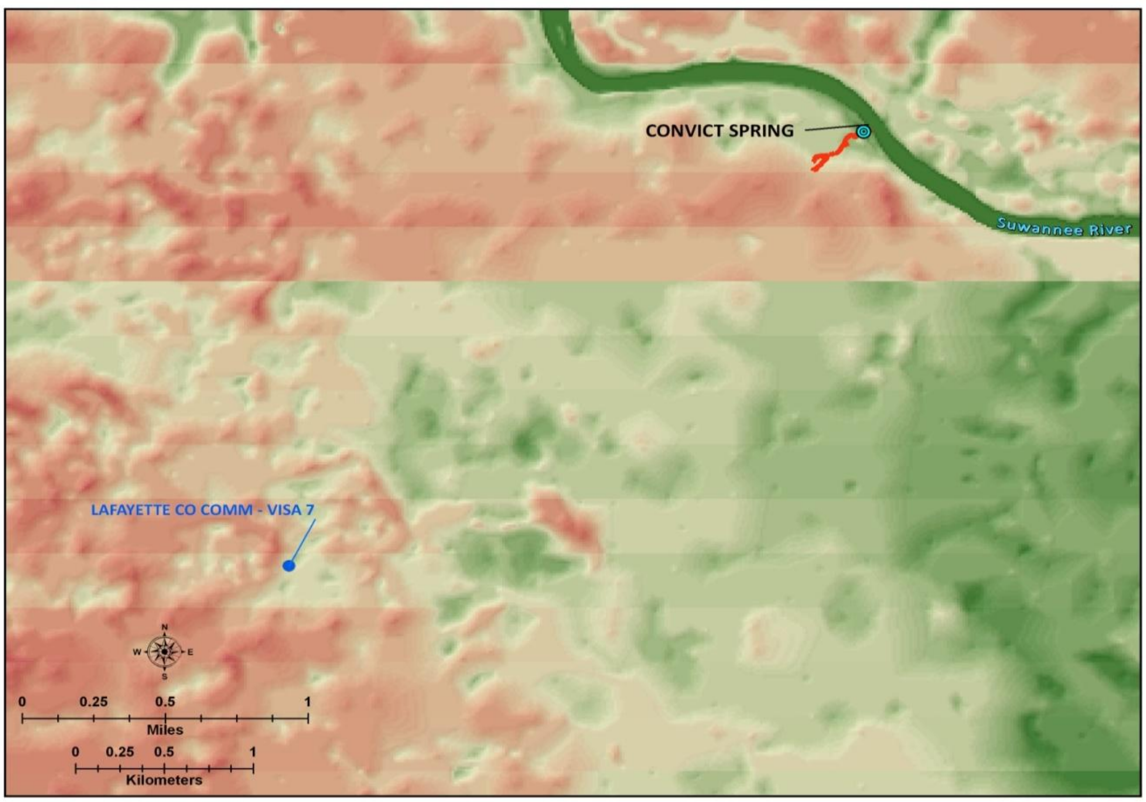

Figure 16. Convict Springs cave system.

Nitrogen and Oxygen Isotope Approach

Analysis of nitrogen and oxygen isotopes contained in aqueous nitrate has been used to identify nitrate sources in groundwater for about three decades (Heaton, 1986; Bottcher et al., 1990, Roadcap et al., 2002; Xue et al., 2009). Modern laboratories can analyze for the individual isotopes of both nitrogen and oxygen and provide a precise ratio of the abundances of each isotope ($^{15}N/^{14}N$ and $^{18}O/^{16}O$). Delta notation ($\delta^{15}N$ for nitrogen and $\delta^{18}O$ for oxygen) is used to express the difference between the isotopic ratio of the sample and a known reference, relative to the isotopic ratio of the reference, in units of parts per thousand (‰). The reference for nitrogen is atmospheric air (AIR) and for oxygen the reference is Vienna Standard Mean Ocean Water (VSMOW). Positive delta values indicate enrichment of the heavier isotope, relative to the reference material.

Inorganic fertilizer is made from atmospheric nitrogen; therefore, its $\delta^{15}N$ is close to that of air (~0‰). Isotopic analyses of groundwater contaminated by fertilizers yield values close to 0‰, ranging from about -6‰ to +6‰ (Heaton, 1986). $\delta^{15}N$ values for organically-derived nitrate are typically much higher because organisms preferentially utilize lighter isotopes in their metabolic processes; therefore, nitrogen present in animal wastes and septic systems typically show enrichments. Preferential volatilization of isotopically light ammonia causes additional fractionation, such that these wastes show enrichments in excess of +10‰ (AIR). Nitrate derived from soil organic matter typically has $\delta^{15}N$ values in the range of +6‰ to +10‰. However, in the study area, most of the soils are silica sands with very little organic matter (<1%); therefore, $\delta^{15}N$ values in this range are generally attributed to a mix of organic and inorganic sources.

The oxygen in fertilizers is largely derived from the atmosphere, and the $\delta^{18}O$ values for fertilizers are similar to those for air, approximately 20-25‰ (VSMOW). Upon application, however, nitrification processes (also referred to as mineralization) convert some of the ammonium present in the fertilizer to nitrate. Because mineralization relies primarily on oxygen from water, the $\delta^{18}O$ in mineralized fertilizer is decreased to a range of 0 to +10‰ (VSMOW). Nitrate produced microbially in the soil generally has low $\delta^{18}O$ values, between -0.8‰ and +5.8‰. Because most of the oxygen in biologically-produced nitrate is from water, its $\delta^{18}O$ value is similar to that of water, which is depleted in ^{18}O, relative to air; thus, nitrate in animal wastes is expected to be depleted in ^{18}O. It should be noted the chemical and biological processes controlling $\delta^{18}O$ values are complicated; hence there is some overlap in the range of values attributed to the various sources of nitrate.

In the soils and subsurface, denitrifying bacteria reduce nitrate to dinitrogen (N_2). These bacteria preferentially utilize nitrate molecules with lighter isotopic composition; therefore, the groundwater nitrate levels decrease, and the unutilized nitrate becomes progressively enriched with heavier isotopes, ^{15}N and ^{18}O.

Isotope Sampling and Results

Two sets of water samples were collected for isotopic analyses. The first sampling event was on May 12, 2010. Eight private drinking water wells and three springs were sampled. Duplicate samples were collected from two wells and one spring. These results are shown in Table 3.

Figure 17 shows a crossplot of $\delta^{18}O$ versus $\delta^{15}N$ for the May samples, from which nitrate sources may be inferred (Bottcher et al., 1990). The source domains, discussed above, are also color-coded in the figure, and the dashed line shows the general manner in which denitrification alters the isotopic composition. Perhaps the most striking feature is that most of the well samples plot in the lower left area of the diagram, indicating that the main source of nitrate to these wells is mineralized inorganic fertilizer. Two wells, SUWVW_SW and SUWV_CJW fall slightly outside of this domain, possibly the result of denitrification, which leads to isotopic enrichment.

Table 3. May 2010 isotope sampling results.

May 2010 Isotope Sampling Results				
Site Name	**Sampled**	**N (mg/L)**	**$\delta^{15}N$ (‰)**	**δ^{18} O (‰)**
SUWVW_GA (post-filter)	5/12/10 5:00 PM	6.34	1.37	4.56
SUWVW_JR	5/12/10 4:35 PM	17.55	1.73	5.03
SUWVW_GA	5/12/10 5:00 PM	21.01	1.85	4.40
SUWVW_JR (dup)	5/12/10 4:35 PM	17.55	2.07	5.25
SPRING SUW 725971	5/12/10 3:00 PM	18.18	2.61	5.70
SUWAW_TD	5/12/10 5:35 PM	10.74	3.15	5.39
SUWVW_SRG	5/12/10 9:35 AM	3.33	3.22	4.64
SUWAW_TD (dup)	5/12/10 5:35 PM	10.74	3.27	6.28
SUWVW_JML	5/12/10 11:45 AM	3.90	3.81	4.91
SUWMW_JS 7	5/12/10 11:25 AM	3.69	4.43	4.81
SUWVW_CJW	5/12/10 10:35 AM	3.23	5.77	6.12
SUWVW_TC	5/12/10 1:00 PM	1.89	5.87	11.80
SUWVW_SW	5/12/10 10:45 AM	3.08	6.24	5.74
CONVICT SPRING	5/12/10 6:15 PM	14.80	8.56	4.48
CONVICT SPRING (dup)	5/12/10 6:15 PM	14.80	8.76	4.33
ROYAL SPRING	5/12/10 1:50 PM	2.85	10.04	8.18

Well SUWVW_TC plots well outside the mineralized fertilizer domain, with higher $\delta^{18}O$. It is possible that the nitrate in this well derives from a less weathered fertilizer source. One spring sample (SUW725971) also plotted in the mineralized fertilizer domain.

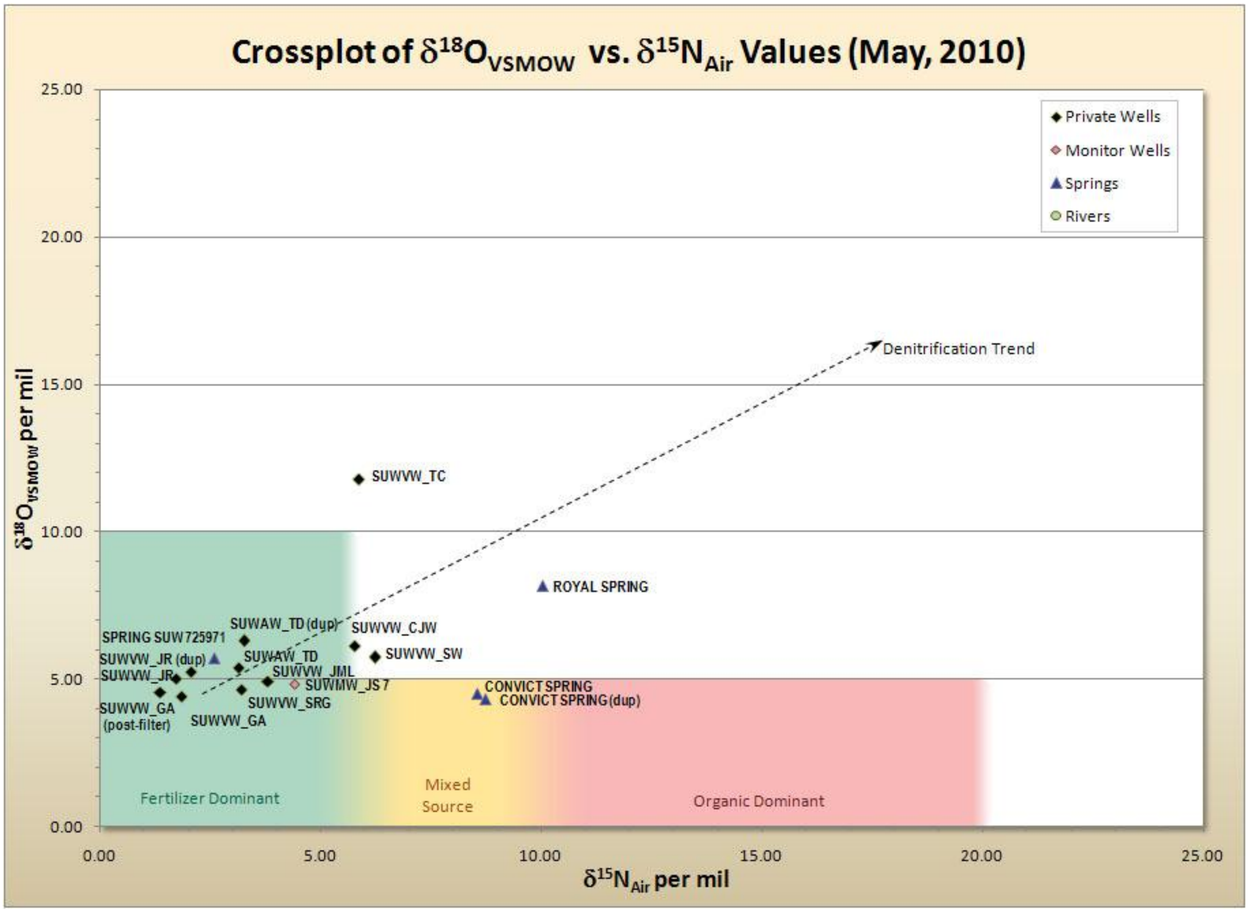

Figure 17. $\delta^{15}N$ versus $\delta^{18}O$ for May samples.

Mineralized fertilizer was also the likely source of nitrate to two of the springs. Spring SUW 725971 had $\delta^{15}N$ and $\delta^{18}O$ of 2.61 and 5.70‰, respectively, placing it unequivocally in the fertilizer domain. The signatures at Royal Spring plot outside this domain, most likely because of denitrification processes acting on an inorganic fertilizer or mixed nitrate source. The $\delta^{15}N$ for the Convict Spring samples were 8.56‰ and 8.76‰ (duplicate), with $\delta^{18}O$ values of 4.48 and 4.33. These values suggest that the nitrate in Convict Spring is probably derived from both organic and mineralized fertilizer sources.

A plot of the $\delta^{15}N$ values versus nitrate concentrations for the May sampling event is shown in Figure 18. The significant range in nitrate concentration detected (1.89 – 21.01 mg/L) suggests that both the sources of nitrate and the processes controlling its fate in the subsurface are highly variable. The figure also suggests that high nitrate concentrations can arise regardless of source, also indicated by the June results (discussed below)

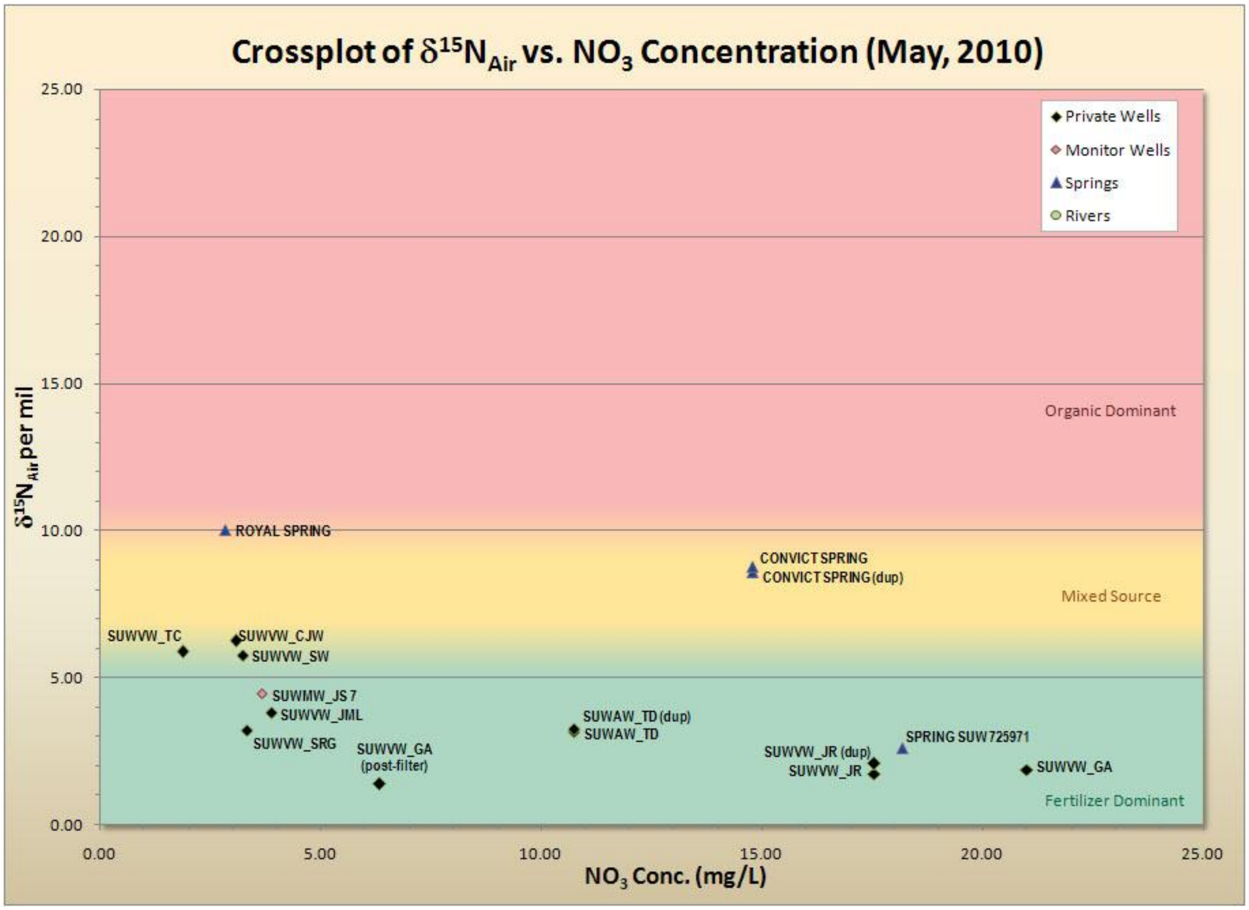

Figure 18. δ^{15}N versus nitrate concentration for May samples.

A second set of samples for isotopic analyses was collected on June 28-29, 2010. Fourteen wells, three springs, and two sites on the Suwannee River (one upstream of the study area and another downstream) were sampled. The data for this sampling event are listed in Table 4 and the δ^{18}O is shown plotted against δ^{15}N in Figure 19.

Data from the June event closely matched the May data, with most well samples plotting in the mineralized fertilizer source domain. A few well samples plotted outside this domain. LAFVW_HE plots far outside the usual domains; however, the extremely low concentration of nitrate in the well may have adversely affected the quality of the results (CPISL, pers. comm.). SUWVW_SW, which was also sampled in May, continued to show minor enrichment, possibly because of denitrification. The relatively high $\delta^{18}O$ for LAFVW_PC suggests that the nitrate in this well may derive from a less weathered fertilizer source, while SUWMW_EC5 shows signatures that imply mixture of organic and inorganic sources.

Table 4. June 2010 isotope sampling results.

June 2010 Isotope Sampling Results				
Site Name	**Sample Date**	**N (mg/L)**	**$\delta^{15}N_{Air}$ (‰)**	**$\delta^{18}O_{vsmow}$ (‰)**
SUWVW_GA (dup)	6/29/10 11:35 AM	17.62	2.25	4.48
SUWVW_JR	6/29/10 12:00 PM	17.55	2.59	4.71
SUWVW_GA	6/29/10 11:35 AM	17.62	2.86	6.47
SPRING SUW 725971	6/29/10 11:50 AM	19.85	3.24	6.60
SUWVW_SRG	6/28/10 1:35 PM	3.14	3.69	4.99
SUWVW_SRG (dup)	6/28/10 1:35 PM	3.14	3.82	5.09
SUWAW_TD	6/28/10 4:47 PM	8.71	3.92	6.42
SUWVW_JML	6/28/10 4:42 PM	3.67	4.32	4.34
LAFAYETTE CO COMM - VISA 5	6/28/10 1:20 PM	0.33	4.62	4.65
SUWMW_JS 19	6/28/10 5:06 PM	3.60	4.71	4.31
LAFVW_PC	6/28/10 12:04 PM	1.30	6.22	12.03
SUWVW_SW	6/28/10 3:50 PM	2.90	6.86	6.11
SUW RIVER_US_BRANFORD	6/29/10 12:50 PM	1.22	8.00	8.42
SUWMW_EC 5	6/28/10 5:35 PM	10.86	8.14	4.93
SUW RIVER_HAL ADAMS BRIDGE	6/29/10 2:00 PM	0.69	8.14	8.15
SUWMW_DD 3	6/28/10 4:17 PM	19.60	8.27	4.28
SUWMW_DD 3 (dup)	6/28/10 4:17 PM	19.60	8.30	4.15
CONVICT SPRING	6/29/10 11:03 AM	13.86	8.61	3.09
ROYAL SPRING	6/29/10 11:34 AM	3.43	10.27	7.70
LAFAYETTE CO COMM - VISA 7	6/28/10 11:44 AM	24.67	10.89	3.75
LAFMW_DB 11 (dup)	6/28/10 2:05 PM	72.46	16.48	6.38
LAFMW_DB 11	6/28/10 2:05 PM	72.46	16.50	6.21
LAFVW_HE	6/28/10 12:41 PM	0.02	20.59	13.69

Two of the sampled wells were specifically targeted because they had previously shown high nitrate levels that could confidently be attributed to organic (manure) sources. The LAFMW_DB 11 well is located on a dairy farm, in an area with a high density of milk cows. It plots slightly above the expected domain, suggesting that denitrification processes may have caused minor alterations of the expected organic signature. The SUWMW_DD 3 well, located in a hayfield fertilized with chicken litter, plots as a mixed source, either inorganic fertilizers had been used in the recent past, or possibly because of horizontal transport of isotopically-light nitrate. In spite of these minor discrepancies, the results are reasonably consistent with expected values.

Samples from Convict and Royal Springs closely matched those measured in May, and continued to indicate that nitrate sources to Convict Spring are a mix of organic and inorganic sources. Isotopes from Royal Spring continue to indicate denitrification of a predominantly inorganic source with some mixed source component.

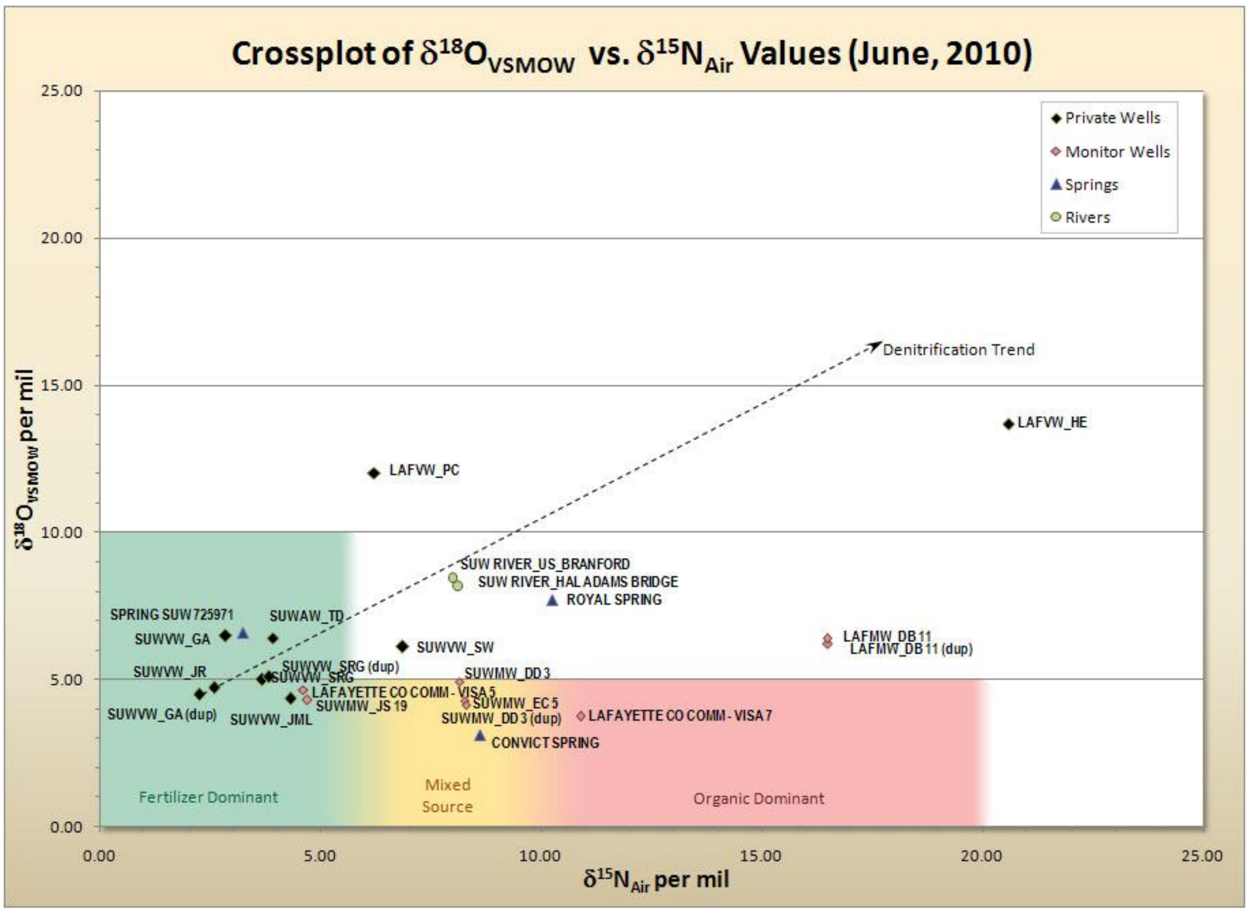

Figure 19. δ^{15}N versus δ^{18}O for June samples.

