2015

Olmsted County Dye Traces

Mundell Spring

Bear Spring House

Jones Spring

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Introduction

A collaborative partnership between the Minnesota Department of Natural Resources, University of Minnesota and the Olmsted County Feedlot Technician was started in 2014 to delineate springsheds in Olmsted County. The partnership has been useful in facilitating field work, sharing expertise and educating landowners about groundwater sensitivity. Protection of groundwater quality in karst geology requires detailed knowledge of their hydrogeologic properties such as recharge areas, discharge points and conduits. The delineation of springsheds helps to identify pollution source points and potential environmental impact. The information gained from dye tracing in Olmsted County has been shared with land owners and livestock producers to encourage implementation of best management practices.

Sensitive areas were identified in Olmsted where previous fluorescent dye traces have not been conducted and where karst aquifers are highly vulnerable to contamination. Separate Dye traces were completed on April 21, 2015 and on November 16, 2015. The spring dye traces were completed in Eyota, Marion, Orion and Pleasant Grove Townships in the North Branch Root River (Chance Hollow) and North Branch Bear Creek watersheds. The fall dye traces were completed in Eyota and Marion Townships in the South Branch Bear Creek watershed.

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.

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.

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 (Figures 3, 4 and 5.) During these traces on April 21, 2015 it was cloudy. A brisk 45 degree wind blew from the North with scattered snow showers. The soil was damp which prevented vehicle travel into the farm fields; however the sinkholes were dry. On November 16, 2015 there was steady rain and soil conditions became very damp throughout the day. The dye was flushed into the sinkholes with 500 - 1,000 gallons of water to insure that the dye reached the groundwater system. The water was supplied by a 1,000 gallon tanker.

On April 21, 2015; 1022 grams of 17.7 wt. % Rhodamine WT solution was injected into the VonWald Sinkhole (MN55:D01221) located at 558345 E / 4867990 N. This sinkhole is on the Steve VonWald property. It is shallow with a swallow hole approximately 2 meters by 1 meter deep. About 200 gallons of water was poured into the depression. The dye was poured at 9:43 am and the rest of the 1,000

gallons was poured into the depression. The water stopped at 9:54 am. Recharge into the VonWald sinkhole was rapid with only slight ponding.

1035 grams of 33 wt. % Eosine solution was injected at 10:44 am into the Fence Post Sinkhole (MN55:D01312) located at 560322 E / 4868051 N in the north ditch of county road 23. It shallow and broad in the landscape with county road 23 constructed over much of the sinkhole. The swallow hole is approximately 2 meters wide by 1 meter deep. The sinkhole is located within the road right of way. Two hundred gallons of water was initially introduced into the sinkhole followed by the dye and 600 more gallons of water. The sinkhole accepted all the water and dye with some ponding; water injection was reduced during ponding.

508 grams of 33 wt. % Eosine solution was injected into the Big Dump Sinkhole (MN55:D00390) located at 556316 E / 4862120 N. This sinkhole is within the township road right of way in the east ditch of 90th avenue. It is approximately 120 meters wide by 5 meters deep, with a swallow hole approximately 3 meters by 1 meters deep. A significant amount of garbage has been dumped in the sinkhole. The dumping is ongoing with recent garbage along the road ditch of 90th avenue. About 150 gallons of water was poured into the depression. The dye was poured at 11:46 am and the rest of the 500 gallons was poured into the depression. Recharge into the Big Dump Sinkhole was rapid with only slight ponding.

800 grams of 17.7 wt. % Rhodamine WT solution was injected into the Thatcher Sinkhole (MN55:D00396) located at 556319 E / 4862588 N. This sinkhole is also within the township road right of way in the east ditch of 90th avenue. It is approximately 80 meters wide by 3 meters deep, with a swallow hole approximately 2 meters by 1 meters deep. A significant amount of new and old waste has also been dumped in the sinkhole. About 150 gallons of water was poured into the depression. The dye was poured at 12:09 am and the rest of the 500 gallons was poured into the depression. Recharge into the Thatcher Sinkhole was rapid with only no ponding.

On November 16, 2015 494.71 grams of 35 wt. % Uranine HS (Chromatint) solution was injected into the Jim Vrieze Sinkhole (MN55:D00824) located at 556491 E / 4867892 N. This sinkhole is on the Jim Vrieze property. It is deep with a swallow hole that cannot be seen under the scrap metal and garbage. About 275 gallons of water was poured into the depression. The dye was poured at 10:27 am and an additional 525 gallons was poured into the depression. Recharge into the Jim Vrieze sinkhole was rapid with no ponding. (Figure 6.)

Dye Trace Setting

Figure 1 shows the location of the dye trace features in relation to the state of Minnesota and Olmsted County.

