

Contract Nos:

REPORT ON 2007 FGS-FSU UMBRELLA CONTRACT TASKS (5-8)
PERFORMED BY HAZLETT-KINCAID, INC.

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9 p.; Appendices I-IV

OVERVIEW

Hazlett-Kincaid, Inc. (HKI) was contracted by the Florida Geological Survey (FSU) via the Florida State University Geophysical Fluid Dynamics Institute (FSU-GFDI) to perform four tasks contributing to the FGS' ongoing hydrogeological characterization of the Woodville Karst Plain (WKP) Florida. The four tasks were as follows.

- Task-5: continued development and support of the Data Portal and telemetry systems.
- Task-6: development and execution of two karst short courses.
- Task-7: instrumentation of five of the Spring Creek vents with water samplers and insitu fluorometers to support future groundwater tracing studies.
- Task-8: design and execution of a tracer study focused on Spring Creek consisting of one injection at Turner Sink and one injection at the primary Lost Creek swallet.

A copy of the formal scope of work is provided as Appendix I. The contract was executed on February 13, 2007 for a period of performance of December 1, 2006 – May 31, 2007. Due to the delayed execution date, an extension to December 31, 2007 was granted for the submittal of contract deliverables. This report provides a summary of the performance and results of each task, includes or references the specific deliverables as appendices, and constitutes the final deliverable for this project. The report is submitted under the H2H Associates, LLC (H2H) letterhead because HKI merged with that firm in August 2007.

TASK 5: DATA PORTAL DEVELOPMENT AND CONTINUATION OF DATA MANAGEMENT

This task included: 1) the organization of a coordinating meeting, in cooperation with the Hydrogeology Consortium, to familiarize and educate data generating organizations with the Data Portal and encourage their participation and data sharing; and 2) collaboration with FSU/GFDI staff to identify the necessary hardware and software to link the telemetry system being installed by GFDI for the Falmouth meters and hydraulic pressure transducers deployed in the WKP to the existing Data Portal database server and render the data accessible on line through the Data Portal website.

Soon after the contract was executed the FGS and FSU modified the project priorities to focus almost exclusively on the telemetry system. HKI was asked to assist in the evaluation of the telemetry system status and in the design of a work plan aimed at bringing it online. In accordance with the modified priorities, HKI completed the following tasks associated with Task-5.

- The Falmouth meter database was continually updated with velocity, temperature, and conductivity data received from FSU/FGS via regular manual meter downloads. The data was then made available through the preliminary project Data Portal. The current status of the Falmouth meter database can be viewed and evaluated via the Data Portal at: www.h2hmodeling.com/FGS/Meters/.
- Historical Falmouth meter, water level, and fluorometer data was received from FSU and uploaded to our project servers where it is regularly backed up. Various components of the data were then transmitted back to FSU for use in their statistical analyses. These data have been categorized and stored in preparation for an expansion of the Data Portal scheduled to be carried out in 2008.
- Kevin Day of HKI traveled to Tallahassee Florida on June 25 – 27, 2007 to evaluate the telemetry systems and attempt to bring all or part of the system on line. Working in conjunction with Scott Dyer, Gareth Davies, and Ken Decoteau, he was able to complete and test one telemetry assembly at the K-Tunnel station in Wakulla Springs State Park. The system was not brought on line because the required data server had not yet been constructed and deployed. His report on the trip including a recommended work plan is included as Appendix II.
- An analysis of the data streams from six new Falmouth meters was performed to evaluate the possibility that one or more of the meters was damaged in shipping. The results of the analysis brought to light a problem with inconsistencies in the data readings particularly for temperature and velocity. Those results were shared with the project team members and posted to the project website. They remain available at: www.h2hmodeling.com/FGS/Meters/.
- Kevin Day and Todd Kincaid of HKI traveled to Tallahassee Florida on October 4, 2007 to hold a meeting focused on the purpose, design, and capabilities of the Data Portal. The meeting was primarily attended by representatives of the Florida Department of Environmental Protection. Positive feedback was received and the primary comments focused on aligning the Data Portal development effort with other FDEP database efforts. It was concluded that the Portal should be expanded to include water level data streams now being collected and that additional effort should be directed at

including a broader spectrum of participation in both the Data Portal development and utilization. A copy of the presentation is provided as Appendix III.