A cross plot of the δ^{15}N values vs. nitrate concentration in the well and spring samples collected on June 28-29, 2010, are shown in Figure 20. The significant range in nitrate concentration detected (1.89 – 21.01 mg/L) indicates that groundwater contamination is not uniformly distributed in the springshed, same as what was detected in the water quality sampling in March and April, 2010 and May 2010, isotopic data.

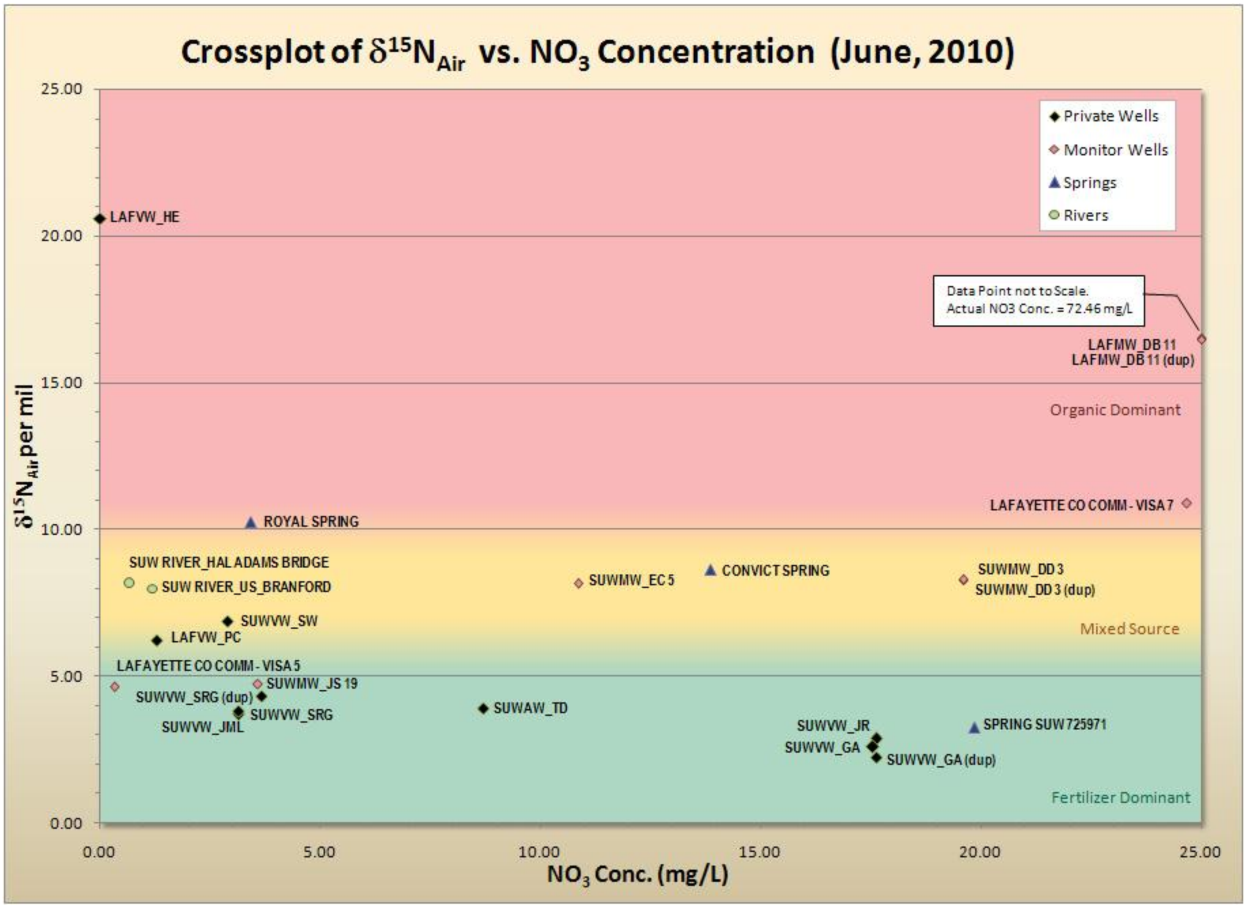

Figure 20. δ15N versus nitrate concentration for June samples.

Briefly summarizing, the isotopic data indicate that most of the private drinking water wells are impacted by inorganic fertilizer; however, the impact on well water quality (i.e. nitrate concentration) is highly variable. This may be a function of the locations of the wells with regard to adjacent land use, or the possibility of heterogeneous flow paths, as suggested for the VISA #7 well. Organic signatures can be detected at wells where animal waste loading is occurring in the immediate vicinity. $\delta^{15}N$ and $\delta^{18}O$ values at Royal Spring indicate that the nitrate there is primarily from inorganic sources and is likely undergoing denitrification. At Convict Spring, $\delta^{15}N$ and $\delta^{18}O$ values indicate it is being impacted by both inorganic and organic nitrate sources. The VISA #7 well shows large fluctuations in nitrate concentrations, with $\delta^{15}N$ and $\delta^{18}O$ values showing a very strong organic signature. These observations suggest either an intermittent source or perhaps an influence of the Suwannee River via a conduit or other highly-transmissivity zone.

Springs Loading

Available nitrate concentration and flow data for Convict and Royal Springs were compiled to compare nitrate loading over time. Concentrations and loadings for these springs are plotted in Figures 21 and 22.

Since 1992, nitrate concentrations in Convict Spring have been increasing. Concentrations during the early 1990's were around 7 mg/L; since 2006, these levels have ranged from 9 to nearly 15 mg/L.

Convict Spring flows intermittently, and only a few flow measurements are available. Because of this, it is difficult to determine how loads may have changed over time. However, from the diagram it should be noted that the nitrate load measured during this study (~ 840 lbs/day) is the highest that has been observed since observations began.

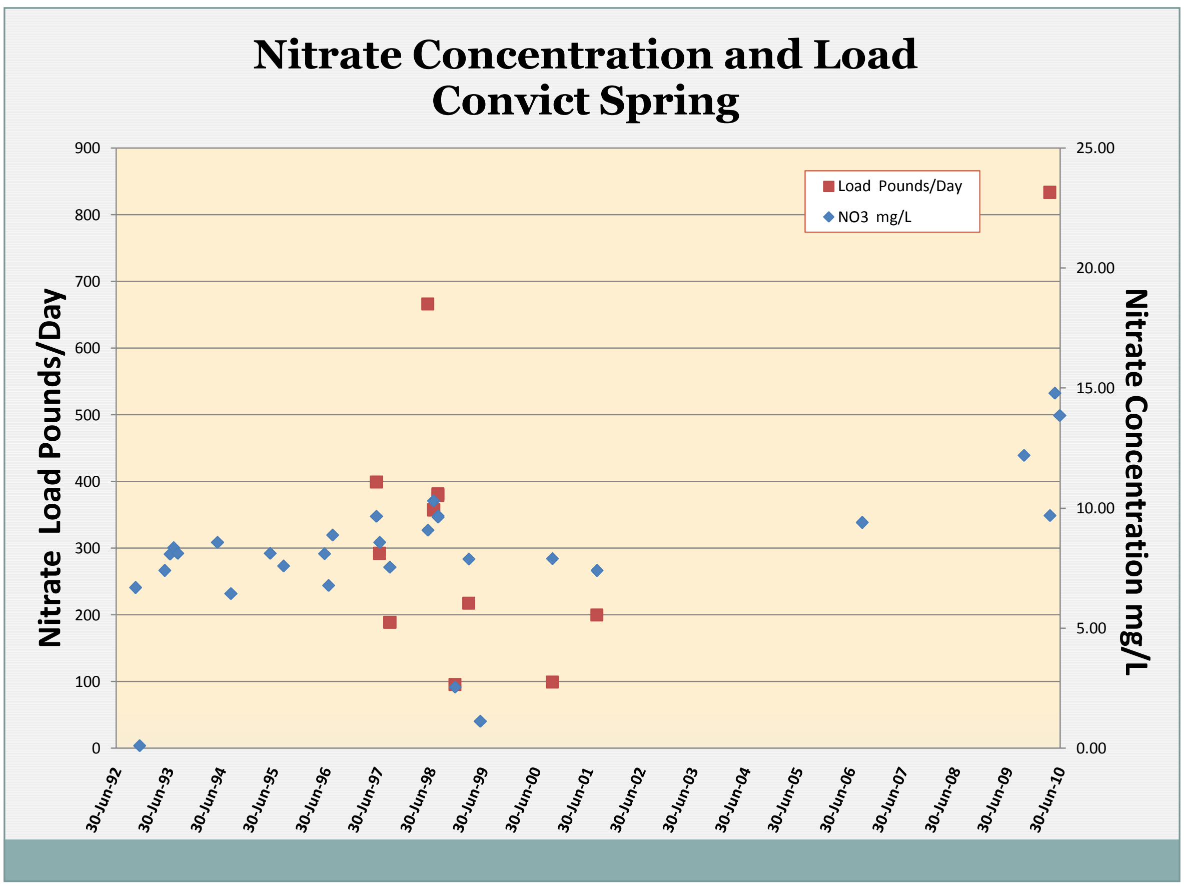

Figure 21. Convict Spring nitrate concentration and load.

Since 1992, nitrate concentrations at Royal Springs have ranged from <1 to nearly 4 mg/L; the highest concentrations were observed during this study. As with Convict Springs, flow at Royal Springs has not been frequently measured, and it also intermittently flows. The nitrate load estimated during this study (~220 lbs/day) is very similar to the load detected in 1998 following the flood that year, thus it appears that load reduction within the springshed has been minimal.

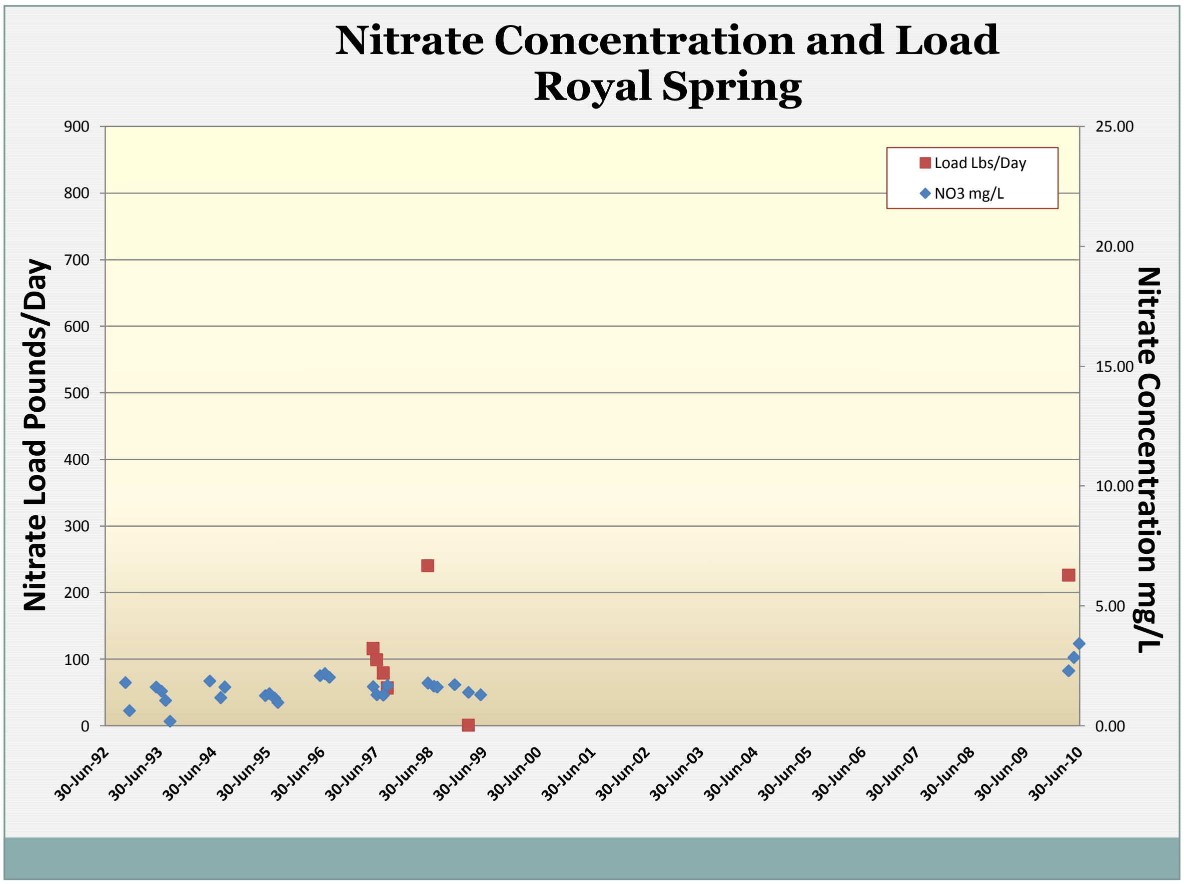

Figure 22. Royal Spring nitrate concentration and load.

LAND USE

By overlaying the Convict and Royal Spring springshed maps on the SRWMD 2006-08 land use map, percentages of the various land uses within the springsheds were obtained (Figure 23, following page). The level I land use acreages and percentages are shown for both springsheds in Table 5. Upland forest is the predominant land use, by area, in both springsheds; the second highest category is agricultural.

Convict Spring Springshed

At the level I (most general) land use category, nearly 50 percent or 3,083 acres of Convict Springs' springshed is upland forest category. At Level III category (more specific), the upland forest category contained six categories: upland coniferous plantations, coniferous plantations, forest regeneration areas, pine flatwoods, upland hardwood forests, and mixed hardwood coniferous. For this report, the first three categories were combined into one category called "planted pines" (Table 6), which accounted for approximately 80 percent of the upland forest land use category (~2440 acres). Most of this acreage was previously used in row crop agriculture or as pastures but was replanted with slash pine in the late 1980's, when those land uses became less profitable.

At level I, agricultural land use is the second largest land use in the springshed, with approximately 32 percent (1,975 acres) devoted to this land use. At level III, the highest agricultural land uses by area are improved pastures, dairies, hay fields and woodland pastures (Table 7). Because both poultry operations and dairies are essentially confined to production houses or to limited areas adjacent to milking parlors, they represent minor land uses categories when determined by area.

Table 5. Level I land use in the Convict and Royal springsheds.

	Description	Convict Springs	Convict Springs	Royal Springs	Royal Springs
		Acres	percentage	Acres	percentage
1000	Urban and Built Up	321	5.21%	2649	7.43%
2000	Agricultural	1975	31.99%	12641	35.45%
3000	Rangeland	101	1.64%	1039	2.91%
4000	Upland Forests	3083	49.92%	18905	53.03%
5000	Water	114	1.84%	22	0.06%
6000	Wetlands	562	9.10%	160	0.45%
7000	Barren Land	0	0.00%	66	0.19%
8000	Transportation Communications Utilities	18	0.30%	170	0.48%
	Totals	6175	100%	35653	100%

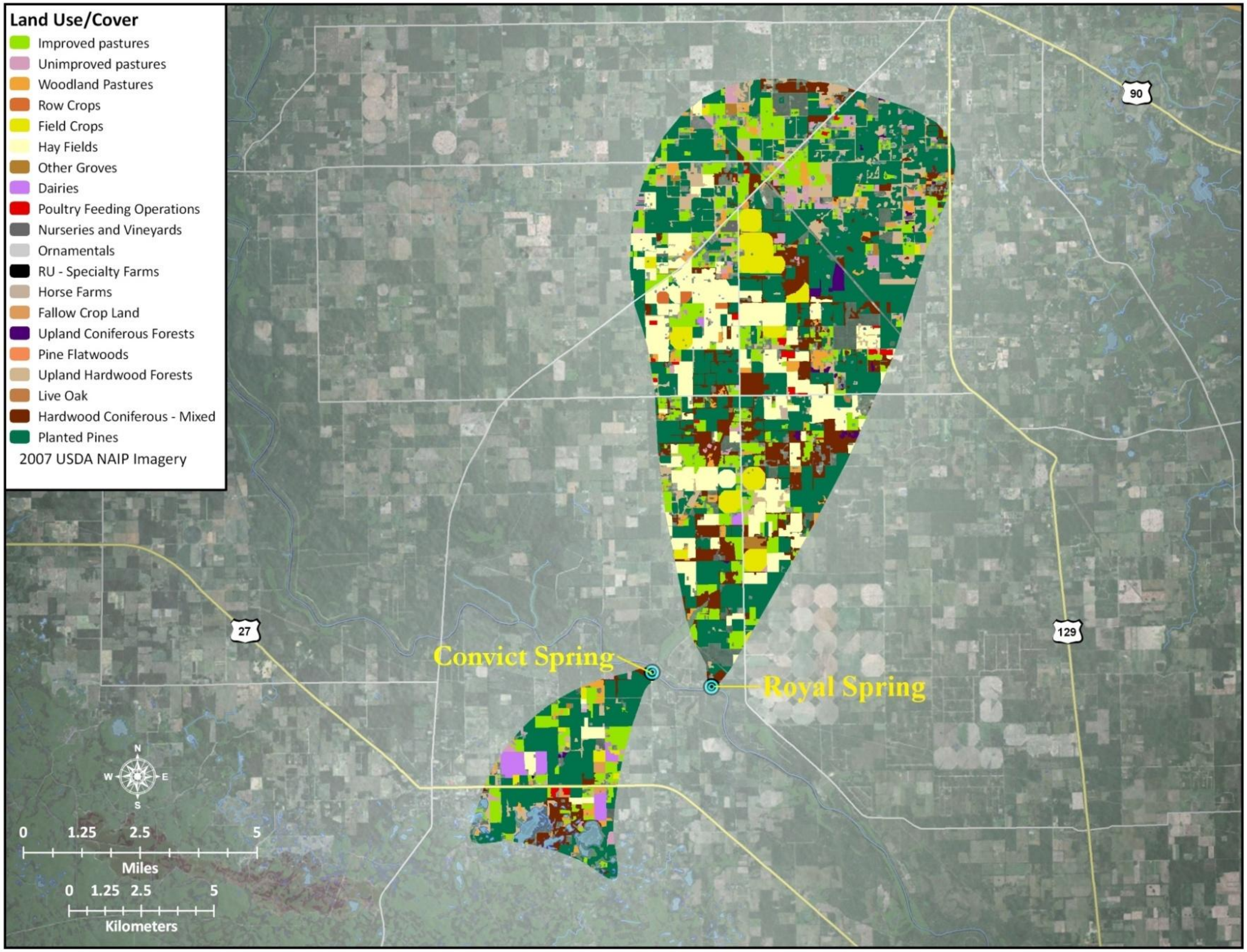

Figure 23. Level III land use map for Convict and Royal springsheds.

Table 6. Level III Upland Forest Land Use in Convict Springshed.

LEVEL_3	Description	Acres	Percentage
	Planted Pines	**2440**	**79%**
4110	Pine Flatwoods	2	0%
4200	Upland Hardwood Forests	256	8%
4340	Hardwood Coniferous - Mixed	384	12%
	Totals	**3083**	**100%**

Table 7. Level III Agricultural Land Use in Convict Springshed.

LEVEL_3	Description	Acres	Age
2110	Improved Pastures	815	41%
2520	Dairies	392	20%
2153	Hay Fields	215	11%
2130	Woodland Pastures	182	9%
2150	Field Crops	116	6%
2120	Unimproved Pastures	102	5%
2610	Fallow Crop Land	92	5%
2320	Poultry Feeding Operations	39	2%
	Other 2000 Level Land Uses	22	1%
	Total	**1976**	**100%**

Royal Spring Springshed

At the level I land use category, 18,905 acres are in the upland forest category, representing slightly more than 53% of the Royal springshed. At level III, the upland forest category contained seven categories: upland coniferous plantations, coniferous plantations, forest regeneration areas, pine flatwoods, upland hardwood forests, live oak, and mixed hardwood-coniferous. The first three categories have been combined into a single category called "planted pines" (Table 8).

At level I, agricultural land use is the second largest land use in the Royal springshed with approximately 35 percent (12,641 acres) devoted to this land use. By acreage, the top four level III agricultural land uses are hay fields, improved pastures, field crops, and woodland pastures (Table 9). Similar to the Convict springshed, poultry and dairy operations occupy minor acreages in this springshed. However, the Royal springshed contains 188 acres of poultry operations, which represents a significant amount of poultry production. The springshed also has a significant amount of agriculture land in hay fields and improved pastures. These land uses represent approximately 72 percent of the agricultural land use acreage (9,142 acres) in this springshed.

Table 8. Level III Upland Forest Land Use in Royal Springshed.

LEVEL_3	Description	Acres	Percentage
	Planted Pines	**12850**	**68%**
4110	Pine Flatwoods	21	0%
4200	Upland Hardwood Forests	2420	13%
4270	Live Oak	20	0%
4340	Hardwood Coniferous - Mixed	3594	19%
	Total	**18905**	**100%**

Table 9. Level III Agricultural Land Use in Royal Springshed.

LEVEL_3 Land use	Description	Acres	percentage
2153	Hay Fields	5208	41%
2110	Improved Pastures	3933	31%
2150	Field Crops	1444	11%
2130	Woodland Pastures	845	7%
2120	Unimproved Pastures	547	4%
2320	Poultry Operations	188	1%
	Other 2000 Level Land Uses	476	4%
	Total	**25335**	**100%**

VULNERABILITY

The Florida Aquifer Vulnerability Assessment (FAVA) model assessed the contamination vulnerability of the Floridan aquifer system at a state-wide scale. It found highest vulnerabilities in areas with thin or no confinement, close proximity to karst features (sinkholes), and high soil hydraulic conductivity. These characteristics apply to both the Royal and Convict springsheds, and the FAVA model correctly ranks the entire study area as "most vulnerable." However, because a finer resolution was desired, another means of ranking vulnerability of the aquifer was sought.

