Dye Trace Report
Gorman Creek

Trace: March 2011

Wabasha County, Minnesota

Jeffrey A. Green[1], Andrew Luhmann[2,3], Scott Alexander[2],
Betty Wheeler[2], and E. Calvin Alexander, Jr.[2]

[1] Minnesota Department of Natural Resources
Ecological and Water Resources Division
3555 9th St. NW Suite 350
Rochester MN 55901

[2] University of Minnesota
Earth Sciences Department
310 Pillsbury Dr. SE
Minneapolis MN 55455

[3] Current address:
New Mexico Institute of Mining & Technology
Earth & Environmental Science Department
801 Leroy Place
Socorro, NM 87801

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Introduction

The karst lands of southeast Minnesota contain more than one hundred trout streams that receive perennial discharge from Paleozoic bedrock springs. Several of the Paleozoic bedrock aquifers that provide discharge to these streams are dominated by conduit-flow. Field investigations into the flow characteristics of these aquifers have been conducted using fluorescent dyes to map groundwater springsheds and characterize groundwater flow velocities for use in water resource protection. Gorman Creek is one of these designated trout streams. The creek is located roughly 14 kilometers (8.5 mi.) northeast of Plainview, Minnesota in Wabasha County (Figure 1). This trace was completed to add to delineated springsheds of the region as part of the Environmental and Natural Resources Trust Fund (ENRTF) Springshed Mapping project.

