Wiskow Dye Traces 2014
Olmsted County, Minnesota

9 April 2014 to 12 June 2014

Final Report – 3 September 2014

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Introduction

The Wiskow dye traces were conducted near Predmore, Minnesota in Eyota, Marion, Orion and Pleasant Grove Townships in Olmsted County from April 9, 2014 to June 12, 2014 (Figures 1 and 2). Dye traces have been completed in this area in the past. This recent effort further refined the delineation of the springsheds in close proximity to Kinney Creek and Mill Creek which are designated trout streams in Minnesota. In addition, there are growing concerns amongst citizens in the area and local units of government regarding the spreading of manure in winter. During snow melt there is a greater potential for contaminated surface water to infiltrate into sinkholes and negatively impact domestic well water quality and groundwater dependent resources such as springs and trout streams.

The groundwater contamination concerns are associated with a large array of sinkholes in southern Olmsted County roughly south of I90 and north of the North Branch of the Root River; bounded on the west by Kinney Creek and on the east by the Mill Creek drainage (Figure 3). This area is the Orion sinkhole plain. Dye tracing by Lopez-Burgos and others (2003) and by Eagle and Alexander (2007) have begun to define springsheds in this area. Two of the springsheds are along the southern edge of the sinkhole plain and one is along the western edge (Figure 4).

Domestic well owners in the area reported a change in well water quality following 0.87 inches of rain on Saturday, March 9, 2013, and 6.8 inches of snow the next day. Well water changed from clear water to colored water with foam and odor (Larsen, 2013, Eyota Township Manure Runoff Incident, unpublished). The Minnesota Pollution Control Agency (MPCA) and Olmsted Soil and Water Conservation District (SWCD) completed an investigation into the possible reasons for the degraded water quality. The investigation documented that three feedlots had recently spread manure in the area. Inspection of the farms near the affected wells led to the discovery of an unmapped sinkhole under a brush pile in the Wiskow farmstead yard. The Wiskow farmstead is in the northeastern part of the sinkhole array. The working hypothesis is that this sinkhole was capturing manure contaminated runoff.

Testing of water from nearby wells found two wells with high total coliform and *E. coli*. Other wells tested high for nitrate. The investigation raised citizen and agency interest in surface and groundwater interaction within the Galena Group formations and their vulnerability to contamination. The goal of these dye traces was to determine if there was any connection between the sinkholes receiving contaminated overland surface flow and the nearby springs, domestic wells and designated trout streams and to begin the process of springshed delineation in this part of the sinkhole plain

Dye Trace Methods

Dye tracing uses the injection of fluorescent dyes into karst surface features such as sinkholes to track groundwater flow directions and travel times (Figure 5). During these traces the sinkholes were dry. The dye was flushed into the sinkhole with 1,000 gallons of water to insure that the dye reached the groundwater system. The water was supplied by a tanker from the Chatfield Fire Department.

On 6 May 2014, 1095 grams of 35 wt. % Uranine C solution (this dye is often called fluorescein) was input into the Wiskow Sinkhole (MN55:D00983) located at 557550 E / 4865569 N ± 3.9 m. This sinkhole is on the Cole Wiskow property. It was known that water sank in that area but there was no surface expression of a sinkhole. A bobcat excavated a shallow depression in an area where the water had sunk in the 2013 event. About 300 gallons of water were poured into the depression. The dye was poured at 10:10 am and the rest of the 1,000 gallons was poured into the depression (Figures 6 and 7).The water stopped at 10:25 am. Recharge into the Wiskow sinkhole was very slow until about an hour after the initial watering/dye injection when it rapidly began to accept the water and dye.

On 6 May 2014, 435 grams 17.7 wt. % Rhodamine WT solution was input at 10:35 am into the large, Applen sinkhole (MN55:D00282) located at 557516 E / 4863617 N ± 3.3 m. The sinkhole is funnel-shaped, about 70 feet in diameter, with an approximate 2-foot diameter swallow hole and a 1-foot open hole in the bottom. The sinkhole is located on the Viola Applen property. Two hundred gallons of water was initially introduced into the sinkhole followed by the dye and then followed by 800 more gallons of water (Figures 8 and 9). The water was supplied by a tanker of the Chatfield Fire Department. The sinkhole accepted all the water and dye with no ponding.

Dye Trace Setting

Figure 5 shows the location of the dye trace features in relation to the road network in the area. The two selected dye injection points are within the Prosser Formation of the Galena Group. The 12 springs targeted for sampling emanate from the Prosser and Cummingsville Formations above the Decorah Shale Formation (Figure 10). Four vulnerable domestic wells were identified but only two landowners agreed to participate in the monitoring of their wells. Neither well had a well and boring record in the County Well Index (CWI). Based on other nearby CWI well records and the Olmsted County geologic map, these two shallow wells are thought to be open to Galena Group formations. A list of the injection points, springs and wells identified for use in this dye trace can be found in Table 1.

ID #	X UTM	Y UTM	Karst Feature DB Number	Name or Description	Classification:
1IP	557550	4865569	MN55:D00983	Wiskow Sinkhole in Brushpile	Injection Point
3IP	557516	4863617	MN55:D0000282	Open Sinkhole Near Hwy 52	Injection Point
1S	558102	4865505	MN55:A00567	Spring in Pagel's Pasture	Spring Sample Point
2S	559125	4863987	MN55:A00014	Spring in Boyd Gasner's Pasture (CCC Structure)	Spring Sample Point
3S	558970	4863883	MN55:A00564	Spring in Boyd Gasner's Pasture	Spring Sample Point
4S	558388	4863918	MN55:A00566	Spring in Boyd Gasner's Farmyard	Spring Sample Point
5S	553931	4863520	MN55:A00009	Old Jug Spring	Spring Sample Point
6S	555586	4861618	MN55:A0003	Chance Hollow Spring	Spring Sample Point
9S	556304	4867026	MN55:A0443	County Rd 19 Crossing Spring	Spring Sample Point
10S	554189	4865208	MN55:A0492	Kinney Creek Headwater Spring	Spring Sample Point
11S	556374	4861274	MN55:A0002	Billy's Springs Run	Spring Sample Point
12S	557204	4861156	MN55:A0003	Devils Den Springs Run	Spring Sample Point
13S	554354	4862907	MN55:A00006	McConnel Spring	Spring Sample Point
15W	557606	4865482	MN55:X00013	Wiskow Well	Vulnerable Well
16W	558450	4866578	MN55:X00012	Boyd S Jr Gasner Well	Vulnerable Well
19S	558631	4864067	MN55:A00565	Applen Spring	Spring Sample Point

Table 1. Dye trace features and locations.

Sampling Schedule

Prior to injection, charcoal packet detectors (bugs) were placed within the identified springs and in the tanks of toilets serviced by targeted domestic wells to determine background conditions. Charcoal detectors were distributed for the first time two weeks before dye injection. The background bugs were changed one week before dye injection. Bugs were changed a second time the day before the dye injection and direct water samples were taken. The bugs were replaced 3 days following the injection. Bugs were then replaced four days later and then on a weekly basis. Direct water samples at all sites were taken daily for seven days after dye injection and weekly thereafter. By consensus agreement among participants, sampling was terminated on 12 June 2014. Both direct water samples and passive dye detectors were used for sample collection. All samples were analyzed at the University of Minnesota, Department of Earth Science laboratory using a scanning spectrofluorophotometer.

Participating Agencies

The dye traces were conducted by Jeff Green and Scot Johnson of the MNDNR Ecological and Water Resources Division, Martin Larsen of the Olmsted County Soil and Water Conservation District and E. Calvin Alexander, Jr of the University of Minnesota Earth Sciences Department. DNR provided dye, charcoal detectors, logistical support and staff time. Olmsted SWCD gained permission to access the injection/sampling locations and provided staff time and logistical support. Analysis of the charcoal detectors was done at the University of Minnesota by Scott Alexander and Sophie Kasahara. Betty Wheeler prepared appendices A, B and C. The cost of analysis and data reduction was covered by the U of MN project: "Innovative Trout Stream Springshed Mapping in Southeast Minnesota", funded by the Minnesota Legislative-Citizen Commission on Minnesota Resources. Other state agencies were notified of the dye trace prior to commencement.

We thank the local landowners for their participation in this effort and for permission to visit the springs and sinkholes on their property. These traces would have been impossible without the participation and permission.

Results

Rhodamine WT was traced from the Applen sinkhole near Highway 52 (MN55:D00282) to the Gasner Farmyard Spring (MN55:A00566) as shown in Figures 11 and 12. The dye took less than one day to travel from the sinkhole to the spring at a minimum velocity of 3025 feet per day. Dye continued to be detected in the spring throughout the dye trace sampling period.

Uranine C was traced from the Wiskow sinkhole (MN55:D00983) to the Pagel Spring (MN55:00567) as shown in Figures 11 and 13. The dye took 2 days to reach the spring at an approximate velocity of 913 feet per day.

No dye was detected in any of the other springs or in the two domestic wells tested. However, during the retrieval of the last charcoal bug from Mr. Wiskow's water system he mentioned that, in response to the previous year's contamination episode, a large charcoal filter had been installed in the connection between his well and house. He had changed that charcoal filter about once a month. Those filters would have adsorbed any dye before the water reached the charcoal bug in his toilet tank. An attempt was made to extract dye from the household charcoal filter but the large amount of other organic compounds adsorbed by the filter precluded the identification of any dye that might have been present.

Surface water entering the karst conduit system through sinkholes in the vicinity of the two injection sinkholes appears to stay within the Prosser Limestone because the dyes did not reach the lower Cummingsville Formation springs (Figures 14 and 15).

References

Eagle, Sarah D. and E. Calvin Alexander, Jr. (2007) 2 July 2007 Morehart Farm Dye Trace. Unpublished Dye Trace Report, Geology & Geophysics Dept., Univ. of Minn. Twin Cities, 16 pages.

Lopez Burgos, Viviana, Scott C. Alexander, Adam Nagle, E. Calvin Alexander, Jr., Jeffrey A. Green and Jeremy Pavlish (2003) Recent Advances in Springshed Mapping Using Dye Tracing, GIS and Structural Geology Tools. Poster prepared for the 2003 NSF Summer Intern presentation.

Figures

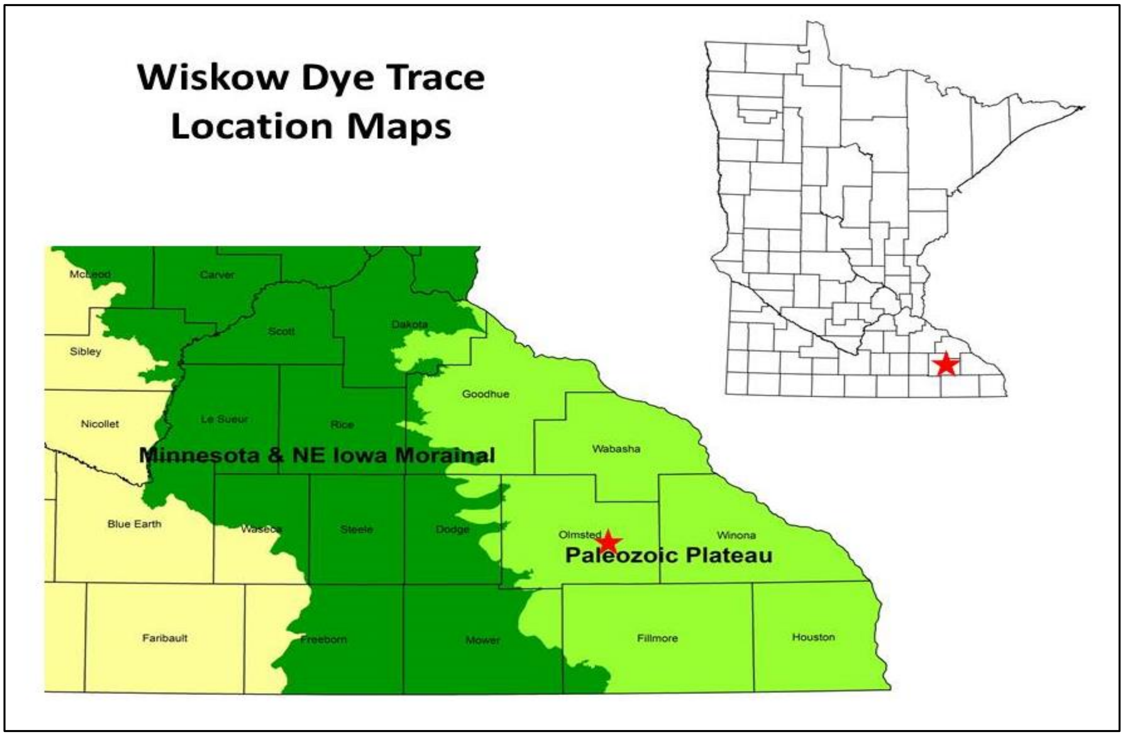

Figure 1. Wiskow dye trace location maps.

