Crystal Springs State Fish Hatchery and Kieffer Valley Dye Trace

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Introduction

The Kieffer Valley Creek is a major tributary to the South Branch of the Whitewater River (SBWR), a designated trout stream in Winona County, Minnesota. Trout streams are sustained by the constant, cool, and clear water supplied by springs, which are under increasing pressure from human activities. Greater withdrawals of groundwater may be decreasing spring flow, while domestic and agricultural pollutants are affecting water quality. The springs in Kieffer Valley and the rest of Southeast Minnesota are especially vulnerable to these pressures because they are in an area of active karst, in which soluble carbonate material dissolves as groundwater flows through fractures, bedding planes, and conduits. Documenting groundwater flow paths is essential in such an area because the groundwater can flow rapidly through subsurface karst features. Here, the groundwater flows through Ordovician and Cambrian sandstone and carbonate aquifers, which feed the Crystal Springs State Fish Hatchery (CSSFH) via two major springs. Because it is very difficult to establish protective measures for trout streams without understanding the layout of the groundwater flow system, this study aims to begin the delineation of the springshed surrounding the CSSFH.

Background

Two previous dye traces have been conducted in the Kieffer Valley. The first, in 1980, occurred after sinkholes developed in the storage pond of the Altura Waste Water Treatment Facility, causing the sewage water to drain into the ground. This study traced the effluent from the two remaining aeration lagoons, which flowed on the surface into the Kieffer Valley and sank. That water then resurged into four springs in the Keiffer Valley in about one week (Alexander E.C. Jr., 1984). Originally, the researchers thought the sink point was in the Jordan Sandstone, but as knowledge improved in the subsequent 25 years, they realized it to be in the St. Lawrence Formation. In 1980, the St. Lawrence Formation was thought to be an aquitard. The second trace took place in 2008, this time pouring the dye directly into the same stream sink in the Kieffer Valley. The dye reappeared in the same four springs again within a week, confirming that the St. Lawrence Formation functions as an aquifer. The current study injected Rhodamine WT dye in a different Kieffer Valley stream sink approximately one half mile upstream of the 2008 input site, in the lower Jordan Sandstone.

The Crystal Springs State Fish Hatchery is 1.25 miles southwest of the Kieffer Valley dye input location, although it is on the other side of the SBWR. The CSSFH is supplied by two large springs in the St. Lawrence Formation. Paul Wotzka's monitoring of the CSSFH springs has shown significant evidence of varying concentrations of herbicides and nitrates. Approximately 1.25 farther to the southwest, surface water sinks into the Coon Valley Member of the Oneota Dolomite. The current study injected Uranine HS into this sink.