Because the Upper Floridan aquifer system in the study area is unconfined and heavily karstified, the primary factor in distinguishing the relative vulnerability of the aquifer system is the leaching potential of the overlying soils. Most of the agricultural soils in the study area are greater than 95 percent silica sand with less than two percent organic matter and have water holding capacities averaging less than one inch per foot. Most crops grown on these soils have rooting depths two feet or less, and water that moves beyond this depth is lost to deep percolation (i.e. aquifer recharge). Nitrate is a very soluble, mobile compound under these conditions, as the elevated concentrations and extensive distribution of groundwater contamination in the study area confirm.

The Soil Environmental and Agricultural Management Systems (SEAMS) model (Hoogeweg and Hornsby, 1998) was used to establish soil leaching potential for the two springsheds (Figure 24). The IFAS soil ratings are based on soil permeability. A soil rated as highly vulnerable has a permeability of more than 6.0 inches per hour (in/hr) throughout the upper 80 inches of soil column. A soil rated as moderately vulnerable has a permeability between 0.6 and 6.0 in/hr, and low vulnerability soil has a permeability of less than 0.6 in/hr and may contain a muck or peat layer in the soil profile.

Because soils have been mapped in detail, soil ratings can be made to the property parcel level. Agricultural activities are believed to be the primary sources of the nitrate contamination in the springsheds; therefore, groundwater vulnerability of the acreage in the top four agricultural land uses (including dairies and poultry operations) were determined and are presented in Table 10 and Table 11. From Table 10 it can be seen that in the Convict springshed most of the agricultural land uses occur on soils with the highest leaching rating. For the Royal springshed, most of the agricultural land uses are located on soils with medium leaching ratings (Table 11).

FERTILIZER AND ANIMAL WASTE

Fertilizer

The results of the present study suggest that synthetic fertilizer is the principal source of nitrate in groundwater within the Convict and Royal springsheds. This is consistent with the results of previous studies of other springs within the Suwannee River basin (Ceryak and Hornsby, 1998; Hornsby and Mattson, 1998). However, it is difficult to accurately determine fertilizer use within the springsheds. Although fertilizer sales data at the county level are available, simple extrapolation to the springshed level is complicated because crop acreages vary by season and production practices (i.e. fertilizer types and rates) vary from farm to farm. Previous research has shown wide ranges in fertilizer applications rates by producers in the basin, and annual fertilizer consumption data for the Suwannee basin indicate that actual fertilizer application rates often exceed IFAS-recommended rates (Katz et al., 1999).

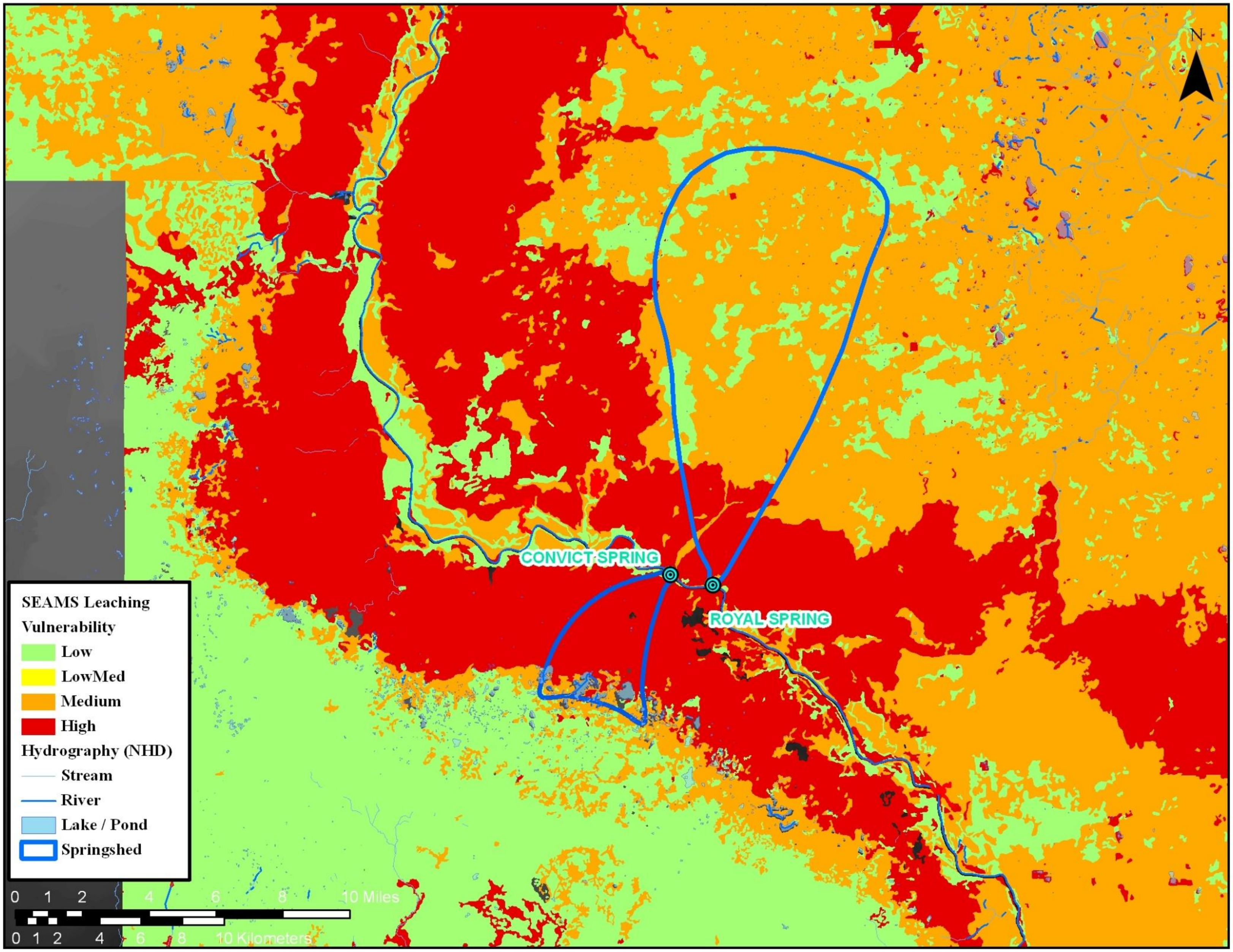

Figure 24. Soil leaching potential from SEAMS model.

Table 10. Convict Spring springshed agricultural land use vulnerability

Soil Leachability		High		Medium		Low	
Land Use	**Total Acres**	**Acres**	**%**	Acres	%	Acres	%
Improved Pastures	810	764	94%	46	6%	0	0
Dairies	392	392	100%	0	0	0	0
Hay Fields	215	215	100%	0	0	0	0
Woodland Pastures	182	151	83%	31	17%	0	0
Poultry	39	39	100%	0	0	0	0

Table 11. Royal Spring springshed agricultural land use vulnerability.

Soil Leachability		High		Medium		Low	
Land Use	**Total Acres**	**Acres**	**%**	Acres	%	Acres	%
Hay Fields	5209	362	7%	4062	78%	785	15%
Improved Pastures	3993	347	9%	2631	67%	955	24%
Field Crops	1445	49	3%	1396	97%	0	0
Woodland Pastures	844	30	3%	674	80%	140	17%
Dairies	52	0	0	52	100%	0	0
Poultry	188	0	0	180	96%	8	4%

The following calculation of synthetic fertilizer application rates assumes that 50 percent of the acreage designated as hay fields and improved pastures is fertilized with synthetic fertilizer at the IFAS-recommended rate of 80 lbs of nitrogen per cutting (and that the remaining 50 percent of acreage is fertilized with organic fertilizers). If it is further assumed that there are five cuttings per year, then the total annual application rate for hay fields and improved pastures is 400 lbs of nitrogen applied per acre. Finally, assuming that field crops are fertilized at similar rates, approximately 6,650 acres in the Convict and Royal Spring springsheds are treated with 2,660,000 lbs of nitrogen annually. Groundwater studies at production sites near the study area indicate that approximately 50 percent of the synthetic fertilizer used in irrigated row crop production may leach to the groundwater, with the remainder taken up by plants or volatilized to the atmosphere (UF-IFAS and SRWMD, 2008). Thus, the annual nitrogen load to groundwater is estimated to be 1,330,000 lbs of N for the combined springsheds.

Animal Waste

Accurate information on chicken and dairy cow populations within the springsheds is maintained by the poultry integrator, the poultry producers and individual dairy operators, their contractors, and possibly with the dairy industry associations. However, this information is difficult to obtain.

The Suwannee River Partnership, the Office of Agricultural Water Policy (OAWP), and the DEP Industrial Waste Program were contacted to obtain any readily available data. The Suwannee River Partnership provided no information but did assist in reviewing shapefiles that were provided by the OAWP. Unfortunately, it was determined that the information provided by the OAWP and the Industrial Waste Program was incomplete and not current. For example, the largest broiler producer in the Convict Springs springshed was not included in the data provided.

Nonetheless, data obtained from the Industrial Waste Program for the Convict springshed indicated that during 2009 there were 2,700 dairy cows and 659,901 chickens in the production flock. The term "production flock" is used to indicate broiler production, which is based on a six-week grow-out period. Producers attempt to produce as many flocks as possible and may produce more than five flocks per year. Assuming five flocks per year, more than three million chickens are produced in the springshed on an annual basis.

The same dataset indicated there were 1,187 dairy cows and 1,473,391 chickens in production in the Royal Spring springshed; assuming five flocks per year, more than seven million chickens are being produced annually.

Published nitrogen waste yields provided by The American Society for Testing and Materials are, for milk cows: 0.45 lbs of N per 1000 lbs per day, mean weight = 1,400 lbs; and for broilers: 1.10 lbs of N per 1,000 lbs per day, mean weight = 2 lbs. Using these figures along with the population estimates, and further assuming that animal wastes are not transported out of the springshed, an estimate of the potential nitrogen load for dairy and poultry operation in the two springsheds was calculated. This information is provided in Table 12. Assuming half of the animal waste nitrogen leaches to the groundwater, nearly two million lbs of N was loaded to the groundwater system in these springsheds.

Table 12. 2009 potential animal nitrogen loading*.

Milk Cows	Animals	lbs. N/year	Chickens (boilers)	lbs. N/year	Total (lbs. N/year)
Convict	2,700	620,865	659,901	365,849	2,076,513
Royal	1,187	272,951	1,473,391	816,848	1,763,321
Totals	3,887	893,816	2,133,292	1,182,697	3,839,834

*assumes poultry production season of 252 days per year

The Florida Department of Agriculture and Consumer Services provided information regarding the number of milk cows and chickens in the springsheds for 2011. These numbers and nitrogen loading are provided in Table 13. One dairy did not report any milk cow numbers in the Royal Spring springshed. Assuming half of this nitrogen leaches to the groundwater, it is estimated that 879,444 lbs of nitrogen was loaded to the groundwater system during 2011.

Table 13. 2010 potential animal nitrogen loading*.

Milk Cows	Animals	lbs. N/year	Chickens (boilers)	lbs. N/year	Total (lbs. N/year)
Convict	2,005	461,050	581,660	322,472	783,522
Royal	520	119,574	1,543,636	855,792	975,366
Totals	2,525	580,624	2,125,296	1,178,264	1,758,888

*assumes poultry production season of 252 days per year

CONCLUSIONS AND RECOMENDATIONS

In the Middle Suwannee, springshed boundaries were determined on a monthly basis over a seven-month period. For each sampling period, water level elevations in wells tapping the Floridan aquifer system were manually contoured to produce a potentiometric surface map, from which the approximate springshed boundaries were inferred. Temporal changes in the springshed boundaries were indicated by changes in the potentiometric surface. Significant interaction between the Suwannee River and the Floridan aquifer system was also indicated by rapid rises in the river stage that stemmed spring discharge and redirected groundwater flow. This method is extremely useful for predicting the direction of diffuse groundwater flow, in spite of limitations dictated by the karst terrain. It is known that the cave/conduit systems greatly influence aquifer system discharge; however, beyond those mapped by divers, a means of discerning these preferential flow paths is not currently available. Thus, springshed delineation remains a matter of best professional judgment under the assumption that general flow paths can be inferred from the potentiometric surface. It is recommended that future springshed studies incorporate a means of quantifying any uncertainty inherent in the method, and to devise an independent means of validating the inferred springshed boundaries.

In the study area, nitrate contamination was found to be widespread and yet highly variable. Concentrations in well water were above drinking water standards in approximately ten percent of the sampled wells, while concentrations in the springs were at or near their highest levels of the last decade.

Isotopic analyses revealed that the nitrate in Convict Spring is being derived from a combination of animal waste and inorganic fertilizer, while at Royal Spring $\delta^{15}N$ and $\delta^{18}O$ values suggest a predominantly inorganic source that has undergone some denitrification and some mixed source component. The isotopic composition of well water also indicated that inorganic fertilizer was the principal source of nitrate to area wells. These data are broadly consistent with estimates of loadings, which indicate that loadings in the Royal springshed may be mostly attributable to inorganic sources, while organic sources predominate in the Convict springshed.

Upland forests, primarily planted pines, accounts for approximately 50 percent of the acreage in the springsheds. Agricultural land uses occur on over 30 percent of the acreage in the springsheds. Hay fields, improved pastures, and field crops are the major agricultural land uses. Dairy and poultry production are significant in both springsheds but occupies minor acreages.

Soil leachability ratings developed by the University of Florida’s Institute of Food and Agricultural Sciences using the Soil Environmental and Agricultural Management Systems

(SEAMS) model indicate almost 100 percent of Convict springshed agricultural activities exist on "high" vulnerability soils. Most of Royal springshed is rated as a "medium" vulnerability.

It is difficult to accurately estimate the amounts of fertilizer that are being applied in the springsheds because good data records are either not kept or are not readily available. However, rough calculations suggest that within these springsheds, inorganic fertilizer contributes around 1.3 million pounds of nitrogen to groundwater each year. To better understand the sources of nitrate to the groundwater system, and its fate once it has entered that system, an accurate means of determining fertilizer application rates and sites needs to be developed. Because synthetic fertilizer is such a significant source of groundwater nitrate contamination; it is recommended that a means to determine synthetic fertilizer use at the field level be developed. This could be accomplished by bar coding the fertilizer and linking it with its application site to the property parcel level. Alternatively, fertilizer use could be recorded in the nutrient management plans that are developed by the permitted producers and other members of the Suwannee Partnership.

Dairy and poultry production in the study area generate significant potential nutrient loads. Using 2011 data, it is estimated that these activities could contribute as much as 0.9 million pounds per year to groundwater, nearly 50 percent of the total nitrate load. These activities are more concentrated in the Convict Spring springshed. In addition to acquiring and maintaining accurate numbers for dairy cows and poultry production, it is recommended that the location and application rates of the manure and litter be documented. This will facilitate more accurate assessments of the groundwater loadings from these sources.

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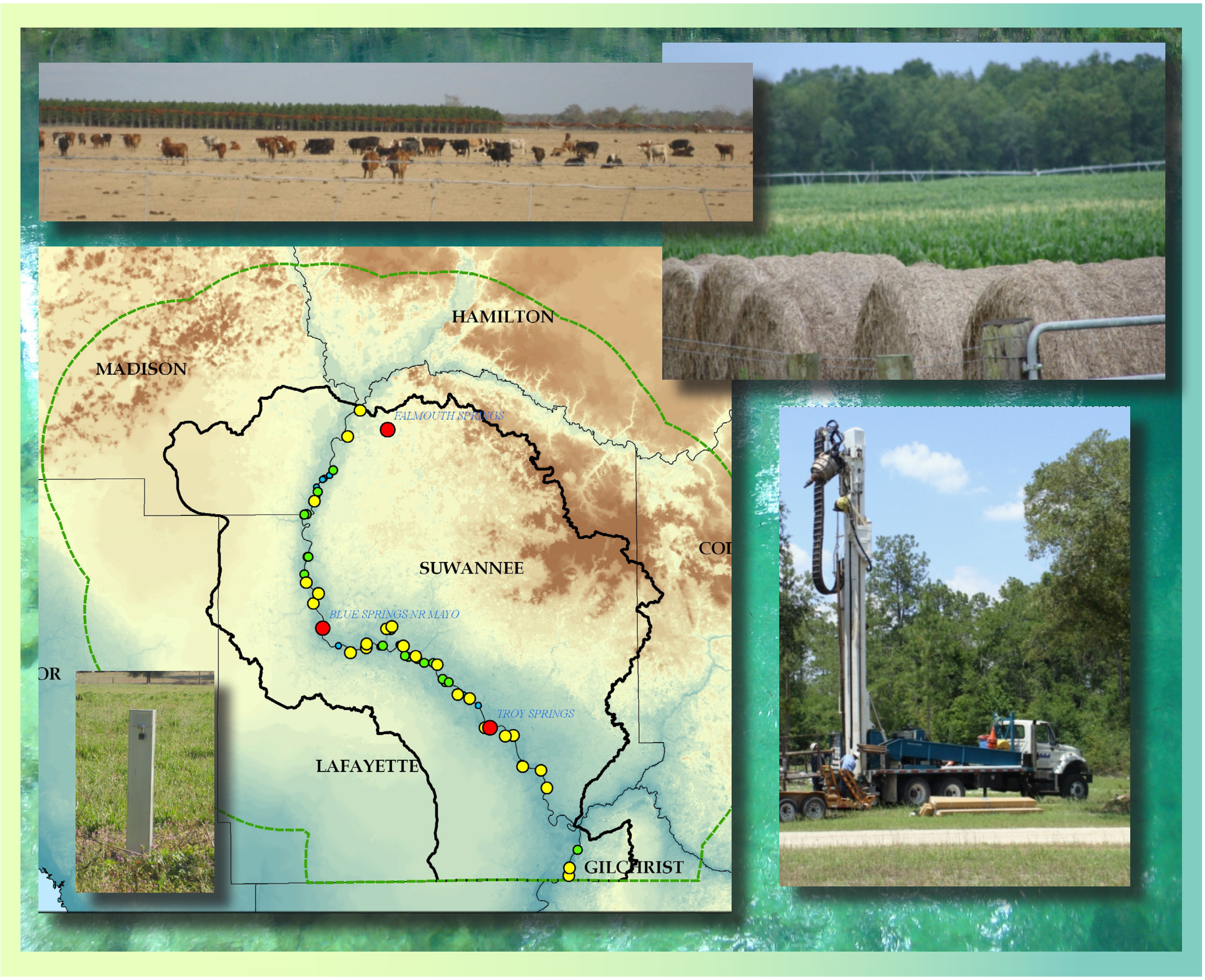
Appendix A.

Middle Suwannee Springshed Delineation
Project Update
FY ’08-‘09

Middle Suwannee Springshed Delineation Project Update FY '08-'09



Florida Geological Survey
Florida Department of Environmental Protection
June 30, 2009

903 W. Tennessee St., MS 720
Tallahassee, Florida 32304
http://www.dep.state.fl.us/geology/

Summary

- The Florida Geological Survey is conducting a springshed delineation study in the Middle Suwannee basin. This project will lead to a better understanding of the potentiometric surface of the Floridan aquifer system. Springshed maps will be generated for approximately 63 Middle Suwannee springs.

- Eight employees were hired for this project:
    - Office Staff
        - James McClean, Project Data Manager
        - Alexandra Walrath, GIS Technician
    - Field Crew (Environmental Specialists I)
        - James Bobrycki
        - John Carroll
        - Caitlin Cerame
        - Jacob Mast
        - Melinda Spall
        - Eric Thomas

- Employees received the following training:
    - Required FDEP training:
        - New Employee Orientation
        - Harassment Is…
        - Diversity in the Real World
        - DEP Code of Ethics
        - DEP Public Records
    - Basic First Aid and CPR for Adults and Children
    - FDEP Purchasing Card Training
    - FDEP SOP Sampling Training for Groundwater, Surface Water and Wastewater
    - FDEP Snorkeling/Skin Diving Training

- The field crew visited and accessed 527 homeowner wells in the study area.

- An informational brochure was mailed to every homeowner contacted by the field crew.

- Sixteen new monitoring wells were installed in the study area.

- For the 2008-2009 fiscal year the project was awarded $347,695. Total expenditures amounted to $241,985.71. The difference between the amount awarded and the total expenditures is largely due to a delay in the staff hiring process and an inability to purchase GPS surveying units during this past fiscal year.

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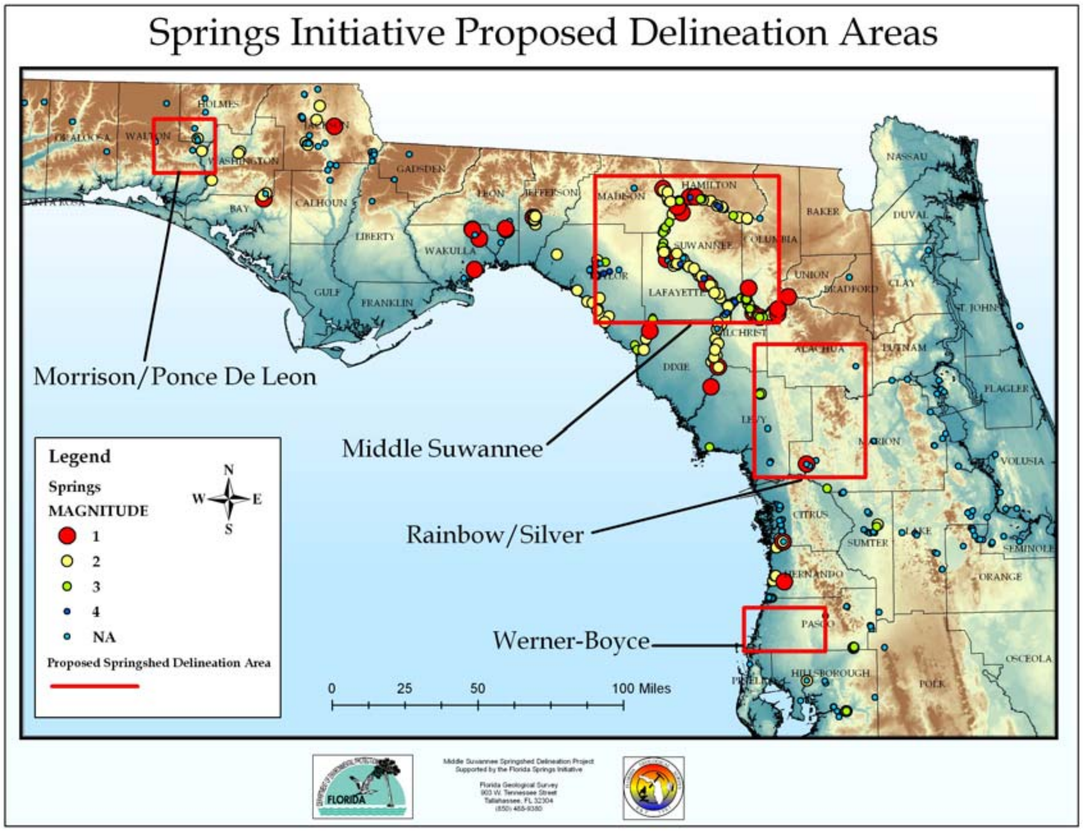


Figure 1

Working cooperatively with the Florida Springs Initiative, the Florida Geological Survey (FGS) is a conducting a four-year springshed delineation project (Figure 1). Delineating springsheds for the springs along the Suwannee River in an area known as the "Middle Suwannee" is the priority. The Middle Suwannee springshed delineation project is expected to take approximately two years to complete, including eighteen months of fieldwork. Next, refinements in the springshed boundary between Rainbow and Silver Springs are scheduled. The delineation of the boundary between Rainbow and Silver Springs is expected to take approximately twenty months. Lastly, springshed delineations for Morrison, Ponce de Leon and Werner-Boyce Springs are to be completed. Delineation of the springsheds for Morrison, Ponce de Leon and Werner-Boyce is expected to take nine to twelve months. Each of these delineations could be completed as a stand-alone project. So far we have completed approximately five months of fieldwork for the Middle Suwannee springshed delineation project.