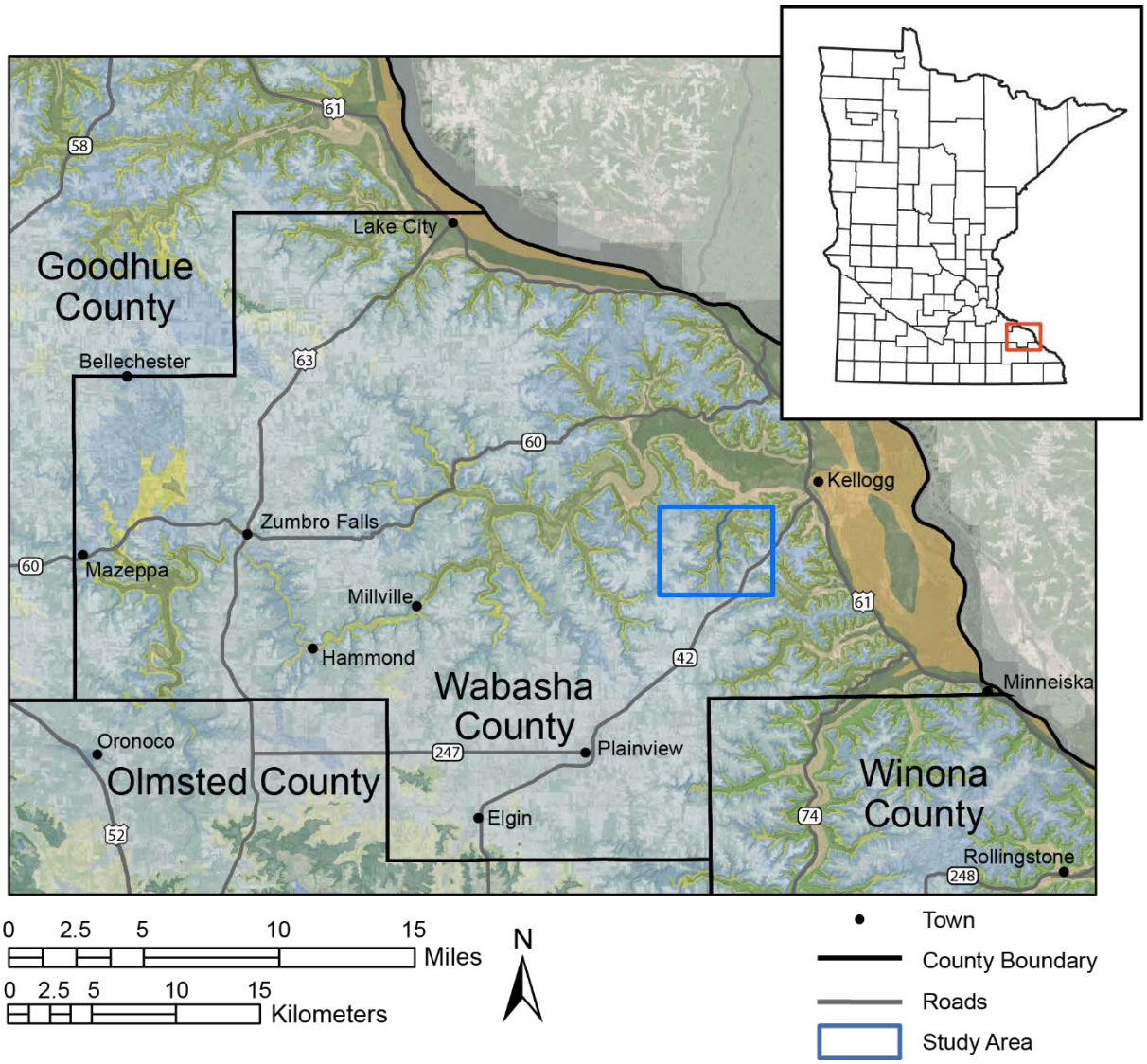

FIgure 1. Location map for Gorman Creek

In Wabasha county, bedrock units from the Upper Cambrian through the Upper Ordovician are generally within 15 meters of the land surface and are capped by unconsolidated sediments such as loess, sand, and colluvium (Mossler, 2001; Hobbes, 2001). The topography is dominated by a broad plateau of resistant dolostone of the Ordovician Prairie du Chien Group (OPDC). The OPDC is karst; on the land surface are many sinkholes, dry valleys and springs and in the subsurface the OPDC is characterized by solution-enlarged joints, fractures and conduits. A geologic column for Wabasha County (Figure 2) shows lithostratigraphic and generalized hydrostratigraphic properties for each of the units (modified from Runkel et. al. 2013). Hydrostratigraphic attributes have been generalized into either aquifer or aquitard based on their relative permeability. Layers assigned as aquifers are permeable and easily transmit water through porous media, fractures or conduits. Layers assigned aquitard have lower permeability that vertically retards flow, effectively hydraulically separating aquifer layers. However, layers designated as aquitards may contain high permeability bedding plane fractures conductive enough to yield large quantities of water.