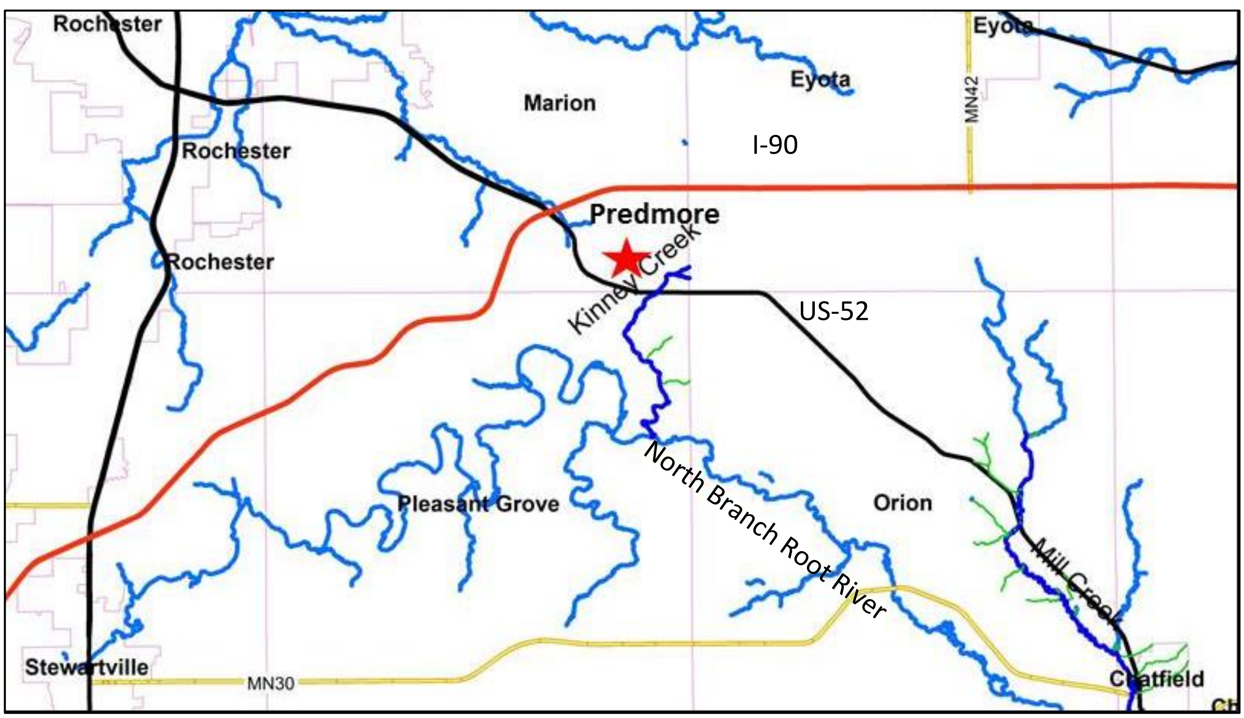

Figure 2. Wiskow dye trace location map showing the Townships in Olmsted County, Predmore (red star), I90, North Branch Root River, Kinney Creek and Mill Creek. The dark blue lines represent the designated trout streams and the green lines are tributaries to the designated trout streams. The light blue lines are other perennial streams.

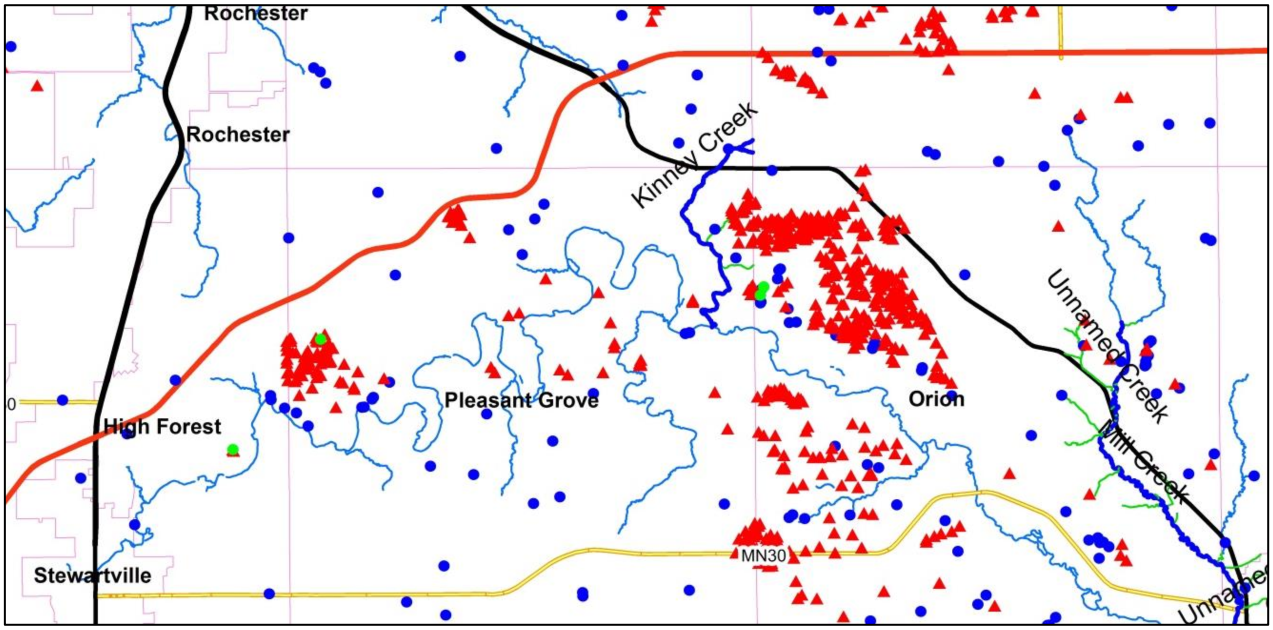

Figure 3. Location of mapped sinkholes (red triangles), sinks (green dots) and springs (blue dots) from the karst features data base maintained by the University of Minnesota.

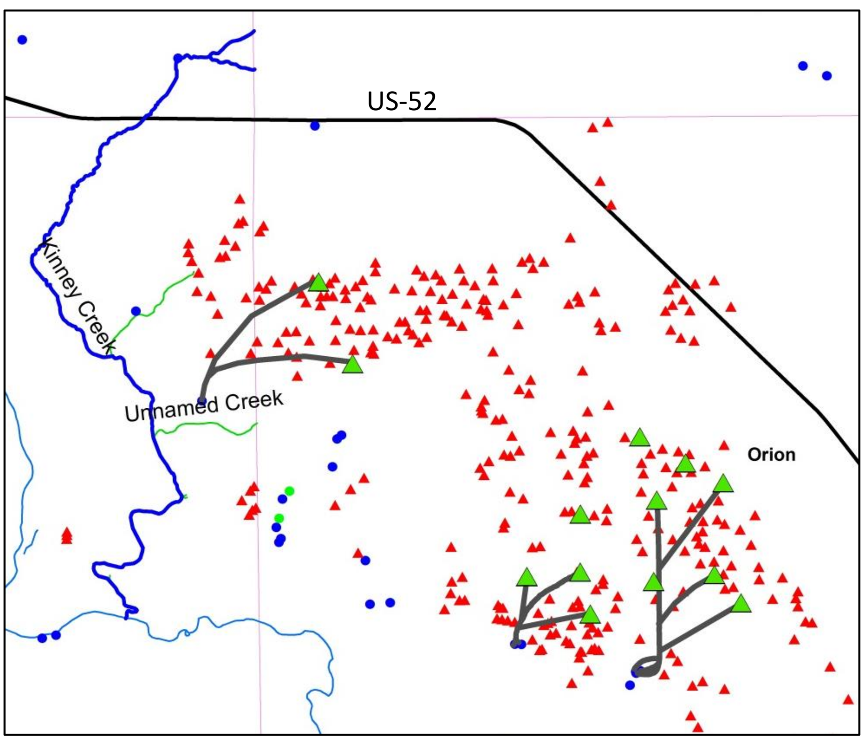

Figure 4. Previous dye trace vectors in vicinity of the sinkhole array shown as dark gray rays with injection points shown as green triangles. The dark blue lines represent the designated trout streams, green lines are tributaries to the designated trout streams and light blue lines are other perennial streams.

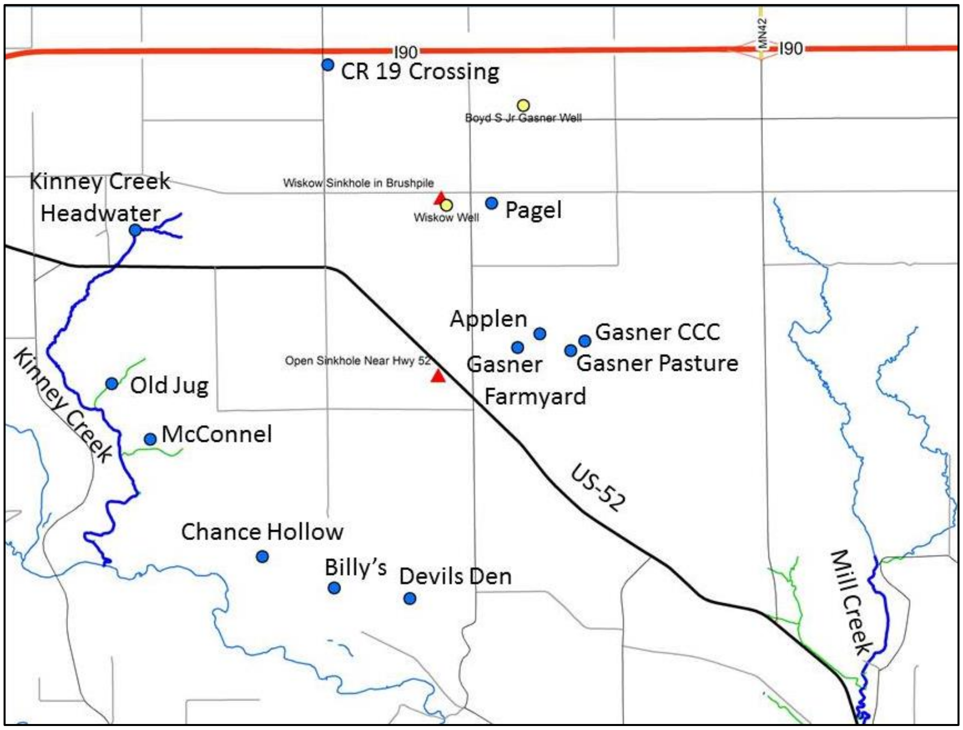

Figure 5. Dye trace water sampling locations: springs (blue dots), wells (yellow dots) and injection sinkholes (red triangles).