Springshed delineation, or springshed mapping, is a relatively new and evolving science. Groundwater level maps called potentiometric surface maps are used to delineate springsheds. These maps look like topographic maps with contour lines, but they represent the groundwater levels under the land surface. Other springshed delineation techniques include dye tracing and the analysis of water chemistry domains, contaminant loadings, and discharge/recharge rates.

The FGS's approach to delineating springsheds in the Middle Suwannee is as follows:

1. Compile information including existing springshed maps and historic water chemistry/discharge data.
2. Locate existing wells within the study area and obtain permission to use them as monitoring wells.
3. Identify gaps in our well network and install new monitoring wells as needed.
4. Survey the wells within our network.
5. Collect water levels and water chemistry samples from the wells.
6. Use these water level and water chemistry data to generate potentiometric surface maps and delineate springsheds.
7. Provide a written report and springshed maps.

Study Area Description:

For descriptive purposes our study area has been named the Middle Suwannee River Basin, being a subset of the larger hydrologic unit known as the Lower Suwannee River Basin. This hydrologic unit code (HUC) encompasses 620,800 acres (970 square miles). Our study area includes a ten mile buffer around the upper portion of the Lower Suwannee River hydrologic unit encompassing a total area of 1,539,200 acres (2,405 square miles). This section is bounded on the north by the confluence of the Withlacoochee River and at the southern end is bounded by the confluence with the Santa Fe River. See Figure 2 showing both the hydrologic unit code boundary and the ten mile buffer zone. This study area contains portions of and/or entirely encompasses the following counties: Taylor, Madison, Suwannee, Lafayette, Hamilton, Columbia, and Gilchrist. Within this reach of the Middle Suwannee River Basin are a total of 63 documented springs, listed in Table 1 of Appendix A. These include the following first magnitude springs: Lafayette Blue Spring, Falmouth Spring and Troy Spring. Falmouth Spring is known to be a karst window and not technically a spring in that the flow of water reverses direction depending upon the stage of the Suwannee River.

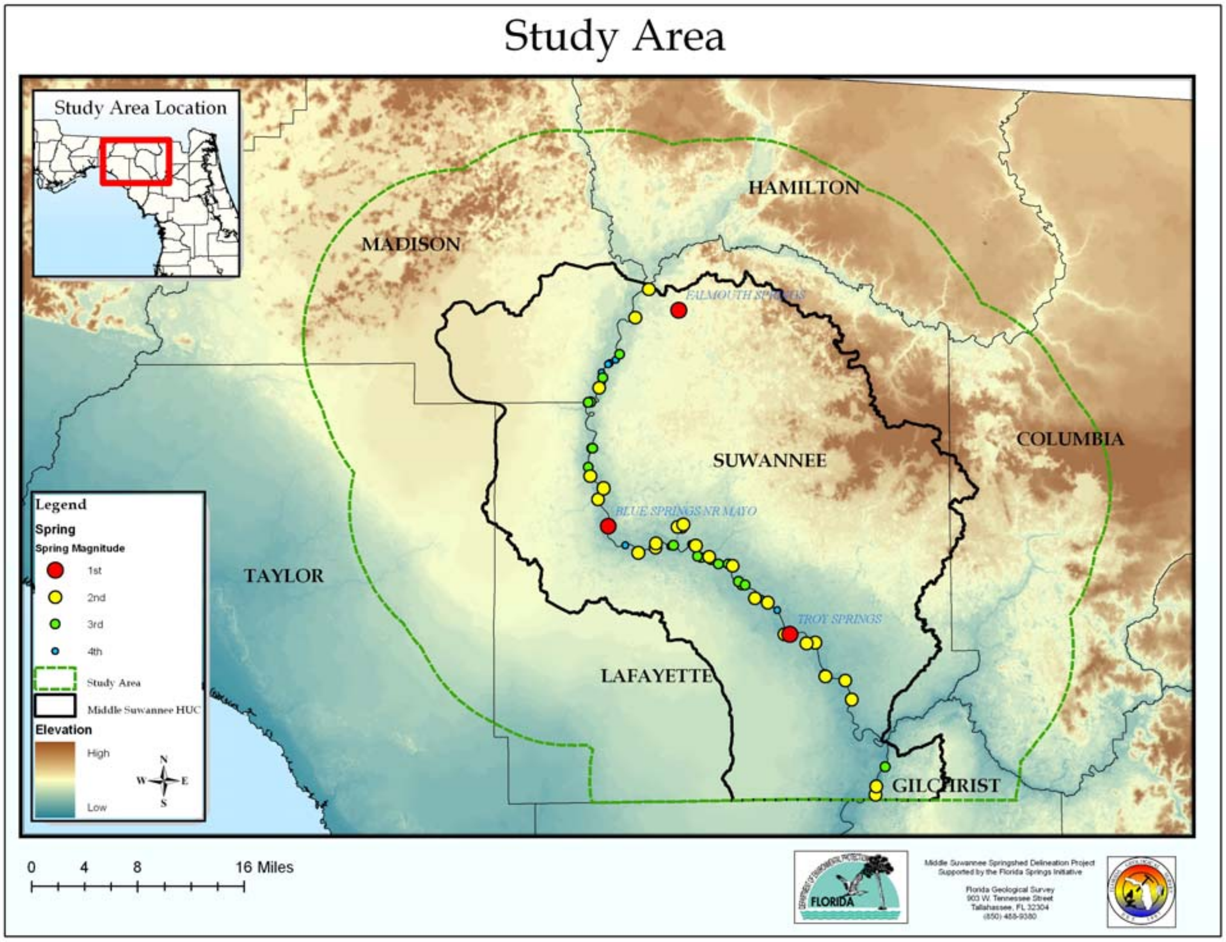


Figure 2

Field Data Set Development:

The Suwannee River Water Management District (SRWMD) has provided the Florida Geological Survey with a database containing over 15,000 wells that are located within the water management district. Using Geographic Information System (GIS) software we have filtered this data set to identify approximately 6,600 wells within our defined study area (Figure 3). Of these wells, 6,188 are privately owned. The remaining 436 wells that are on state property have been used in previous scientific studies.

The accuracy of our potentiometric surface maps will depend in part on the positional accuracy of our well network. With this in mind we analyzed our data set to identify high precision points (Figure 4). These points include wells and benchmarks for which we already have accurate locations. We identified 526 wells within the study area that have been professionally surveyed. We also identified wells that are monitored by the SRWMD either continuously or on a monthly basis. Our network of high precision points also includes 908 benchmarks used in the National Geodetic Survey.

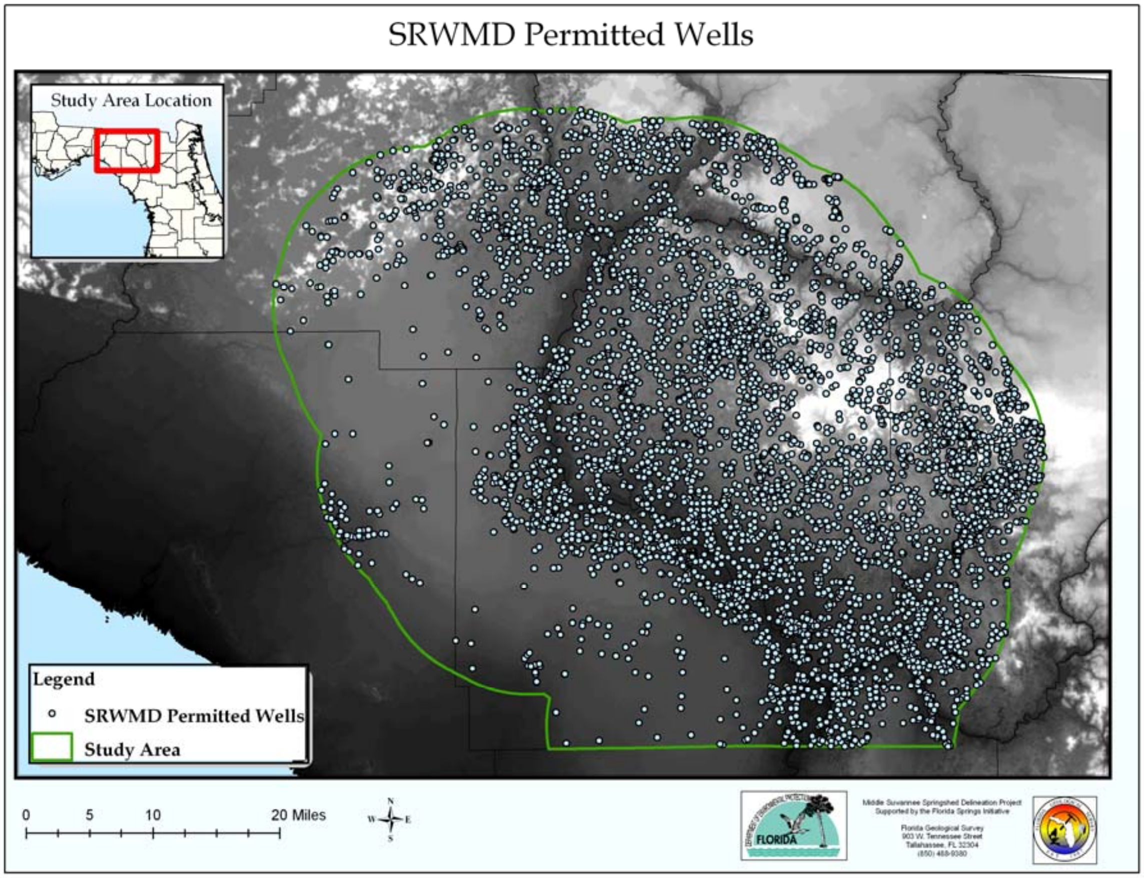


Figure 3

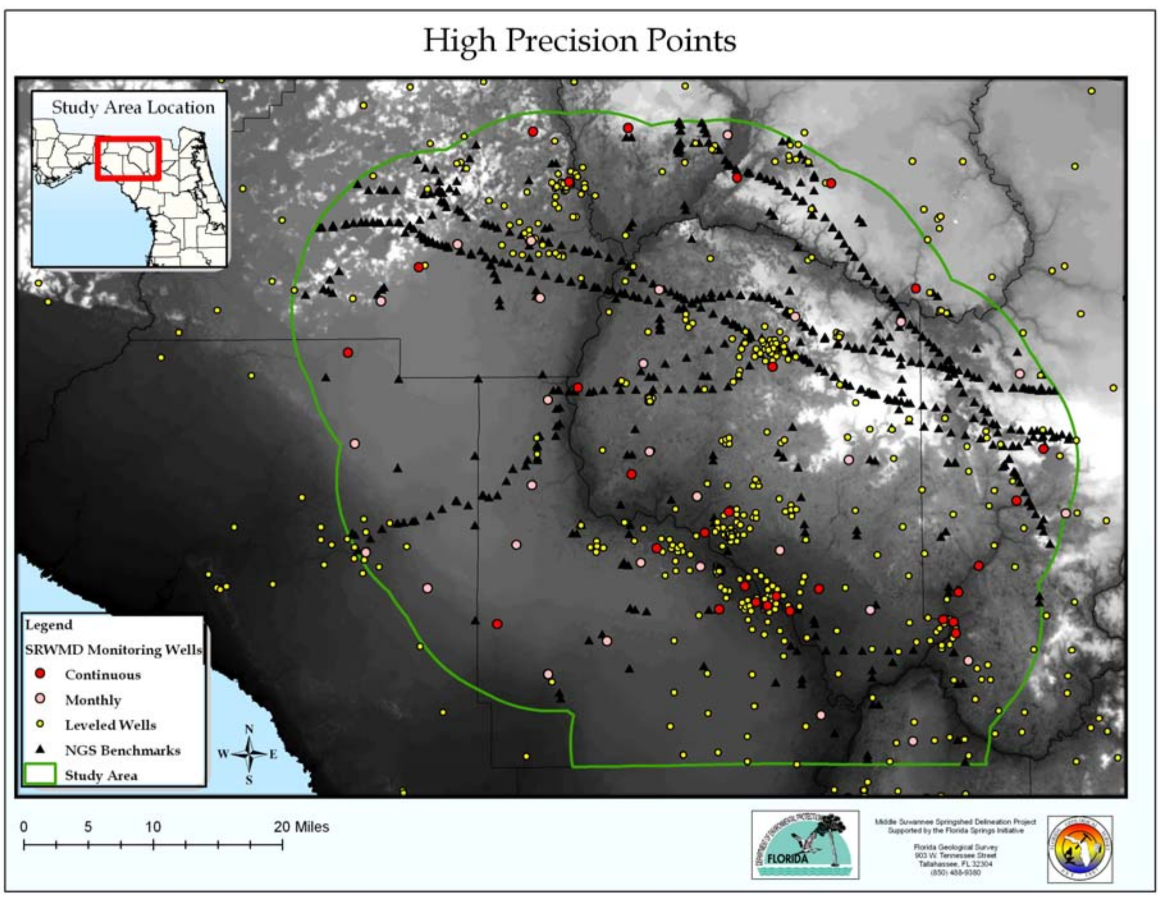


Figure 4

Data Collection Methods:

The primary objective of this past fiscal year has been to establish a network of wells suitable for water level measurements and groundwater chemistry sampling throughout the study area. The data set provided to us by the SRWMD includes an abundance of wells. However, not all of these wells are suitable for this study. Most of the wells in our data set are private homeowner wells, not monitoring wells. Many of these homeowner wells cannot accommodate a water level meter. Also, not all homeowners are willing to allow their wells to be sampled.

We hired a field crew to canvass the study area, searching for usable wells and obtaining site access permission from landowners. Our field team consists of six employees hired in February 2009 to conduct site evaluations and to secure landowner permission to access and sample selected wells. The field crew was dispatched in three teams of two persons to canvass homeowners to secure their cooperation with our sampling plans.

To streamline integration of this growing data set into our GIS databases, an interactive Well Attribute Form was created using Adobe Acrobat Professional (Form 1, Appendix B). Field data parameters are recorded in log books by each field team and then transposed into the data set by means of electronic data entry by typing the relevant data into the fillable form back in the office. Each form created is then stored as an Extensible Markup Language (xml) file which can then be read by a wide variety of software packages. At the end of several weeks, these forms are then combined in a batch process within Adobe Acrobat Professional which generates a tabular database file readable in Microsoft Excel. The resulting table of well attributes is then output as Shapefiles for use in Environmental Science Research Institute (ESRI) ArcGIS software. These Shapefiles form the backbone of our geographic databases.

Summary of Project Year to Date Accomplishments:

Hiring

Two office staff and six field crew were hired for this project. Mr. James McClean, a former FGS employee, was hired in December 2008 as the project data manager and functions as the assistant project manager. Office space was cleared and organized in early December in the Florida Geological Survey Gunter Building for the use of project staff. Three computer work stations were established in addition to a previously established workstation, for a total of four computer stations for staff use. In early January Ms. Alexandra Walrath was hired as the project GIS technician. Mr. McClean and Ms. Walrath have their own computer workstations with GIS and publication software loaded for their regular full time use. During February 2009 the following six personnel were hired as Environmental Specialists I: Mr. James Bobrycki, Mr. John

Carroll, Ms. Caitlin Cerame, Mr. Jacob Mast, Ms. Melinda Spall and Mr. Eric Thomas. These six staff members serve as the project's field crew. The field crew rotates use of the remaining two computer work stations at the beginning and end of each week to submit travel related documents, complete data entry assignments and input time cards. Usually the field crew spends Tuesday-Thursday in the study area. The entire springshed delineation team gathers in the office on Mondays and Fridays to complete paperwork and attend project staff meetings.

Training

Project timelines and objectives were outlined throughout the months of December and January including the development of the well database. The month of February was devoted to new employee orientation and training in compliance with FDEP hiring regulations (New Employee Orientation, Harassment Is…Government Version, Diversity in the Real World, DEP Code of Ethics, DEP Public Records). Staff also received classroom instruction and certification in Basic First Aid and CPR for Adults and Children during the month of February. In March staff completed training on the use of state purchasing cards. In April the springshed delineation team attended a one-day workshop on FDEP SOP Sampling Training for Groundwater, Surface Water and Wastewater at the University of Florida's TREEO Center. Skin diving/snorkeling training is scheduled for July.

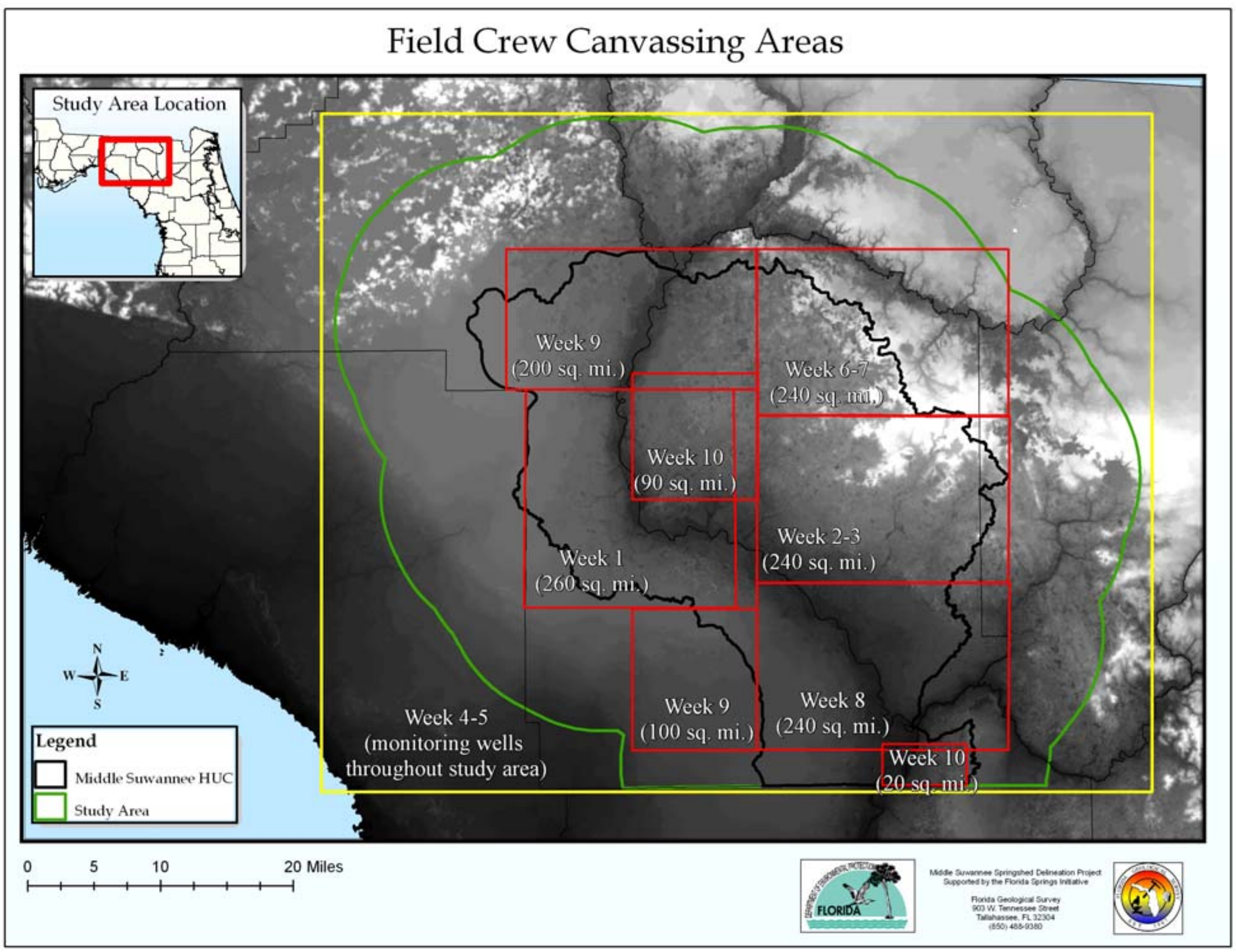


Figure 5

Well Location and Site Access

Field work began in February, 2009. Over the course of ten weeks the field crew visited landowners throughout the study area. Before dispatching the field crew, we overlaid a ten mile grid on the study area. Using this grid we divided the study area into blocks of approximately 250 square miles, focusing on the Middle Suwannee HUC (the central portion of our study area). Each week the field crew was assigned one of these 250 square mile blocks (Figure 5). The field crew received maps of each block showing the locations of wells in our data set. We also provided the crew with contact information for each well's owner based on cadastral records. In the fourth and fifth weeks of field work we experimented with a different strategy, sending the field crew to locate existing monitoring wells throughout the entire study area. See Table 2 of Appendix A for weekly totals of wells accessed by the field crew.

Armed with well maps and contact information, the field crew visited as many wells as possible. In addition to visiting the wells marked on their maps, the crew also looked for wells that were not included in our data set. During this first phase of fieldwork the crew photographed each well they visited, collected preliminary well location data using handheld GPS units, and obtained verbal permission from landowners to access the wells. Each two-person field crew team kept detailed field notes describing daily activities (see Example of Field Notes, Appendix C). For every well visited, the field crew filled out a Well Attribute Form detailing relevant information (Form 1, Appendix B). As discussed above, these forms are electronically input into our well database. The database currently includes 527 wells visited by the field crew (Figure 6).