Figure 1. 2008 Kieffer Valley Trace

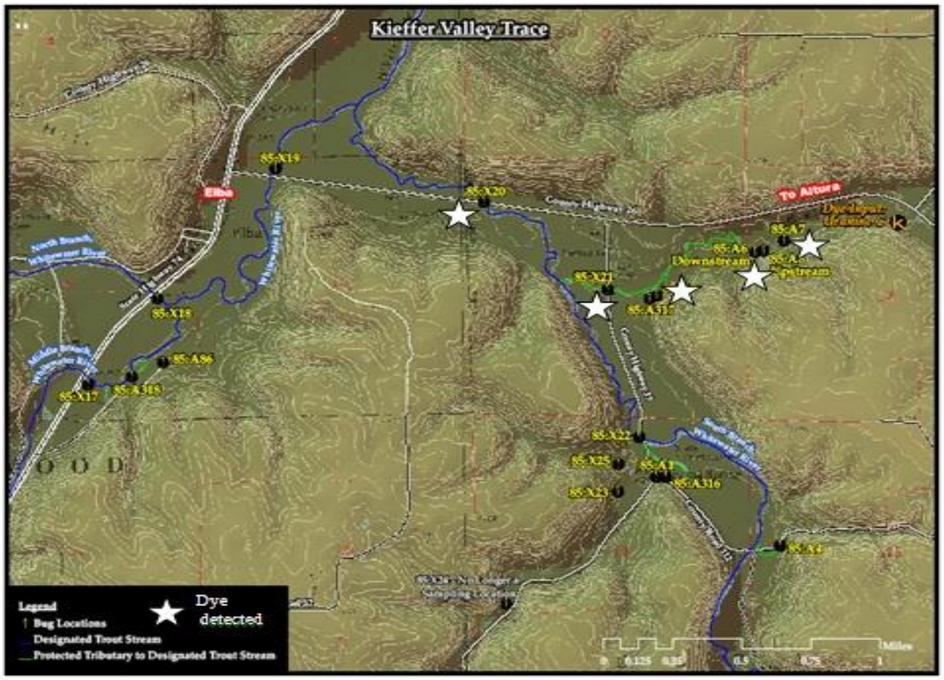

Figure 2. 2010 Kieffer Valley Trace (using Light Detection and Ranging Data)