Figure 6. Wiskow sinkhole Uranine C dye injection.

Figure 7. Temporary pooling of water and dye in the Wiskow sinkhole.

Figure 8. Applen sinkhole from Highway 52.

Figure 9. Injection of Rhodamine WT dye into the swallow hole of the Applen sinkhole.

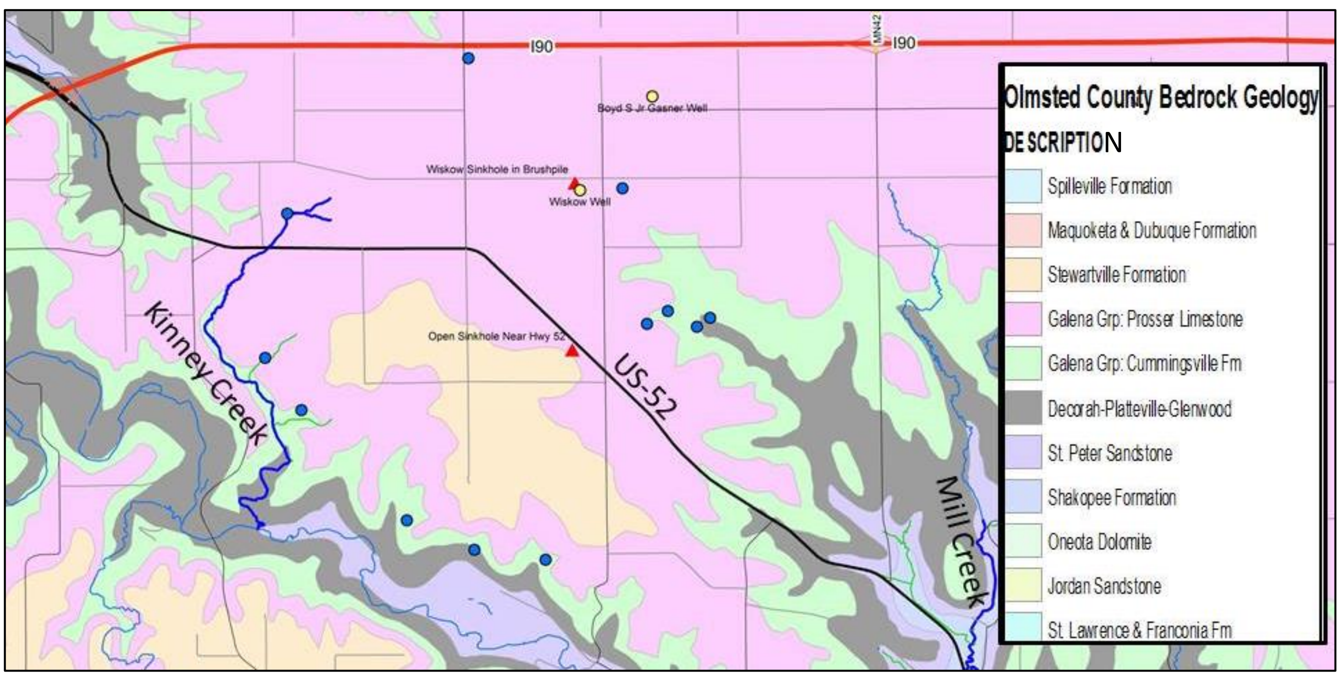

Figure 10. Wiskow dye trace sampling and injection feature locations and bedrock geology: springs (blue dots), wells (yellow dots) and injection sinkholes (red triangles).

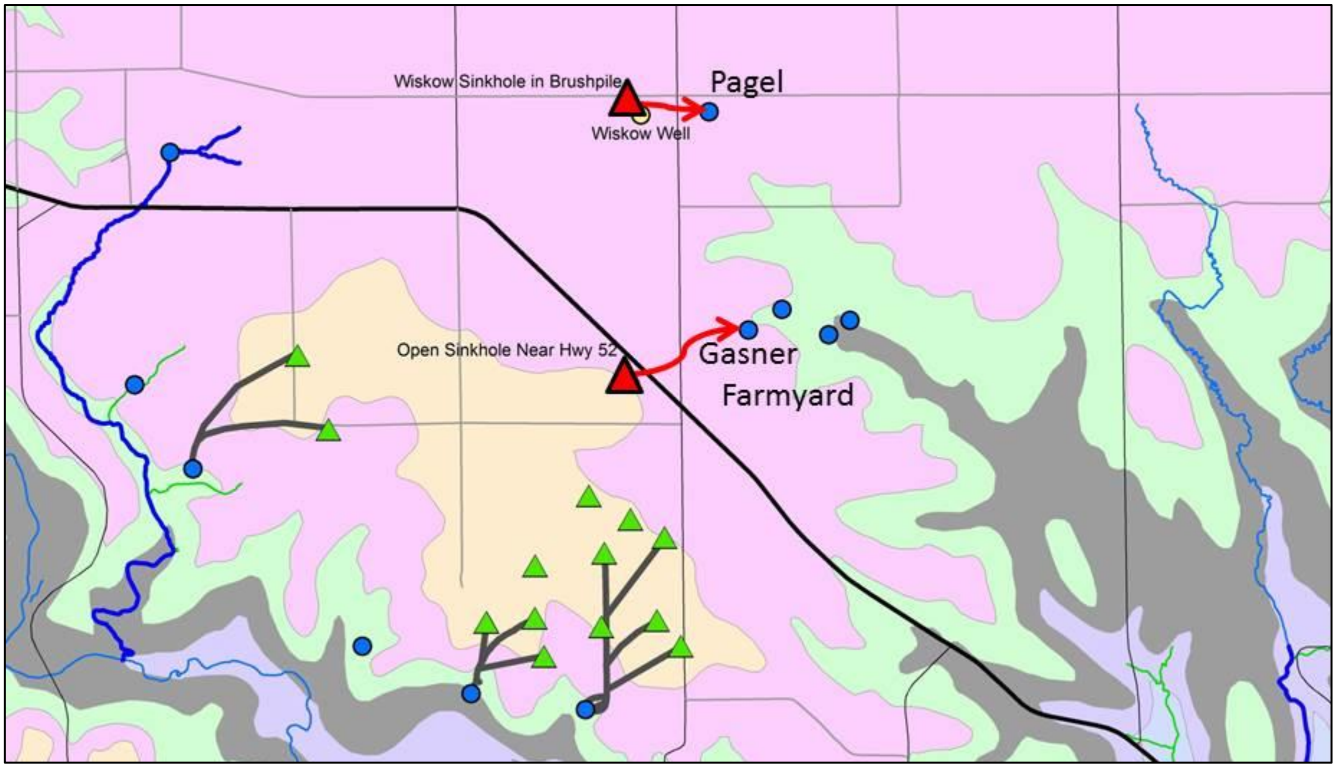

Figure 11. Wiskow dye traces vectors (red vectors) plotted with previous dye trace vectors (dark gray), springs (blue dots), wells (yellow dots) and injection sinkholes (red triangles).


Figure 12. Pagel Spring sampling point - the Prosser Formation spring where Uranine C was detected.

Figure 13. Gasner Farmyard Spring - the Prosser Formation spring where Rhodamine WT was detected.

Figure 14. Entrance to McConnell Spring - an example of a Cummingsville Formation spring.

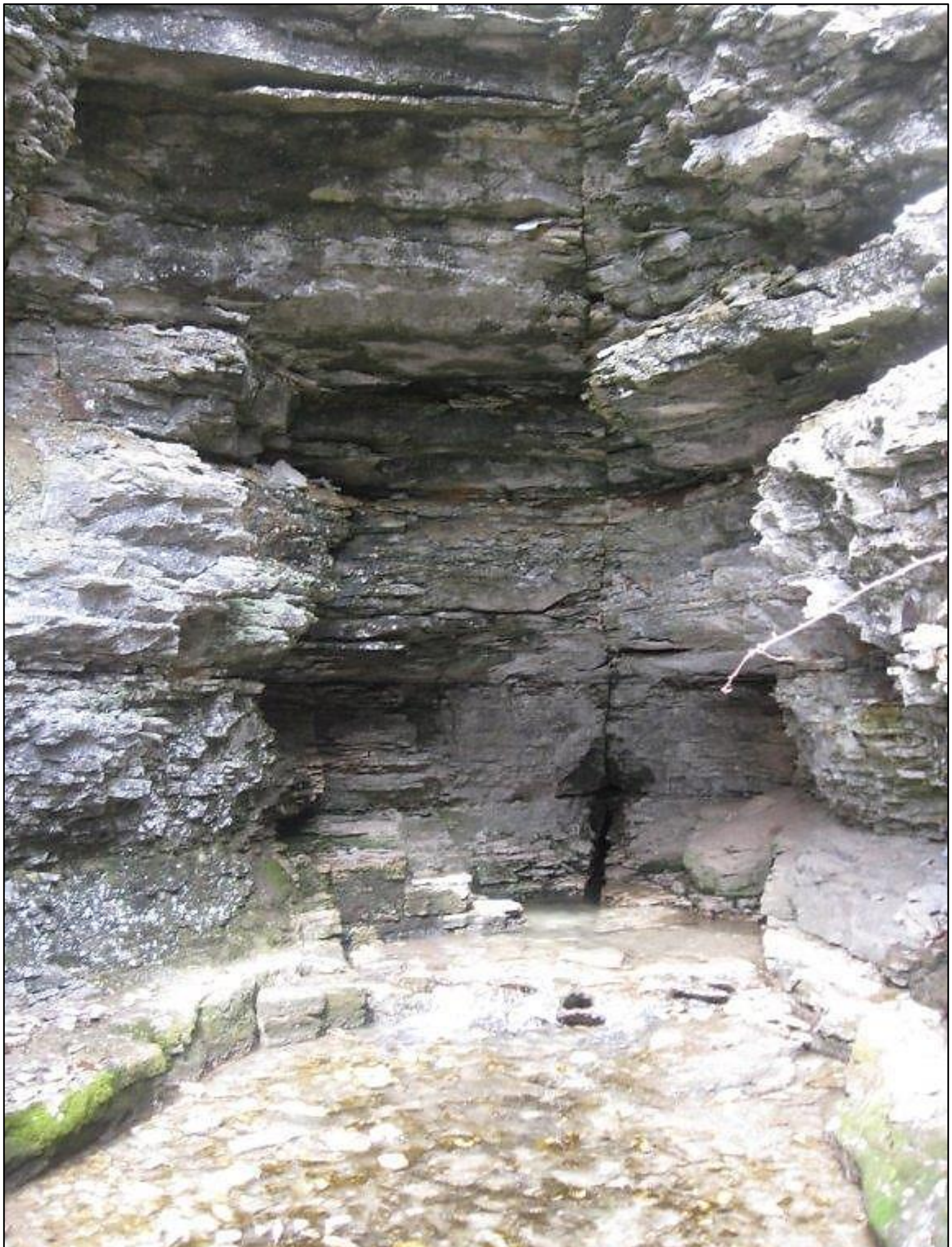
Figure 15. Close up of the McConnell Spring.

