UROP Final Report

Defining Freiheit Spring's Springshed, Fillmore Co., MN

Su Yi Chai
Geology & Geophysics Dept.
University of Minnesota
Minneapolis, MN 55455

July 2010

Introduction

Southeastern Minnesota is an area of research interest for hydrogeology because of its karst landscapes. The abundant karst features like sinkholes and caves scattered around Southeastern Minnesota are the result of karst processes, which involve carbonic acid in water dissolving carbonate minerals in soluble bedrock. This project focused on defining Freiheit Spring's springshed.

Dye tracing is an important technique used in springshed mapping because it allows us to determine the direction of groundwater flow and measure groundwater travel times. In dye tracing, fluorescent dyes are introduced into sinkholes or sinking streams and flows with the groundwater through the karst system and emerges at a spring or springs. Charcoal detectors known as bugs are placed in monitoring sites around the springs to determine from which spring or springs the dye emerges. By periodically changing the charcoal bugs, the groundwater travel-time from the sink points to the springs can be determined.

Study Area and Methods

Freiheit Spring is located in section 19, T103N, R12W of Fillmore County, Minnesota. Field work began on 29 November 2009, when Professor E. Calvin Alexander, Jr. and I installed the first background bugs in two locations, Forestville Creek and Freiheit Spring. Further field work was delayed because of the onset of winter weather. Field work was resumed on 4 April 2010, when we installed four more bugs in other locations around Freiheit Spring. This brought the total monitored locations to six. The locations of these sampling points are listed in Table 1 in the appendix to this report and are shown in Figure 1. These bugs were changed on a weekly basis to determine background levels of fluorescent materials before we initiated the dye tracing.

On 24 April 2010, Professor Alexander and I introduced dyes in two locations. Using a 500 gallon tank from the Department of Natural Resources (DNR), we first injected approximately 1/3 of the water into our first location, a sinkhole located on the Jahn property. We then injected the first dye, eosin, at 3:15 PM. A total of 207.3 g of a 33 wt % eosin solution was used. The remaining 2/3 of the water was used to flush the dye into the groundwater system. Our next location was 151st St. Bridge over Spring Valley Creek, where we used our second dye, sulforhodamine B. A total of 517.6 g of a 18 wt % solution of sulforhodamine B was introduced into the stream at 5:40 PM. On 1 May 2010, uranine was injected into our third location, which

was a sinkhole on the Schmidt property. A total of 320 gallons of water was first pumped into the sinkhole, from an adjacent pond, to wet the walls. A total of 112.9 g of a 35 wt % uranine solution was then injected into the sinkhole at 1:17 PM. The dye was then flushed into the system with another 800 gallons of pumped water. The locations of these dye input points are listed in Table 1 in the Appendix and are shown in Figure 1.

Figure 1. A Google Earth image of Fillmore County, Minnesota, between Spring Valley and Wykoff showing the locations of the monitoring points (green stars) and the dye input points (red triangles).

The bugs from the six locations were changed weekly over the next several weeks and brought back to the laboratory at the University to be analyzed. During the analysis, the charcoal is removed from the bugs and allowed to sit in an eluent solution of 70% isopropyl alcohol, 30% deionized water and 10g/L sodium hydroxide for an hour. After an hour, the elutant was extracted and scanned using a spectrofluorophotometer to detect any presence of three of the

fluorescent dyes. The spectra produced from the spectrofluorophotometer will then be fitted with PeakFit software to quantify the results.

Results

The results of the spectrofluorometric analyses of the various charcoal bugs are summarized in Table 2 in the Appendix. The data in Table 2 show that the eosin injected into the Jahn sinkhole on 24 April 2010 was recovered at Freiheit Spring. The uranine injected into the Schmidt sinkhole on 1 May 2010 was recovered at Mahoods Spring. Figure 2 summarizes the dye input points and springs in Freiheit Springshed and other adjacent springsheds.