- The Cave Data base files for Wakulla and Leon sinks caves were continually updated to reflect the exploration advances made by the Woodville Karst Plain Project divers in 2007. The current map now shows the connected cave system – Wakulla-Leon sinks Cave system.

TASK 6: EDUCATION AND OUTREACH - HYDROGEOLOGY FIELD TRIPS

The purpose of this task was to disseminate the knowledge our team is gaining through the WKP hydrogeological characterization effort to the professional and regulatory communities through the offering of a short course on karst hydrogeology in Florida with an associated field trip focused on a specific groundwater basin. Two short courses were performed. One was held in Tallahassee and focused on the WKP and the other was held in Gainesville and focused on the Santa Fe River Basin (SFRB).

The WKP course performed on December 5 and 6, 2006 and was attended by 24 people from the FLDEP, SWFWMD, Leon county, City of Tallahassee, the Nature Conservancy, and professional consulting community. The SFRB course was performed on August 23 and 24, 2007 in cooperation with the University of Florida TREEO center. It was attended by 30 people from FLDEP, SJRWMD, SRWMD, and professional consulting community. Copies of the course flyers and the filed trip guidebooks are provided in Appendix IV.

TASK 7: SPRING CREEK INSTRUMENTATION AND SAMPLING

The purpose of this task was to set up long-term sampling stations at the primary Spring Creek vents that can be used for groundwater tracing experiments and periodic water sampling. To accomplish this task, Todd Kincaid from HKI traveled to Florida for the first week of March 2007 and joined Chris Werner of FSU-GFDI and Scott Dyer of the FGS to design and install 3/8" ID tubing into five spring vents and set up sampling stations at each one. Tubing was installed into the individual spring vents such that water could be drawn from beyond the zone where the discharge water mixes with surface water from the Spring Creek estuary and pumped up to a sampling station located on the land surface above the high tide level. All tubing installations were performed by volunteer divers from the Woodville Karst Plain Project. Table 1 lists the spring vents and the length of the associated tubing runs.

Three sampling stations were setup to service the five spring vents. Insitu filter fluorimeters and automatic water samplers were set up at each station to sample the individual vents. Two of the stations were set up on private property owned by the Spears family with their cooperation and agreement. Those stations draw water from vents 1 and 2. Vents 8, 10, and 11 are serviced by one station set up on a small island between vents 8 and 10. This station is subject to vandalism and we subsequently had two batteries stolen from that station.

Table 1. Spring Creek sampling stations and tubing runs.

Spring Vent	Tubing Length (ft)
Vent #1	160
Vent #2	350
Vent #8	100
Vent #10	150
Vent #11	400
Revel Sink	220

Exploration conducted by the WKPP divers after the tubing installations revealed that vents 8 and 10 are connected by a conduit where #8 is upstream of #10 and that vent #1 is connected to a very large diameter conduit that trends north and drops to more than 160 feet below the water surface. The WKPP divers also performed reconnaissance dives into Revel Sink, which is located approximately 1 mile south of the southernmost point in the Wakulla-Leon Sinks cave system. Their exploration revealed a large conduit at the bottom of a small vertical shaft that trends east – southeast at a depth of ~220 feet below the water surface. The trend and depth indicate that it may connect to the conduits trending south from Wakulla Spring toward Spring Creek. A sampling tube was installed to the base of the shaft and a sampling station set up at the land surface to collect water samples from the sink during the Turner sink – spring Creek groundwater tracer test.