Appendix A. Rhodamine WT Report Summary Table
Appendix B. Uranine Report Summary Table
Appendix C. Monitoring Sites Detailed Results
Appendix D. Spring Water Chemistry Anion Analyses
Appendix E. Final Summary Table of Results

Appendix A: Rhodamine WT Report Summary
Wiskow [6 May 2014] Traces

Input KFDB #	Dye	Input UTM Coordinates	Dye Quantity
MN55:D00282	**Rhodamine WT**	[1] 557516 E / 4863617 N ± 3.3 m	435.28 grams (17.7 wt. % solution)
Input Notes	[1, 4] On 6 May 2014, 435 grams Rhodamine WT was input at 10:35 into (an unnamed) sinkhole (MN55:D00282); located at: 557516 E / 4863617 N ± 3.3 m. The sinkhole is funnel-shaped with an approximate 2-foot diameter swallow hole, and a 1-foot open hole, on the Viola Applen property. Two hundred gallons of water was introduced into the sinkhole initially; followed by the dye; and then followed by 800 more gallons of water. The water was supplied by a tanker of the Chatfield Fire Department. The sinkhole accepted all the water with no ponding.		
Background Monitoring	**Number of Positives from Background Monitoring**	**All Intervals Monitored (single dates are water samples; time intervals are bugs)**	**Date All Monitoring Ended**
9Apr2014-5May2014	0 of 28	9Apr2014-15Apr2014; 9Apr2014-5May2014; 15Apr2014-5May2014; 5May2014-7May2014; 5May2014-9May2014; 7May2014; 7May2014-8May2014; 8May2014; 8May2014-9May2014; 9May2014; 9May2014-13May2014; 10May2014; 12May2014; 13May2014; 13May2014-20May2014; 13May2014-27May2014; 20May2014; 20May2014-27May2014; 27May2014; 27May2014-3Jun2014; 27May2014-14Jun2014; 3Jun2014-11Jun2014or12Jun2014	14Jun2014

Wiskow [6 May 2014] Traces (p. 2)

Site with Positive Detections

Monitored Site KFDB #s (with field book UTMs)	Monitored Site Name	Intervals Monitored (positives underlined)	Number of Charcoal Bugs or Water Samples with Detectable Dye
MN55:A00566 [3] 558391 E / 4863918 N	4S - Gasner Farmyard Spring (aka, Gasner's Barnyard Spring) (aka, Gasner FY)	9Apr2014-15Apr2014; 15Apr2014-5May2014; <u>5May2014-9May2014;</u> <u>7May2014;</u> <u>8May2014;</u> <u>9May2014;</u> <u>9May2014-13May2014;</u> <u>10May2014;</u> <u>12May2014;</u> <u>13May2014;</u> <u>20May2014;</u> <u>20May2014-3Jun2014;</u> <u>27May2014;</u> <u>27May2014-3Jun2014;</u> <u>3Jun2014-12Jun2014</u>	13 of 15

Sites with No Detections

Monitored Site KFDB #s (with field book UTMs)	Monitored Site Name	Intervals Monitored (positives underlined)	Number of Charcoal Bugs or Water Samples with Detectable Dye
MN55:A00567 [2] 558111 E / 4865491 N ± 4.4 m [3] 558108 E / 4865518 N	1S - Pagel Spring	9Apr2014-15Apr2014; 15Apr2014-5May2014; 5May2014-9May2014; 7May2014; 8May2014; 9May2014; 9May2014-13May2014; 10May2014; 12May2014; 13May2014; 13May2014-20May2014; 20May2014; 20May2014-27May2014; 27May2014; 27May2014-3Jun2014; 3Jun2014-12Jun2014	0 of 16

Wiskow [6 May 2014] Traces (p. 3)

Sites with No Detections (continued)			
Monitored Site KFDB #s (with field book UTMs)	**Monitored Site Name**	**Intervals Monitored (positives underlined)**	**Number of Charcoal Bugs or Water Samples with Detectable Dye**
MN55:X00014 [3] 559124 E / 4863988 N	2S - CCC Structure (aka, 2S - CCC Dam) (aka, Gasner CCC Structure) (aka, Gasner CCC)	9Apr2014-15Apr2014; 15Apr2014-5May2014; 5May2014-9May2014; 7May2014; 8May2014; 9May2014; 9May2014-13May2014; 10May2014; 12May2014; 13May2014; 13May2014-20May2014; 20May2014; 20May2014-27May2014; 27May2014; 27May2014-3Jun2014; 3Jun2014-12Jun2014	0 of 16
MN55:A00564 [2] 558976 E / 4863877 N ± 4.2 m [3] 558967 E / 4863871 N	3S - Gasner Spring	9Apr2014-15Apr2014; 15Apr2014-5May2014; 5May2014-9May2014; 7May2014; 8May2014; 9May2014; 9May2014-13May2014; 10May2014; 12May2014; 13May2014; 13May2014-20May2014; 20May2014; 20May2014-27May2014; 27May2014; 27May2014-3Jun2014; 3Jun2014-12Jun2014	0 of 16

Wiskow [6 May 2014] Traces (p. 4)

Sites with No Detections (continued)			
Monitored Site KFDB #s (with field book UTMs)	**Monitored Site Name**	**Intervals Monitored (positives underlined)**	**Number of Charcoal Bugs or Water Samples with Detectable Dye**
MN55:A00009 [3] 553940 E / 4863524 N	5S - Old Jug Spring	9Apr2014-15Apr2014; 15Apr2014-5May2014; 5May2014-9May2014; 7May2014; 8May2014; 9May2014; 9May2014-13May2014; 10May2014; 12May2014; 13May2014; 13May2014-20May2014; 20May2014; 20May2014-27May2014; 27May2014; 27May2014-3Jun2014; 3Jun2014-12Jun2014	0 of 16
MN55:X00001 [3] 555296 E / 4861298 N	6S - Chance Hollow Spring Run	9Apr2014-15Apr2014; 15Apr2014-5May2014; 5May2014-9May2014; 7May2014; 8May2014; 9May2014; 9May2014-13May2014; 10May2014; 12May2014; 13May2014; 13May2014-20May2014; 20May2014; 20May2014-27May2014; 27May2014; 27May2014-3Jun2014; 3Jun2014-11Jun2014	0 of 16

Wiskow [6 May 2014] Traces (p. 5)

Sites with No Detections (continued)			
Monitored Site KFDB #s (with field book UTMs)	**Monitored Site Name**	**Intervals Monitored (positives underlined)**	**Number of Charcoal Bugs or Water Samples with Detectable Dye**
MN55:X00009 [3] 556229 E / 4867025 N	9S - County19 Crossing (aka, 9S - Co. Rd. 19 Spring Run) (aka, Hwy 19 Xing) (aka, Bear Creek)	9Apr2014-15Apr2014; 15Apr2014-5May2014; 5May2014-9May2014; 7May2014; 8May2014; 9May2014; 9May2014-13May2014; 10May2014; 12May2014; 13May2014; 13May2014-20May2014; 20May2014; 20May2014-27May2014; 27May2014; 27May2014-3Jun2014; 3Jun2014-12Jun2014	0 of 16
MN55:X00011 [3] 553965 E / 4864831 N	10S - Kinney Creek (aka, 10S - Kinney Creek Bug Set)	9Apr2014-15Apr2014; 15Apr2014-5May2014; 5May2014-9May2014; 7May2014; 8May2014; 9May2014; 9May2014-13May2014; 10May2014; 12May2014; 13May2014; 13May2014-20May2014; 20May2014; 20May2014-27May2014; 27May2014; 27May2014-3Jun2014; 3Jun2014-11Jun2014	0 of 16

Wiskow [6 May 2014] Traces (p. 6)

Sites with No Detections (continued)			
Monitored Site KFDB #s (with field book UTMs)	**Monitored Site Name**	**Intervals Monitored (positives underlined)**	**Number of Charcoal Bugs or Water Samples with Detectable Dye**
MN55:X00010 [3] 556092 E / 4860845 N	11S - Billy's Spring Run (aka, Billy's Spring Run Bug Set 2014)	9Apr2014-15Apr2014; 15Apr2014-5May2014; 5May2014-9May2014; 7May2014; 8May2014; 9May2014; 9May2014-13May2014; 10May2014; 12May2014; 13May2014; 13May2014-20May2014; 20May2014; 20May2014-27May2014; 27May2014; 27May2014-3Jun2014; 3Jun2014-11Jun2014	0 of 16
MN55:X00015 [3] 557182 E / 4861152 N	12S - Devil's Den Spring (aka, Devil's Den Spring Run Bug Set 2014)	9Apr2014-15Apr2014; 15Apr2014-5May2014; 5May2014-9May2014; 7May2014; 8May2014; 9May2014; 9May2014-13May2014; 10May2014; 12May2014; 13May2014; 13May2014-20May2014; 20May2014; 20May2014-27May2014; 27May2014; 27May2014-3Jun2014; 3Jun2014-11Jun2014	0 of 16

Wiskow [6 May 2014] Traces (p. 7)

Sites with No Detections (continued)			
Monitored Site KFDB #s (with field book UTMs)	**Monitored Site Name**	**Intervals Monitored (positives underlined)**	**Number of Charcoal Bugs or Water Samples with Detectable Dye**
MN55:A00006 [3] 554346 E / 4862948 N	13S - McConnell Spring	9Apr2014-15Apr2014; 15Apr2014-5May2014; 5May2014-9May2014; 7May2014; 8May2014; 9May2014; 9May2014-13May2014; 10May2014; 12May2014; 13May2014; 13May2014-20May2014; 20May2014; 20May2014-27May2014; 27May2014; 27May2014-3Jun2014; 3Jun2014-11Jun2014	0 of 16
MN55:A00565 [2] 558634 E / 4864007 N ± 3.5m [3] 558630 E / 4864077 N	19S - Applen Spring	9Apr2014-15Apr2014; 15Apr2014-5May2014; 5May2014-9May2014; 7May2014; 8May2014; 9May2014; 9May2014-13May2014; 10May2014; 12May2014; 13May2014; 13May2014-20May2014; 20May2014; 20May2014-27May2014; 27May2014; 27May2014-3Jun2014; 3Jun2014-12Jun2014	0 of 16

Wiskow [6 May 2014] Traces (p. 8)

Sites with No Detections (continued)			
Monitored Site KFDB #s (with field book UTMs)	**Monitored Site Name**	**Intervals Monitored (positives underlined)**	**Number of Charcoal Bugs or Water Samples with Detectable Dye**
MN55:X00013 [3] 557616 E / 4865479 N	16W - Wiskow Well * (aka, Cole Wiskow Well)	9Apr2014-5May2014; 5May2014-7May2014; 7May2014-8May2014; 8May2014-9May2014; 9May2014-13May2014; 13May2014-27May2014; 27May2014-14Jun2014	0 of 7
MN55:X00012 [3] 558468 E / 4866580 N [4] 558466 E / 4866586 N ± 6.9 m	17W - Junior Gasner Well (aka, Boyd Gasner Jr. Well)	9Apr2014-15Apr2014; 15Apr2014-5May2014; 5May2014-7May2014; 7May2014-8May2014; 8May2014-9May2014; 9May2014-13May2014; 13May2014-20May2014	0 of 7

* Wiskow well samples were collected from a home water supply, but 'downstream' of (after water passed through) a whole-house charcoal filter. Samples from that filter were separately analyzed (not reported here), but no dye was detected.