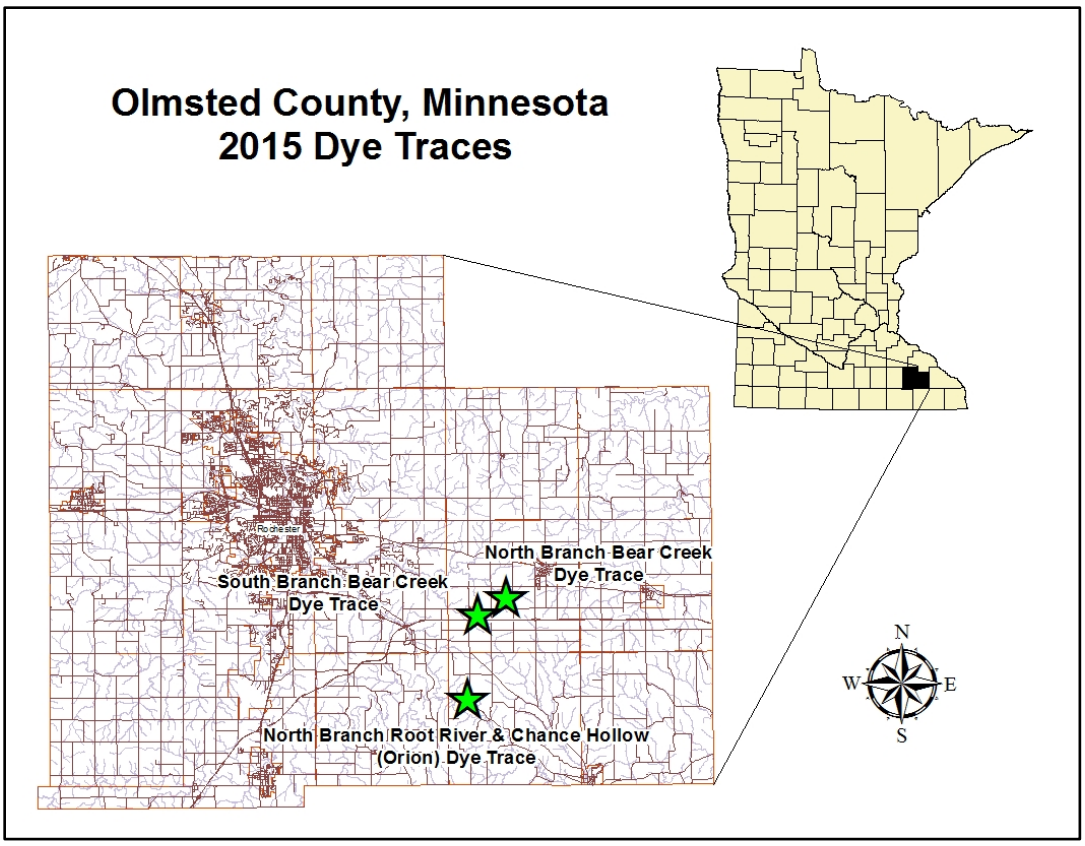


Figure 1. Dye Trace Locations

The three selected dye injection points in Eyota Township are within the Prosser Formation of the Galena Group. The two selected dye injection points in Orion Township are within the Stewartville Formation of the Galena Group. All of the sample points are connected to springs that emanate from the Lower Prosser and upper Cummingsville Formations above the Decorah Shale Formation (Figure 2.) A list of the injection points and springs identified for use in these dye traces can be found in Tables 1 & 2.

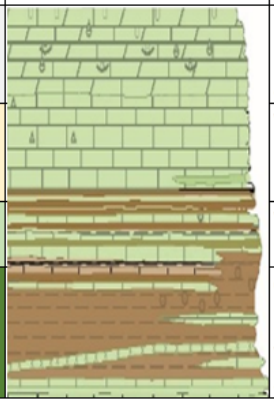
GP	FORMATION	GRAPHIC	DESCRIPTION	
Galena	Stewartville		Fine Grained dolomite and dolomitic limestone; weathered surfaces appear pitted.	Highly karstified.
	Prosser		Very Fined Grained, thin bedded limestone that becomes dolomitic near the top.	
	Cummingsville		Very fine grained limstone and interbedded calcareous shale.	
	Decorah		Green, calcareous shale with thin interbeds of limestone and is commonly very fossiliferous. Widely considered an aquitard.	

Figure 2. Dye Trace Geologic Stratigraphy (Alexander, et. al. 1988)