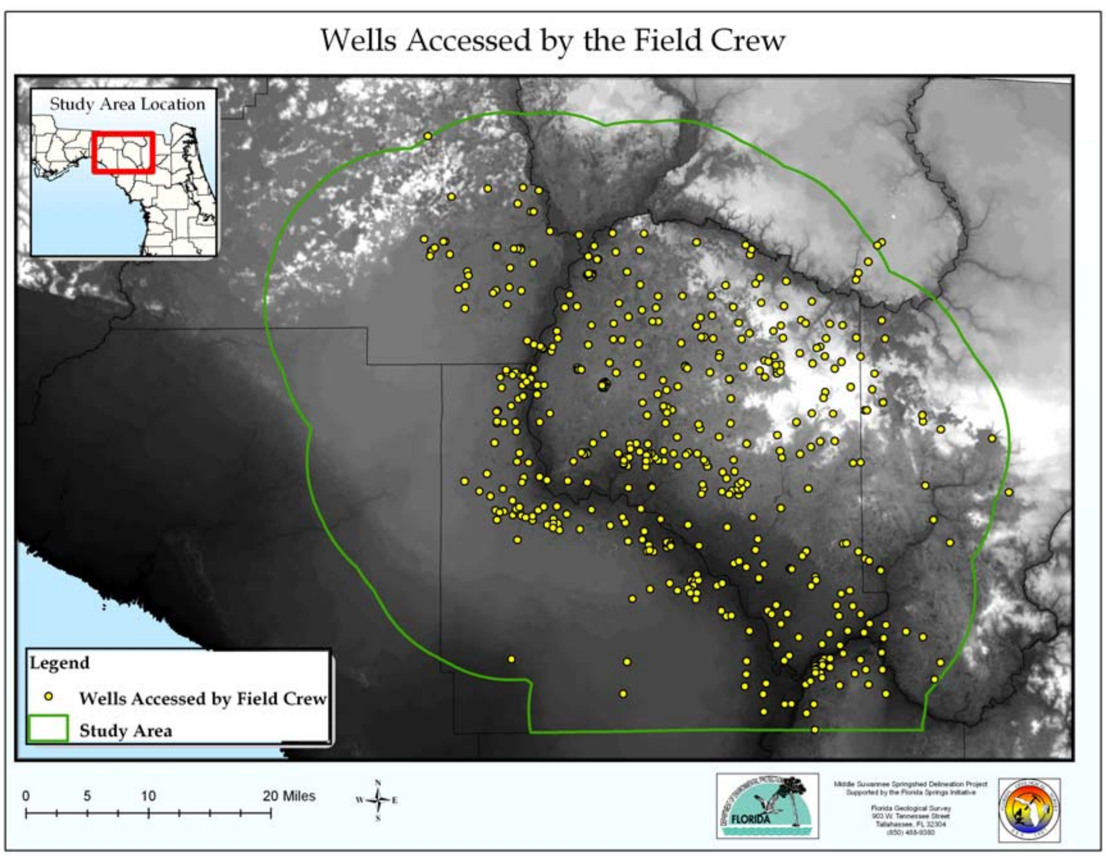


Figure 6

Informational Brochure
At the request of the Florida Farm Bureau and the Suwannee River Partnership, we produced a brochure on the Middle Suwannee springshed delineation project (see Informational Brochure, Appendix D). The brochure introduces readers to springshed delineation and describes the scope of our project. After being reviewed by the FGS and the FDEP's Communications Department, the brochure was mailed to every landowner contacted by the field crew. Additional copies of the brochure are available to other interested parties upon request.

Monitoring Well Installation
After ten weeks of field work we analyzed the project database of 527 wells and looked for gaps in the well coverage. Between May 25 and June 1, 2009 sixteen new monitoring wells were installed to fill these gaps (Figure 7).

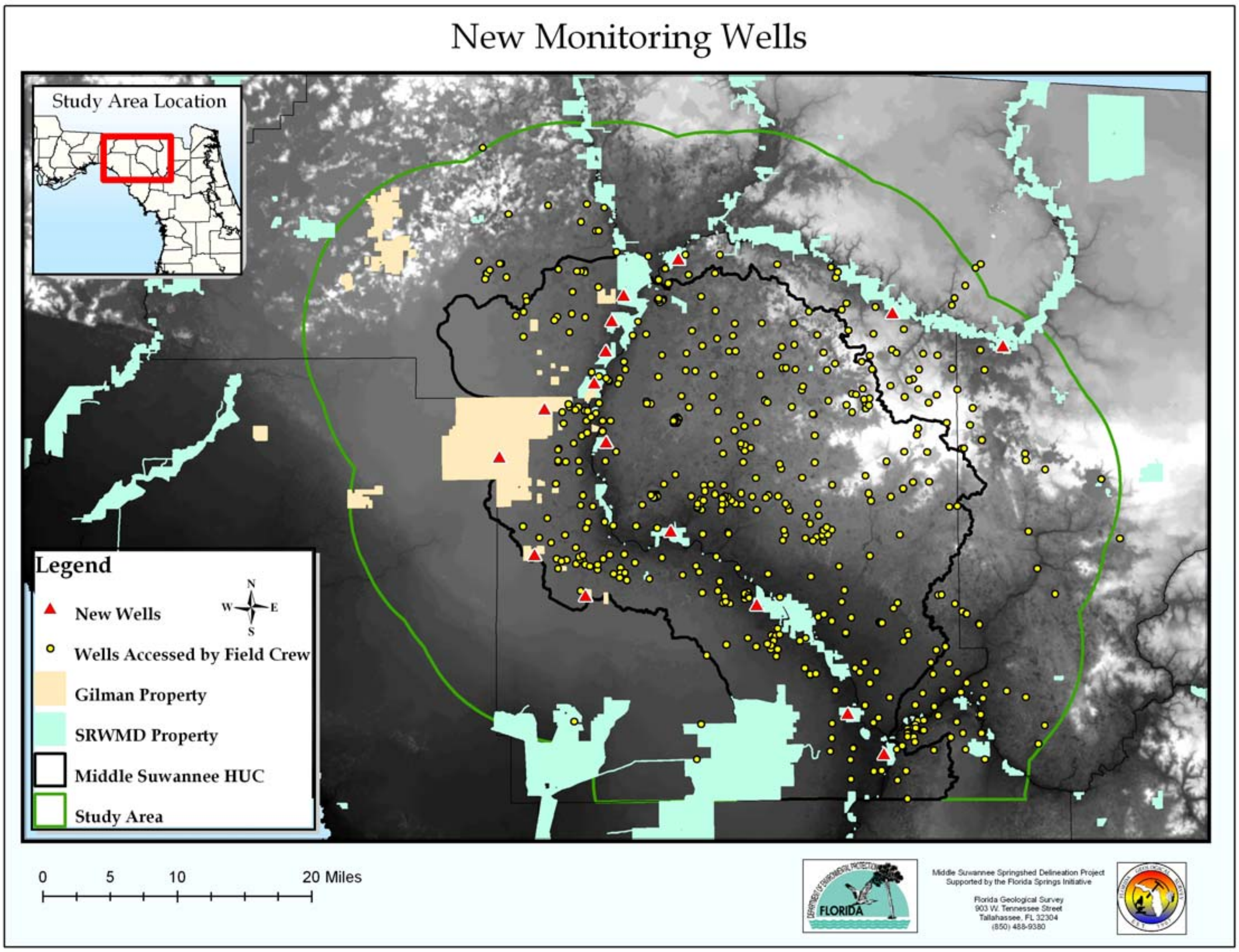


Figure 7

When searching for potential new well sites, we focused on property owned by two of the largest landholders in the study area: the SRWMD and the Gilman family trust. The SRWMD owns approximately 67,800 acres of land in the study area, while the Gilman family trust owns approximately 41,700 acres of land in the study area. Representatives of the SRWMD and the Gilman family signed a legally binding form granting the FGS permission to install monitoring wells and collect water levels and water quality samples on their property (Form 2, Appendix B). The FGS is guaranteed access to these wells for the next two years, after which time ownership of the wells will revert to the landholders. Each will is permitted by the SRWMD (see Example of Well Permit, Appendix E). Twelve of the sixteen new monitoring wells were drilled on SRWMD property, with the remaining four on Gilman property.

Monitoring well installation was administered under the FDEP's contract with URS Southern Corporation (URS). URS selected and contracted a drilling contractor, Groundwater Protection, Inc. (GPI) to install and develop the wells. Drilling was completed by GPI with oversight by three URS staff members (a Florida licensed geologist, a geologist, and a senior scientist). The springshed delineation field crew was also onsite to oversee well installation. Two additional wells were installed by FGS staff.

Three teams of drillers worked simultaneously during the two-week period of well installation. Eight wells were installed by GPI's sonic rotary rig, six wells were installed by GPI's hollow stem auger/mud rotary rig, and two wells were installed by the FGS's mobile core drilling rig. Wells were installed to depths from 29 to 90 feet below land surface. Lithologic logs of each borehole were prepared by describing the drill cuttings at five-foot intervals. The wells were constructed of polyvinyl chloride (PVC) casing with twenty feet of well screen. Seven wells have four inch diameters, and the remaining nine wells have two inch diameters. Each well was fitted with a locking protective casing (Figure 8). After completing the well installation, URS provided the FGS with a report summarizing the construction details, location, and lithologic log of each monitoring well (see Selections from URS Report, Appendix F).

Figure 8

Grant:	10609			Summary	
CATEGORY ALLOTMENTS			**Grant Funds or Matching Funds?**	**TOTAL EXPENDITURES**	**TOTAL REMAINING**
Total Grant Amount	**$**	**355,092.00**			
OPS Salary	$	140,195.00	Grant Funds	$ 120,337.96	$ 19,857.04
FTE Salary (Match)	$	-	Matching Funds	$ -	$ -
EXPENSE--Purchases/Perquisites	$	-	Grant Funds	In "Travel Expense"	In "Travel Expense"
EXPENSE--Travel	$	38,100.00	Grant Funds	$ 35,881.10	$ 2,218.90
EXPENSE--Drilling	$	-	Matching Funds	$ -	$ -
OCO	$	-	Grant Funds	$ -	$ -
CONTRACTUAL SERVICES	$	165,400.00	Grant Funds	$ 81,766.65	$ 83,633.35
OVERHEAD/INDIRECT	$	4,000.00	**From budget sheets**	$ 4,000.00	$ -
TOTAL	**$**	**347,695.00**	**TOTAL**	**$ 241,985.71**	**$ 105,709.29**

Figure 9
Budget summary as tracked by FGS personnel. This table is up to date as of the last week of June and therefore does not account for an additional eight (8) days of OPS salary expense from the last pay period of FY 08-09.

Budget Narrative:

Our project budget is comprised of three general spending categories: OPS Salary, Travel Expense and Contracted Services (Figure 9).

OPS Salary funds were used to pay the salaries of the two office support staff and six field personnel. The Travel Expense funds were used to pay for field work expenses related to this project such as meals, per diem and lodging. Each of the eight employees hired for this project was issued a State of Florida Purchasing Card through the Division of Environmental Assessment and Restoration (DEAR). Travel authorization forms were submitted to and authorized by FGS administrative staff for the purpose of tracking employee travel and project use of FGS vehicles. However, fiscal management of project funds remains in the hands of DEAR personnel. Ms. Linda Quinn-Godwin is assigned as our P-Card "Watcher" who is responsible for tracking and approving P-Card usage and travel expenses for this project. While we track all expenses in house and maintain triple redundancy in our paperwork records, ultimate fiscal accountability lies with the Division of Environmental Assessment and Restoration. We believe that the above documented budget summary is a true representation of actual project expenses for this past fiscal year based upon the allotment values stated to us by the Florida Springs Initiative.

The Contractual Services funds allocation was used to contract with Ground Water Protection Incorporated through URS Incorporated of Tallahassee, Florida for the installation of fourteen monitoring wells on both SRWMD and privately owned land parcels within the study area. The cost of installing these wells was $81,766.65.

An additional $75,000 of these funds were earmarked for a contractual lease agreement to obtain use of a high precision survey grade GPS real time kinematic base station and rover system to facilitate vertical elevation measurements of these and other wells to be used to meet our project's data collection objectives. Leasing this equipment with a long term buy out option would enable the project to survey in hundreds of wells for a mere fraction of what it would cost to contract a professional surveyor charging $5,000 per well to accomplish the same goals. Our intention was to establish a contractual lease agreement with a local vendor to provide access to the required surveying equipment for a three year period. Unfortunately this request was curtailed by Finance and Accounting as being an incompatible use of funds designated for Contractual Services. As such there exists an excess of at least the $75,000 earmarked for a three year lease of a Trimble R8 GNSS surveying system at the end of our budget year. A delay in the staff hiring process accounts for much of the remaining excess. According to the Florida Springs Initiative Coordinator a portion of these excess funds will be used to support other Initiative projects.

In addition to the use of the above outlined funds, project financial support was received from the Florida Geological Survey in the form of vehicle usage and payment of vehicle expenses accrued by project field staff using vehicles loaned to us for use throughout the term of the project by the Division of Water Resource Management. Our Springshed Delineation Project has been loaned the use of DEP 3999 and DEP 4549, a Ford F-250 with tool storage topper and a Jeep Cherokee respectively. The Voyager Fleet card for the purchase of fuel and periodic preventative maintenance for DEP 3999 has been assigned to the Florida Geological Survey, while those costs associated with DEP 4549 are being paid for from the Springshed Delineation Travel Expense budget. To date FGS has contributed $1099.06 for fuel and vehicle maintenance to support our project. Vehicle expenses for DEP4549 are accounted for in the above budget summary.

Goals for Next Year:

Refine the Well Network

Our next step is to identify wells in the project database that are suitable for water levels and water sampling. The field crew photographed each well that they visited while canvassing the study area. Based on these photographs we will isolate wells that can accommodate water level meters and sampling equipment. Once the usable wells have been identified, the field crew will obtain written permission from landowners to access these wells (Form 3, Appendix B).

Install Additional Monitoring Wells
Additional monitoring wells will be installed on property owned by Foley Land and Timber. The largest landholder in the study area, Foley Land and Timber owns approximately 186,700 acres within the study area (Figure 10). Foley representatives have already granted us tentative permission to install wells on their property.

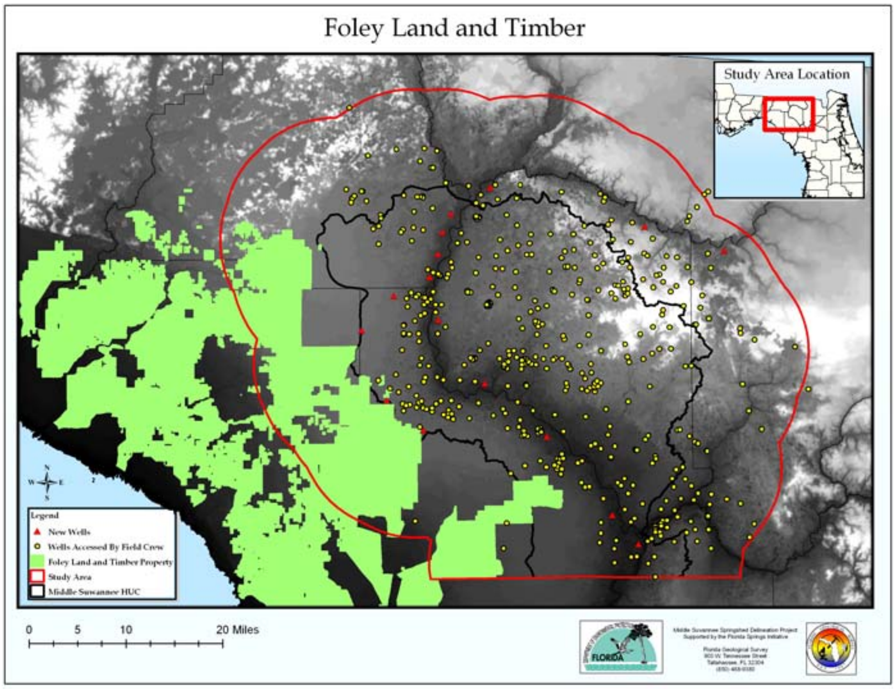


Figure 10

We will finalize our agreement with Foley and complete well installation in the next fiscal year.

Survey the Wells
Once our well network has been finalized, we will survey each well in the network. One of the major expenses for previous springshed delineations has been surveying the wells used in the generation of potentiometric maps. In order to map the potentiometric surface, it is important to obtain accurate surface elevations for every well used to generate the potentiometric surface. The surface elevation of the well must be compared to the water level in the well with a high degree of accuracy. The FGS proposes to acquire survey grade GPS units to accomplish this task. The GPS vendor will train springshed delineation staff on the use of the GPS equipment.

Water Levels, Water Sampling, and Springshed Delineation
We expect to obtain two sets of water levels and water chemistry samples from the wells in our network. Sampling is tentatively scheduled for October, 2009 and May, 2010. Water conditions permitting, the crew will also obtain water chemistry samples from approximately 35 of the study area's 63 springs. These water levels and water chemistry samples will be used to create new potentiometric maps of the study area. Given the density of our well network, we expect that these potentiometric maps will be more refined than previous efforts. Based on potentiometric maps and water chemistry analysis we will delineate springsheds for the springs in the study area. We anticipate that multiple small springs will be grouped into single springsheds. After completing the springshed delineation we will produce springshed maps and a final written report.

Appendices

Appendix A

Table 1: Middle Suwannee Springs

Spring ID Code	Spring Name	Magnitude
LBS010C1	BLUE SPRINGS NR MAYO	1
FAM010C1	FALMOUTH SPRINGS	1
TRY010C1	TROY SPRINGS	1
AMP010C1	ALLEN MILL POND	2
ANS010C1	ANDERSON SPRING IN SUWANNEE RIVER	2
BON010C1	BONNET SPRINGS	2
BRA010C1	BRANFORD SPRINGS	2
BTS010C1	BATH TUB SPRINGS	2
CHS010C1	CHARLES SPRINGS	2
LAF718971	UN-NAMED SPRING	2
LAF718972	UN-NAMED SPRING	2
LAF924971	UN-NAMED SPRING	2
LAF929973	UN-NAMED SPRING	2
LRS010C1	LITTLE RIVER SPRINGS	2
ELL010C1	ELLAVILLE SPRINGS	2
GIL84971	UN-NAMED SPRING	2
MAD922977	FARA SPRINGS	2
MEA010C1	MEARSON SPRINGS	2
ORG010C1	ORANGE GROVE SPRING	2
OWN010C1	OWENS SPRINGS	2
PER010C1	PERRY SPRINGS	2
RLS010C1	RUTH/LITTLE SULFUR SPRINGS	2
RUN010C1	RUNNING SPRINGS	2
SBL010C1	SUWANNEE BLUE SPRINGS	2
SHN010C1	SHINGLE SPRINGS	2
TEL010C1	TELFORD SPRINGS	2
TUR010C1	TURTLE SPRINGS	2
CON010C1	CONVICT SPRING	3
LAF57981	UN NAMED SPRING	3
LAF57982	UN NAMED SPRING	3
LAF919972	UN-NAMED SPRING	3
LAF922975	UN-NAMED SPRING	3
LAF922976	UN-NAMED SPRING	3
LAF929971	UN-NAMED SPRING	3

Spring ID Code	Spring Name	Magnitude
LAF929972	UN-NAMED SPRING	3
LAF93971	UN-NAMED SPRING	3
GIL917972	UN-NAMED SPRING	3
LUR010C1	LURAVILLE SPRINGS	3
PEA010C1	PEACOCK SPRING	3
ROY010C1	ROYAL SPRINGS	3
SHY010C1	SHIRLEY SPRINGS	3
SUW718971	UN-NAMED SPRING	3
SUW725971	UN-NAMED SPRING	3
SUW919971	UN-NAMED SPRING	3
SUW919973	UN-NAMED SPRING	3
SUW922971	UN-NAMED SPRING	3
SUW922973	UN-NAMED SPRING	3
LAF710981	UN-NAMED SPRING	4
LAF919971	UN-NAMED SPRING	4
LAF922977	UN-NAMED SPRING	4
LAF924972	UN-NAMED SPRING	4
GIL917973	UN-NAMED SPRING	4
MAD922971	UN-NAMED SPRING	4
MAD922972	UN-NAMED SPRING	4
MAD922973	UN-NAMED SPRING	4
MAD922974	UN-NAMED SPRING	4
MAD922975	UN-NAMED SPRING	4
MAD922976	UN-NAMED SPRING	4
SUW106971	UN-NAMED SPRING	4
SUW919972	UN-NAMED SPRING	4
SUW919974	UN-NAMED SPRING	4
SUW922972	UN-NAMED SPRING	4
SUW922974	UN-NAMED SPRING	4

Table 2: Wells Accessed by the Field Crew

Wells Accessed by Springshed Delineation Field Crew		
Month	**Week**	**Number of Wells**
February	Week 1: 02/23/09-02/27/09	52
March	Week 2: 03/02/09-03/06/09	55
	Week 3: 03/09/09-03/13/09	21
	Week 4: 03/16/09-03/20/09	60
	Week 5: 03/23/09-03/27/09	36
April	Week 6: 03/30/09-04/03/09	48
	Week 7: 04/06/09-04/10/09	31
	Week 8: 04/13/09-04/17/09	109
	Week 9: 04/20/09-04/24/09	66
	Week 10: 04/27/09-05/01/09	49
Total		**527**

Appendix B

Form 1: Well Attribute Form

Florida Department of Environmental Protection
Florida Geological Survey
903 West Tennessee Street Gunter Building
Tallahassee, FL 32304-7716
Phone: (850) 488-4191 Fax: (850) 488-8086

Charlie Crist
Governor

Jeff Kottkamp
Lt. Governor

Michael W. Sole
Secretary

Suwannee River Springshed Delineation Project

Well Attribute Survey

Please take a moment to fill in this form and return to our field samplers or mail to the address above, attention James McClean, Suwannee River Springshed Delineation Project.

Landowner Name: ____ Telephone: ____

Physical Address: ____

City/Town: ____ County: ____

State: FL Zip Code: ____ Well Type: ____

Mailing Address (if different from above)

Address: ____ Mobile Phone: ____

City/Town: ____

State: ____ Zip Code: ____ E-Mail: ____

Check applicable answers:

Is Landowner willing to sign Well Access Permission Form? ____ Allow Water Level? ____ Allow Water Sample? ____

Is well accessible for level measurement? ____ Is area clear of canopy for GPS survey? ____

Please fill in the following well construction details: Well ID: ____ Permit #: ____

Depth of Well (ft): ____ Well Diameter (in): ____ Casing Depth (ft): ____

Max Daily Production (Millions Gallons/Day): [Pump Capacity x 24 hours] ____ Depth of Screen (ft): ____

Type of Pump: ____

Latitude DD: ____ Latitude MM: ____ Latitude SS.ssss: ____ Location Method: ____

Longitude DD: ____ LongitudeMM: ____ Longitude SS.ssss: ____ Date of Location (YYYY-MM-DD): ____

Land Surface Elevation (ft): ____ Method of Levelling: ____

Measure Point Elevation (ft): ____ Name of Surveyor: ____

Date of Sample (YYYY-MM-DD): ____ Water Level Depth (ft): ____

Field Crew Names: ____ Water Quality Sample: ____

Date of Sample (YYYY-MM-DD): ____ Water Level Depth (ft): ____

Field Crew Names: ____ Water Quality Sample: ____

Comments: ____

E-Mail form

Florida Department of Environmental Protection
Florida Geological Survey
903 West Tennessee Street • Gunter Building
Tallahassee, FL 32304-7716
Phone: (850) 488-4191 Fax: (850) 488-8086

PERMISSION TO ENTER PROPERTY

1. The undersigned property owner, **Charles E. Gilman III, Sondra Gilman Gonzalez-Falla, as Trustee of Article 3 Trust, and Celso Gonzalez-Falla, as Trustee of Article 3 Trust**, ("undersigned"), hereby gives permission to the State of Florida, Department of Environmental Protection ("Department") and its agents and contractors to enter the undersigned's property ("the property") located within Jefferson, Lafayette, Madison, & Taylor Counties.

2. This permission is specifically limited to the following activities that may be performed by the Department, its agents or contractors: The Department's Florida Geological Survey shall have access "the property" for the installation of monitoring wells, obtaining well elevations and the collection water levels and water quality samples on approved sites.

3. The Department will provide notice to undersigned of the scope and location of the Department's activity at least 48 hours prior to accessing the property.

4. The undersigned will have the right to have a representative present while the Department is on the undersigned's property.

5. The granting of this permission by the undersigned is not intended, nor should it be construed, as an admission of liability on the part of the undersigned or the undersigned's successors and assigns for any contamination discovered on the property.