References:

E. Calvin Alexander, Jr. Field Book #10 (ECA-J20, ECA-J21, ECA-J33, ECA-J34, ECA-J43, ECA-J44)
Jeff Green Field Book # 13 (JG-N52, JG-N53)

[1] From: ECA-J43, ECA-J44
[2] From: ECA-J20
[3] From: "Karst Features Data Base" (online database)
[4] From JG-N52, JG-N53

Researchers involved in this trace (trace background and design, field work, lab analyses, data compilation, etc.):

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Appendix B: Wiskow Uranine Report Summary Table
Wiscow [6 May 2014] Traces

Input KFDB #	Dye	Input UTM Coordinates	Dye Quantity
MN55:D00983	Uranine (Fluorescein)	[1] 557550 E / 4865569 N ± 3.9 m [2] 557552 E / 4865567 N ± 4.9 m	1094.85 grams (35 wt. % solution)
Input Notes	[1, 4] On 6 May 2014, 1095 grams Uranine C was input at 10:10 into the Wiskow Sinkhole (MN55:D00983) (located at: 557550 E / 4865569 N ± 3.9 m). Initially, it was known that water sank in an area, but there was no surface expression of a sinkhole. A bobcat excavated part of the sinking area. At 09:53, a water test was done, which ponded somewhat. The bobcat excavated more, and produced a depression (of a size of approximately 10 ft. x 8 ft. x 1 ft.). Then more water was supplied at 20-30 gpm, which was obviously sinking; the dye was poured at 10:10, and the rest of the 1,000 gallons was poured into the depression. The water stopped at 10:25. This sinkhole is on the Cole Wiskow property. The water was supplied by a tanker of the Chatfield Fire Department.		
Background Monitoring	**Number of Positives from Background Monitoring**	**All Intervals Monitored (single dates are water samples; time intervals are bugs)**	**Date All Monitoring Ended**
9Apr2014-5May2014	0 of 28	9Apr2014-15Apr2014; 9Apr2014-5May2014; 15Apr2014-5May2014; 5May2014-7May2014; 5May2014-9May2014; 7May2014; 7May2014-8May2014; 8May2014; 8May2014-9May2014; 9May2014; 9May2014-13May2014; 10May2014; 12May2014; 13May2014; 13May2014-20May2014; 13May2014-27May2014; 20May2014; 20May2014-27May2014; 27May2014; 27May2014-3Jun2014; 27May2014-14Jun2014; 3Jun2014-11Jun2014or12Jun2014	14Jun2014

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Site with Positive Detections			
Monitored Site KFDB #s (with field book UTMs)	Monitored Site Name	Intervals Monitored (positives underlined)	Number of Charcoal Bugs or Water Samples with Detectable Dye
MN55:A00567 [2] 558111 E / 4865491 N ± 4.4 m [3] 558108 E / 4865518 N	1S - Pagel Spring	9Apr2014-15Apr2014; 15Apr2014-5May2014; 5May2014-9May2014; 7May2014; 8May2014; 9May2014; 9May2014-13May2014; 10May2014; 12May2014; 13May2014; 13May2014-20May2014; 20May2014; 20May2014-27May2014; 27May2014; 27May2014-3Jun2014; 3Jun2014-12Jun2014	9 of 16

Sites with No Detections			
Monitored Site KFDB #s (with field book UTMs)	Monitored Site Name	Intervals Monitored (positives underlined)	Number of Charcoal Bugs or Water Samples with Detectable Dye
MN55:X00014 [3] 559124 E / 4863988 N	2S - CCC Structure (aka, 2S - CCC Dam) (aka, Gasner CCC Structure) (aka, Gasner CCC)	9Apr2014-15Apr2014; 15Apr2014-5May2014; 5May2014-9May2014; 7May2014; 8May2014; 9May2014; 9May2014-13May2014; 10May2014; 12May2014; 13May2014; 13May2014-20May2014; 20May2014; 20May2014-27May2014; 27May2014; 27May2014-3Jun2014; 3Jun2014-12Jun2014	0 of 16

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Sites with No Detections (continued)			
Monitored Site KFDB #s (with field book UTMs)	**Monitored Site Name**	**Intervals Monitored (positives underlined)**	**Number of Charcoal Bugs or Water Samples with Detectable Dye**
MN55:A00564 [2] 558976 E / 4863877 N ± 4.2 m [3] 558967 E / 4863871 N	3S - Gasner Spring	9Apr2014-15Apr2014; 15Apr2014-5May2014; 5May2014-9May2014; 7May2014; 8May2014; 9May2014; 9May2014-13May2014; 10May2014; 12May2014; 13May2014; 13May2014-20May2014; 20May2014; 20May2014-27May2014; 27May2014; 27May2014-3Jun2014; 3Jun2014-12Jun2014	0 of 16
MN55:A00566 [3] 558391 E / 4863918 N	4S - Gasner Farmyard Spring (aka, Gasner's Barnyard Spring) (aka, Gasner FY)	9Apr2014-15Apr2014; 15Apr2014-5May2014; 5May2014-9May2014; 7May2014; 8May2014; 9May2014; 9May2014-13May2014; 10May2014; 12May2014; 13May2014; 20May2014; 20May2014-3Jun2014; 27May2014; 27May2014-3Jun2014; 3Jun2014-12Jun2014	0 of 15

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Sites with No Detections (continued)			
Monitored Site KFDB #s (with field book UTMs)	**Monitored Site Name**	**Intervals Monitored (positives underlined)**	**Number of Charcoal Bugs or Water Samples with Detectable Dye**
MN55:A00009 [3] 553940 E / 4863524 N	5S - Old Jug Spring	9Apr2014-15Apr2014; 15Apr2014-5May2014; 5May2014-9May2014; 7May2014; 8May2014; 9May2014; 9May2014-13May2014; 10May2014; 12May2014; 13May2014; 13May2014-20May2014; 20May2014; 20May2014-27May2014; 27May2014; 27May2014-3Jun2014; 3Jun2014-12Jun2014	0 of 16
MN55:X00001 [3] 555296 E / 4861298 N	6S - Chance Hollow Spring Run	9Apr2014-15Apr2014; 15Apr2014-5May2014; 5May2014-9May2014; 7May2014; 8May2014; 9May2014; 9May2014-13May2014; 10May2014; 12May2014; 13May2014; 13May2014-20May2014; 20May2014; 20May2014-27May2014; 27May2014; 27May2014-3Jun2014; 3Jun2014-11Jun2014	0 of 16

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Sites with No Detections (continued)			
Monitored Site KFDB #s (with field book UTMs)	**Monitored Site Name**	**Intervals Monitored (positives underlined)**	**Number of Charcoal Bugs or Water Samples with Detectable Dye**
MN55:X00009 [3] 556229 E / 4867025 N	9S - County19 Crossing (aka, 9S - Co. Rd. 19 Spring Run) (aka, Hwy 19 Xing) (aka, Bear Creek)	9Apr2014-15Apr2014; 15Apr2014-5May2014; 5May2014-9May2014; 7May2014; 8May2014; 9May2014; 9May2014-13May2014; 10May2014; 12May2014; 13May2014; 13May2014-20May2014; 20May2014; 20May2014-27May2014; 27May2014; 27May2014-3Jun2014; 3Jun2014-12Jun2014	0 of 16
MN55:X00011 [3] 553965 E / 4864831 N	10S - Kinney Creek (aka, 10S - Kinney Creek Bug Set)	9Apr2014-15Apr2014; 15Apr2014-5May2014; 5May2014-9May2014; 7May2014; 8May2014; 9May2014; 9May2014-13May2014; 10May2014; 12May2014; 13May2014; 13May2014-20May2014; 20May2014; 20May2014-27May2014; 27May2014; 27May2014-3Jun2014; 3Jun2014-11Jun2014	0 of 16

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Sites with No Detections (continued)			
Monitored Site KFDB #s (with field book UTMs)	**Monitored Site Name**	**Intervals Monitored (positives underlined)**	**Number of Charcoal Bugs or Water Samples with Detectable Dye**
MN55:X00010 [3] 556092 E / 4860845 N	11S - Billy's Spring Run (aka, Billy's Spring Run Bug Set 2014)	9Apr2014-15Apr2014; 15Apr2014-5May2014; 5May2014-9May2014; 7May2014; 8May2014; 9May2014; 9May2014-13May2014; 10May2014; 12May2014; 13May2014; 13May2014-20May2014; 20May2014; 20May2014-27May2014; 27May2014; 27May2014-3Jun2014; 3Jun2014-11Jun2014	0 of 16
MN55:X00015 [3] 557182 E / 4861152 N	12S - Devil's Den Spring (aka, Devil's Den Spring Run Bug Set 2014)	9Apr2014-15Apr2014; 15Apr2014-5May2014; 5May2014-9May2014; 7May2014; 8May2014; 9May2014; 9May2014-13May2014; 10May2014; 12May2014; 13May2014; 13May2014-20May2014; 20May2014; 20May2014-27May2014; 27May2014; 27May2014-3Jun2014; 3Jun2014-11Jun2014	0 of 16

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Sites with No Detections (continued)			
Monitored Site KFDB #s (with field book UTMs)	**Monitored Site Name**	**Intervals Monitored (positives underlined)**	**Number of Charcoal Bugs or Water Samples with Detectable Dye**
MN55:A00006 [3] 554346 E / 4862948 N	13S - McConnell Spring	9Apr2014-15Apr2014; 15Apr2014-5May2014; 5May2014-9May2014; 7May2014; 8May2014; 9May2014; 9May2014-13May2014; 10May2014; 12May2014; 13May2014; 13May2014-20May2014; 20May2014; 20May2014-27May2014; 27May2014; 27May2014-3Jun2014; 3Jun2014-11Jun2014	0 of 16
MN55:A00565 [2] 558634 E / 4864007 N ± 3.5m [3] 558630 E / 4864077 N	19S - Applen Spring	9Apr2014-15Apr2014; 15Apr2014-5May2014; 5May2014-9May2014; 7May2014; 8May2014; 9May2014; 9May2014-13May2014; 10May2014; 12May2014; 13May2014; 13May2014-20May2014; 20May2014; 20May2014-27May2014; 27May2014; 27May2014-3Jun2014; 3Jun2014-12Jun2014	0 of 16

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Sites with No Detections (continued)			
Monitored Site KFDB #s (with field book UTMs)	**Monitored Site Name**	**Intervals Monitored (positives underlined)**	**Number of Charcoal Bugs or Water Samples with Detectable Dye**
MN55:X00013 [3] 557616 E / 4865479 N	16W - Wiskow Well * (aka, Cole Wiskow Well)	9Apr2014-5May2014; 5May2014-7May2014; 7May2014-8May2014; 8May2014-9May2014; 9May2014-13May2014; 13May2014-27May2014; 27May2014-14Jun2014	0 of 7
MN55:X00012 [3] 558468 E / 4866580 N [4] 558466 E / 4866586 N ± 6.9 m	17W - Junior Gasner Well (aka, Boyd Gasner Jr. Well)	9Apr2014-15Apr2014; 15Apr2014-5May2014; 5May2014-7May2014; 7May2014-8May2014; 8May2014-9May2014; 9May2014-13May2014; 13May2014-20May2014	0 of 7

* Wiskow well samples were collected from a home water supply, but 'downstream' of (after water passed through) a whole-house charcoal filter. Samples from that filter were separately analyzed (not reported here), but no dye was detected.