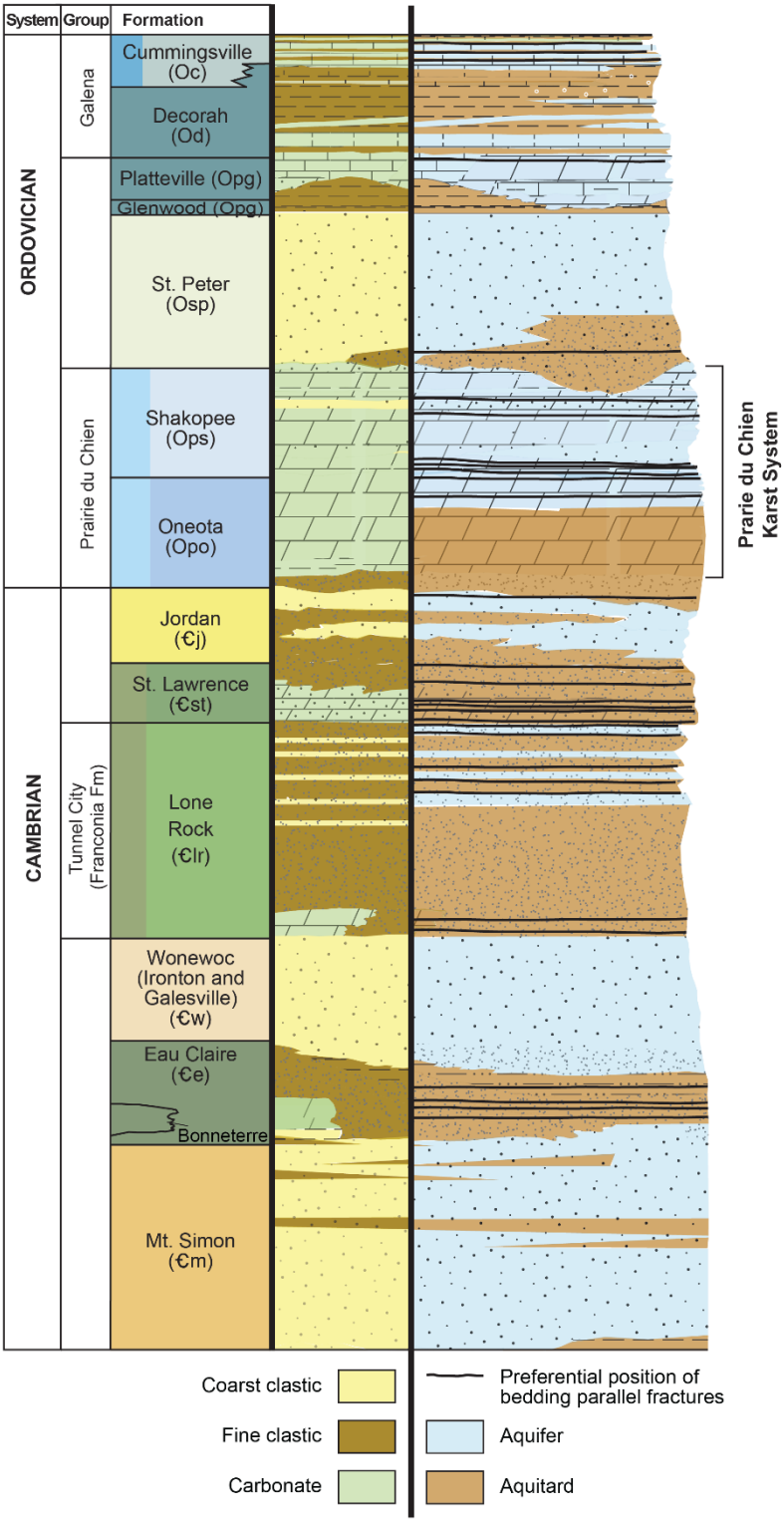

Figure 2. Geologic and hydrogeologic attributes of Paleozoic rocks in southeastern Minnesota. Modified from Runkel et al., 2013.

Canfield Spring (MN79:A003) is the headwater of Gorman Creek. Water from Costello Spring (MN79:A002) joins the flow from Canfield Spring 4000 ft. downstream. The tributary valleys that meet at Canfield spring do not have perennial flow; they only have flowing water during runoff events. This dye trace was completed using snowmelt runoff and was initiated to determine if an ephemeral stream with no obvious sinking point was losing flow into the St. Lawrence Formation and resurging at nearby St. Lawrence Formation springs.

Methods

A dye trace was conducted in a tributary valley to Gorman Creek on 17 March 2011. Eosine dye was poured into a runoff stream upstream of where it crosses the top of the St. Lawrence Formation. Passive sampler charcoal detectors (bugs) were placed in Canfield Spring, Costello Spring and one tributary stream that discharges to Gorman Creek. Table 1 contains the dye input information, the location information for the sample sites, and the dye detection summary.

Dye tracing entails using fluorescent dyes to track groundwater flow directions and travel times. The dye is poured into a sinking stream or sinkhole; from there it flows through a conduit system until it re-emerges at a spring. The bugs were returned to the University of Minnesota Geology & Geophysics Department Hydrochemistry Laboratory for analysis. There, the charcoal detectors were opened, the charcoal was removed, and using an eluent solution of 70% isopropyl alcohol, 30% deionized water, and 10g/L NaOH, the fluorescent materials were then extracted for analysis. The eluent solution was then run through the Shimadzu RF5000U scanning spectrofluorophotometer to detect and record the spectra. Spectral components, including the background spectral components, were quantified using PeakFit software as described in Alexander (2005). E. Calvin Alexander, Jr., of the University of Minnesota Geology Department performed sample analysis and interpretation.