6. The Department, its agents or contractors may enter the property during normal business hours and may also make arrangements to enter the property at other times after agreement from the undersigned.

7. The undersigned shall not be liable for any injury, damage or loss on the property suffered by the Department, its agents or employees not caused by the negligence or intentional acts of the undersigned's agents or employees.

8. The Department acknowledges and accepts its responsibility under applicable law (Section 768.28, Florida Statutes) for damages caused by the acts of its employees while on the property.

9. The Department assumes all financial and regulatory responsibilities (including, without limitation, any permitting or reporting obligations).

10. The undersigned will be provided an insurance certificate by any company performing services for the Department on the undersigned's property, naming the undersigned as an additional insured party.

11. The Department will provide the undersigned with a copy of any analysis summaries, reports, surveys, or other published data in a timely manner.

12. At the conclusion of the authorized activity, the Department will return the key provided for access to the undersigned's property and will grant the undersigned ownership of their choice of the monitoring wells installed for this project and properly abandoned the rest.

13. This permit will expire on August 31, 2011.

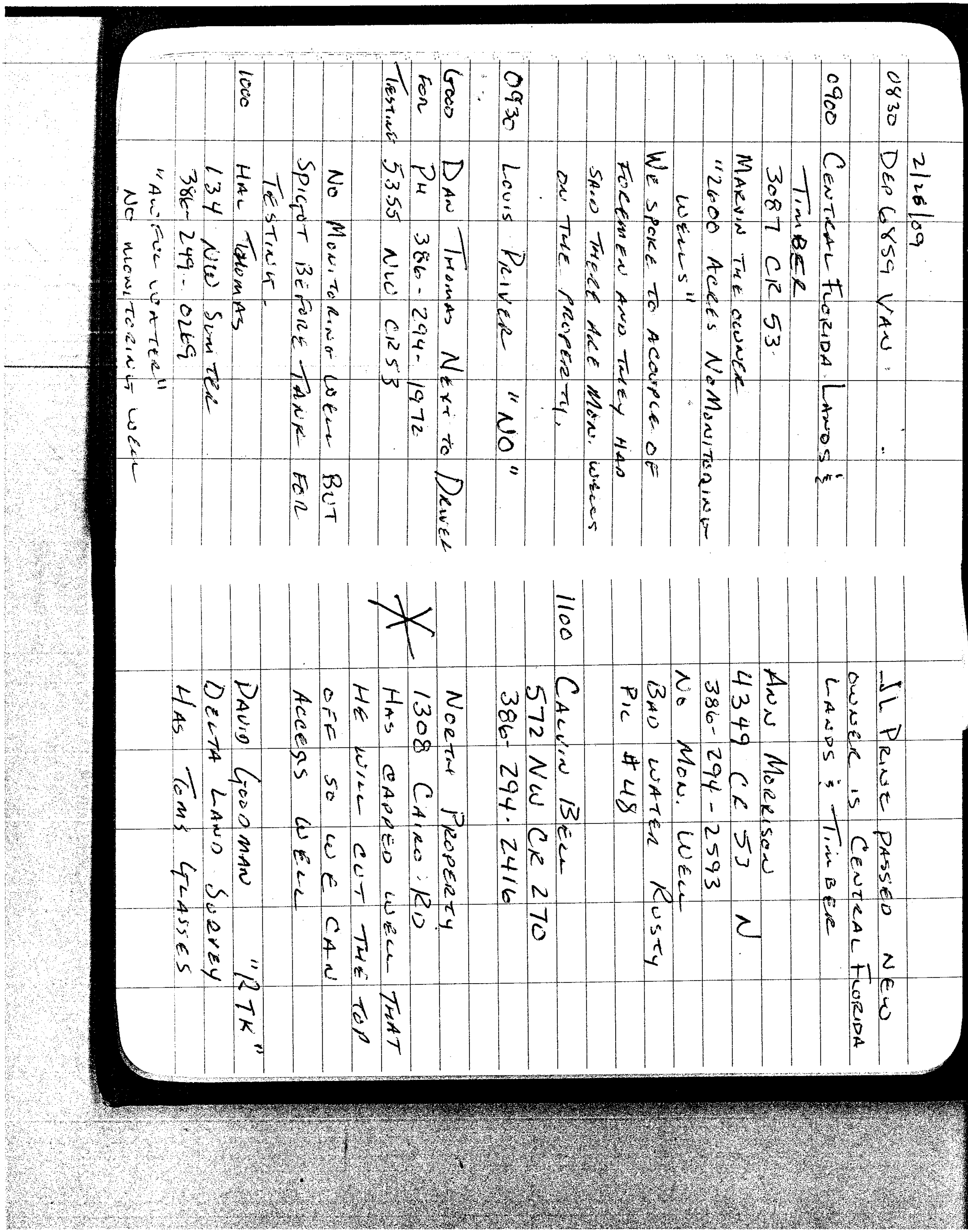
Signature of Undersigned (Property Owner)	Signature of Witness
Print Name Date	Print Name Date
Signature of Undersigned (Property Owner)	Signature of Witness
Print Name Date	Print Name Date
Signature of Undersigned (Property Owner)	Signature of Witness
Print Name Date	Print Name Date

Accepted by the State of Florida Department of Environmental Protection by the following authorized agent.

Signature of Department Representative	Signature of Witness
Print Name Date	Print Name Date

Appendix C

Example of Field Notes



2/26/09

0830 DEP 6859 VAN

0900 CENTRAL FLORIDA LANDS &
TIMBER
3087 CR 53
MARVIN THE OWNER
"2600 ACRES NO MONITORING
WELLS"
WE SPOKE TO A COUPLE OF
FOREMEN AND THEY HAD
SAID THERE ARE MON. WELLS
ON THE PROPERTY,

0930 LOUIS PRIVER "NO"

GOOD FOR TESTING DAN THOMAS NEXT TO DRIVER
PH 386-294-1972
5355 NW CR 53

NO MONITORING WELL BUT
SPIGOT BEFORE TANK FOR
TESTING.

1000 HAL THOMAS
134 NW SUMTER
386-249-0269
"AWFUL WATER"
NO MONITORING WELL

JL PRINE PASSED NEW
OWNER IS CENTRAL FLORIDA
LANDS & TIMBER

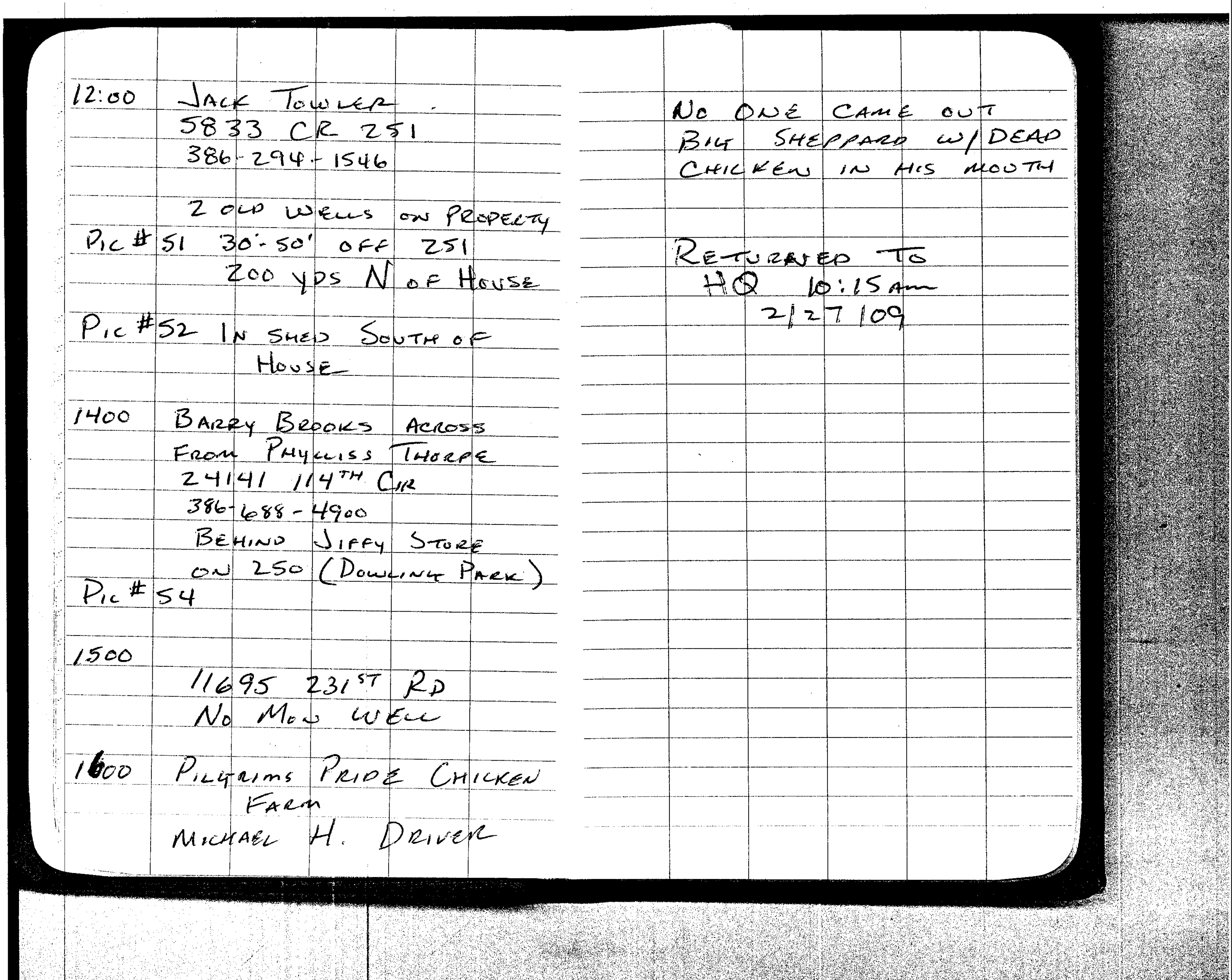
ANN MORRISON
4349 CR 53 N
386-294-2593
NO MON. WELL
BAD WATER RUSTY
PIC #48

1100 CALVIN BELL
572 NW CR 270
386-294-2416

NORTH PROPERTY
1308 CAIRO RD
HAS CAPPED WELL THAT
HE WILL CUT THE TOP
OFF SO WE CAN
ACCESS WELL

DAVID GOODMAN "RTK"
DELTA LAND SURVEY
HAS TOMS GLASSES

Example of Field Notes



12:00 JACK TOWLER
5833 CR 251
386-294-1546

2 OLD WELLS ON PROPERTY
PIC #51 30'-50' OFF 251
200 YDS N OF HOUSE

PIC #52 IN SHED SOUTH OF
HOUSE

1400 BARRY BROOKS ACROSS
FROM PHYLLISS THORPE
24141 114TH CIR
386-688-4900
BEHIND JIFFY STORE
ON 250 (DOWLING PARK)
PIC #54

1500
11695 231ST RD
NO MOW WELL

1600 PILGRIMS PRIDE CHICKEN
FARM
MICHAEL H. DRIVER

NO ONE CAME OUT
BIG SHEPPARD W/DEAD
CHICKEN IN HIS MOUTH

RETURNED TO
HQ 10:15am
2/27/09

Appendix D

Informational Brochure

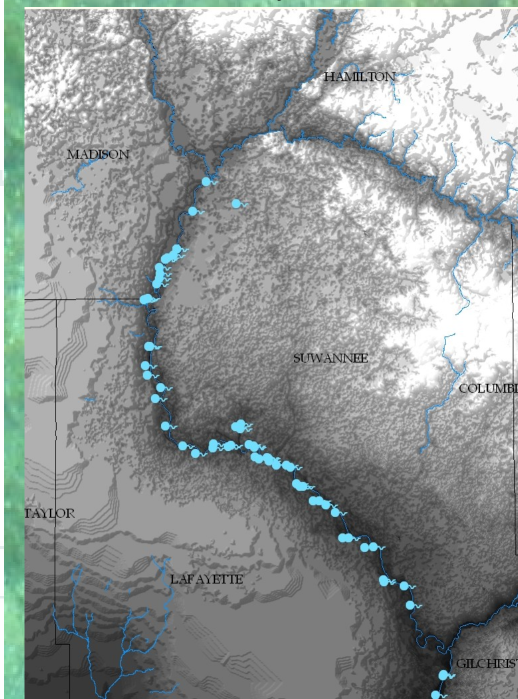
How long will the project last?
The Middle Suwannee Springshed Delineation Project will take approximately two years to complete. The project includes eighteen months of fieldwork (locating wells, getting permission to sample, installing wells, sampling/water levels, and data analysis). Our field teams may contact you for permission to measure your well's water level and water chemistry.

Where can I get more information?
If you have questions about the Middle Suwannee Springshed Delineation Project, please contact Tom Greenhalgh of the FDEP/FGS at (850) 488-4191.

Figure 3: The FGS springshed delineation team. From left to right: Jim Bobrycki, Eric Thomas, Alexandra Walrath, Caitlin Cerame, Melinda Spall, John Carroll, Jake Mast, Tom Greenhalgh (Photo by James McClean, FDEP/FGS).

Florida Geological Survey
903 W. Tennessee St.
Tallahassee, FL 32304

Middle Suwannee Springshed Delineation Project



FLORIDA GEOLOGICAL SURVEY
903 W. TENNESSEE STREET
TALLAHASSEE, FL 32304
(850) 488-4191
www.dep.state.fl.us/geology

Project Description
The Middle Suwannee Springshed Delineation Project is a study of springsheds, or spring drainage basins, along the Middle Suwannee River. Some of the rainwater that falls to the ground recharges the underlying aquifer. After traveling underground through the aquifer, some of the groundwater resurfaces through springs. There are sixty-three known springs along the Middle Suwannee (Figure 1), each of which drains an area of land. However, at this point we are not sure where the water in each spring comes from. The purpose of this study is to identify the land area that drains to each of the sixty-three springs. In some cases, we anticipate that several springs will share the same land area.

Who is conducting the project?
The Florida Department of Environmental Protection/Florida Geological Survey (FDEP/FGS) is conducting this study with funding from the Florida Springs Initiative through the FDEP. The Suwannee River Water Management District (SRWMD) and the Suwannee River Partnership (SRP) are also sharing data and resources with the FDEP/FGS.

What is springshed delineation?
Springshed delineation, or springshed mapping, is a relatively new and evolving science. Groundwater level maps called potentiometric surface maps are used to delineate springsheds. These maps look like topographic maps with contour lines, but they represent the groundwater levels under the land surface. Other springshed delineation techniques include dye tracing and water chemistry analysis. For this project, the FGS will first compile water level and water chemistry data in cooperation with the SRWMD, the SRP and the United States Geological Survey. We will then locate existing wells to collect water-level data that can be sampled for water quality, drill additional wells as needed and create new potentiometric surface maps.

Who is being asked to participate?
Field teams from the FDEP/FGS are visiting landowners throughout the study area and asking permission to sample their wells. For the most part, field teams visit wells that have already been sampled at some point by the SRWMD.

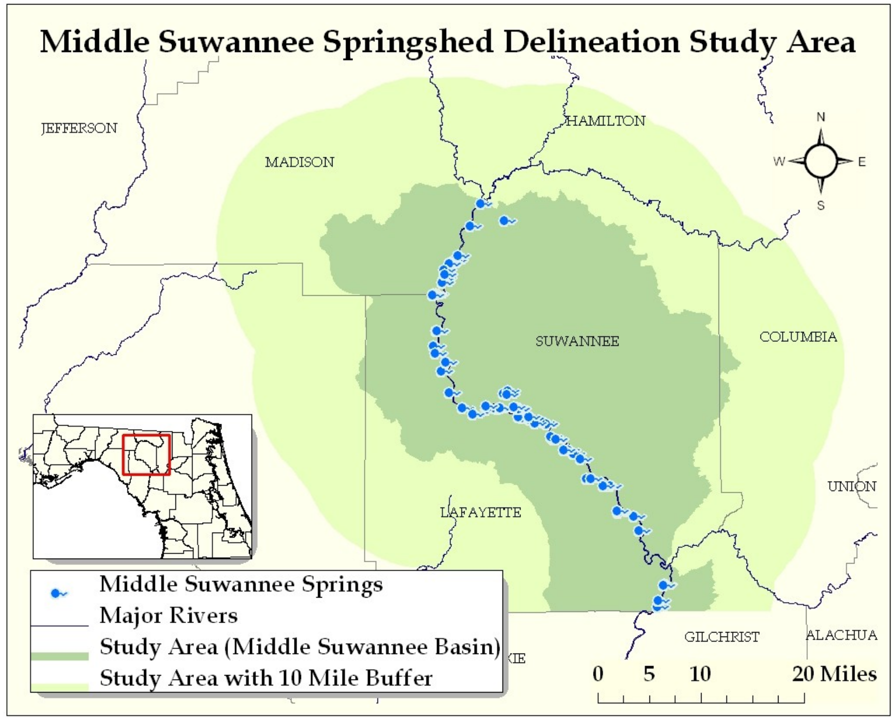


Figure 1: Study area and springs

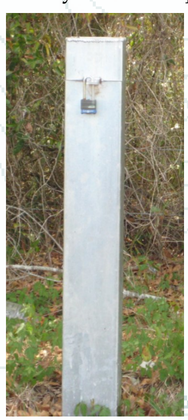


Figure 2: Monitoring well (Photo by Melinda Spall, FDEP/FGS)

What data are being collected?
Field teams record the location of each well using a GPS (Global Positioning System) unit so they can find the well again, assessing the well's suitability for use in this study (for example, teams make sure that the well casing is large enough to accommodate a water-level meter). Water chemistry samples will be collected from some wells in an attempt to match water chemistry in the aquifer to that of individual springs. The parameters analyzed will probably be the same as those the SRWMD and others are collecting from their sample networks or springs monitoring.

How will the data be used?
The FDEP/FGS will use the data to create potentiometric surface maps and delineate springsheds. Data will also be shared with other divisions of the FDEP, the Natural Resources Conservation Service and other researchers to support their efforts and activities in the Middle Suwannee River Basin.

Appendix E

Example of Well Permit

No. 0155 P. 2

99160

STATE OF FLORIDA PERMIT APPLICATION TO CONSTRUCT, REPAIR, MODIFY, OR ABANDON A WELL

☐ Southwest
☐ Northwest
☐ St. Johns River
☐ South Florida
☐ Suwannee River

CHECK BOX FOR APPROPRIATE DISTRICT ADDRESS ON BACK OF PERMIT FORM

THIS FORM MUST BE FILLED OUT COMPLETELY.

The water well contractor is responsible for completing this form and forwarding the permit to the appropriate delegated county where applicable.

Permit No. 99160
Florida Unique I.D. ____
Permit Stipulations Required (See attached) ____
62-524 Quad # ____ Delineation # ____
CUP/WUP Application No. ____

1. SRWMD — 9225 CR 49 — Live Oak — FL 32060 — 386.362.1001
Owner, Legal Name of Entity if Corporation — Address — City — Zip — Telephone Number

2. WOODS Ferry
Well Location – Address, Road Name or number, City
Parcel # (Pin) 192700.00000

3. Charles Bucher — 9417 — 407 426-7885
Well Drilling Contractor — License No. — Telephone No.
2300 Silver Star Rd
Address
Orlando FL 32804
City State Zip

4. SE 1/4 of SE 1/4 of Section 36
5. Township 1S Range 14E (Indicate Well on Chart)

NW NE SW SE

6. Suwannee
County — Subdivision Name — Lot — Block — Unit

7. Number of proposed wells 1 Check the use of well: (See back of permit for additional choices) ____ Domestic Monitor (type) Water level Chemistry
____ Irrigation (Type) Public Water Supply (type) ____ List Other ____
Distance from septic system NA ft. Description of facility Pasture Estimated start of construction date 6/2/09

8. Application for: X New Construction ____ Repair/Modify ____ Abandonment ____ (Reason for Abandonment)

RECEIVED
JUN 01 2009

9. Estimated: Well Depth 75' Casing Depth 50' Screen Interval from 50' to 75'
Casing Material: Blk-Steel / Gal / PVC Casing Diameter 2" Seal Material GROUT

10. If applicable: Proposed Grouting Interval
From 0 to 45 Seal Material Cement
From 45 to 50 Seal Material Sand
From ____ to ____ Seal Material ____

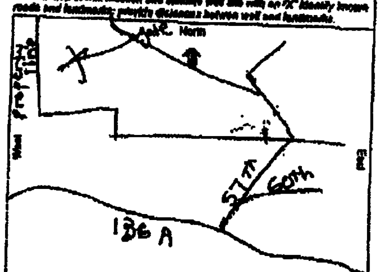
11. Telescope Casing ____ or Liner ____ (check one) Diameter ____
Blk-Steel / Galvanized / PVC Other (specify:) ____

12. Method of Construction: ____ Rotary ____ Cable Tool X Combination
____ Auger ____ Other (specify:) ____

13. Indicate total No. of wells on site 0 List number of unused wells on site 0

14. Is this well or any other well or water withdrawal on the owner's contiguous property covered under a Consumptive/Water Use Permit (CUP/WUP) or CUP/WUP Application? ____ No ____ Yes
(IF YES, COMPLETE THE FOLLOWING) CUP/WUP No. ____
District well I.D. No. ____
Latitude 30°21'0.2" Longitude 82°52'24.9"
Data obtained from GPS X or map ____ or survey ____ (map datum NAD 27 ____ NAD 83 X)

Draw a map of well location and indicate well site with an "X". Identify known roads and landmarks; provide distances between well and landmarks.



15. I hereby certify that I will comply with the applicable rules of Title 40, Florida Administrative Code ...

Charles Bucher 9417
Signature of Contractor — License No.

I certify that I am the owner of the property, that the information provided is accurate, and that I am aware of my responsibilities under Chapter 373, Florida Statutes ...

Owner's or Agent's Signature — 6/1/09 Date

Approval Granted By: ____ Issue Date: 6.1.09 Hydrologist Approval ____ Initials
Owner Number: ____ Fee Received: $ 40 Receipt No.: 149188 Check No.: ____

THIS PERMIT NOT VALID UNTIL PROPERLY SIGNED BY AN AUTHORIZED OFFICER OR REPRESENTATIVE OF THE WMD. IT SHALL BE AVAILABLE AT THE WELL SITE DURING ALL DRILLING OPERATIONS. *This permit is valid for 90 days from the date of issue.*

FORM 41.10 - 410 (1) REV.6/04

WHITE: ORIGINAL FILE
YELLOW: DRILLING CONTRACTOR
PINK: OWNER

Appendix F

Selections from URS Report

Summary of Well Installation

URS

June 12, 2009

Sent via email: ***Richard.w.hicks@dep.state.fl.us***

Mr. Richard Hicks, PG, Administrator
Florida Department of Environmental Protection
Ground Water Protection Section
Bureau of Watershed Management
2600 Blair Stone Road, MS 3575
Tallahassee FL 32399-2400

Subject: **Report of Monitor Well Construction in Suwannee and Lafayette Counties, Florida, Florida Department of Environmental Protection Task Assignment WM946-2**

Dear Mr. Hicks:

URS Corporation Southern (URS) has prepared this letter report describing the installation of 14 monitoring wells in Suwannee and Lafayette Counties, Florida. The work was performed under Task Assignment WM946-2 to the Florida Department of Environmental Protection (FDEP) WM-946 contract with URS. The well locations are shown on **Figure 1** and were selected by the Florida Geologic Survey (FGS).