Bug Locations, North Branch Bear Creek & North Branch Root River - 21 Apr 2015					
NAME	**KFDB #**	**Classification**	**Label**	**UTM E**	**UTM N**
Dye Input Points					
VonWald Sinkhole	MN55:D01221	Sinkhole Injection Point	1IP	558353	4867973
Fence Post Sinkhole	MN55:D01312	Sinkhole Injection Point	2IP	560288	4868054
Big Dump Sinkhole	MN55:D00390	Sinkhole Injection Point	3IP	556288	4862135
Thatcher Sinkhole	MN55:D00396	Sinkhole Injection Point	4IP	556321	4862590
Dye Monitoring Points					
A0447 Spring Run	MN55:X00016	Spring Run Sample Point	1S	556603	4869620
Bear Creek Spring	MN55:A00406	Spring Sample Point	2S	557705	4869620
Hammell Spring Run	MN55:X00017	Spring Run Sample Point	3S	558398	4869360
Ellringer Spring Run	MN55:X00018	Spring Run Sample Point	4S	558420	4869370
Co Rd 136 Spring Run	MN55:X00019	Spring Run Sample Point	5S	564233	4869350
Jones Spring Run	MN55:X00023	Spring Run Sample Point	6S	555976	4868040
I-90 Spring Run	MN55:X00022	Spring Run Sample Point	7S	556001	4867240
Jacobson / Pagel Spring Run	MN55:X00024	Spring Run Sample Point	8S	558605	4864810
Schoenfelder Spring	MN55:X00025	Spring Sample Point	9S	559689	4864770
County Road 7 Spring Run	MN55:X00026	Spring Run Sample Point	10S	561077	4864340
Quarry Spring Run	MN55:X00020	Spring Run Sample Point	11S	561731	4864820
Old Jug Spring	MN55:A00009	Spring Sample Point	12S	553944	4863530
McConnell Spring	MN55:A00006	Spring Sample Point	13S	554342	4862900
Chance Hollow Spring	MN55:X00027	Spring Run Sample Point	14S	555243	4861210
Billy's Spring Run	MN55:X00028	Spring Run Sample Point	15S	556088	4860840
Devils Den Spring Run	MN55:X00021	Spring Sample Point	16S	557158	4861150

Table 1. Dye Trace Features and Locations for April 21, 2015.

Bug Locations, South Branch Bear Creek – 16 November 2015					
NAME	**KFDB #**	**Classification**	**Label**	**UTM E**	**UTM N**
Jim Vrieze Sinkhole	MN55:D00824	Sinkhole		556491	4867892
Dye Monitoring Points					
Jacobson / Pagel Spring Run	MN55:X00024	Spring Run Sample Point	1S	558605	4864810
Hammell, Ellringer Spring Run	MN55:X00033	Spring Run Sample Point	2+3S	558374	4869355
Bear Creek Spring	MN55:A00406	Spring Sample Point	4S	557705	4869620
Lewis Spring Run	MN55:X00016	Spring Run Sample Point	5S	556603	4869620
Jones Spring Run	MN55:X00023	Spring Run Sample Point	6S	555976	4868040
I-90 Spring	MN55:X00022	Spring Sample Point	7S	556025	4867224
Springdale Spring Run	MN55:X00009	Spring Run Sample Point	8S	556229	4867025
Birdman Spring	MN55:A00590	Spring Sample Point	9S	555055	4867352
Kinney Creek @ Hwy 52	MN55:X00011	Spring Run Sample Point	10S	553973	4864825
70th Avenue North Spring Run	MN55:X00030	Spring Run Sample Point	11S	553046	4866585
70th Avenue Middle Spring Run	MN55:X00031	Spring Run Sample Point	12S	553038	4866355
70th Avenue South Spring Run	MN55:X00032	Spring Run Sample Point	13S	553054	4865431

Table 2. Dye Trace Features and Locations for November 16, 2015.

Sampling Schedule

Prior to injection, charcoal packet detectors (bugs) were placed in the identified springs or the spring runs downstream of the identified springs to determine background conditions. 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.

Background charcoal detectors were distributed for the first time on April 2 - 10, 2015. The background bugs were changed on April 14, 2015. Bugs were changed a third time the day before the dye injection. 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 the day after dye injection on April 22, 2015. By consensus agreement among participants, sampling was terminated on May 27, 2015.

Background charcoal detectors were also distributed on November 3, 2015. The background bugs were changed on November 9, 2015. Bugs were replaced on the morning of the dye trace on November 16, 2016. Bugs were replaced 4 times following injection of the dye on November 19 and 23, 2015; December 7, 2015; and removed on January 21, 2016.

Results

Rhodamine WT was traced from the VonWald Sinkhole (MN55:D01221) to Bear Spring (MN55:A00406) as shown in Figure 3. The land owner reported that Bear Spring turned visibly bright red in less than six hours after the dye input in the sinkhole. Less than six hours for the Rhodamine WT dye to travel from the sinkhole to the spring corresponds to a minimum groundwater velocity of 22,700 feet/day. Rhodamine WT continued to be detected at the spring for the remainder of the sampling period.

Eosine was traced from the Fencepost Sinkhole (MN55:D01312) to the Bear and Hammell Springs (MN55:A00406 & MN55:A00446) as shown in Figure 3. The dye took less than one day to travel from the sinkhole to both of the springs at a minimum groundwater velocity of 10,126 feet per day. Dye was detected at both springs until May 15, 2015. Eosine was not detected at either spring in the last bug sets that were placed on May 15 and removed on May 27, 2015.

Eosine was traced from the Big Dump Sinkhole (MN55:D00390) to Mundell Spring (MN55:A00017) as shown in Figure 4. The dye took less than one day to trace from the sinkhole to the spring at a minimum groundwater velocity of 4,500 feet per day. Eosine continued to be detected at the spring for the remainder of the sampling period.