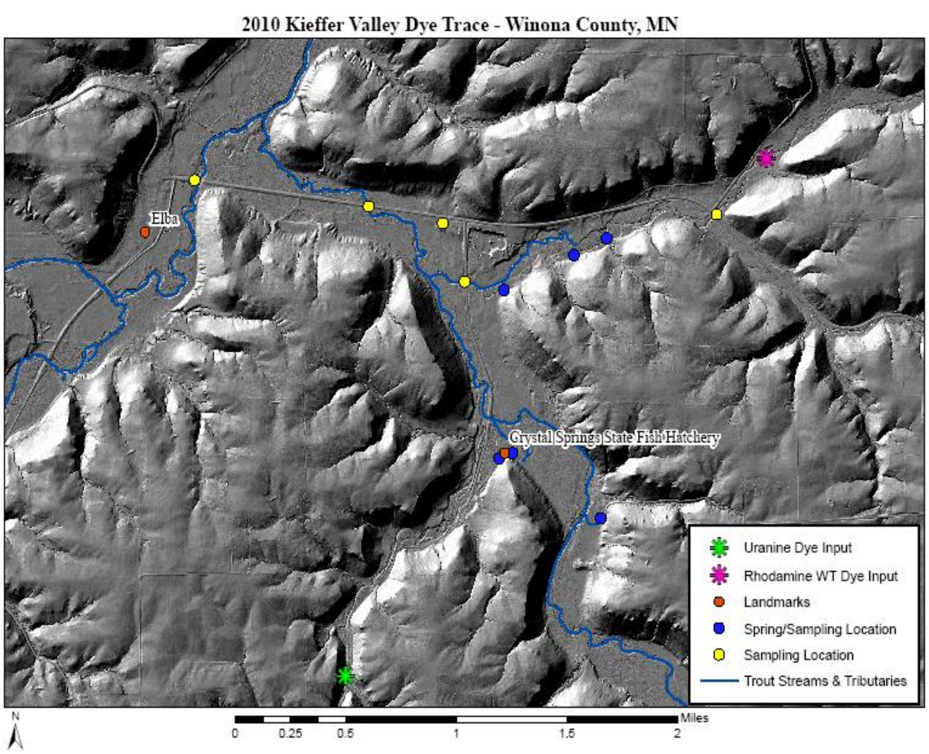

Figure 3. Stratigraphic column at Kieffer Valley

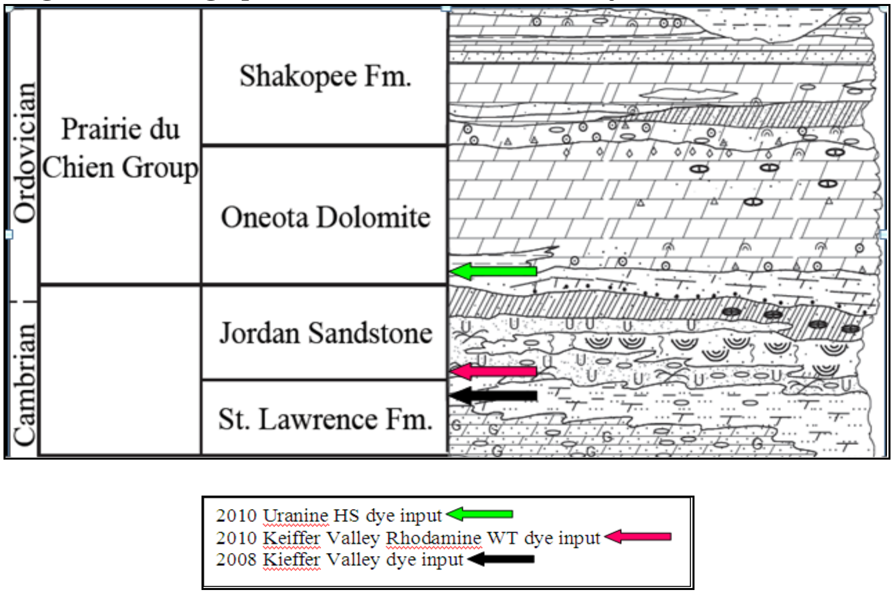

Figure modified from Mossler (2008)

Methods

Eleven locations in and around the Kieffer Valley were monitored using teabag-sized, integrating charcoal detectors ("bugs"). The bugs were anchored underwater to adsorb fluorescent dye and changed approximately once/week starting on June 22 and continuing into the present. Background bugs were collected for over two weeks prior to dye input, June 22 – July 9.

On July 9, two types of dye were poured into two stream sinks. For the Kieffer Valley dye input, 282.02 grams of 20% by weight D13800 Chromatint Rhodamine WT solution (56 grams of dye) was used in a stream sink on the Brozig Farm alongside County Road 114. The other dye input site was located 1.25 miles southwest of the Crystal Springs State Fish Hatchery, using 420.73 grams of 35% by weight D11006 Chromatint Uranine HS solution (147 grams of dye). At both stream sinks, the dye was diluted on-site with stream water using a five-gallon bucket and flushed into the sink.

Once changed, bugs were brought back to the University of Minnesota Department of Geology and Geophysics Hydrochemistry Laboratory for analysis. The fluorescent dye was extracted from the charcoal using an eluent solution of 70% isopropyl alcohol, 30% deionized water, and 5 grams sodium hydroxide per half liter solution. These samples were analyzed by the Shimadzu RF5000U scanning spectrofluorophotometer to detect fluorescent spectra, which were then quantified using PeakFit® software (Alexander S., 2005).

Results and Discussion

As of August 9, 2010, dye has yet to be detected from either trace. It has been over one month since the dye injection. There are four potential explanations for the lack of detection.

1) The dye has not yet reached the detection points. We have not waited long enough. The flow is slower than hypothesized.
2) The dye was diluted below the detection limit. We did not use enough dye.
3) The dye flowed to unmonitored locations. We did not look in the right places.
4) The dye may have been adsorbed or chemically changed. Something happened to the dye.

In the Kieffer Valley, dye was detected in the two previous traces in about a week. Whatever the reason, this dye trace is different from the 1980 and 2008 traces. One obvious difference is the input location. The input point for the first two traces was in the St. Lawrence Formation, whereas the input point for this trace is in the lower Jordan Sandstone. This may be a different flow system, either with much slower flow or flow in a different direction.

The Uranine HS dye input was the first attempt to trace to the CSSFH springs and was the first trace in Minnesota through the Jordan Sandstone. The above four potential explanations apply to this trace as well.

Although I will be returning to my home university in August, my advisor plans to continue monitoring these springs into the fall.

Acknowledgements
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