WELL CONSTRUCTION

Groundwater Protection, Inc. (GPI) was retained by URS to install the monitor wells. The wells were installed during the weeks of May 25, 2009 and June 1, 2009. Eight of the wells were installed by the sonic rotary (sonic) method and six of the wells were installed by the Hollow Stem Auger/Mud Rotary (HSA/rotary) method. A lithologic log of each borehole installed by the HSA/rotary method was prepared by describing the drill cuttings on 5-foot intervals. A lithologic core was collected from each well installed by the sonic method. The cores were described to develop a lithologic log of those boreholes and the cores were then provided to FGS. The lithologic logs and Field notes of each borehole are provided as **Attachment A**.

The construction details of the wells installed by GPI are presented in **Table 1**. The wells ranged from 44 to 90 feet (ft) deep. All of the wells except the Hatch Bend well were completed in the limestone underlying the unconsolidated surficial deposits. Limestone was not encountered to a

URS Corporation
1625 Summit Lake Drive
Tallahassee, FL 32317
Tel: 850.574.3197
Fax: 850.576.3676

URS

depth of 75 ft in the Hatch Bend borehole and the well was completed in the unconsolidated deposits to a depth of 75 ft at the request of FGS. Nine of the wells were constructed of 2-inch diameter (dia.) polyvinyl chloride (PVC) casing and screen. Five wells were constructed of 4-inch dia. PVC casing and screen. Each well was fitted with 20 ft of No. 10 slot PVC well screen. A filter sand pack of 20/30 size silica sand was place around the screen to a depth 2 ft above the top of the screen. A two foot thick seal of 30/65 size silica sand was then placed on top of the filter sand pack. A two foot thick seal of bentonite was then placed on top of the 30/65 silica sand and the remaining annular space was grouted to land surface.

Water for well construction was obtained from an irrigation well at the Harrell property location arranged by FDEP and at the City of Live Oak Fire Station (arranged by GPI).

At the request of FGS, all wells installed by GPI were developed prior to inserting the bentonite seal and grout seal in the annular well space to allow for the sand filter pack to settle. Each 2-inch dia. well was developed by pumping for at least ½ hour with a submersible pump. The 4-inch dia. wells were developed by pumping the well with a combination of the submersible pump and a centrifugal pump. Development of some wells was extended up to an hour to reduce the turbidity of the purge water. Each well was completed with an above ground locking protective casing. Well permits and well completion reports are provided as **Attachment B**. All drill cuttings and development water were disposed of in the vicinity of each well.

URS appreciates the opportunity to assist the FDEP with this project. Please contact either of us at 850-574-3197 if you have any questions regarding this information.

Sincerely,

Sid O'Neal
Senior Scientist

William H. Colona III, PG
Senior Project Geologist

Attachments

Selections from URS Report

Table of Well Locations

TABLE 1

Floridan Aquifer Monitoring Well Construction Information
Suwannee River Watershed Project
Suwannee and Lafayette Counties, Florida

WELL ID	DATE INSTALLED	INSTALLATION METHOD	TOTAL WELL DEPTH (FT)	SCREENED INTERVAL (FT BLS)	WELL DIAMETER (IN)	Latitude/Longitude
Harrell	6/3/2009	Rotosonic	90	70-90	4	N 30° 24' 36.7" / W 83° 08' 24.8"
Ellaville	5/27/2009	Mud Rotary	44	24-44	2	N 30° 22' 16.996" / W 83° 12' 30.899"
Black River Road	5/27/2009	Rotosonic	46	26-46	2	N 30° 20' 37.5" / W 83° 13' 24.8"
Mill Creek North	5/28/2009	Mud Rotary	45	25-45	2	N 30° 18' 40" / W 83° 13' 54.6"
Mill Creek South	5/27/2009	Rotosonic	40	20-40	2	N 30° 16' 34.8" / W 83° 14' 45.4"
Christian Path	5/28/2009	Rotosonic	50	30-50	2	N 30° 12' 44.9" / W 83° 13' 54.4"
Peacock Slough	5/29/2009	Rotosonic	55	35-55	2	N 30° 6' 58.4" / W 83° 9' 7.6"
Hatch Bend	5/29/2009	Mud Rotary	70	50-70	2	N 29° 52' 22.9" / W 82° 53' 20.3"
Woods Ferry	6/2/2009	Mud Rotary	75	55-75	2	N 30° 21' 02" / W 82° 52' 24.9"
Gar Pond	6/3/2009	Rotosonic	80	60-80	2	N 30° 18' 46.2" / W 82° 44' 9.3"
Big Horn	6/4/2009	Mud Rotary/HSA	44	24-44	4	N 30° 14' 55.6" / W 83° 18' 29.4"
Camp "P"	6/5/2009	Rotosonic	80	60-80	4	N 30° 11' 48.9" / W 83° 21' 53.2"
Yellow Jacket	6/5/2009	Mud Rotary/HSA	60	40-60	4	N 30° 05' 29.8" / W 83° 19' 19.1"
Byrd 700	6/6/2009	Rotosonic	70	50-70	4	N 30° 02' 49.2" / W 83° 15' 30.8"

HSA = Hollow Stem Auger

FT BLS = Feet Below Land Surface

IN = Inches

All wells constructed with threaded coupling polyvinyl chloride (PVC) screen and riser pipe

Selections from URS Report

Example of Boring Log

Florida Department of Environmental Protection - Division of Waste Management - Bureau of Petroleum Storage Systems

BORING LOG

Page 1 of 1

Boring/Well Number: Mill Creek South	Permit Number: 99129	FDEP Facility Identification Number:
Site Name: Suwannee River Watershed	Borehole Start Date: 05/27/09 End Date: 05/27/09	Borehole Start Time: 1431 ☐ AM ☑ PM End Time: 1737 ☐ AM ☑ PM
Environmental Contractor: URS	Geologist's Name: Deborah C. Hilton	Environmental Technician's Name:

Drilling Company: Groundwater Protection	Pavement Thickness (inches): 0	Borehole Diameter (inches): 6	Borehole Depth (feet): 40
Drilling Method(s): Sonic	Apparent Borehole DTW (in feet from soil moisture content): ~19	Measured Well DTW (in feet after water recharges in well): ~21	OVA (list model and check type): ☐ FID ☐ PID

Disposition of Drill Cuttings [check method(s)]: ☐ Drum ☐ Spread ☐ Backfill ☐ Stockpile ☑ Other

(describe if other or multiple items are checked): FGS collected sleeved cores

Borehole Completion (check one): ☑ Well ☐ Grout ☐ Bentonite ☐ Backfill ☐ Other (describe)

Sample Type	Sample Depth Interval (feet)	Sample Recovery (feet)	SPT Blows (per six inches)	Unfiltered OVA	Filtered OVA	Net OVA	Depth (feet)	Sample Description (include grain size based on USCS, odors, staining, and other remarks)	USCS Symbol	Moisture Content	Lab Soil and Groundwater Samples (list sample number and depth or temporary screen interval)
SC	0-5	~3					5	Light brown-orange fine sand		D	
SC	5-10	~3					10	Light brown-orange fine sand with clay		D	
SC	10-15	~4					15	Light brown fine sand with little clay		D	
SC	15-20	~5					20	Tan-white limestone with clay		W	
SC	20-30	~10					30	~4'tan-white clayey sand, ~3' tan-white sand with little clay, ~3' limestone with clay		W	
SC	30-40	~7					40	~2' orange brown limestone, clay, fine sand, ~5' tan white limestone with varying amounts of clay & sand		W	
								Lithologies taken through plastic sleeve			

Sample Type Codes: **PH** = Post Hole; **HA** = Hand Auger; **SS** = Split Spoon; **ST** = Shelby Tube; **DP** = Direct Push; **SC** = Sonic Core; **DC** = Drill Cuttings
Moisture Content Codes: **D** = Dry; **M** = Moist; **W** = Wet; **S** = Saturated

Selections from URS Report

Example of Well Completion Report

WELL COMPLETION REPORT (Please complete in black ink or type.)

PERMIT # 99178 CUP/WUP # ____ DID # ____

If permit is for multiple wells, indicate the number of wells drilled 1

Indicate remaining wells to be cancelled 0

WATER WELL CONTRACTOR'S SIGNATURE Charles Burke Llicense # 9417

I certify that the information provided in this report is accurate and true.

Grout	No. of Bags	From (Ft.)	To (Ft.)
Neat Cement:	5	36'	0
Bentonite:	.27	38'	36'

WELL LOCATION: County Lafayette

NE 1/4 of SE 1/4 of Section 33 Twp: 04 Rge: 10

Latitude ____ Longitude ____

DATE STAMP

Official Use Only

Sketch of well location on property N

Give distances from septic tank and house or other reference points

CHEMICAL ANALYSIS WHEN REQUIRED

Iron: ____ ppm Sulfate: ____ ppm

Chlorides: ____ ppm

[ ] Lab Test [ ] Field Test Kit

Pump Type

[ ] Centrifugal [ ] Jet [ ] Submersible [ ] Turbine

Horsepower ____ Capacity ____ G.P.M. ____

Pump Depth ____ Ft. Intake Depth ____ Ft.

Form 41.10-410(2) Rev. 8/96

OWNER'S NAME Gilman Trust/DEP/Cumberland

COMPLETION DATE 06/04/2009 Florida Unique I.D. ____

WELL USE: DEP/Public ____ Irrigation ____ Domestic ____

Monitor ✓ HRS Limited ____ 62-524 ____ Other ____

DRILL METHOD [ ] Rotary [ ] Cable Tool [✓] Combination

[ ] Jet [ ] Auger Other ____

Measured Static Water Level ____ Measured Pumping Water Level ____

After ____ Hours at ____ G.P.M. Measuring Pt. (Describe): ____

Which is ____ Ft. [ ] Above [ ] Below Land Surface

Casing: [ ] Black Steel [ ] Galv. [✓] PVC Other ____

[ ] Open Hole [✓] Screen	Depth (Ft.)		DRILL CUTTINGS LOG Examine cuttings every 20 ft. or at formation changes. Note cavities, depth to producing zones.
Casing Diameter & Depth (Ft.)	From	To	*Color* | *Grain Size* | *Type of Material*
Diameter 4" From 0 To 40'	0	18'	White Fine Sand
	18'	34	Clay with Sand Limestone
	34	60'	Cavernous Limestone with Sand
Diameter ____ From ____ To ____			
Liner [ ] *or* Casing [ ] Diameter ____ From ____ To ____			
			20' of Screen

Driller's Name: *(print or type)* Kevin Valentino - GPI WO 509007 Yellow Jacket 01

Example of Well Completion Log

WELL COMPLETION LOG

Water Mgmt. Dist.:
Permit Number:

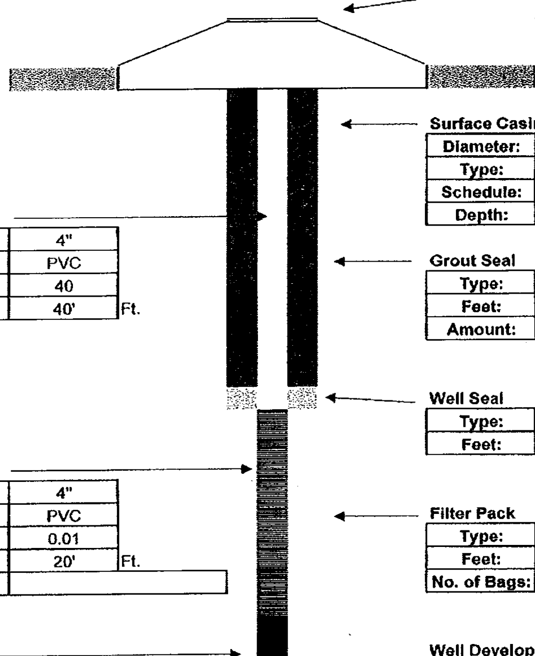
Work Order: 509007
Type of Well: MW
Well Number: Yellow Jacket 01
Method Used: 6".25 H.S.A. / 6" TCR
Borehole Diaz. 10.25" - 25' / 6" - 60'

Site Information:
Name: Yellow Jacket
Address:
C,S,Z: Suwannee, FL
S/T/R:

Client / Consultant Information
Consultant: URS
Field Rep: Sid O'Niel

Well Diameter	Well Type	Well Depth	Screen Length	Casing Length	Bags Grout	Sand Bags/Weight	Filter Type	Well Seal
4"	PVC	60'	20'	40'	5	9 / 50 lbs.	20/30	30/65
40 ←	Schedule	Slot Size: →	0.01		36'	← Feet →	22'	2'

Surface Completion
6" AGP 2 x 2



Surface Casing

Diameter:	
Type:	
Schedule:	
Depth:	

Intermediate Casing

Diameter:	
Type:	
Schedule:	
Depth:	

Well Casing

Diameter:	4"	
Type:	PVC	
Schedule:	40	
Length:	40'	Ft.

Grout Seal

Type:	I PORTLAND	
Feet:	36'	
Amount:	5	Bags

Well Seal

Type:	30/65
Feet:	2'

Well Screen

Diameter:	4"	
Type:	PVC	
Slot:	0.01	
Length:	20'	Ft.
Note:		

Filter Pack

Type:	20/30
Feet:	22'
No. of Bags:	9 / 50 lbs.

Sump

Length:	0.25	Ft.
Type:	PVC	

Well Development

Water Level:	18'		
Method:	Whale		
Start:		Finish:	
Time:	2 hrs.		
GPM:	2		

Contractor Information

Contractor #:	9417
Completion:	6/4/2009
Driller:	Kevin Valentino
Lead Hand:	Theron Stanford
3rd Man:	Ricky Cisneros
Drill Rig:	D120A

Company:	Groundwater Protection, Inc.
Address:	2300 Silver Star Road
C,S,Z:	Orlando, Florida 32804-3310
Phone/FAX:	(407) 426-7885 / (407) 426-7586

Appendix B.

Surveyed Locations

Surveyed Locations

WELL_NAME	Longitude	Latitude	Measuring Pt.	Elevation (ft)
SUWVW_AT	-83.021694	30.169472	TSS	111.60
SUWVW_BV	-82.993444	30.200222	TSS	103.40
SUWVW_LC	-83.145833	30.176389	TSS	80.10
SUWVW_CD 1	-82.993028	30.220222	TSS	135.20
SUWVW_CJW	-83.102778	30.181444	TSS	89.10
SUWVW_FR	-83.040611	30.061917	TSS	45.50
SUWVW_GA	-83.049889	30.071042	TSS	48.70
LAFVW_HT	-83.112667	30.053917	TSS	63.80
SUWVW_HC	-83.041500	30.130194	TSS	76.50
SUWXW_HP	-83.071944	30.223889	TSS	85.90
SUWMW_ JS 7	-83.114167	30.149722	TSS	69.50
SUWVW_JML	-83.112778	30.138056	TSS	62.90
SUWVW_JR	-83.049478	30.068611	TSS	46.70
SUWVW_LJ	-83.024278	30.230861	TSS	104.40
SUWVW_LCI	-83.079917	30.220972	TOC	93.40
SUWVW_MN	-83.026694	30.189333	TSS	98.00
LAFVW_PC	-83.099583	30.043056	TSS	68.50
SUWVW_SRG	-83.115778	30.210306	TSS	85.40
SUWVW_RS	-83.079611	30.134028	TSS	70.00
SUWVW_SR	-83.055583	30.129528	TOC	64.40
SRWMD- OWENS TRACT	-83.045694	30.039300	TOC	47.30
SRWMD - PEACOCK SLOUGH	-83.152139	30.116167	TOC	56.90
SUWVW_ST	-83.068889	30.214556	TSS	88.90
SUWVW_SL	-83.098889	30.260278	TSS	91.30
SUWVW_SJ	-83.101444	30.165278	TSS	75.00
SUWAW_TD	-83.058778	30.112000	TOC	61.30
SUWAW_TV	-83.064194	30.243722	TSS	93.20
SUWVW_ WW 1	-83.016917	30.043306	TSS	44.50
SUWVW_WH	-83.091472	30.241611	TSS	95.00

CONVICT SPRING	Top of domed cap in permanent poured benchmark located between spring and river, near SRWMD sign. Elevation 32.5 feet.
ROYAL SPRING	Nail head in staff gauge at 7.00 foot mark on observation deck on north rim of spring. Elevation 23.5 feet. (secondary point) Floor of gauge recorder box near fence north of spring. Elevation 41.7 feet.

TSS- Top of Sanitary Seal TOC- Top of Casing

All elevations datum NVGD 29.

Appendix C.

Water Level Data

Water Level Data

SITE_NAME	X	Y	WTYPE	MPELEV	DATE_DTW	DTW	Z
DEP - TROY MW#2	-82.995146	30.002776	MW	43.58	16-Nov-09	31.67	11.91
DOT - SR 129 & 97 DR	-82.944806	30.076444	MW	69.32	17-Nov-09	48.71	20.61
DOT - SR 129 &144th ST	-82.987833	30.187889	MW	105.40	17-Nov-09	75.41	29.99
IFAS MW #2	-82.899772	30.302946	MW	165.88	17-Nov-09	15.20	150.68
SRWMD - MALLORY SWAMP - 01S	-83.105311	29.836012	MW	65.43	17-Nov-09	4.72	60.71
SRWMD - MALLORY SWAMP - 02	-83.121904	29.868176	MW	66.57	17-Nov-09	6.20	60.37
SRWMD - MALLORY SWAMP - 03	-83.116357	29.906114	MW	68.44	17-Nov-09	7.42	61.02
SRWMD - MALLORY SWAMP - 04	-83.073225	29.927238	MW	67.43	17-Nov-09	4.79	62.64
SRWMD - MALLORY SWAMP - 05	-83.072847	29.882263	MW	67.22	17-Nov-09	5.35	61.87
SRWMD - MALLORY SWAMP - 07	-83.022157	29.855839	MW	67.42	17-Nov-09	5.58	61.84
SRWMD - MALLORY SWAMP - 08F	-83.012984	29.889873	MW	67.41	17-Nov-09	5.30	62.11
SRWMD - MALLORY SWAMP - 08S	-83.012962	29.889924	MW	68.17	17-Nov-09	5.78	62.39
SRWMD - MALLORY SWAMP - 09F	-83.015677	29.925628	MW	67.95	17-Nov-09	6.36	61.59
SRWMD - MALLORY SWAMP - 09S	-83.015715	29.925648	MW	68.11	17-Nov-09	6.24	61.87
SRWMD - MALLORY SWAMP - 10F	-83.022621	29.827503	MW	66.61	17-Nov-09	6.08	60.53
SRWMD - MALLORY SWAMP - 10S	-83.022724	29.827540	MW	66.68	17-Nov-09	5.91	60.77
SUWANNEE CO AIRPORT	-83.021667	30.297306	MW	100.92	17-Nov-09	86.77	14.15
SUWANNEE CO COMM	-83.052641	30.069960	MW	42.82	17-Nov-09	27.52	15.30
SUWANNEE CO COMM-COLLISEUM	-83.007203	30.290759	MW	92.54	17-Nov-09	57.41	35.13
SUWMW_HP 1	-82.963268	30.115269	MW	93.55	17-Nov-09	67.93	25.62
SUWMW_RE #2	-82.949484	30.028511	MW	53.11	17-Nov-09	34.94	18.17
DOF BEACHVILLE TOWER	-82.862383	29.997131	MW	58.51	18-Nov-09	33.98	24.53
DOF-MIDWAY TOWER 002	-83.057554	29.999236	MW	67.13	18-Nov-09	29.98	37.15
LAFMW_DO #2	-83.016549	29.997061	MW	51.27	18-Nov-09	36.86	14.41
LAFMW_DO #4	-83.020285	29.987149	MW	51.32	18-Nov-09	17.88	33.44
SRWMD - BRANTLEY #04	-82.994564	30.020742	MW	37.76	18-Nov-09	24.81	12.95
SRWMD - BRANTLEY #05	-82.974628	30.013831	MW	34.52	18-Nov-09	22.78	11.74
SRWMD - BRANTLEY #06	-82.988492	30.024841	MW	37.17	18-Nov-09	25.40	11.77
SRWMD - BRANTLEY #07	-82.995706	30.030603	MW	46.41	18-Nov-09	33.91	12.50
SRWMD - BRANTLEY #08	-83.002884	30.036338	MW	54.91	18-Nov-09	42.56	12.35
SRWMD - BRANTLEY #09	-83.010098	30.042072	MW	52.97	18-Nov-09	39.07	13.90
SRWMD - BRANTLEY #10	-82.988929	30.013357	MW	33.67	18-Nov-09	21.95	11.72
SRWMD - BRANTLEY #14	-82.995931	30.007678	MW	40.39	18-Nov-09	29.13	11.26
SRWMD - PEACOCK SLOUGH	-83.152139	30.116167	MW	56.90	18-Nov-09	35.34	21.56
SRWMD - RUTH MW#2	-82.985404	29.998579	MW	43.57	18-Nov-09	31.60	11.97
SRWMD - RUTH MW#2	-82.985406	29.998578	MW	43.57	18-Nov-09	31.60	11.97
SRWMD - WALKER MW#1	-83.008635	30.011461	MW	34.05	18-Nov-09	18.58	15.47
SRWMD - WALKER MW#2	-83.009331	30.008885	MW	31.00	18-Nov-09	21.72	9.28
SUWMW_ JS 19	-83.111389	30.149167	VW	69.50	18-Nov-09	41.50	28.00
SUWMW_EC 1	-83.051913	30.187977	MW	86.15	18-Nov-09	64.76	21.39
SUWMW_EC 2	-83.046898	30.184436	MW	84.87	18-Nov-09	64.33	20.54
SUWVW_SR	-83.055583	30.129528	VW	64.40	18-Nov-09	40.05	24.35
LAFAYETTE CO COMM - VISA 2	-83.100415	30.078561	MW	47.40	19-Nov-09	30.89	16.51
LAFAYETTE CO COMM - VISA 5	-83.095524	30.042657	MW	62.73	19-Nov-09	28.35	34.38
LAFAYETTE CO COMM - VISA 6	-83.112898	30.042652	MW	71.28	19-Nov-09	14.94	56.34
LAFAYETTE CO COMM - VISA 7	-83.129798	30.064312	MW	58.01	19-Nov-09	30.28	27.73
LAFAYETTE CO COMM - VISA 7	-83.129798	30.064312	MW	58.01	3-Feb-10	27.91	30.10
SRWMD - BRANTLEY #08	-83.002884	30.036338	MW	54.91	3-Feb-10	31.75	23.16
SRWMD - BRANTLEY #09	-83.010098	30.042072	MW	52.97	3-Feb-10	32.11	20.86
SUWAW_TD	-83.058778	30.112000	AW	61.30	3-Feb-10	33.21	28.09
SUWAW_TV	-83.064194	30.243722	AW	93.20	3-Feb-10	58.34	34.86
SUWMW_EC 1	-83.051913	30.187977	MW	86.15	3-Feb-10	64.52	21.63
SUWMW_EC 3	-83.043055	30.184394	MW	92.13	3-Feb-10	56.90	35.23
SUWMW_JS 19	-83.111389	30.149167	VW	69.50	3-Feb-10	36.50	33.00
SUWVW_ WW 1	-83.016917	30.043306	VW	44.50	3-Feb-10	22.02	22.48
SUWVW_SR	-83.055583	30.129528	VW	64.40	3-Feb-10	36.60	27.80
LAFAYETTE CO COMM - VISA 6	-83.112898	30.042652	MW	71.28	4-Feb-10	12.35	58.93
SRWMD - BRANTLEY #06	-82.988492	30.024841	MW	37.17	4-Feb-10	13.42	23.75
SRWMD - PEACOCK SLOUGH	-83.152139	30.116167	MW	56.90	4-Feb-10	25.81	31.09
DOT - SR 129 & 97 DR	-82.944806	30.076444	MW	69.32	5-Feb-10	46.80	22.52
DOT - SR 129 &144th St	-82.987833	30.187889	MW	105.40	5-Feb-10	76.71	28.69
SUWMW_HP 1	-82.963268	30.115269	MW	93.55	5-Feb-10	68.48	25.07
SUWVW_WH	-83.091472	30.241611	VW	95.00	10-Feb-10	59.82	35.18
SRWMD - BRANTLEY #06	-82.988492	30.024841	MW	37.17	11-Feb-10	12.12	25.05
SRWMD - BRANTLEY #09	-83.010098	30.042072	MW	52.97	11-Feb-10	29.38	23.59
SRWMD- OWENS TRACT	-83.046194	30.038500	MW	47.30	11-Feb-10	21.36	25.94
SRWMD - PEACOCK SLOUGH	-83.152139	30.116167	MW	56.90	11-Feb-10	25.28	31.62
SUWVW_SRG	-83.115778	30.210306	VW	85.40	11-Feb-10	54.47	30.93
LAFAYETTE CO COMM - VISA 6	-83.112898	30.042652	MW	71.28	16-Feb-10	11.98	59.30
SRWMD- OWENS TRACT	-83.046194	30.038500	MW	47.30	16-Feb-10	20.65	26.65