Rhodamine WT was traced from the Thatcher Sinkhole (MN55:D00396) to Mundell Spring (MN55:A00017) as shown in Figure 4. The dye took less than one day to trace from the sinkhole to the spring at a minimum groundwater velocity of 5,500 feet per day. Rhodamine WT continued to be detected at the spring for the remainder of the sampling period.

Uranine HS was traced from the Jim Vrieze sinkhole (MN55:D00824) to Jones Spring (MN55:A00008) as shown in Figure 5. Uranine HS continued to be detected at the spring for the remainder of the sampling period.

No dye was detected in any of the other springs. Surface water entering the conduit system in the VonWald, Fence Post and Jim Vrieze Sinkholes (Eyota Township) appears to stay in the lower portions of the Prosser Limestone where Hammell, Bear and Jones springs are located. Surface water entering the conduit system in the Big Dump and Thatcher Sinkholes (Orion Township) travels through the Prosser and flows in the Cummingsville Formation where Mundell Spring is located.

Alexander, E. C., Jr., and Maki, G. L. 1988. Sinkholes and Sinkhole Probability. Plate 7 in Geologic Atlas of Olmsted County, Minnesota. County Atlas Series, Atlas C-3. Minnesota Department of Natural Resources, St. Paul.

Olsen, Bruce M. 1988 Bedrock Geology. Plate 2 in Geologic Atlas of Olmsted County, Minnesota. County Atlas Series, Atlas C-3. Minnesota Department of Natural Resources, St. Paul.