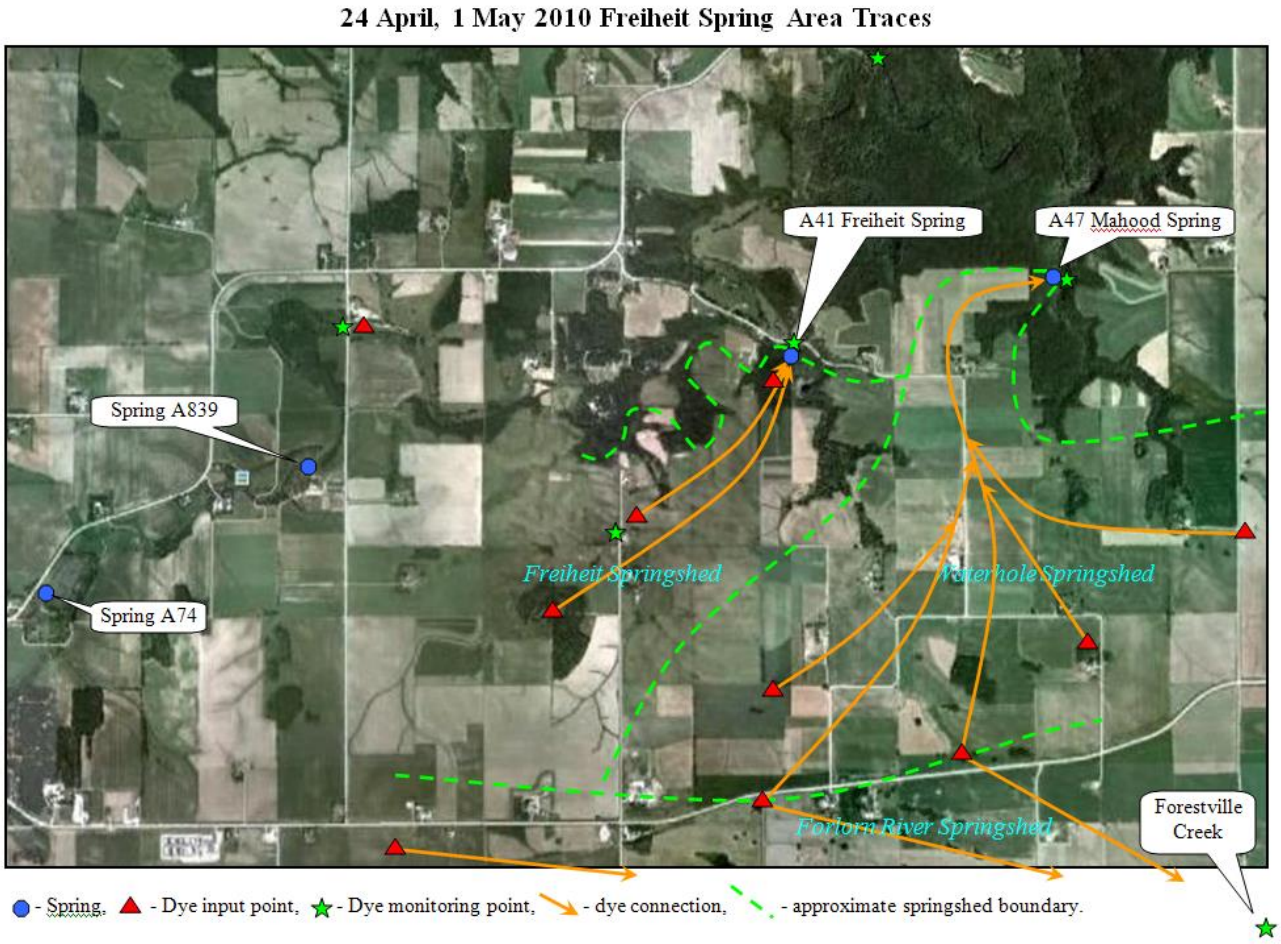

Figure 2: A Google Earth image of Freiheit Springshed and other adjacent springsheds in Fillmore County showing springs, dye input points, dye monitoring points, dye connections and approximate springshed boundaries.

Conclusion

From the results of the dye tracing, we can see that the Jahn sinkhole lies within the boundaries of Freiheit Springshed. However, we discovered that the Schmidt sinkhole feeds to Mahoods Spring rather than Freiheit Spring, thus placing the sinkhole within Waterhole Springshed. These results we obtained have allowed us to further delineate Freiheit Springshed and draw a more accurate springshed boundary between Freiheit Springshed and its adjacent Waterhole Springshed. Additional dye tracing can be performed in the future to further refine Freiheit Springshed.

Acknowledgments

Support for this project from the University of Minnesota's Undergraduate Research Opportunities Program is gratefully acknowledged. This work would have been impossible without the permission from the Kohlings who own Freiheit Spring to visit and study the spring, from the Jahn and Schmidt families to trace from the sinkholes on their property. My UROP project is part of an ongoing research effort by Professor Alexander which is funded by the Legislative Citizen's Committee on Minnesota Resources and their support is also acknowledged.