SITE_NAME	X	Y	WTYPE	MPELEV	DATE_DTW	DTW	Z
SUWVW_ WW 1	-83.016917	30.043306	VW	44.50	16-Feb-10	18.60	25.90
SUWVW_FR	-83.040611	30.061917	VW	45.50	16-Feb-10	18.25	27.25
SUWVW_CJW	-83.102778	30.181444	VW	89.10	17-Feb-10	58.79	30.31
SUWVW_LJ	-83.024278	30.230861	VW	104.40	17-Feb-10	71.83	32.57
SUWVW_ST	-83.068889	30.214556	VW	88.90	17-Feb-10	22.15	66.75
LAFAYETTE CO COMM - VISA 7	-83.129798	30.064312	MW	58.01	9-Mar-10	24.30	33.71
SUWAW_TV	-83.064194	30.243722	AW	93.20	9-Mar-10	54.40	38.80
SUWVW_ WW 1	-83.016917	30.043306	VW	44.50	9-Mar-10	19.70	24.80
SUWVW_CJW	-83.102778	30.181444	VW	89.10	9-Mar-10	57.86	31.24
SUWVW_FR	-83.040611	30.061917	VW	45.50	9-Mar-10	20.41	25.09
SUWVW_JR	-83.049478	30.068611	VW	46.70	9-Mar-10	21.70	25.00
SUWVW_LC	-83.146000	30.176139	VW	80.10	9-Mar-10	48.55	31.55
SUWVW_LJ	-83.024278	30.230861	VW	104.40	9-Mar-10	70.89	33.51
SUWVW_ST	-83.068889	30.214556	VW	88.90	9-Mar-10	56.61	32.29
SUWVW_WH	-83.091472	30.241611	VW	95.00	9-Mar-10	56.52	38.48
SRWMD - PEACOCK SLOUGH	-83.152139	30.116167	MW	56.90	10-Mar-10	28.65	28.25
SUWAW_TD	-83.058778	30.112000	AW	61.30	10-Mar-10	32.19	29.11
SUWVW_HC	-83.041389	30.130222	VW	76.50	10-Mar-10	47.40	29.10
SUWVW_MN	-83.026694	30.189333	VW	98.00	10-Mar-10	87.80	10.20
SUWVW_SR	-83.055583	30.129528	VW	64.40	10-Mar-10	34.35	30.05
SUWVW_SRG	-83.115778	30.210306	VW	85.40	10-Mar-10	25.70	59.70
LAFAYETTE CO COMM - VISA 5	-83.095524	30.042657	MW	62.73	12-Mar-10	24.59	38.14
SRWMD- OWENS TRACT	-83.046194	30.038500	MW	47.30	12-Mar-10	22.90	24.40
SRWMD - PEACOCK SLOUGH	-83.152139	30.116167	MW	56.90	12-Mar-10	28.90	28.00
SUWVW_ WW 1	-83.016917	30.043306	VW	44.50	12-Mar-10	20.15	24.35
SUWXW_HP	-83.077722	30.218556	XW	85.90	15-Mar-10	52.84	33.06
SUWVW_CD 1	-82.993028	30.220222	VW	135.20	16-Mar-10	103.10	32.10
SUWVW_LCI	-83.079972	30.221222	VW	93.40	16-Mar-10	58.37	35.03
SUWVW_SW	-83.101444	30.165278	VW	75.00	16-Mar-10	44.88	30.12
LAFVW_PC	-83.099583	30.043056	VW	68.50	17-Mar-10	27.00	41.50
SUWAW_TD	-83.058778	30.112000	AW	61.30	14-Apr-10	55.00	6.30
SUWAW_TV	-83.064194	30.243722	AW	93.20	14-Apr-10	54.70	38.50
SUWVW_CJW	-83.102778	30.181444	VW	89.10	14-Apr-10	58.87	30.23
SUWVW_HC	-83.041389	30.130222	VW	76.50	14-Apr-10	48.87	27.63
SUWVW_LJ	-83.024278	30.230861	VW	104.40	14-Apr-10	69.61	34.79
SUWVW_SRG	-83.115778	30.210306	VW	85.40	14-Apr-10	51.81	33.59
SUWVW_ST	-83.068889	30.214556	VW	88.90	14-Apr-10	55.71	33.19
SUWVW_WH	-83.091472	30.241611	VW	95.00	14-Apr-10	56.68	38.32
LAFAYETTE CO COMM - VISA 2	-83.100415	30.078561	MW	47.40	15-Apr-10	26.13	21.27
LAFAYETTE CO COMM - VISA 5	-83.095524	30.042657	MW	62.73	15-Apr-10	24.71	38.02
LAFAYETTE CO COMM - VISA 6	-83.112898	30.042652	MW	71.28	15-Apr-10	11.52	59.76
LAFAYETTE CO COMM - VISA 7	-83.129798	30.064312	MW	58.01	15-Apr-10	24.64	33.37
LAFVW_PC	-83.099583	30.043056	VW	68.50	15-Apr-10	28.39	40.11
SUWMW_JS 19	-83.111389	30.149167	VW	69.50	15-Apr-10	42.42	27.08
SUWVW_RS	-83.079611	30.134028	VW	70.00	15-Apr-10	40.85	29.15
SUWVW_SL	-83.099028	30.260250	VW	91.30	15-Apr-10	52.86	38.44
SUWMW_EC 1	-83.051913	30.187977	MW	86.15	16-Apr-10	54.90	31.25
SUWMW_EC 2	-83.046898	30.184436	MW	84.87	16-Apr-10	54.31	30.56
SUWVW_CD 1	-82.993028	30.220222	VW	135.20	16-Apr-10	102.32	32.88
SUWVW_GA	-83.049889	30.071042	VW	48.70	16-Apr-10	27.87	20.83
SUWANNEE CO - ROYAL SPRINGS WELL	-83.075252	30.085187	MW	41.69	20-Apr-10	22.43	19.26
LAFAYETTE CO COMM - VISA 6	-83.112898	30.042652	MW	71.28	26-Apr-10	11.68	59.60
LAFAYETTE CO COMM - VISA 7	-83.129798	30.064312	MW	58.01	26-Apr-10	25.03	32.98
SRWMD- OWENS TRACT	-83.046194	30.038500	MW	47.30	26-Apr-10	27.50	19.80
SRWMD - PEACOCK SLOUGH	-83.152139	30.116167	MW	56.90	26-Apr-10	32.97	23.93
SUWMW_JS 19	-83.111389	30.149167	VW	69.50	26-Apr-10	48.63	20.87
SUWVW_JML	-83.112778	30.138056	VW	62.90	26-Apr-10	36.97	25.93
SUWVW_LC	-83.146000	30.176139	VW	80.10	26-Apr-10	49.47	30.63
SUWVW_SJ	-83.101444	30.165278	VW	75.00	26-Apr-10	45.76	29.24
DOT - SR 129 &144th ST	-82.987833	30.187889	MW	105.40	28-Apr-10	73.29	32.11
SUWMW_EC 2	-83.046898	30.184436	MW	84.87	28-Apr-10	54.41	30.46
SUWVW_CJW	-83.102778	30.181444	VW	89.10	28-Apr-10	58.10	31.00
SUWVW_LCI	-83.079972	30.221222	VW	93.40	28-Apr-10	57.71	35.69
SUWVW_LJ	-83.024278	30.230861	VW	104.40	28-Apr-10	69.37	35.03
SUWVW_MN	-83.026694	30.189333	VW	98.00	28-Apr-10	67.60	30.40
SUWVW_SRG	-83.115778	30.210306	VW	85.40	28-Apr-10	57.86	27.54
SUWVW_ST	-83.068889	30.214556	VW	88.90	28-Apr-10	55.64	33.26
SUWXW_HP	-83.077722	30.218556	XW	85.90	28-Apr-10	51.17	34.73
SUWAW_TD	-83.058778	30.112000	AW	61.30	30-Apr-10	36.45	24.85
SUWAW_TV	-83.064194	30.243722	AW	93.20	30-Apr-10	55.54	37.66
SUWVW_ WW 1	-83.016917	30.043306	VW	44.50	30-Apr-10	25.37	19.13
SUWVW_GA	-83.049889	30.071042	VW	48.70	30-Apr-10	30.62	18.08
SUWVW_HC	-83.041389	30.130222	VW	76.50	30-Apr-10	48.85	27.65
SUWVW_RS	-83.079611	30.134028	VW	70.00	30-Apr-10	41.48	28.52
SUWVW_SR	-83.055583	30.129528	VW	64.40	30-Apr-10	36.98	27.42
SRWMD- OWENS TRACT	-83.046194	30.038500	MW	47.30	4-May-10	27.77	19.53
SRWMD - PEACOCK SLOUGH	-83.152139	30.116167	MW	56.90	5-May-10	32.61	24.29

SITE_NAME	X	Y	WTYPE	MPELEV	DATE_DTW	DTW	Z
DOF BEACHVILLE TOWER	-82.862383	29.997131	MW	58.51	17-May-10	29.94	28.57
DOT - SR 129 &144th ST	-82.987833	30.187889	MW	105.40	17-May-10	73.25	32.15
SUWVW_GTD	-83.045043	30.138175	VW	77.69	17-May-10	50.18	27.51
IFAS MW OLD SF	-82.902889	30.303029	MW	165.88	18-May-10	92.90	72.98
SUWMW_EC 1	-83.051913	30.187977	MW	86.15	18-May-10	53.97	32.18
SUWVW_LC	-83.146000	30.176139	VW	80.10	18-May-10	49.98	30.12
SUWVW_LJ	-83.024278	30.230861	VW	104.40	18-May-10	69.14	35.26
SUWVW_WH	-83.091472	30.241611	VW	95.00	18-May-10	57.95	37.05
DOT - SR 129 & 97 DR	-82.944806	30.076444	MW	69.32	19-May-10	42.95	26.37
ICHETUCKNEE STATE PARK MW #7	-82.785165	29.961927	MW	51.03	19-May-10	34.27	16.76
LAFMW_DB 11	-83.056074	30.041826	MW	46.87	19-May-10	25.33	21.54
SUWANNEE CO - ROYAL SPRINGS WELL	-83.075252	30.085187	MW	41.69	19-May-10	21.49	20.20
DOF-LIVE OAK W/C	-83.020401	30.310314	MW	106.69	20-May-10	67.90	38.79
LAFVW_HT	-83.112667	30.053917	VW	63.80	20-May-10	31.23	32.57
SRWMD - BRANTLEY #01	-82.982189	30.021116	MW	41.48	20-May-10	32.76	8.72
SRWMD - PEACOCK SLOUGH	-83.152139	30.116167	MW	56.90	20-May-10	32.36	24.54
SUWVW_SR	-83.055583	30.129528	VW	64.40	20-May-10	49.25	15.15
SUWVW_SRG	-83.115778	30.210306	VW	85.40	20-May-10	52.18	33.22
LAFVW_MMA	-83.084034	29.992472	VW	72.81	24-May-10	3.95	68.86
SRWMD - MALLORY SWAMP - 04	-83.073225	29.927238	MW	67.43	24-May-10	3.59	63.84
SRWMD - MALLORY SWAMP - 05	-83.072847	29.882263	MW	67.22	24-May-10	4.84	62.38
SRWMD - MALLORY SWAMP - 06	-83.060487	29.838517	MW	68.15	24-May-10	6.47	61.68
SUWAW_TD	-83.058778	30.112000	AW	61.30	24-May-10	36.60	24.70
IFAS MW#1 JOHN TAYLOR	-83.181171	30.253213	MW	85.37	25-May-10	47.59	37.78
IFAS MW#2 JOHN TAYLOR	-83.179038	30.253248	MW	88.71	25-May-10	51.37	37.34
IFAS MW#3 JOHN TAYLOR	-83.176182	30.253230	MW	90.68	25-May-10	53.71	36.97
IFAS MW#4 JOHN TAYLOR	-83.181541	30.255881	MW	84.83	25-May-10	47.06	37.77
SRWMD - MALLORY SWAMP - 01F	-83.105330	29.836009	MW	64.32	25-May-10	3.55	60.77
SRWMD - MALLORY SWAMP - 01S	-83.105311	29.836012	MW	65.43	25-May-10	4.45	60.98
SRWMD - MALLORY SWAMP - 02	-83.121904	29.868176	MW	66.57	25-May-10	4.92	61.65
SRWMD - MALLORY SWAMP - 03	-83.116357	29.906114	MW	68.44	25-May-10	5.60	62.84
SRWMD - MALLORY SWAMP - 07	-83.022157	29.855839	MW	67.42	25-May-10	5.37	62.05
SRWMD - MALLORY SWAMP - 08F	-83.012984	29.889873	MW	67.41	25-May-10	4.67	62.74
SRWMD - MALLORY SWAMP - 08S	-83.012962	29.889924	MW	68.17	25-May-10	5.37	62.80
SRWMD - MALLORY SWAMP - 09F	-83.015677	29.925628	MW	67.95	25-May-10	4.98	62.97
SRWMD - MALLORY SWAMP - 09S	-83.015715	29.925648	MW	68.11	25-May-10	4.96	63.15
SRWMD - MALLORY SWAMP - 10F	-83.022621	29.827503	MW	66.61	25-May-10	5.33	61.28
SRWMD - MALLORY SWAMP - 10S	-83.022724	29.827540	MW	66.68	25-May-10	6.25	60.43
LAFVW_CB	-82.973614	29.962972	VW	48.69	26-May-10	21.76	26.93
SUWMW_RE #2	-82.949484	30.028511	MW	53.11	26-May-10	28.72	24.39
SUWPW_PHC	-82.978744	30.122681	PW	96.76	26-May-10	68.13	28.63
SUWVW_HDL	-82.819444	30.090278	VW	89.78	28-May-10	56.53	33.25
SRWMD - PEACOCK SLOUGH	-83.152139	30.116167	MW	56.90	2-Jun-10	32.90	24.00
SUWAW_TD	-83.058778	30.112000	AW	61.30	2-Jun-10	37.00	24.30
SUWMW_EC 5	-83.042926	30.191141	MW	85.27	2-Jun-10	54.10	31.17
SUWVW_ WW 1	-83.016917	30.043306	VW	44.50	2-Jun-10	26.12	18.38
SUWVW_HC	-83.041389	30.130222	VW	76.50	2-Jun-10	49.69	26.81
SUWVW_JML	-83.112778	30.138056	VW	62.90	2-Jun-10	37.45	25.45
SUWVW_JR	-83.049478	30.068611	VW	46.70	2-Jun-10	29.35	17.35
SUWVW_MN	-83.026694	30.189333	VW	98.00	2-Jun-10	67.72	30.28
SUWVW_SR	-83.055583	30.129528	VW	64.40	2-Jun-10	37.62	26.78
SRWMD - BRANTLEY #01	-82.982189	30.021116	MW	41.48	3-Jun-10	33.53	7.95
SRWMD - BRANTLEY #01	-82.982189	30.021116	MW	41.48	3-Jun-10	33.53	7.95
SUWAW_TV	-83.064194	30.243722	AW	93.20	3-Jun-10	56.91	36.29
SUWVW_CD 1	-82.993028	30.220222	VW	135.20	3-Jun-10	102.01	33.19
SUWVW_GTD	-83.045043	30.138175	VW	77.69	3-Jun-10	50.45	27.24
SUWVW_LC	-83.146000	30.176139	VW	80.10	3-Jun-10	50.20	29.90
SUWVW_LCI	-83.079972	30.221222	VW	93.40	3-Jun-10	58.29	35.11
SUWVW_SRG	-83.115778	30.210306	VW	85.40	3-Jun-10	52.08	33.32
SUWVW_ST	-83.068889	30.214556	VW	88.90	3-Jun-10	55.79	33.11
SUWVW_WH	-83.091472	30.241611	VW	95.00	3-Jun-10	58.35	36.65
SUWXW_HP	-83.077722	30.218556	XW	85.90	3-Jun-10	52.36	33.54
LAFAYETTE CO COMM - VISA 2	-83.100415	30.078561	MW	47.40	4-Jun-10	25.66	21.74
SRWMD- OWENS TRACT	-83.046194	30.038500	MW	47.30	4-Jun-10	30.13	17.17
SUWMW_JS 19	-83.111389	30.149167	VW	69.50	4-Jun-10	43.47	26.03
SUWVW_CJW	-83.102778	30.181444	VW	89.10	4-Jun-10	58.50	30.60
SUWVW_GA	-83.049889	30.071042	VW	48.70	4-Jun-10	31.35	17.35
SUWVW_SJ	-83.101444	30.165278	VW	75.00	4-Jun-10	46.41	28.59
LAFVW_HT	-83.112667	30.053917	VW	63.80	8-Jun-10	15.28	48.52
LAFVW_PC	-83.099583	30.043056	VW	68.50	8-Jun-10	25.47	43.03
SRWMD- OWENS TRACT	-83.046194	30.038500	MW	47.30	8-Jun-10	29.25	18.05
SRWMD - PEACOCK SLOUGH	-83.152139	30.116167	MW	56.90	8-Jun-10	33.23	23.67
SUWAW_TD	-83.058778	30.112000	AW	61.30	8-Jun-10	37.26	24.04
SUWVW_ WW 1	-83.016917	30.043306	VW	44.50	8-Jun-10	26.58	17.92
SUWVW_GA	-83.049889	30.071042	VW	48.70	8-Jun-10	31.73	16.97
SUWVW_HC	-83.041389	30.130222	VW	76.50	8-Jun-10	49.83	26.67
SUWVW_JML	-83.112778	30.138056	VW	62.90	8-Jun-10	37.61	25.29

SITE_NAME	X	Y	WTYPE	MPELEV	DATE_DTW	DTW	Z
SUWVW_JR	-83.049478	30.068611	VW	46.70	8-Jun-10	29.78	16.92
SUWVW_SR	-83.055583	30.129528	VW	64.40	8-Jun-10	37.68	26.72
DOT - SR 129 &144th ST	-82.987833	30.187889	MW	105.40	9-Jun-10	73.25	31.71
SUWMW_EC 1	-83.051913	30.187977	MW	86.15	9-Jun-10	54.81	31.34
SUWMW_EC 2	-83.046898	30.184436	MW	84.87	9-Jun-10	62.34	22.53
SUWVW_CD 1	-82.993028	30.220222	VW	135.20	9-Jun-10	102.13	33.07
SUWVW_CJW	-83.102778	30.181444	VW	89.10	9-Jun-10	58.51	30.59
SUWVW_LC	-83.146000	30.176139	VW	80.10	9-Jun-10	50.28	29.82
SUWVW_LJ	-83.024278	30.230861	VW	104.40	9-Jun-10	68.15	36.25
SUWVW_MN	-83.026694	30.189333	VW	98.00	9-Jun-10	67.83	30.17
SUWVW_WH	-83.091472	30.241611	VW	95.00	9-Jun-10	58.64	36.37
SUWVW_SJ	-83.101444	30.165278	VW	75.00	9-Jun-10	46.56	28.44
LAFAYETTE CO COMM - VISA 6	-83.112898	30.042652	MW	71.28	10-Jun-10	9.57	61.71
LAFAYETTE CO COMM - VISA 7	-83.129798	30.064312	MW	58.01	10-Jun-10	25.89	32.12
SRWMD - BRANTLEY #01	-82.982189	30.021116	MW	41.48	10-Jun-10	34.03	7.45
SUWVW_LCI	-83.079972	30.221222	VW	93.40	10-Jun-10	58.33	35.07
SUWVW_RS	-83.079611	30.134028	VW	70.00	10-Jun-10	42.17	27.83
SUWVW_SRG	-83.115778	30.210306	VW	85.40	10-Jun-10	55.25	30.15
SUWVW_ST	-83.068889	30.214556	VW	88.90	10-Jun-10	55.78	33.12
SUWXW_HP	-83.077722	30.218556	XW	85.90	10-Jun-10	52.47	33.43
LAFVW_CB	-82.973614	29.962972	VW	48.69	11-Jun-10	22.41	25.54
SUWPW_PHC	-82.978744	30.122681	PW	96.76	11-Jun-10	88.14	8.62
LAFAYETTE CO COMM - VISA 5	-83.095524	30.042657	MW	62.73	28-Jun-10	23.35	39.38
LAFAYETTE CO COMM - VISA 7	-83.129798	30.064312	MW	58.01	28-Jun-10	26.12	31.89
LAFMW_DB 11	-83.056074	30.041826	MW	46.87	28-Jun-10	27.92	18.95
LAFVW_PC	-83.099583	30.043056	VW	68.50	28-Jun-10	25.38	43.12
SUWAW_TD	-83.058778	30.112000	AW	61.30	28-Jun-10	38.03	23.27
SUWMW_DD 3	-83.012800	30.104400	MW	85.00	28-Jun-10	59.77	25.23
SUWMW_EC 5	-83.042926	30.191141	MW	85.27	28-Jun-10	54.31	30.96
SUWMW_JS 19	-83.111389	30.149167	VW	69.50	28-Jun-10	43.98	25.52
SUWVW_JML	-83.112778	30.138056	VW	62.90	28-Jun-10	37.86	25.04
SUWVW_SRG	-83.115778	30.210306	VW	85.40	28-Jun-10	53.12	32.28
SUWVW_GA	-83.049889	30.071042	VW	48.70	29-Jun-10	32.79	15.91
SUWVW_JR	-83.049478	30.068611	VW	46.70	29-Jun-10	30.19	16.51