Sampling was conducted at all six of the sampling stations described above beginning in April 2007 and continuing through September 2007. Vents 1 and 2 were sampled with both automatic water samplers and insitu fluorimeters. Vents 8, 10, 11 and Revel Sink were sampled with automatic water samplers only. Sampling was also conducted at the Wakulla Spring vent and Wakulla K-tunnel with both automatic water samplers and insitu fluorimeters. Approximately 530 water samples were collected from the Spring Creek vents and approximately 300 from Revel Sink and the Wakulla stations.

The sampling stations were dismantled in September meaning that the automatic water samplers and the insitu fluorometers were removed. The tubing was left in place at all of the Spring Creek vents and at Revel Sink such that it can be used for future tracing experiments and water sampling.

TASK-8: SPRING CREEK CHARACTERIZATION - TRACER TESTING

The purpose of this task was to carry out two parallel groundwater tracing experiments designed to map groundwater flow patterns to Spring Creek springs. The scope of work called for two tracer injections: one at Turner Sink and one at the Lost Creek swallet and continuous sampling for 30 days at the Spring Creek Vents and the Wakulla Spring Vent. Drought conditions resulted in insufficient flow in Lost Creek to activate the swallet, which necessitated that we abandon the plan for the Lost Creek injection. Instead, all focus was directed to the Turner Sink injection and an expanded sampling program.

The Turner Sink injection was performed on April 28 2007 wherein approximately 10 kg of uranine dye was injected via tubing installed in the downstream tunnel by the WKPP divers. Water sampling began at the Spring Creek and Wakulla sampling stations approximately one week after the injection. Sampling for the tracer was conducted at the five Spring Creek vents, Revel Sink and the two Wakulla sampling stations. Automatic water samplers were installed at all eight locations to collect water samples at 12-24 hour intervals. The samples were collected from the samplers at 1-2 week intervals and shipped to Gareth Davies in Oak Ridge Tennessee to be analyzed on a scanning spectrofluorometer.

Insitu filter fluorometers (IFF) were also installed at Spring Creek vents #1 and #2 and at the two Wakulla sampling stations, which measured green (uranine) fluorescence, turbidity, and temperature at 15-minute intervals in water that was continuously pumped from the sampling points into buckets. IFFs could not be installed at the remaining stations because all other available IFFs were either deployed for the Tallahassee spray field test or being serviced after prolonged deployments. Both the water sampling and the IFF measurements were maintained through the end of August 2007.

Figure 1 provides a map showing the location of the injection point at Turner Sink and the sampling stations at Wakulla Springs State Park, Revel Sink, and Spring Creek. Note that the conduit connecting Turner Sink with Wakulla Spring had not been discovered and explored at the time of the injection leaving the Leon Sinks and Wakulla Caves as independent systems with a connection that had only been demonstrated by tracing performed in 2004.

Logistical problems at the sampling stations prevented us from being able to collect a continuous record for either water samples or IFF measured fluorescence. The most consequential problems included:

- equipment failures at Wakulla Vent and K-Tunnel resulting in the loss of the first round (~2 weeks) of IFF data from both locations;
- problems with landowner relations that forced us to dismantle the Spring Creek #1 station after the first 2 weeks of sampling; and
- a potential equipment problem at Spring Creek #2 resulting in a potentially erroneous IFF signal after the first 3 weeks of operation.

Uranine was detected visually at Wakulla Spring on May 10, 2007 wherein the water in the entire Wakulla Spring basin took on a light neon green tint that reduced water clarity and forced the Park to stop glass bottom boat tours for 2-3 days. Breakthrough curves marking the passing of the dye were recorded at both the Wakulla Vent and Wakulla K-Tunnel sampling stations. Approximately 30 days later, a significantly smaller and more dispersed breakthrough curve was recorded at Revel Sink. No dye was detected at any of the five Spring Creek sampling stations during the four month sampling period.