Results & Discussion

Background bugs were in place at monitoring locations from 11 March 2011 to 17 May 2011. Following introduction of dye on 17Mar2011, the three sampling points (Figure 3) were monitored from 17 March 2011 to 25 May 2011. No dye was detected at any of the sites. One possible interpretation of this result is that the ephemeral stream was not losing flow into the St. Lawrence Formation; three other possibilities are: 1) that the dye took longer than the sampling period to reach the sampled springs, or 2) the flow went to another, unmonitored spring or far-field discharge location such as the Mississippi River, or 3) that the dye was diluted to below the detection limit before it reached the springs. While this trace was not successful in terms of recovering the dye; it did serve as a useful test case to see if flow in the normally dry valleys could be detected in the groundwater emerging from Canfield or Costello Springs.

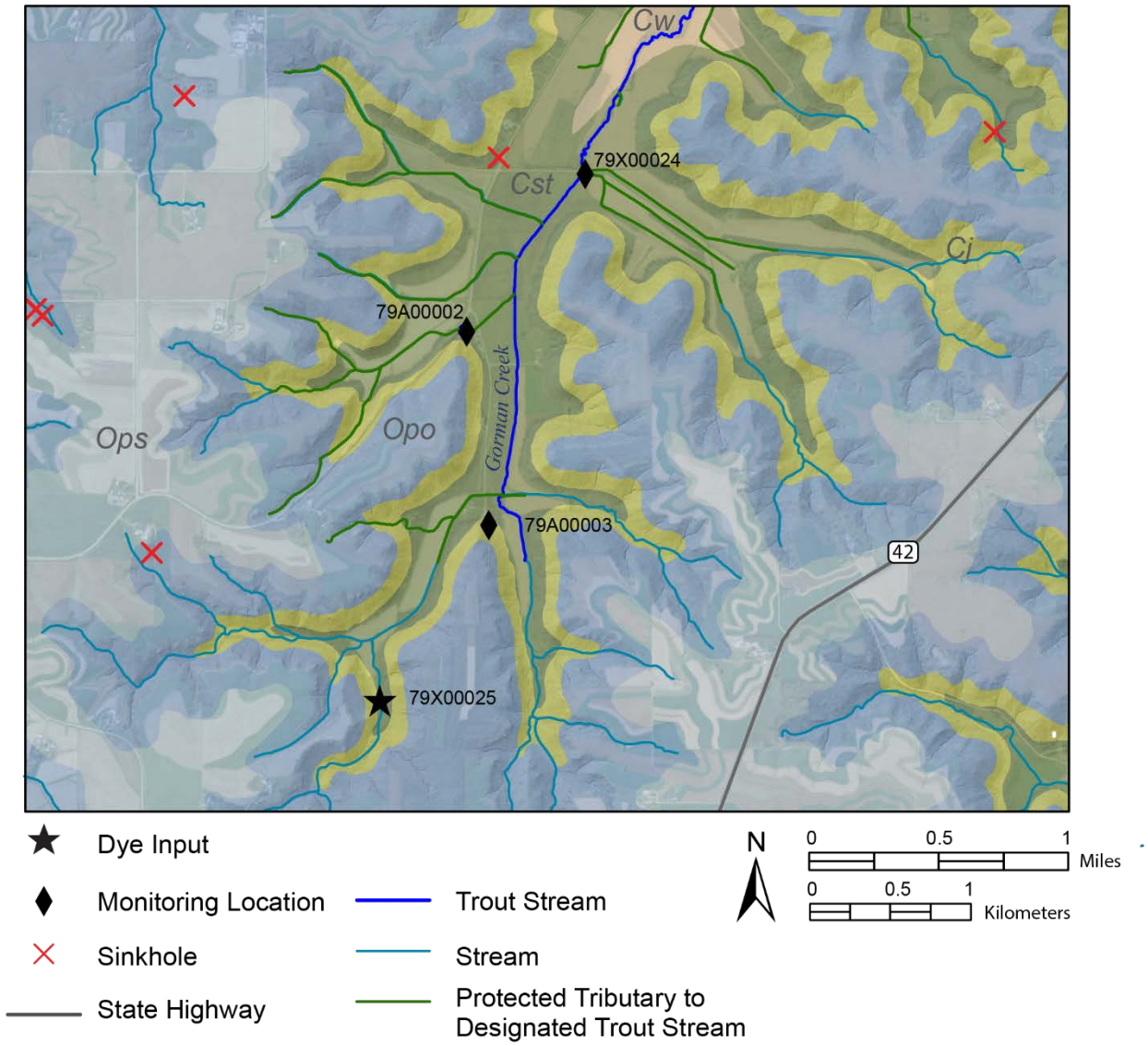

Figure 3. Monitoring points and dye release site

References

Alexander, S.C., 2005, Spectral deconvolution and quantification of natural organic material and fluorescent tracer dyes *in* Beck B, editor, Sinkholes and the engineering and environmental Impacts of karst: Proceedings of the Tenth Multidisciplinary Conference, San Antonio, 24-28 September 2005, ASCE Geotechnical Special Publication 144, Amer. Soc. Civil Engineers, Reston, VA, p. 441-448.

Green, J.A., Runkel, A.C., Alexander, E.C. Jr., 2012, Karst conduit flow in the Cambrian St. Lawrence confining unit, southeast Minnesota, USA: Carbonates and Evaporites. 27 (2): 167-172.

Hobbs, H.C., 2001, Surficial Geology, plate 3, C-14 Geologic atlas of Wabasha County, Minnesota [Part A], Minnesota Geological Survey.

Runkel, A.C., Steenberg, J.R., Tipping, R.G., Retzler, A.J., 2013, Physical hydrogeology of the groundwater-surface water system of southeastern Minnesota and geologic controls on nitrate transport and stream baseflow concentrations: Minnesota Geological Survey report delivered to the Minnesota Pollution control agency, Contract number B50858 (PRJ07522).