Educational Objectives

Completion of this project has allowed me to fulfill my educational objectives by acquiring additional knowledge and valuable experience outside the classroom. This project has also allowed me to provide useful information to the state and people of Fillmore County. Because of the high risk of contamination in karst regions and to protect trout streams, defining springsheds is crucial in improving groundwater quality.

Reflection

My UROP experience was a very positive one and overall, a very valuable one. Being involved in this research project with Professor Alexander increased my understanding of the dye tracing process and gave me a lot of hands-on experience. It also has given me the opportunity to work closely with Professor Alexander.

Furthermore, this UROP project has also broadened my perspective on having a career in karst hydrogeology. Conducting dye traces in Southeastern Minnesota involves not only the actual dye tracing process itself, but also obtaining permission from land owners and looking to find sinkholes suitable enough for our dye tracing.

Overall, I am very appreciative of having been awarded this UROP award because it has positively contributed to my undergraduate experience here at the University of Minnesota. As an international student, traveling to Southeastern Minnesota has been one of the highlights of my time here and I look forward to opportunities like this in the near future.

Appendix

Table 1. Charcoal bug locations and instructions and dye input details.

Bug Locations

23X132 Spring Valley Creek 151st St Bridge: (4,839,561 N, 552,416 E)

Starting in Spring Valley, MN at the junction of St Hwy 16 and US 63 take St Hwy 16 east to 151st St. Turn north on 151st St and proceed 1.7 miles north to the bridge over Spring Valley Creek. The bug is tied a rock on the south side of Spring Valley Creek about 40 feet west (up stream) of the bridge at the tree line.

23X???, 161st St. Culvert (4,838,485 N; 554,034 E)

Starting in Spring Valley, MN at the junction of St Hwy 16 and US 63 take St Hwy 16 east to 161st St. Turn north on 161st St. and proceed 1.0 miles north to a culvert. The bug is tied to a log across the upstream end of the northern of two culvert pipes.

23A41, Freiheit Spring Bug: (4,839,445 N, 554,978 E)

Starting in Spring Valley, MN at the junction of St Hwy 16 and US 63 take St Hwy 16 east to Open West LP. Turn north and proceed north and east for 1.0 miles to junction with Orchard Rd. Turn north on Orchard Rd and proceed north and west 1.5 miles to driveway for emergency number (EN) 24239 (at a red metal gate). The gate is normally open, but if it is not you can open it. Follow driveway 0.2 miles to Freiheit Spring on the right. The bug is tied off a tree root close to the mouth of the largest spring orifice.

23X??? Old Timber Bridge Rd. (DS): (4,841,169 N, 555,484 E)

From junction of Co Rd 8 and Old Timber Bridge Rd northeast of Spring Valley, drive down Old Timber Bridge Rd until you reach a gate. If open proceed to bridge over Spring Valley Creek. If closed, park and walk down the road to the bridge. We have permission from Peter Grove the land owner. The bug is tied to a nail on the foundation of the north end of the bridge at water level.

23A47 Mahood's Spring: (4,839,889 N, 556,596 E)

Starting in Spring Valley, MN at the junction of St Hwy 16 and US 63 take St Hwy 16 east to 183rd Ave. Turn north on 183rd Ave and proceed north 1.4 miles to EN 24499 (just south of EN 24573 – a red brick house). Turn west into driveway and proceed 0.2 miles to a small "Barr" sign on the left (a farm house is on the right). Turn left and follow the driveway 0.4 miles to the Barr cabin. Park there and walk north, downhill past the cabin to the bottom of the hill to the creek. Proceed upstream over a wooden arch foot bridge, over a wooden plank foot bridge, past a spring on the left and cross back to the north side of the creek that emerges over ledges about 4 feet above the valley floor in a waterfall. The bug is tied to a large log across the spring run immediately in front of the spring.

23X??? Forestville Creek: (4,832,025 N, 561,212 E)

Go to Maple Springs Campground just north of the Forestville/Mystery Cave State Park Ranger Station. Check in with the owners at the campground. Drive to the back of the campground. Park there and walk north along the road to Forestville Creek. Bug tied to a rock on the south side of the creek up stream of the camp site at Forestville Creek.