References:

E. Calvin Alexander, Jr. Field Book #10 (ECA-J20, ECA-J21, ECA-J33, ECA-J34, ECA-J43, ECA-J44)
Jeff Green Field Book # 13 (JG-N52, JG-N53)

[1] From: ECA-J43, ECA-J44
[2] From: ECA-J20
[3] From: "Karst Features Data Base" (online database)
[4] From JG-N52, JG-N53

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Appendix C: Monitoring Sites Detailed Results

Wiskow Traces [6 May 2014]

KFDB #	Site Name	Sample Type	In Date	Out Date	Results (Peaks)	Notes	Amplitude	Sigma (Amp:SE)	Center	FWHM
MN55:A00567	**1S Pagel Spring**	charcoal bug	9-Apr-14	15-Apr-14	no dye	background	x	x	x	x
		charcoal bug	15-Apr-14	5-May-14	no dye	background	x	x	x	x
		---	**6-May-14**	**Input 1094.85 grams Uranine C (35% weight) into the Wiskow Sinkhole (MN55:D00983), located at: 557550 E / 4865569 N ± 3.9 m [1]**						
		---	**6-May-14**	**Input 435.28 grams Rhodamine WT (17.7% weight) into an unnamed sinkhole (MN55:D00282), located at: 557516 E / 4863617 N ± 3.3 m [2]**						
		charcoal bug	5-May-14	9-May-14	no dye		x	x	x	x
		water	---	7-May-14	no dye		x	x	x	x
		water	---	8-May-14	**Fluorescein / Uranine**	peak is very wide	2.3	**7.8**	506.6	38.4
		water	---	9-May-14	**Fluorescein / Uranine**	peak is very wide	1.3	**5.5**	506.6	39.0
		charcoal bug	9-May-14	13-May-14	**Fluorescein / Uranine**	peak is a bit wide	9.0	**17.9**	515.3	24.3
		water	---	10-May-14	**Fluorescein / Uranine**	peak is very wide	2.2	**8.4**	505.3	34.9
		water	---	12-May-14	**Fluorescein / Uranine**	peak is very wide	3.2	**11.8**	505.9	34.2
		water	---	13-May-14	**Fluorescein / Uranine**	peak is very wide	1.5	**6.2**	505.7	33.6
		charcoal bug	13-May-14	20-May-14	no dye		x	x	x	x
		water	---	20-May-14	no dye		x	x	x	x
		charcoal bug	20-May-14	27-May-14	**Fluorescein / Uranine**		55.6	**50.0**	514.5	22.8
		water	---	27-May-14	**Fluorescein / Uranine**	peak is very wide; also standard error is just above detection limit	0.9	**3.9**	507.2	34.0
		charcoal bug	27-May-14	3-Jun-14	no dye		x	x	x	x
		charcoal bug	3-Jun-14	12-Jun-14	**Fluorescein / Uranine**	peak is a bit wide	10.0	**18.7**	515.4	25.5

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KFDB #	Site Name	Sample Type	In Date	Out Date	Results (Peaks)	Notes	Amplitude	Sigma (Amp:SE)	Center	FWHM
MN55:X00014	2S CCC Structure	charcoal bug	9-Apr-14	15-Apr-14	no dye	background	x	x	x	x
	(aka, 2S CCC Dam)	charcoal bug	15-Apr-14	5-May-14	no dye	background	x	x	x	x
	(aka, Gasner CCC Structure)	---	**6-May-14**	**Input 1094.85 grams Uranine C (35% weight) into the Wiskow Sinkhole (MN55:D00983), located at: 557550 E / 4865569 N ± 3.9 m [1]**						
	(aka, Gasner CCC)	---	**6-May-14**	**Input 435.28 grams Rhodamine WT (17.7% weight) into an unnamed sinkhole (MN55:D00282), located at: 557516 E / 4863617 N ± 3.3 m [2]**						
		charcoal bug	5-May-14	9-May-14	no dye	(diluted two fold)	x	x	x	x
		water	---	7-May-14	no dye		x	x	x	x
		water	---	8-May-14	no dye		x	x	x	x
		water	---	9-May-14	no dye		x	x	x	x
		charcoal bug	9-May-14	13-May-14	no dye		x	x	x	x
		water	---	10-May-14	no dye		x	x	x	x
		water	---	12-May-14	no dye		x	x	x	x
		water	---	13-May-14	no dye		x	x	x	x
		charcoal bug	13-May-14	20-May-14	no dye	(diluted two fold)	x	x	x	x
		water	---	20-May-14	no dye		x	x	x	x
		charcoal bug	20-May-14	27-May-14	no dye		x	x	x	x
		water	---	27-May-14	no dye		x	x	x	x
		charcoal bug	27-May-14	3-Jun-14	no dye	low for emission from charcoal; no 2nd result to confirm, so not counted as positive	**5.0**	**7.0**	**511.3**	**21.7**
		charcoal bug	3-Jun-14	12-Jun-14	no dye		x	x	x	x

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KFDB #	Site Name	Sample Type	In Date	Out Date	Results (Peaks)	Notes	Amplitude	Sigma (Amp:SE)	Center	FWHM
MN55:A00564	3S Gasner Spring	charcoal bug	9-Apr-14	15-Apr-14	no dye	background	x	x	x	x
		charcoal bug	15-Apr-14	5-May-14	no dye	background (diluted two fold)	x	x	x	x
		---	**6-May-14**	**Input 1094.85 grams Uranine C (35% weight) into the Wiskow Sinkhole (MN55:D00983), located at: 557550 E / 4865569 N ± 3.9 m [1]**						
		---	**6-May-14**	**Input 435.28 grams Rhodamine WT (17.7% weight) into an unnamed sinkhole (MN55:D00282), located at: 557516 E / 4863617 N ± 3.3 m [2]**						
		charcoal bug	5-May-14	9-May-14	no dye		x	x	x	x
		water	---	7-May-14	no dye		x	x	x	x
		water	---	8-May-14	no dye		x	x	x	x
		water	---	9-May-14	no dye		x	x	x	x
		charcoal bug	9-May-14	13-May-14	no dye		x	x	x	x
		water	---	10-May-14	no dye		x	x	x	x
		water	---	12-May-14	no dye		x	x	x	x
		water	---	13-May-14	no dye		x	x	x	x
		charcoal bug	13-May-14	20-May-14	no dye		x	x	x	x
		water	---	20-May-14	no dye		x	x	x	x
		charcoal bug	20-May-14	27-May-14	no dye		x	x	x	x
		water	---	27-May-14	no dye		x	x	x	x
		charcoal bug	27-May-14	3-Jun-14	no dye	(diluted four fold)	x	x	x	x
		charcoal bug	3-Jun-14	12-Jun-14	no dye		x	x	x	x

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KFDB #	Site Name	Sample Type	In Date	Out Date	Results (Peaks)	Notes	Amplitude	Sigma (Amp:SE)	Center	FWHM
MN55:A00566	**4S Gasner Farmyard Spring**	charcoal bug	9-Apr-14	15-Apr-14	no dye	background	x	x	x	x
		charcoal bug	15-Apr-14	5-May-14	no dye	background	x	x	x	x
		---	**6-May-14**	**Input 1094.85 grams Uranine C (35% weight) into the Wiskow Sinkhole (MN55:D00983), located at: 557550 E / 4865569 N ± 3.9 m [1]**						
		---	**6-May-14**	**Input 435.28 grams Rhodamine WT (17.7% weight) into an unnamed sinkhole (MN55:D00282), located at: 557516 E / 4863617 N ± 3.3 m [2]**						
		charcoal bug	5-May-14	9-May-14	**Rhodamine**	(diluted two fold)	2.2	**3.5**	569.6	21.0
		water	---	7-May-14	**Rhodamine**		607.0	**271.5**	573.6	22.3
		water	---	8-May-14	**Rhodamine**		234.9	**214.9**	573.6	22.2
		water	---	9-May-14	**Rhodamine**		98.0	83.5	574.0	23.4
		charcoal bug	9-May-14	13-May-14	**Rhodamine**		51.4	**112.1**	566.2	22.9
		water	---	10-May-14	**Rhodamine**		36.0	**63.6**	573.5	21.9
		water	---	12-May-14	**Rhodamine**		14.7	**27.7**	573.6	21.9
		water	---	13-May-14	**Rhodamine**		15.8	**39.4**	573.9	22.0
		charcoal bug	13-May-14	20-May-14	---	no bug recovered from fieldwork	---	---	---	---
		water	---	20-May-14	**Rhodamine**		4.6	**13.1**	574.6	22.9
		charcoal bug	20-May-14	3-Jun-14	**Rhodamine**	(diluted two fold)	50.9	**78.2**	566.2	23.0
		water	---	27-May-14	**Rhodamine**		2.5	**9.5**	574.4	22.7
		charcoal bug	27-May-14	3-Jun-14	**Rhodamine**	(diluted four fold)	24.8	**40.7**	566.4	21.7
		charcoal bug	3-Jun-14	12-Jun-14	**Rhodamine**		23.2	**36.0**	566.1	22.0

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KFDB #	Site Name	Sample Type	In Date	Out Date	Results (Peaks)	Notes	Amplitude	Sigma (Amp:SE)	Center	FWHM
MN55:A00009	**5S Old Jug Spring**	charcoal bug	9-Apr-14	15-Apr-14	no dye	background	x	x	x	x
		charcoal bug	15-Apr-14	5-May-14	no dye	background	x	x	x	x
		---	**6-May-14**	**Input 1094.85 grams Uranine C (35% weight) into the Wiskow Sinkhole (MN55:D00983), located at: 557550 E / 4865569 N ± 3.9 m [1]**						
		---	**6-May-14**	**Input 435.28 grams Rhodamine WT (17.7% weight) into an unnamed sinkhole (MN55:D00282), located at: 557516 E / 4863617 N ± 3.3 m [2]**						
		charcoal bug	5-May-14	9-May-14	no dye		x	x	x	x
		water	---	7-May-14	no dye		x	x	x	x
		water	---	8-May-14	no dye		x	x	x	x
		water	---	9-May-14	no dye		x	x	x	x
		charcoal bug	9-May-14	13-May-14	no dye		x	x	x	x
		water	---	10-May-14	no dye		x	x	x	x
		water	---	12-May-14	no dye		x	x	x	x
		water	---	13-May-14	no dye		x	x	x	x
		charcoal bug	13-May-14	20-May-14	no dye	(diluted two fold)	x	x	x	x
		water	---	20-May-14	no dye		x	x	x	x
		charcoal bug	20-May-14	27-May-14	no dye	(diluted two fold)	x	x	x	x
		water	---	27-May-14	no dye		x	x	x	x
		charcoal bug	27-May-14	3-Jun-14	no dye	(diluted two fold)	x	x	x	x
		charcoal bug	3-Jun-14	11-Jun-14	no dye		x	x	x	x

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KFDB #	Site Name	Sample Type	In Date	Out Date	Results (Peaks)	Notes	Amplitude	Sigma (Amp:SE)	Center	FWHM
MN55:X00001	6S Chance Hollow Spring Run	charcoal bug	9-Apr-14	15-Apr-14	no dye	background	x	x	x	x
		charcoal bug	15-Apr-14	5-May-14	no dye	background	x	x	x	x
		---	**6-May-14**	**Input 1094.85 grams Uranine C (35% weight) into the Wiskow Sinkhole (MN55:D00983), located at: 557550 E / 4865569 N ± 3.9 m** [1]						
		---	**6-May-14**	**Input 435.28 grams Rhodamine WT (17.7% weight) into an unnamed sinkhole (MN55:D00282), located at: 557516 E / 4863617 N ± 3.3 m** [2]						
		charcoal bug	5-May-14	9-May-14	no dye		x	x	x	x
		water	---	7-May-14	no dye		x	x	x	x
		water	---	8-May-14	no dye		x	x	x	x
		water	---	9-May-14	no dye		x	x	x	x
		charcoal bug	9-May-14	13-May-14	no dye	(diluted two fold)	x	x	x	x
		water	---	10-May-14	no dye		x	x	x	x
		water	---	12-May-14	no dye		x	x	x	x
		water	---	13-May-14	no dye		x	x	x	x
		charcoal bug	13-May-14	20-May-14	no dye		x	x	x	x
		water	---	20-May-14	no dye		x	x	x	x
		charcoal bug	20-May-14	27-May-14	no dye		x	x	x	x
		water	---	27-May-14	no dye		x	x	x	x
		charcoal bug	27-May-14	3-Jun-14	no dye	(diluted two fold)	x	x	x	x
		charcoal bug	3-Jun-14	11-Jun-14	no dye		x	x	x	x