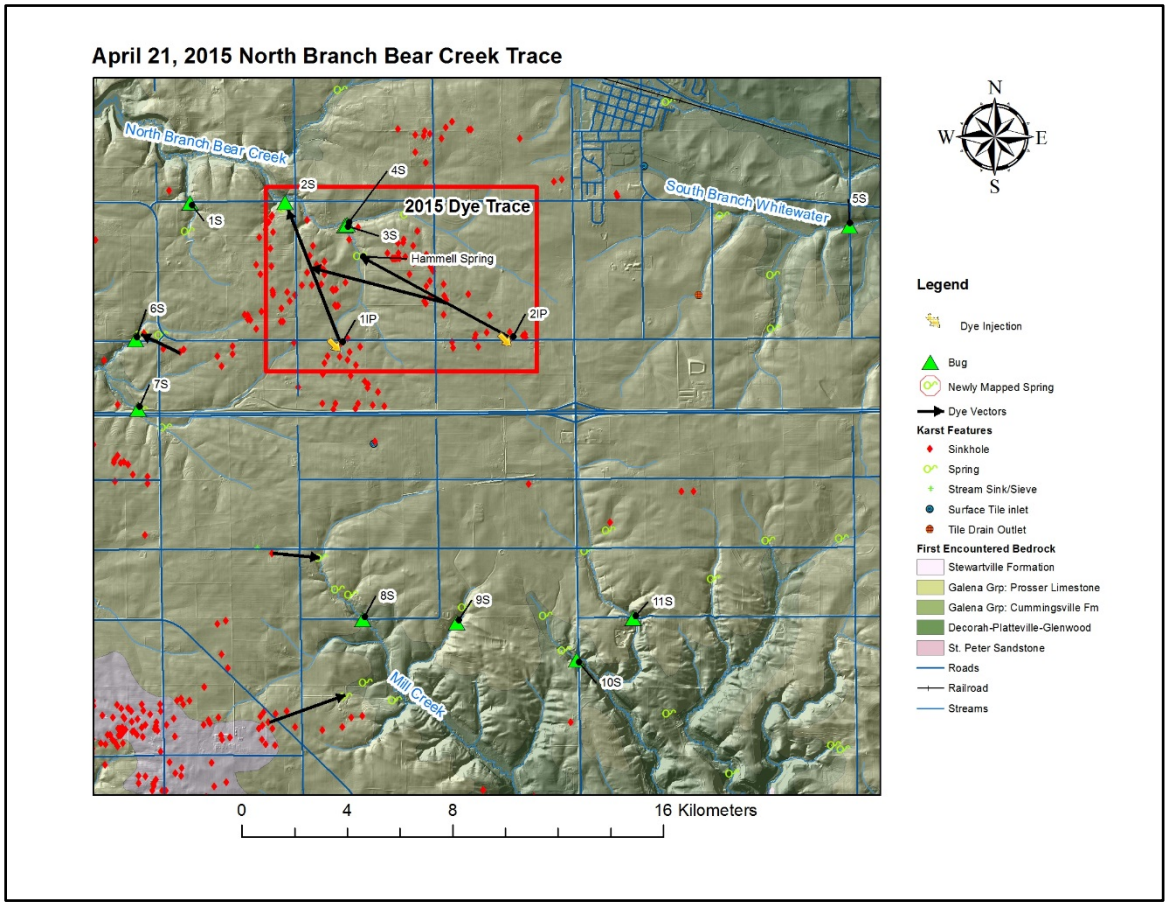


Figure 3 Dye Trace Features and Vectors in the Bear Creek Area

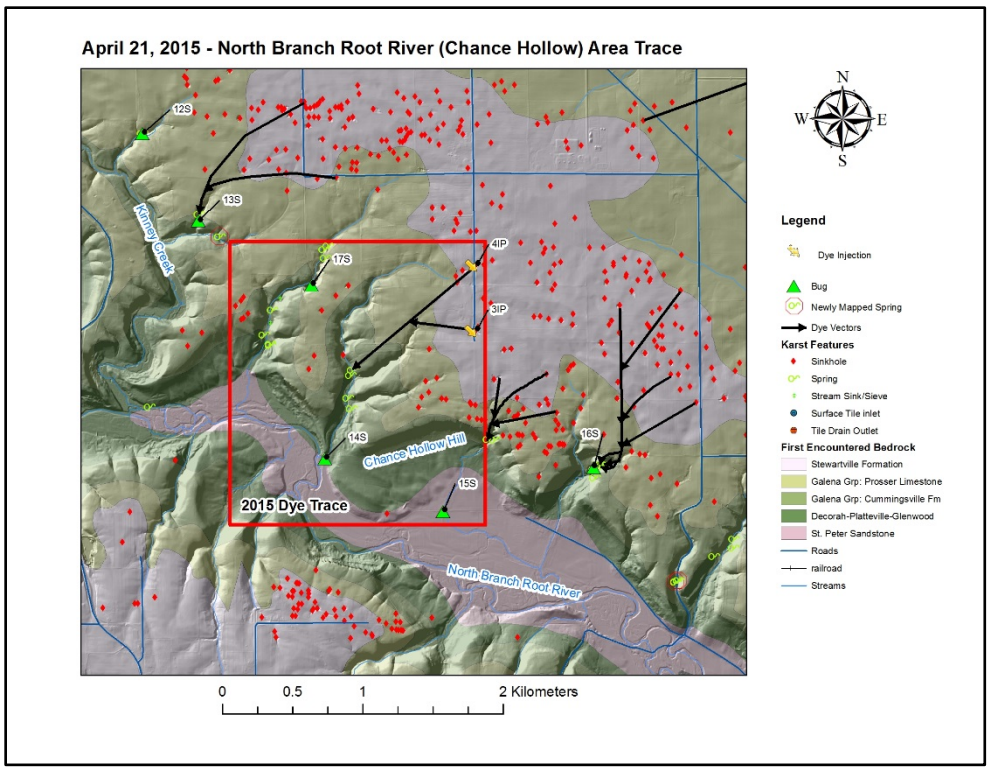


Figure 4. Dye Trace Features and Vectors in the North Branch Root River (Chance Hollow) Area