Dye Input Information

23MN:D2311, Sinkhole on Jahn property (4,837,916 N; 553,639 E)

Using DNR 500 gallon tank, wet down sinkhole with ~ 1/3 of the water. Inject 207.3 gm of 33 Wt % eosin solution (D12802 Chromatint Red 0143 – lot 020706) at 3:15 PM CDT on 24 April 2010. Flush the dye into the system with the remaining 2/3 of the water tank.

Land owner: Rick Jahn
15773 St Hwy 16
Spring Valley, MN
(507) 346-9947

23MN:Xxxx, 151st St. Bridge over Spring Valley Creek

Inject 517.6 gm of 18 Wt % suflorhodamine B solution (M93010X Chromatint Red 0551) at 5:40 PM CDT on 24 April 2010.

Land owner: Township Road

MN23D1956, Sinkhole on Schmidt property

Setup pump from pond just south of the sinkhole. Pumped ~ 320 gallos of water into sinkhole to wet the walls. Input 112.9 gm of 35Wt % fluorescein solution (Chromatint uranine HS – lot 082207C) at 13:17 CDT on 1 May 2010. Flushed the dye into the system with another 800 gallons of pumped water.

Land owner: Harlan Schmidt
23417 Orchard Rd
Wykoff, MN
(507) 352-5861

Land Owner's son: Darvin Schmidt
16846 St. Hwy 16
Wykoff, MN
(507) 346-7857

Table 2. Results

Freiheit Spring

		FS1	FS2	FS3	FS4		FS5		FS6	FS7	FS8
KFDB #s	Site	Nov. 20-29, 2009	Nov. 29, 2009-Apr. 4, 2010	Apr. 4-17, 2010	Apr. 17-24, 2010	24 Apr. 2010 Dye Pour	Apr. 24-May 1, 2010	1 May 2010 Dye Pour	May 1-10, 2010	May 10-24, 2010	May 24-June 6, 2010
	Forestville Creek		nd		nd (Apr. 16-24, 2010)		Eos* (10 σ)		nd	nd	
	Freiheit Spring	Uran (13 σ) (July 2, 2009 dye pour)	Uran (17 σ) (July 2, 2009 dye pour)	nd	Uran (4 σ) (July 2, 2009 dye pour)		Eos		Eos (120 σ)	Uran (25 σ) (July 2, 2009 dye pour) and Eos (78 σ)	Uran (16 σ) (July 2, 2009 dye pour) and Eos (17 σ)
	Timber Bridge over Spring Valley Creek			SrB* (10 σ)	Eos* (16 σ) and SrB* (25 σ)		Uran * (3 σ), Eos* (33 σ)?, and SrB* (390 σ)		Eos* (12 σ) and SrB* (12 σ)	Eos* (18 σ) and SrB* (24 σ)	Eos* (8 σ) and SrB* (19 σ)
	151st Bridge over Spring Valley Creek			nd	SrB* (8 σ)		SrB* (3 σ)		SrB* (5 σ)	SrB* (5 σ)	SrB* (12 σ)
	161st St Culvert						nd		nd	nd	nd
	Mahoods Valley			nd			SrB* (6 σ)		Uran	Uran	Uran

nd = no dye detected

Uran = Uranine dye detected

Eos = Eosin dye detected

SrB = Sulforhodamine B dye detected

Uran* = Uranine dye detected from some unknown source

Eos* = Eosine dye detected from some unknown source

SrB* = Sulforhodamine B dye detected from some unknown source

May 1, 2010 Dye Pour

152.4 g of D11006 Chromatint Uranine HS, Lot 0822078C were poured into sinkhole 23:D1956 (Darv Schmidt's property, water pumped from pond) at 13:17 on May 1, 2010

April 24, 2010 Dye Pour

Eosine (207.3 g) was poured into sinkhole 23:D2311 (Rich Jahn's property) on April 24, 2010
Sulforhodamine B (517.6 g) was poured into 23:X??? (151st St. Bridge on Spring Valley Creek) on April 24, 2010

Uranine and Sulforhodamine B poured July 2, 2009

At 12:00 on July 2, 2009, 128.41g of Sulforhodamine B Chromatint Red 0551, Lot # 082207D was poured into D2631 sinkhole
At 22:20 on July 2, 2009, 580.2g of D1106 Chromatint Uranine HS Liquid, Lot # 082207C was poured into Spring Valley Creek on the downstream end of the north culvert at X131 site