Figures 2-3 provide plots of the fluorescence trends at the Wakulla stations and Spring Creek Vent #2. Figure 4 provides a plot of the tracer recovery data at Wakulla K-Tunnel, the Wakulla Spring Vent, and Revel Sink. The tracer test data is not included in this report but will be provided upon request.

The results of the tracer test indicate that the majority of the water flow during the testing period was to Wakulla Spring. Subsequent exploration by the WKPP divers revealed that, at least, one conduit connects Turner Sink directly to Wakulla Spring and it is assumed that the bulk of the water flowed along that conduit pathway. The divers did however note unexplored conduits leading south from the connecting tunnel in the direction of Revel Sink and Spring Creek.

The detection at Revel sink indicates that at least some of the flow from Turner Sink must overflow into one or more such tunnels and travel south though this was clearly a small fraction of the flow during the testing period. Our original hypothesis was that under very low flow conditions (operative during the testing period) a significant portion of the flow from Turner would be directed toward Spring Creek making Wakulla Spring in effect an overflow. The results of this test however indicate that the opposite must be true, that Wakulla is the primary discharge point and that Spring Creek is the overflow.

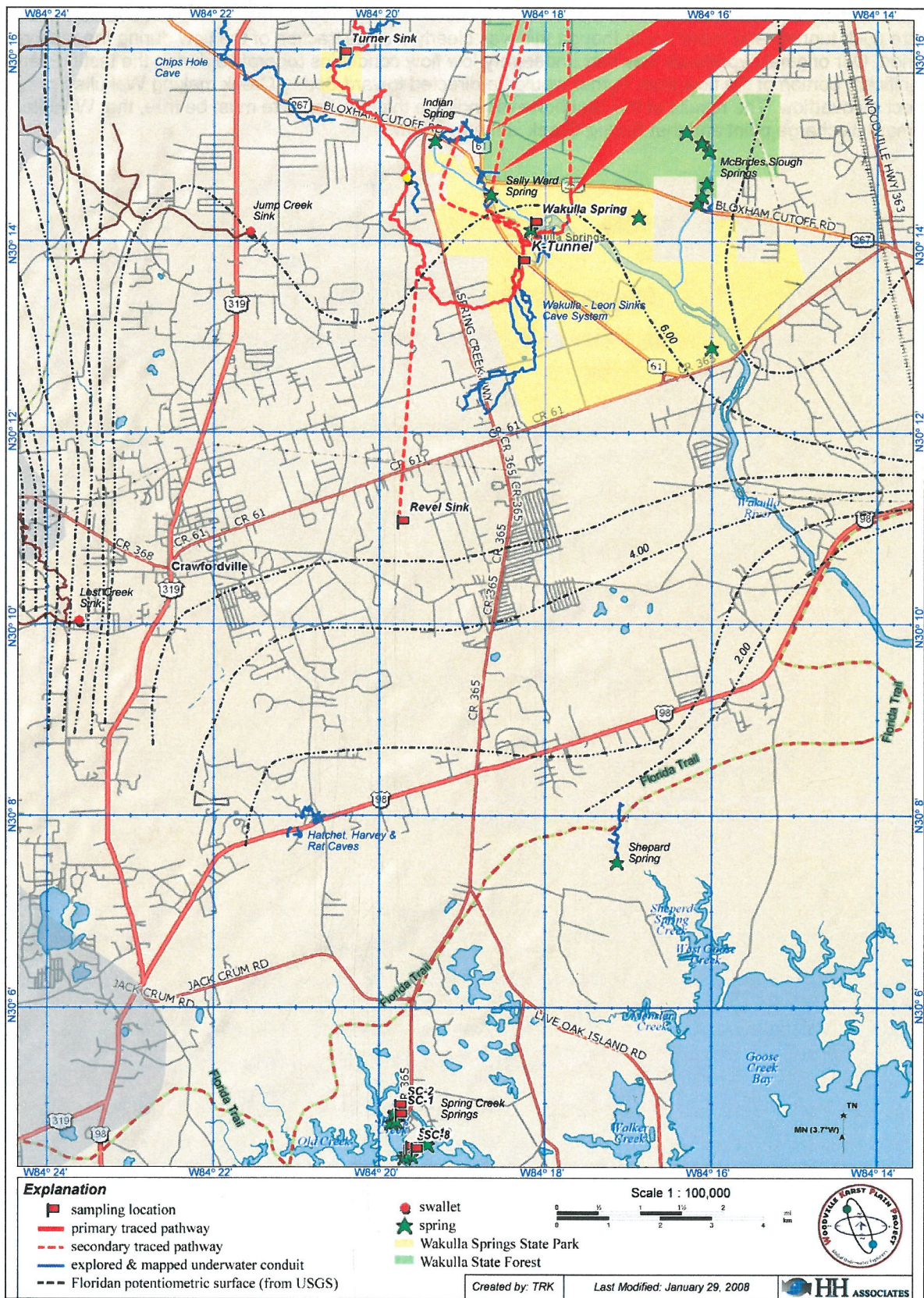


Figure 1. Map showing the location of sampling stations and tracer defined groundwater flow paths between Spring Creek and Wakulla springs, Woodville Karst Plain, Florida.

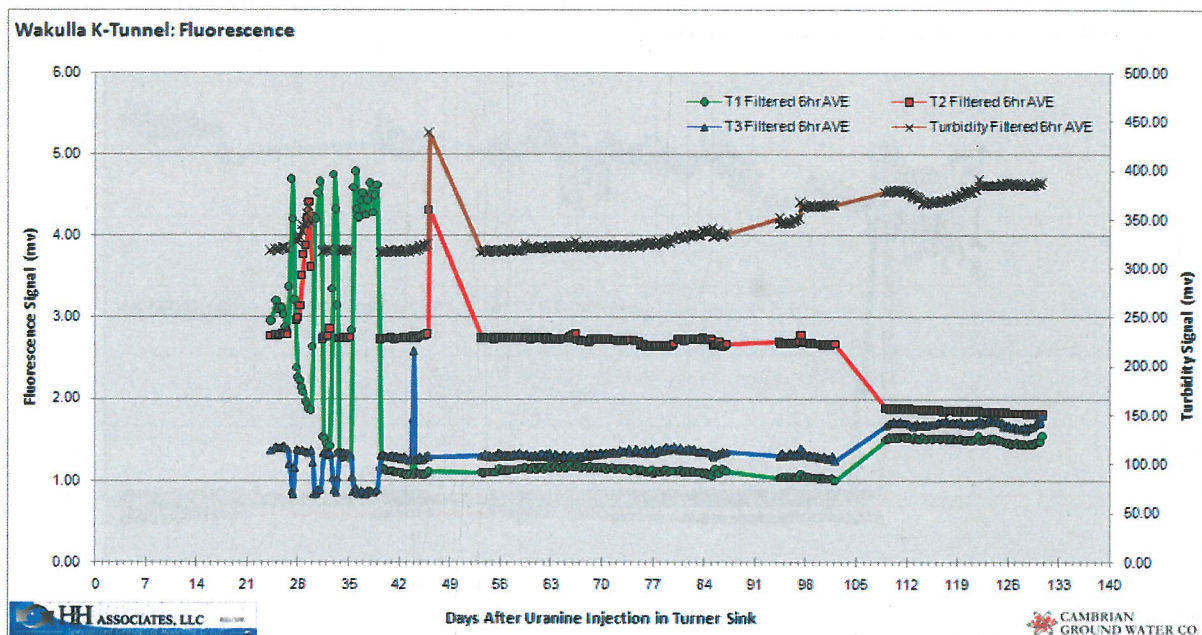
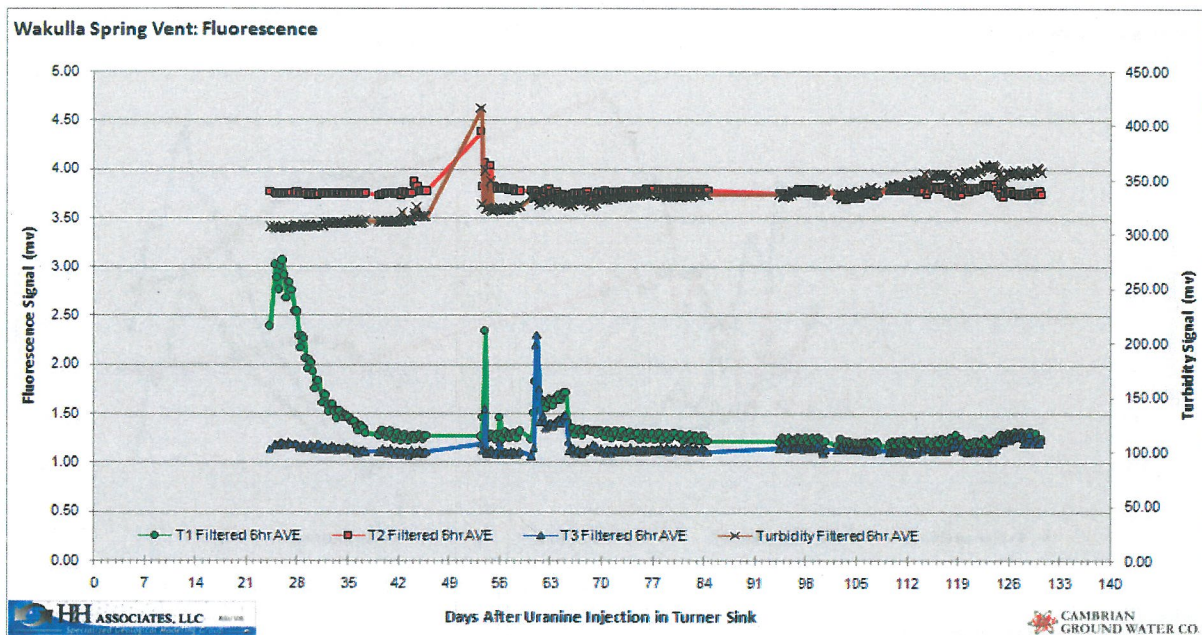