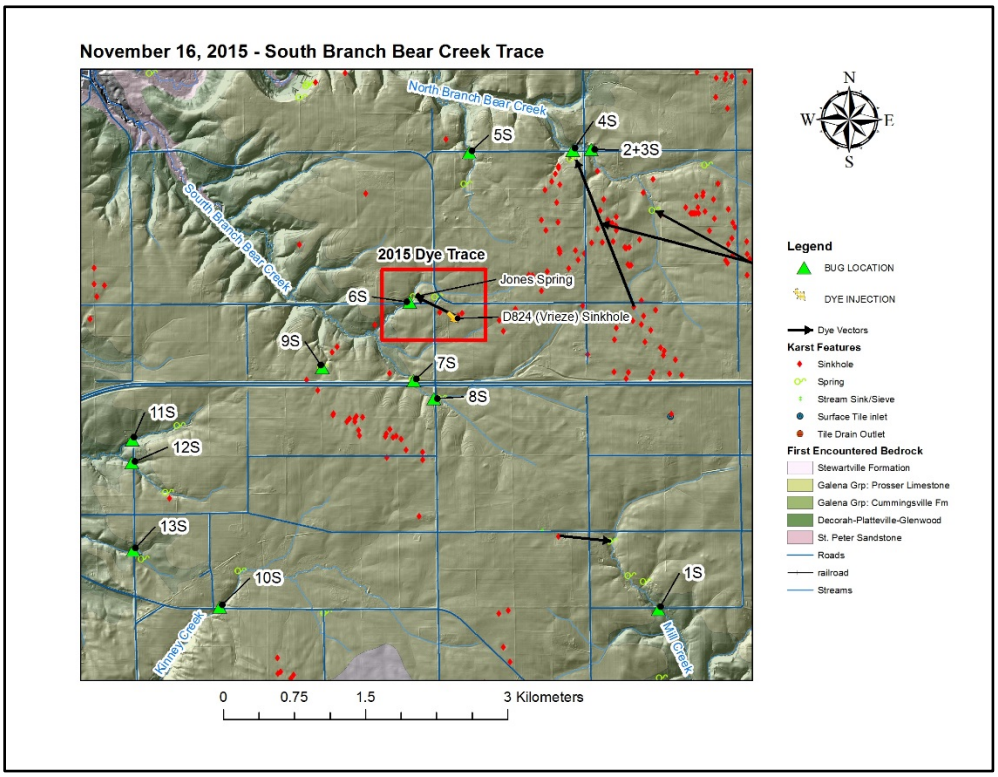


Figure 5. Dye Trace Features and Vectors in the South Branch Bear Creek

Appendix A

Bear Creek South 2015 Traces 21 Apr 2015

Sample Analysis Results

Trace Inputs Dates/Times: 21 Apr 2015
Trace Inputs Locations: 2 Sinkholes
Sinkhole (MN55:D01221) (558,345 E, 4,867,990 N): poured 1,022 g (17.7 wt. %) Rhodamine WT at 09:43
'Fencepost' Sinkhole (MN55:D01312) (560,322 E, 4,868,051 N) poured 1,035 g (33 wt. %) Eosine at 10:44
Field Personnel at Inputs and/or Sampling: Martin Larsen, Scot Johnson, Jeff Green, John Barry
Lab Personnel: Sophie M. Kasahara, Betty J. Wheeler, Scott C. Alexander, Dr. E. Calvin Alexander, Jr.

	Field Name	KFDB #	Site Type	UTM Easting	UTM Northing	Background Bug Results (In: X-Apr-15; Out: 14-Apr-15) (X = 02-Apr, or 08-Apr, or 09-Apr, or 10-Apr)	Background Bug Results (In: 14-Apr-15; Out: 20-Apr-15)	Dye Inputs 21-Apr-2015	Water Sample Results 22-Apr-15	Bug Results In: 20-Apr-15 Out: X-Apr-15 (X=24-Apr or 27-Apr)	Bug Results In: 27-Apr-15 Out: 29-Apr-15	Bug Results In: 29-Apr-15 Out: 07-May-15	Bug Results In: 07-May-15 Out: 15-May-15	Bug Results In: 15-May-15 Out: 27-May-15
1S (A)	A0447 Spring Run (aka, MN55:A0447 Spring Run)	MN55:X00016	spring run	556,603	4,869,620	(in: 08-Apr-15) not detected	not detected		not detected	(out: 27-Apr-15) not detected	not detected	not detected	not detected	not detected
2S (B)	Bear Creek Spring	MN55:A00406	spring	557,705	4,869,620	(in: 02-Apr-15) not detected	not detected		Eos (5.4 σ) -------- RhWT (89 σ)	(out: 27-Apr-15) Eos (22 σ) ------- RhWT (269 σ)	Eos (6.7 σ) -------- RhWT (41 σ)	Eos (18 σ) -------- RhWT (64 σ)	Eos (10 σ) -------- RhWT (29 σ)	Eos not detected -------- RhWT (8.9 σ)
3S (C)	Hammell Spring Run Bug	MN55:X00017 (A0446 Spring Run)	spring run	558,398	4,869,360	(in: 08-Apr-15) not detected	not detected		Eos (66 σ)	(out: 27-Apr-15) Eos (275 σ)	Eos (20 σ)	Eos (7.6 σ)	Eos (5.0 σ)	Eos not detected
4S (D)	Ellringer Spring Run Bug	MN55:X00018 (A0445 Spring Run)	spring run	558,420	4,869,370	(in: 08-Apr-15) not detected	not detected		not detected	(out: 27-Apr-15) not detected	not detected	not detected	not detected	not detected
5S (E)	County Road 136 (Co. Rd. 136)	MN55:X00019	stream	564,233	4,869,350	(in: 08-Apr-15) not detected	not detected		not detected	(out: 27-Apr-15) not detected	not detected	not detected	not detected	not detected
6S (F)	Jones Spring Run Bug	MN55:X00023	spring run	555,976	4,868,040	(in: 10-Apr-15) not detected	not detected		not detected	Bug #1: (out: 24-Apr-15) not detected Bug #2: (out: 27-Apr-15) not detected	not detected	not detected	not detected	not detected
7S (G)	I-90 Spring Run	MN55:X00022	spring run	556,001	4,867,240	(in: 10-Apr-15) not detected	not detected		not detected	Bug #1: (out: 24-Apr-15) not detected Bug #2: (out: 27-Apr-15) not detected	not detected	not detected	not detected	not detected

Appendix A (continued)

Bear Creek South 2015 Traces 21 Apr 2015

	Field Name	KFDB #	Site Type	UTM Easting	UTM Northing	Background Bug Results (In: X-Apr-15; Out: 14-Apr-15) (X = 02-Apr, or 08-Apr, or 09-Apr, or	Background Bug Results (In: 14-Apr-15; Out: 20-Apr-15)		Water Sample Results 22-Apr-15	Bug Results In: 20-Apr-15 Out: X-Apr-15 (X=24-Apr or 27-Apr)	Bug Results In: 27-Apr-15 Out: 29-Apr-15	Bug Results In: 29-Apr-15 Out: 07-May-15	Bug Results In: 07-May-15 Out: 15-May-15	Bug Results In: 15-May-15 Out: 27-May-15
8S (H)	Jacobson / Pagel Bug Set	MN55:X00024	spring run	558,605	4,864,810	(in: 10-Apr-15) not detected	not detected				not detected			
9S (I)	Schoenfelder Bug Set	MN55:X00025	spring run	559,689	4,864,770	(in: 10-Apr-15) not detected	not detected			(out: 27-Apr-15) not detected	not detected	not detected	not detected	not detected
10S (J)	County Road 7 (CR 7)	MN55:X00026	stream	561,077	4,864,340	(in: 10-Apr-15) not detected	not detected		not detected	(out: 27-Apr-15) not detected	not detected	not detected	not detected	not detected
11S (K)	Quarry Bug Set	MN55:X00020	bug set	561,731	4,864,820	(in: 08-Apr-15) not detected	not detected			(out: 27-Apr-15) not detected	not detected	not detected	not detected	not detected