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KFDB #	Site Name	Sample Type	In Date	Out Date	Results (Peaks)	Notes	Amplitude	Sigma (Amp:SE)	Center	FWHM
MN55:X00009	**9S County 19 Crossing**	charcoal bug	9-Apr-14	15-Apr-14	no dye	background	x	x	x	x
	(aka, 9S - Co. Rd. 19 Spring Run)	charcoal bug	15-Apr-14	5-May-14	no dye	background	x	x	x	x
	(aka, Hwy 19 Xing)	---	**6-May-14**	**Input 1094.85 grams Uranine C (35% weight) into the Wiskow Sinkhole (MN55:D00983), located at: 557550 E / 4865569 N ± 3.9 m [1]**						
	(aka, Bear Creek)	---	**6-May-14**	**Input 435.28 grams Rhodamine WT (17.7% weight) into an unnamed sinkhole (MN55:D00282), located at: 557516 E / 4863617 N ± 3.3 m [2]**						
		charcoal bug	5-May-14	9-May-14	no dye		x	x	x	x
		water	---	7-May-14	no dye		x	x	x	x
		water	---	8-May-14	no dye		x	x	x	x
		water	---	9-May-14	no dye		x	x	x	x
		charcoal bug	9-May-14	13-May-14	no dye		x	x	x	x
		water	---	10-May-14	no dye		x	x	x	x
		water	---	12-May-14	no dye		x	x	x	x
		water	---	13-May-14	no dye		x	x	x	x
		charcoal bug	13-May-14	20-May-14	no dye	(diluted two fold)	x	x	x	x
		water	---	20-May-14	no dye		x	x	x	x
		charcoal bug	20-May-14	27-May-14	no dye		x	x	x	x
		water	---	27-May-14	no dye		x	x	x	x
		charcoal bug	27-May-14	3-Jun-14	no dye		x	x	x	x
		charcoal bug	3-Jun-14	12-Jun-14	no dye		x	x	x	x

Wiskow Traces [6 May 2014] (p. 8)

KFDB #	Site Name	Sample Type	In Date	Out Date	Results (Peaks)	Notes	Amplitude	Sigma (Amp:SE)	Center	FWHM
MN55:X00011	**10S Kinney Creek**	charcoal bug	9-Apr-14	15-Apr-14	no dye	background	x	x	x	x
	(aka, 10S - Kinney Creek Bug Set)	charcoal bug	15-Apr-14	5-May-14	no dye	background	x	x	x	x
		---	**6-May-14**	**Input 1094.85 grams Uranine C (35% weight) into the Wiskow Sinkhole (MN55:D00983), located at: 557550 E / 4865569 N ± 3.9 m [1]**						
		---	**6-May-14**	**Input 435.28 grams Rhodamine WT (17.7% weight) into an unnamed sinkhole (MN55:D00282), located at: 557516 E / 4863617 N ± 3.3 m [2]**						
		charcoal bug	5-May-14	9-May-14	no dye		x	x	x	x
		water	---	7-May-14	no dye		x	x	x	x
		water	---	8-May-14	no dye		x	x	x	x
		water	---	9-May-14	no dye		x	x	x	x
		charcoal bug	9-May-14	13-May-14	no dye	(Bug label adds: "headwater")	x	x	x	x
		water	---	10-May-14	no dye		x	x	x	x
		water	---	12-May-14	no dye		x	x	x	x
		water	---	13-May-14	no dye		x	x	x	x
		charcoal bug	13-May-14	20-May-14	no dye	(Bug label adds: "HW")	x	x	x	x
		water	---	20-May-14	no dye		x	x	x	x
		charcoal bug	20-May-14	27-May-14	no dye		x	x	x	x
		water	---	27-May-14	no dye		x	x	x	x
		charcoal bug	27-May-14	3-Jun-14	no dye		x	x	x	x
		charcoal bug	3-Jun-14	11-Jun-14	no dye		x	x	x	x

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KFDB #	Site Name	Sample Type	In Date	Out Date	Results (Peaks)	Notes	Amplitude	Sigma (Amp:SE)	Center	FWHM
MN55:X00010	**11S Billy's Spring Run**	charcoal bug	9-Apr-14	15-Apr-14	no dye	background	x	x	x	x
	(aka, Billy's Spring Run Bug Set 2014)	charcoal bug	15-Apr-14	5-May-14	no dye	background (diluted three fold)	x	x	x	x
		---	**6-May-14**	**Input 1094.85 grams Uranine C (35% weight) into the Wiskow Sinkhole (MN55:D00983), located at: 557550 E / 4865569 N ± 3.9 m [1]**						
		---	**6-May-14**	**Input 435.28 grams Rhodamine WT (17.7% weight) into an unnamed sinkhole (MN55:D00282), located at: 557516 E / 4863617 N ± 3.3 m [2]**						
		charcoal bug	5-May-14	9-May-14	no dye		x	x	x	x
		water	---	7-May-14	no dye		x	x	x	x
		water	---	8-May-14	no dye		x	x	x	x
		water	---	9-May-14	no dye		x	x	x	x
		charcoal bug	9-May-14	13-May-14	no dye		x	x	x	x
		water	---	10-May-14	no dye		x	x	x	x
		water	---	12-May-14	no dye		x	x	x	x
		water	---	13-May-14	no dye		x	x	x	x
		charcoal bug	13-May-14	20-May-14	no dye		x	x	x	x
		water	---	20-May-14	no dye		x	x	x	x
		charcoal bug	20-May-14	27-May-14	no dye		x	x	x	x
		water	---	27-May-14	no dye		x	x	x	x
		charcoal bug	27-May-14	3-Jun-14	no dye	(diluted three fold)	x	x	x	x
		charcoal bug	3-Jun-14	11-Jun-14	no dye		x	x	x	x

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KFDB #	Site Name	Sample Type	In Date	Out Date	Results (Peaks)	Notes	Amplitude	Sigma (Amp:SE)	Center	FWHM
MN55:X00015	**12S Devil's Den Spring**	charcoal bug	9-Apr-14	15-Apr-14 [3]	no dye	background (diluted three fold)	x	x	x	x
	(aka, Devil's Den Spring Run Bug Set 2014)	charcoal bug	15-Apr-14	5-May-14	no dye	background	x	x	x	x
		---	**6-May-14**	**Input 1094.85 grams Uranine C (35% weight) into the Wiskow Sinkhole (MN55:D00983), located at: 557550 E / 4865569 N ± 3.9 m [1]**						
		---	**6-May-14**	**Input 435.28 grams Rhodamine WT (17.7% weight) into an unnamed sinkhole (MN55:D00282), located at: 557516 E / 4863617 N ± 3.3 m [2]**						
		charcoal bug	5-May-14	9-May-14	no dye	(diluted two fold)	x	x	x	x
		water	---	7-May-14	no dye		x	x	x	x
		water	---	8-May-14	no dye		x	x	x	x
		water	---	9-May-14	no dye		x	x	x	x
		charcoal bug	9-May-14	13-May-14	no dye		x	x	x	x
		water	---	10-May-14	no dye		x	x	x	x
		water	---	12-May-14	no dye		x	x	x	x
		water	---	13-May-14	no dye		x	x	x	x
		charcoal bug	13-May-14	20-May-14	no dye		x	x	x	x
		water	---	20-May-14	no dye		x	x	x	x
		charcoal bug	20-May-14	27-May-14	no dye	(diluted three fold)	x	x	x	x
		water	---	27-May-14	no dye		x	x	x	x
		charcoal bug	27-May-14	3-Jun-14	no dye		x	x	x	x
		charcoal bug	3-Jun-14	11-Jun-14	no dye		x	x	x	x

Wiskow Traces [6 May 2014] (p. 11)

KFDB #	Site Name	Sample Type	In Date	Out Date	Results (Peaks)	Notes	Amplitude	Sigma (Amp:SE)	Center	FWHM
MN55:A00006	**13S McConnell Spring**	charcoal bug	9-Apr-14	15-Apr-14	no dye	background (diluted two fold)	x	x	x	x
		charcoal bug	15-Apr-14	5-May-14	no dye	background (diluted two fold)	x	x	x	x
		---	**6-May-14**	**Input 1094.85 grams Uranine C (35% weight) into the Wiskow Sinkhole (MN55:D00983), located at: 557550 E / 4865569 N ± 3.9 m [1]**						
		---	**6-May-14**	**Input 435.28 grams Rhodamine WT (17.7% weight) into an unnamed sinkhole (MN55:D00282), located at: 557516 E / 4863617 N ± 3.3 m [2]**						
		charcoal bug	5-May-14	9-May-14	no dye		x	x	x	x
		water	---	7-May-14	no dye		x	x	x	x
		water	---	8-May-14	no dye		x	x	x	x
		water	---	9-May-14	no dye		x	x	x	x
		charcoal bug	9-May-14	13-May-14	no dye		x	x	x	x
		water	---	10-May-14	no dye		x	x	x	x
		water	---	12-May-14	no dye		x	x	x	x
		water	---	13-May-14	no dye		x	x	x	x
		charcoal bug	13-May-14	20-May-14	no dye		x	x	x	x
		water	---	20-May-14	no dye		x	x	x	x
		charcoal bug	20-May-14	27-May-14	no dye		x	x	x	x
		water	---	27-May-14	no dye		x	x	x	x
		charcoal bug	27-May-14	3-Jun-14	no dye		x	x	x	x
		charcoal bug	3-Jun-14	11-Jun-14	no dye		x	x	x	x

Wiskow Traces [6 May 2014] (p. 12)

KFDB #	Site Name	Sample Type	In Date	Out Date	Results (Peaks)	Notes	Amplitude	Sigma (Amp:SE)	Center	FWHM
MN55:A00565	**19S Applen Spring**	charcoal bug	9-Apr-14	15-Apr-14	no dye	background	x	x	x	x
		charcoal bug	15-Apr-14	5-May-14	no dye	background	x	x	x	x
		---	**6-May-14**	**Input 1094.85 grams Uranine C (35% weight) into the Wiskow Sinkhole (MN55:D00983), located at: 557550 E / 4865569 N ± 3.9 m** [1]						
		---	**6-May-14**	**Input 435.28 grams Rhodamine WT (17.7% weight) into an unnamed sinkhole (MN55:D00282), located at: 557516 E / 4863617 N ± 3.3 m** [2]						
		charcoal bug	5-May-14	9-May-14	no dye		x	x	x	x
		water	---	7-May-14	no dye		x	x	x	x
		water	---	8-May-14	no dye		x	x	x	x
		water	---	9-May-14	no dye		x	x	x	x
		charcoal bug	9-May-14	13-May-14	no dye		x	x	x	x
		water	---	10-May-14	no dye		x	x	x	x
		water	---	12-May-14	no dye		x	x	x	x
		water	---	13-May-14	no dye		x	x	x	x
		charcoal bug	13-May-14	20-May-14	no dye		x	x	x	x
		water	---	20-May-14	no dye		x	x	x	x
		charcoal bug	20-May-14	27-May-14	no dye		x	x	x	x
		water	---	27-May-14	no dye		x	x	x	x
		charcoal bug	27-May-14	3-Jun-14	no dye	(diluted three fold)	x	x	x	x
		charcoal bug	3-Jun-14	12-Jun-14	no dye	peak is a bit wide; no 2nd result to confirm, so not counted as positive	**9.8**	**20.7**	**514.4**	**26.8**