Figure 2. Fluorescence measured by insitu filter fluorometers (IFF) installed at Wakulla Spring and Wakulla K-Tunnel. The initial falling in trend in green fluorescence marks the trailing edge of a uranine plume moving through the conduit system from the injection at Turner Sink. Measurements from the first 10 days of the sampling period were not recorded by the IFF due to an equipment problem.

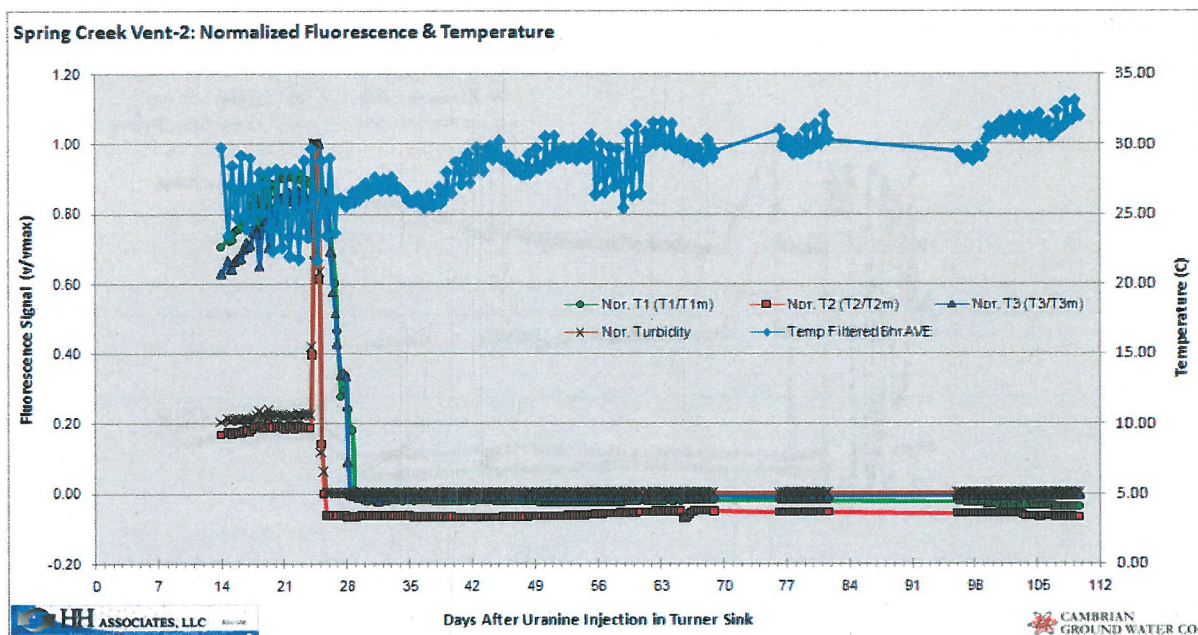
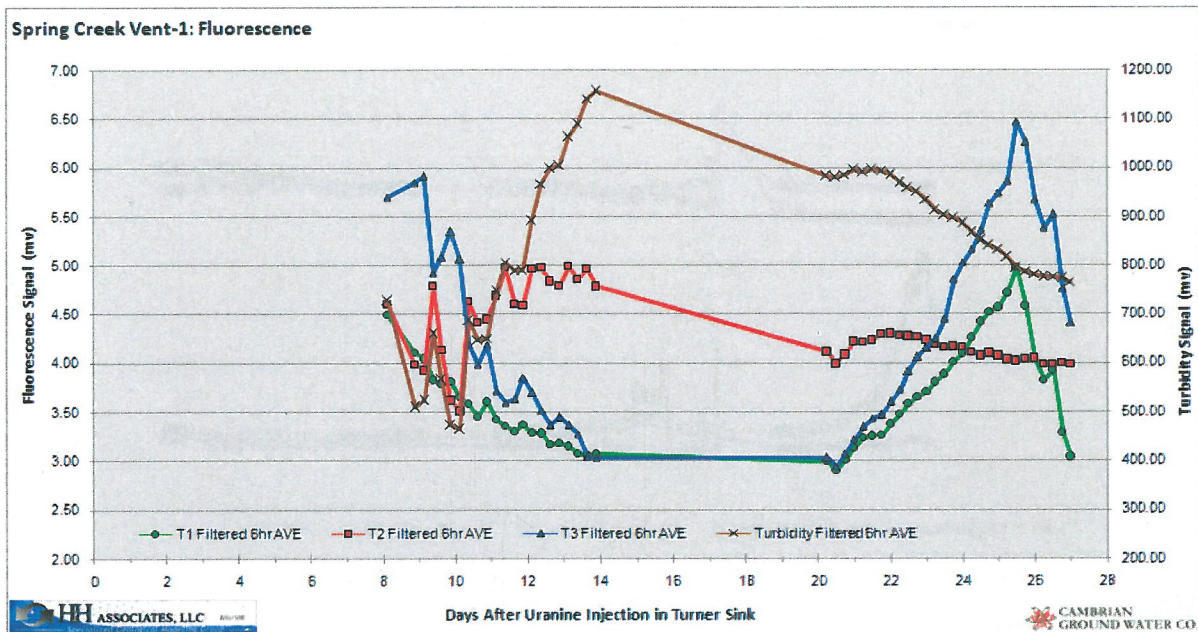


Figure 3. Fluorescence measured by insitu filter fluorimeters (IFF) installed at the Spring Creek #1 and #2 vents. The station at Spring Creek #1 had to be dismantled before the tracer was detected due to conflicts with the property owner. The trend at Spring Creek #2 indicates a possible malfunction in the IFF at approximately 28 days after the injection though there was no apparent problem with the temperature sensor.