Mossler, J.H., 2001, Bedrock Geology, plate 2, C-14 Geologic atlas of Wabasha County, Minnesota [Part A]: Minnesota Geological Survey.

Tables

Gorman Creek 2011 Dye Trace -- 17 March 2011 (1 Trace)

Trace Input: Gorman Creek Headwaters (MN79:X25, 573,366 E / 4,900,834 N, NAD83, Zone 15)

Poured 1,072.25 grams **Eosine** (33 weight %) into runoff flowing into Gorman Creek at 17:15. Creek flow was estimated to be 2-5 cubic feet/second (5.7 $x10^{-3}$ to 1.4 $x\ 10^{-2}$ m^3/s) at the time. Dye input point estimated at 860 feet (262 meters) elevation (from USGS topo map).

Field Personnel at Input and/or Sampling: Jeff Green.

Lab Personnel: Joel T. Groten, Betty J. Wheeler, Dr. E. Calvin Alexander, Jr.

Carbon (Bug) Analysis Results

Field Name	KFD #	Site Type	UTMs NAD 83, Zone 15		11 Mar to 17 Mar 2011	Dye Input 17 Mar 2011	17 Mar to 24 Mar 2011	24 Mar to 5 Apr 2011	5 Apr to 12 Apr 2011	12 Apr to 26 Apr 2011	26 Apr to 25 May 2011
			Easting	Northing							
Costello Spring (79A2)	**MN79:A00002**	spring	573,901	4,903,158	**nd**		Uran * (4 σ)	**nd**	Uran * (10 σ) Eos * (6 σ)	**nd**	**nd**
Canfield Spring (79A3) (in Wabasha County)	**MN79:A00003**	spring	574,041	4,901,956	Uran * (3 σ)		Uran * (8 σ)	Uran * (4 σ)	Uran * (3 σ)	**nd**	**nd**
Gorman Creek Northeast Tributary (79X24) Bug set upstream of township road bridge, over Northeast Tributary to Gorman Creek, in Sec. 31 in Greenfield Twp.	**MN79:X00024**	tributary to creek	574,638	4,904,134			**nd**		**nd**	**nd**	**nd**

Eos indicates Eosine dye detected

Eos * indicates Eosine from some other unknown source

Uran * indicates Uranine (fluorescein) from some other unknown source

nd indicates no dye detected

lost indicates bug was lost in the field

(yellow cell) indicates no bug was received by the lab