Wiskow Dye Traces 2014  
Olmsted County, Minnesota  

9 April 2014 to 12 June 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changed from clear water to colored water with foam and odor (Larsen, 2013, Eyota Township Manure Runoff Incident, unpublished).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.

<table>
<thead>
<tr>
<th>ID #</th>
<th>X UTM</th>
<th>Y UTM</th>
<th>Karst Feature DB Number</th>
<th>Name or Description</th>
<th>Classification:</th>
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<tbody>
<tr>
<td>1IP</td>
<td>557550</td>
<td>4865569</td>
<td>MN55:D00983</td>
<td>Wiskow Sinkhole in Brushpile</td>
<td>Injection Point</td>
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<td>3IP</td>
<td>557516</td>
<td>4863617</td>
<td>MN55:D0000282</td>
<td>Open Sinkhole Near Hwy 52</td>
<td>Injection Point</td>
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<td>1S</td>
<td>558102</td>
<td>4865505</td>
<td>MN55:A00567</td>
<td>Spring in Pagel's Pasture</td>
<td>Spring Sample Point</td>
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<td>2S</td>
<td>559125</td>
<td>4863987</td>
<td>MN55:A00014</td>
<td>Spring in Boyd Gasner's Pasture (CCC Structure)</td>
<td>Spring Sample Point</td>
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<tr>
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<td>4863883</td>
<td>MN55:A00564</td>
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<td>4863918</td>
<td>MN55:A00566</td>
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<td>4863520</td>
<td>MN55:A00009</td>
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<td>6S</td>
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<td>4861618</td>
<td>MN55:A0003</td>
<td>Chance Hollow Spring</td>
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<td>9S</td>
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<td>4867026</td>
<td>MN55:A0443</td>
<td>County Rd 19 Crossing Spring</td>
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<td>10S</td>
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<td>4865208</td>
<td>MN55:A0492</td>
<td>Kinney Creek Headwater Spring</td>
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<td>MN55:A0002</td>
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<td>12S</td>
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<td>4861156</td>
<td>MN55:A0003</td>
<td>Devils Den Springs Run</td>
<td>Spring Sample Point</td>
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<td>13S</td>
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<td>MN55:A0006</td>
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<td>15W</td>
<td>557606</td>
<td>4865482</td>
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<td>Wiskow Well</td>
<td>Vulnerable Well</td>
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<td>16W</td>
<td>558450</td>
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<td>19S</td>
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<td>4864067</td>
<td>MN55:A00565</td>
<td>Applen Spring</td>
<td>Spring Sample Point</td>
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</tbody>
</table>

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


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. Wiskow Rhodamine WT Report Summary Table
Appendix B. Wiskow Uranine Report Summary Table
Appendix C. Wiskow Monitoring Sites Results