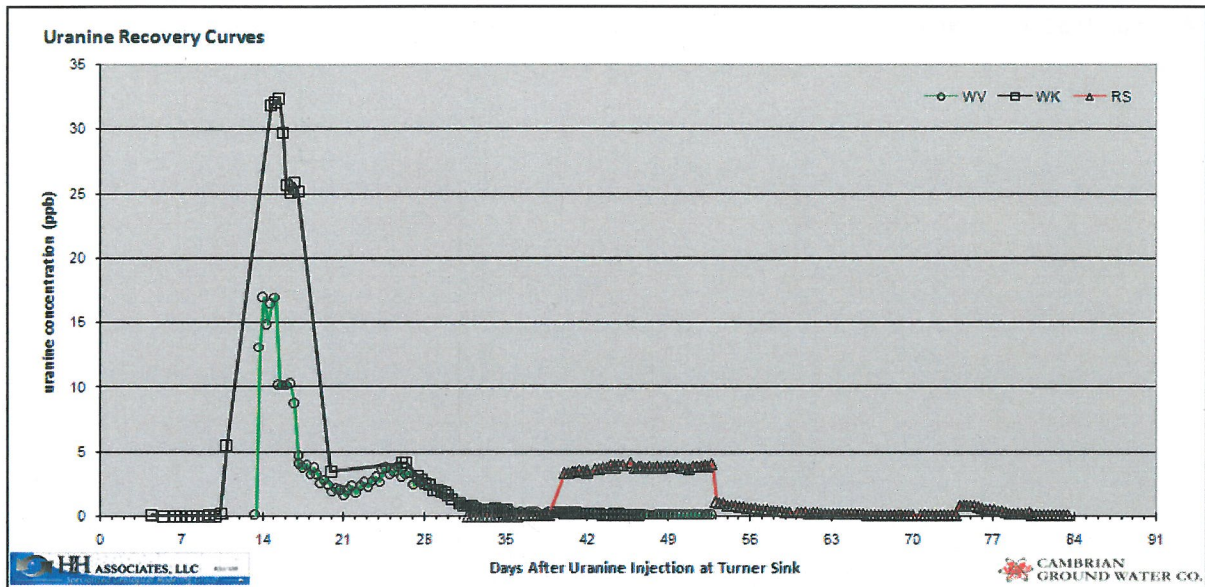


Figure 4. Uranine concentrations measured from water samples collected at the Wakulla Spring Vent, Wakulla K-Tunnel, and Revel Sink. Note that the uranine passed the Wakulla Spring vent less than a day after it passed K-Tunnel and that the plume appears to have passed in two slugs; a large rapid slug at about 14 days and a smaller more diffuse slug at about 26 days. A much smaller and more disperse plume passed the Revel Sink sampling station between 40 and 55 days after the injection. Uranine was not detected at any of the Spring Creek sampling stations throughout the approximate four month (120 days) sampling period. The travel times and concentrations indicate that the primary pathway operative during the testing period was to Wakulla Spring with some overflow to the south that was detected at Revel Sink but not at spring Creek.

APPENDIX I: SCOPE OF WORK

APPENDIX II: LETTER REPORT ON TELEMETRY SYSTEM INSPECTION

APPENDIX III: DATA PORTAL PRESENTATION SLIDES

APPENDIX IV: KARST SHORT COURSE FLYERS AND FIELD TRIP GUIDEBOOKS