Indicates no bug or sample was received by the lab

Appendix B

Orion 2015 Traces 21 Apr 2015

Sample Analysis Results

Trace Inputs Dates/Times: 21 Apr 2015
Trace Inputs Locations: 2 Sinkholes
Sinkhole (MN55:D00390) (556,316 E, 4,862,120 N): poured 508 g (33 wt. %) Eosine at 11:46
Sinkhole (MN55:D00396) (556,319 E, 4,862,588 N): poured 800 g (17.7 wt. %) Rhodamine WT at 12:09
Field Personnel at Inputs and/or Sampling: Martin Larsen, Scot Johnson, Jeff Green, John Barry
Lab Personnel: Sophie M. Kasahara, Betty J. Wheeler, Scott C. Alexander, Dr. E. Calvin Alexander, Jr.

	Field Name	KFDB #	Site Type	UTM Easting	UTM Northing	Background Bug Results (In: X-Apr-15; Out: 14-Apr-15) (X = 02-Apr, or 08-Apr, or 09-Apr, or 10-Apr)	Background Bug Results (In: 14-Apr-15; Out: 20-Apr-15)	Dye Inputs 21-Apr-2015	Water Sample Results 22-Apr-15	Bug Results In: 20-Apr-15 Out: X-Apr-15 (X=24-Apr or 27-Apr)	Bug Results In: 27-Apr-15 Out: 29-Apr-15	Bug Results In: 29-Apr-15 Out: 07-May-15	Bug Results In: 07-May-15 Out: 15-May-15	Bug Results In: 15-May-15 Out: 27-May-15
12S (L)	Old Jug Spring	MN55:A00009	spring	553,944	4,863,530	(in: 09-Apr-15) not detected	not detected			(out: 27-Apr-15) not detected	not detected	not detected	not detected	not detected
13S (M)	McConnell Spring	MN55:A00006	spring	554,342	4,862,900	(in: 09-Apr-15) not detected	not detected			(out: 27-Apr-15) not detected	not detected	not detected	not detected	not detected
14S (N)	Chance Hollow Bug Set 2	MN55:X00027	spring run	555,243	4,861,210	(in: 10-Apr-15) not detected	not detected		Eos (176 σ) -------- RhWT (45 σ)	(out: 27-Apr-15) Eos (114 σ) -------- RhWT (50 σ)	Eos (79 σ) -------- RhWT (241 σ)	Eos (68 σ) -------- RhWT (151 σ)	Eos (21 σ) -------- RhWT (33 σ)	Eos (88 σ) -------- RhWT (133 σ)
15S (O)	Billy's Spring Run 2	MN55:X00002	spring run	556,088	4,860,840	(in: 10-Apr-15) not detected	not detected		Bug #1: (Billy's East) not detected Bug #2: (Billy's West) not detected	(out: 27-Apr-15) not detected	not detected	not detected	not detected	not detected
16S (P)	Devils Den Spring Run	MN55:X00021	spring run	557,158	4,861,150	(in: 09-Apr-15) not detected	not detected		not detected	(out: 27-Apr-15) not detected	not detected	not detected	not detected	not detected
17S (Q)	Morehart Bug Set	MN55:X00028	spring run	555,135	4,862,462					(out: 27-Apr-15) not detected	not detected	not detected	not detected	not detected

Indicates no bug or sample was received by the lab

Appendix C

Marion-Eyota 2015 Trace 16 Nov 2015

Carbon (Bug) Analysis Results

Trace Input Date/Time: 16 Nov 2015

Trace Input Location: 1 Sinkhole

Sinkhole (MN55:D00824) (556,491 E, 4,867,892 N): poured 494.71 g Uranine HS (35 wt. %) (Chromatint) at 10:27
The sinkhole was initially wetted with 275 gallons of water. Dye was poured at 10:27 am on 16 Nov 2015. Then, 525 gallons of additional water was used to flush dye.