Wiskow Traces [6 May 2014] (p. 13)

KFDB #	Site Name	Sample Type	In Date	Out Date	Results (Peaks)	Notes	Amplitude	Sigma (Amp:SE)	Center	FWHM
MN55:X00013	**16W Wiskow Well**	charcoal bug	9-Apr-14	5-May-14	no dye	background	x	x	x	x
	(aka, Cole Wiskow Well)	charcoal bug	5-May-14	7-May-14	no dye	background	x	x	x	x
		---	**6-May-14**	**Input 1094.85 grams Uranine C (35% weight) into the Wiskow Sinkhole (MN55:D00983), located at: 557550 E / 4865569 N ± 3.9 m [1]**						
		---	**6-May-14**	**Input 435.28 grams Rhodamine WT (17.7% weight) into an unnamed sinkhole (MN55:D00282), located at: 557516 E / 4863617 N ± 3.3 m [2]**						
		charcoal bug	7-May-14	8-May-14	no dye		x	x	x	x
		charcoal bug	8-May-14	9-May-14	no dye		x	x	x	x
		charcoal bug	9-May-14	13-May-14	no dye		x	x	x	x
		charcoal bug	13-May-14	27-May-14	no dye		x	x	x	x
		charcoal bug	27-May-14	14-Jun-14	no dye		x	x	x	x

Wiskow Traces [6 May 2014] (p. 14)

KFDB #	Site Name	Sample Type	In Date	Out Date	Results (Peaks)	Notes	Amplitude	Sigma (Amp:SE)	Center	FWHM
MN55:X00012	17W Jr. Gasner Well	charcoal bug	9-Apr-14	15-Apr-14	no dye	background	x	x	x	x
	(aka, Boyd Gasner Jr. Well)	charcoal bug	15-Apr-14	5-May-14 [4]	no dye	background	x	x	x	x
		---	**6-May-14**	**Input 1094.85 grams Uranine C (35% weight) into the Wiskow Sinkhole (MN55:D00983), located at: 557550 E / 4865569 N ± 3.9 m [1]**						
		---	**6-May-14**	**Input 435.28 grams Rhodamine WT (17.7% weight) into an unnamed sinkhole (MN55:D00282), located at: 557516 E / 4863617 N ± 3.3 m [2]**						
		charcoal bug	5-May-14	7-May-14 [4]	no dye		x	x	x	x
		charcoal bug	7-May-14	8-May-14	no dye		x	x	x	x
		charcoal bug	8-May-14	9-May-14	no dye		x	x	x	x
		charcoal bug	9-May-14	13-May-14	no dye		x	x	x	x
		charcoal bug	13-May-14	20-May-14	no dye		x	x	x	x

1 These UTMs are from field measurements taken on the day of input (see E. Calvin Alexander, Jr. field book #9: ECA-J43). Note that they are the same as the recorded UTMs in the KFDB.

2 These UTMs are from field measurements taken on the day of input (see E. Calvin Alexander, Jr. field book #9: ECA-J43). Note that they are the same as the recorded UTMs in the KFDB.

3 Ending ("out") date was labelled "14-Apr-14"; it is assumed that is in error and the out date was really 15-Apr-14, which was the 'in' date for the next bug. (Also, 15-Apr-14 was the same as all the other out dates for the bugs retrieved that week.)

4 Ending ("out") dates were not recorded on these particular bug labels, but it is assumed that the out dates are the same as the dates when they were replaced by new bugs.

Appendix D: Spring Water Chemistry Anion Analyses
Wiskow [6 May 2014] Traces

Name/Site#	Comments	Address	Sample Date	Sample Time	Sampled by	SAMPLE_ID	FL	CL	N-NO2	N-NO3	SO4
5S OLD JUG SPRING	SPRING	43.922815, -92.328037	6/11/14	13:25	MLARSEN	2014-0998	0.15	16.8	ND	20.7	10.6
3S GASNER SPRING	SPRING	43.925614, -92.265379	6/12/14	8:36	MLARSEN	2014-1003	0.12	70.1	ND	19.1	15.8
10S KINNEY CREEK	KINNEY CREEK	43.934579, -92.327535	6/11/14	13:05	MLARSEN	2014-0997	0.08	25	ND	16.7	16.9
1S PAGEL SPRING	SPRING	43.940175, -92.275885	6/12/14	9:22	MLARSEN	2014-1005	0.07	21.9	ND	15.9	17.4
13S MCCONNELL SPRING	SPRING	43.917266, -92.322988	6/11/14	13:43	MLARSEN	2014-0999	0.07	16.9	ND	15.7	9.5
4S GASNER FARMYARD	SPRING	43.926111, -92.272632	6/12/14	9:06	MLARSEN	2014-1002	0.08	43.8	0.2	12.1	19.8
19S APPLEN SPRING	SPRING	43.927388, -92.269594	6/12/14	8:52	MLARSEN	2014-1004	0.10	16.1	ND	12.1	13.6
12S DEVIL'S DEN SPRING	SPRING	43.901205, -92.288027	6/11/14	14:20	MLARSEN	2014-1000	0.13	17.8	ND	11.8	10.6
6S CHANCE HOLLOW	SPRING RUN	43.902368, -92.311684	6/11/14	14:50	MLARSEN	2014-1001	0.13	14.7	ND	7.8	13

Analyzed by Terry Lee, Olmsted County

Appendix E: Final Summary Table of Results
Wiskow 2014 Traces 6 May 2014 (2 Traces)

Carbon (Bug) Analysis Results

Trace Inputs Date/Time: 6 May 2014

Trace Input Location 1: Wiskow Sinkhole

Wiskow Sinkhole (MN55:D00983) (located at: 557,550 E / 4,865,569 N ± 3.9 m): poured 1095 grams Uranine C (fluorescein) (35 weight % solution) into the sinkhole at 10:10. Initially, it was known that water sank in an area, but there was no surface expression of a sinkhole. A bobcat excavated part of the sinking area. At 09:53, a water test was done, which ponded somewhat. The bobcat excavated more, and produced a depression (of a size of approximately 10 ft. x 8 ft. x 1 ft.--or about 3.0 m x 2.4 m x 0.3 m). Then more water was supplied at 20-30 gpm (1.3-1.9 liters per second) , which was obviously sinking. The dye was poured at 10:10, and the rest of the 1,000 gallons was poured into the depression. The water stopped at 10:25. The water was supplied by a tanker of the Chatfield Fire Department.

Trace Input Location 2: Unnamed Sinkhole

Unnamed Sinkhole (MN55:D00282) (557,512 E / 4,863,616 N ± 3.3 m; NAD 83, Zone 15): poured 435.28 grams Rhodamine WT (17.7 weight % solution) at 10:35. The sinkhole is funnel-shaped with an approximate 2-foot diameter swallow hole, and a 1-foot open hole, on the Viola Applen property. Two hundred gallons of water was introduced into the sinkhole initially; followed by the dye; and then followed by 800 more gallons of water. The water was supplied by a tanker of the Chatfield Fire Department. The sinkhole accepted all the water with no ponding.

Field Personnel at Inputs and/or Sampling: Martin Larsen, Dr. E. Calvin Alexander, Jr., Jeff Green

Lab Personnel: Sophie M. Kasahara, Betty J. Wheeler, Dr. E. Calvin Alexander, Jr.

	Field Name	KFD #	Site Type	UTMs NAD 83, Zone 15		Background 9 Apr 14 to 15 Apr 14	Background 15 Apr 14 to 5 May 14	Dye Input 6 May 2014	5 May 14 to 9 May 14	9 May 14 to 13 May 14	13 May 14 to 20 May 14	20 May 14 to 27 May 14	27 May 14 to 3 Jun 14	3 Jun 14 to 12 Jun 14
				Easting	Northing									
1S	Pagel Spring	MN55:A00567	spring	558,111	4,865,491	nd	nd		nd	Uran	nd	Uran	nd	Uran
2S	CCC Structure (aka, 2S - CCC Dam) (aka, Gasner CCC Structure) (aka, Gasner CCC)	MN55:X00014	spring dam	559,124	4,863,988	nd	nd		nd	nd	nd	nd	nd	nd
3S	Gasner Spring	MN55:A00564	spring	558,976	4,863,877	nd	nd		nd	nd	nd	nd	nd	nd
4S	Gasner Farmyard Spring (aka, Gasner's Barnyard Spring) (aka, Gasner FY)	MN55:A00566	spring	558,391	4,863,918	nd	nd		RhWT	RhWT		RhWT	RhWT	RhWT
5S	Old Jug Spring	MN55:A00009	spring	553,940	4,863,524	nd	nd		nd	nd	nd	nd	nd	nd
6S	Chance Hollow Spring Run	MN55:X00001	spring run	555,296	4,861,298	nd	nd		nd	nd	nd	nd	nd	nd (out: 11 Jun)

Wiskow 2014 Traces 6 May 2014

(continued)

	Field Name	KFD #	Site Type	UTMs NAD 83, Zone 15		Background 9 Apr 14 to 15 Apr 14	Background 15 Apr 14 to 5 May 14	Dye Input 6 May 2014	5 May 14 to 9 May 14	9 May 14 to 13 May 14	13 May 14 to 20 May 14	20 May 14 to 27 May 14	27 May 14 to 3 Jun 14	3 Jun 14 to 12 Jun 14
				Easting	Northing									
9S	**County 19 Crossing** (aka, 92 - Co. Rd. 19 Spring Run) (aka, Hwy 19 Crossing) (aka, Bear Creek)	**MN55:X00009**	creek	556,229	4,867,025	**nd**	**nd**		**nd**	**nd**	**nd**	**nd**	**nd**	**nd**
10S	**Kinney Creek @ US 52** (aka, Predmore) (aka, Highway 52)	**MN55:X00011**	creek	553,973	4,864,825	**nd**	**nd**		**nd**	**nd**	**nd**	**nd**	**nd**	**nd** (out: 11 Jun)
11S	**Billy's Spring Run**	**MN55:X00010**	spring run	556,092	4,860,845	**nd**	**nd**		**nd**	**nd**	**nd**	**nd**	**nd**	**nd** (out: 11 Jun)
12S	**Devil's Den Spring Run Bug Set 2014**	**MN55:X00015**	spring run	557,182	4,861,152	**nd**	**nd**		**nd**	**nd**	**nd**	**nd**	**nd**	**nd** (out: 11 Jun)
13S	**McConnell Spring**	**MN55:A00006**	spring	554,346	4,862,948	**nd**	**nd**		**nd**	**nd**	**nd**	**nd**	**nd**	**nd** (out: 11 Jun)
19S	**Applen Spring**	**MN55:A00565**	spring	558,630	4,864,077	**nd**	**nd**		**nd**	**nd**	**nd**	**nd**	**nd**	**nd**
16W	**Wiskow Well**	**MN55:X00013**	well	557,616	4,865,479	**nd**			**nd**	**nd**	**nd**		**nd** (out: 14 Jun)	
17W	**Boyd Gasner Jr. Well**	**MN55:X00012**	well	558,468	4,866,580	**nd**	**nd**		**nd**	**nd**	**nd**			

RhWT indicates Rhodamine WT dye detected
Uran indicates Uranine dye detected

nd indicates no dye detected
(yellow cell) indicates no bug or sample was received by the lab