Field Personnel at Inputs and/or Sampling: Martin Larsen, Angela White, Dr. E. Calvin Alexander, Jr., John Barry, Mary Coburn

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

	Field Name	KFD #	Site Type	UTM Easting	UTM Northing	Background Bug Results (In: 4-Nov-15; Out: 9-Nov-15)	Background Bug Results (In: 9-Nov-15; Out: 16-Nov-15)	Dye Input 16-Nov-2015	Bug Results (In: 16-Nov-15; Out: 19-Nov-15)	Bug Results (In: 19-Nov-15; Out: 23-Nov-15)	Bug Results (In: 23-Nov-15; Out: 07-Dec-15)	Bug Results (In: 07-Dec-15; Out: 21-Jan-16)	Bug Results (In: 18-Feb-16 or In: 19-Feb-16; Out: 28-Feb-16)
1S (A)	Pagel / Jacobson Bug Set	MN55:X00024 (associated with: MN55:A0000444)	spring run	558,605	4,864,810	not detected	not detected		not detected (16 Nov 2015 - 07 Dec 2015)				not detected (in: 19-Feb-16)
2S + 3S (B)	Hammell + Ellringer Spring Run	MN55:X00033 (associated with: MN55:A0000445 and MN55:A0000446)	spring run	558,374	4,869,355	not detected	not detected		not detected	not detected	not detected	not detected	
4S (D)	Bear Spring (aka, Bear Creek Headwaters Perennial Spring)	MN55:A0000406	spring	557,714	4,869,606	not detected	not detected		not detected	not detected	not detected	not detected	not detected (in: 18-Feb-16)
5S (E)	Lewis Spring Run (aka, A0447 Spring Run)	MN55:X00016 (associated with: MN55:A0000447)	spring run	556,603	4,869,620	not detected	not detected		not detected	not detected	not detected	not detected	
6S (F)	Jones Spring Run Bug	MN55:X00023 (associated with: MN55:A0000008)	spring run	555,976	4,868,040	[1] Spring was dry	[3] (see note below)	[2] Spring was running (on 16 Nov 2015)	Strong Uran Positive (diluted 768 x)	Strong Uran Positive (diluted 64 x)	Strong Uran Positive	Uran Positive	not detected (in: 18-Feb-16)
7S (G)	I-90 Spring Run	MN55:X00022 (associated with: MN55:A0000405)	spring run	556,001	4,867,240	[1] Spring was dry		[2] Spring was dry (on 16 Nov 2015)					not detected (in: 19-Feb-16)

Appendix C (continued)

Marion-Eyota 2015 Trace 16 Nov 2015

(continued)

	Field Name	KFD #	Site Type	UTM Easting	UTM Northing	Background Bug Results (In: 4-Nov-15; Out: 9-Nov-15)	Background Bug Results (In: 9-Nov-15; Out: 16-Nov-15)	Dye Input 16-Nov-2015	Bug Results (In: 16-Nov-15; Out: 19-Nov-15)	Bug Results (In: 19-Nov-15; Out: 23-Nov-15)	Bug Results (In: 23-Nov-15; Out: 07-Dec-15)	Bug Results (In: 07-Dec-15; Out: 21-Jan-16)	Bug Results (In: 18-Feb-16 or In: 19-Feb-16; Out: 28-Feb-16)
8S (H)	Springdale Spring Run	MN55:X00009 (associated with: MN55:A0000443)	spring run	556,229	4,867,025	not detected	not detected		not detected	not detected	not detected	not detected	not detected (in: 18-Feb-16)
9S (I)	Bird Man Spring	MN55:A0000590	spring	555,055	4,867,352				not detected (16 Nov 2015 - 07 Dec 2015)				not detected (in: 18-Feb-16)
10S (J)	Kinney Creek @ US 52 (aka, Predmore) (aka, Highway 52)	MN55:X00011 (associated with: MN55:A0000492)	spring run	553,973	4,864,825	not detected	not detected		not detected (16 Nov 2015 - 07 Dec 2015)				not detected (in: 18-Feb-16)
11S (J)	70th Ave. North Spring Run	MN55:X00030 (associated with: MN55:A0000495)	spring run	553,046	4,866,585	not detected	not detected		not detected (16 Nov 2015 - 07 Dec 2015)				not detected (in: 19-Feb-16)
12S (J)	70th Ave. Middle Spring Run	MN55:X00031 (associated with: MN55:A0000494)	spring run	553,038	4,866,355	not detected	not detected		not detected (16 Nov 2015 - 07 Dec 2015)				not detected (in: 19-Feb-16)
13S (K)	70th Ave. South Spring Run	MN55:X00032 (associated with: MN55:A0000493)	spring run	553,054	4,865,431	not detected	not detected		not detected (16 Nov 2015 - 07 Dec 2015)				not detected (in: 18-Feb-16)

Indicates no bug or sample was received by the lab

[1] Information from Martin Larsen, provided to E. Calvin Alexander, Jr. on 16 Nov 2015.

[2] Information noted in the field on 16 Nov 2015 by E. Calvin Alexander, Jr.

[3] Data on IR aerial image received 17-Nov-15 at UM Hydrogeology Lab (with bugs), from Martin Larsen:
Re: Jones Spring: " A8: No flow on 10-Nov-15. [On] 11-Nov: 1+ inch rain. A8 flowing on 13-Nov [at] 0.1 cfs (est.)"

Note on Result Descriptions:

"Trace" means dye was detected at a level too low to quantify, corresponding with a peak height between 3 σ and 10 σ.
"Positive" means dye was detected at a quantifiable level, corresponding with a peak height between 10 σ and 50 σ.
"Strong Positive" means dye was detected at a quantifiable level, with a peak height greater than 50 σ.