

Abstract

Springshed mapping projects have been ongoing in Fillmore County since the 1970s. The purpose of this project is to compliment previous and ongoing dye traces surrounding the study area near Wykoff, MN. Study areas were purposefully chosen to add to the body of known flow paths. Dye tracing was done via the release of select fluorescent dyes into the Karst aquifer system, and the subsequent monitoring of springs and surface streams in the suspected potential paths of the system. Continued mapping of springsheds and their flow patterns within these Karst aquifer systems may lead to a revision of groundwater regulations, as well as industrial and agricultural practice revisions to limit aquifer contamination.

Methodology

- Fourteen sites were monitored using activated charcoal detectors for the presence of fluorescent dyes.
- Bug detectors are constructed in a sanitary lab and then placed in concealed locations on-site, and anchored via a weight and tied to a stationary object via a sturdy cable.
- Selected sites were monitored for two weeks prior to release of dyes to determine background levels of fluorescent materials in the waters. This information was used to select the dyes used.
- Eosin and Rhodamine WT dyes were released into two different sinkhole sites on July 20th 2012, and flushed into the Karst system using approximately 550 gallons of water transported to site. Fluorescein dye was also released into the Root River on July 13th 2012.
- Activated charcoal packets were retrieved and exchanged approximately on a weekly basis, and returned to the University of Minnesota.

Analysis

- Detectors were analyzed by extracting the activated charcoal from each packet and soaking it in an eluent mixture of 70% isopropyl alcohol, 30% high purity deionized water, and 10g (per liter) sodium hydroxide for approximately one hour.
- The eluent was placed in a Shimadzu RF5000U spectrofluorophotometer for detection of fluorescent dyes in the water.
- Fluorescein (aka Uranine) is a fluorescent green dye with an emission wavelength at approximately 512nm.
- Eosin is a fluorescent orange dye with an emission wavelength at approximately 538nm.
- Rhodamine WT is a fluorescent red dye with an emission wavelength at approximately 563nm.
- The spectra from the Shimadzu were analyzed using PeakFit 4.0™



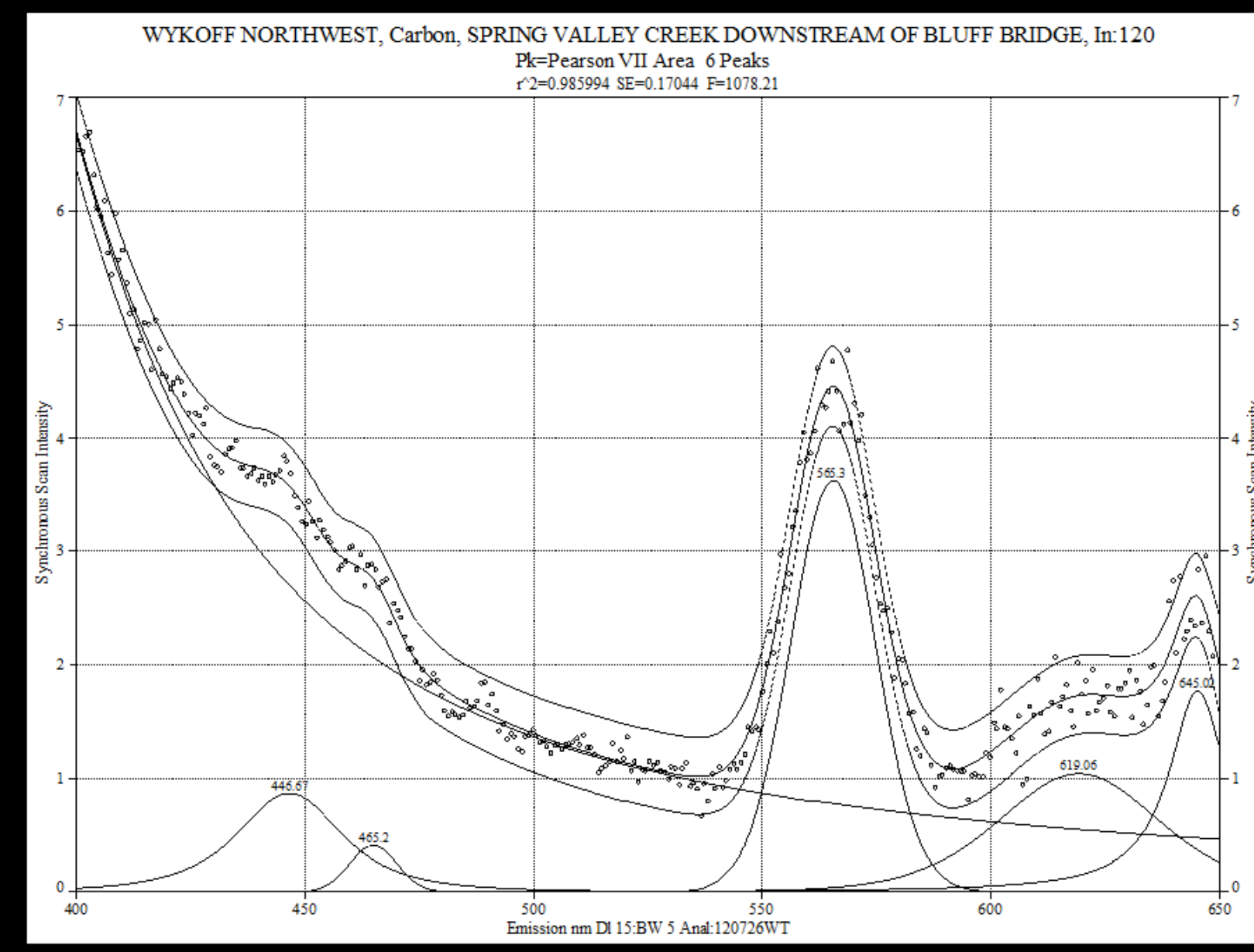
A bug detector contains activated charcoal, a material that's surface area is capable of trapping even the smallest amounts of dye molecules.



Sinkholes are often inconspicuous, techniques for locating sinkholes often utilize aerial photographs and LiDAR imagery.



South branch Root River during the Fluorescein dye trace July 13th 2012.



Spectrum generated by Peak Fit™ illustrating a bug with a positive Rhodamine WT emission wavelength of 565nm.

References

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- Palmer, Arthur N., and Margaret V. Palmer, ed. *Caves and Karst of the USA*. Huntsville: National Speleological Society, Inc., 2009. Print. <<http://www.caves.org>>.
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Karst

Karst landscapes have several identifiable features including caves, sinkholes and springs. Typically karst terrains are formed within limestone and dolostone which occur throughout southeast Minnesota. Karst terrains refer to not only to surficial topography, but also to the subsurface aquifers. Anisotropic and heterogeneous geologic materials create subterranean networks formed by the dissolution of soluble bedrock by the infiltration of meteoric water. Naturally occurring joints in soluble bedrock are enlarged through the repeated infiltration process and result in large scale Karst environments these conditions occur in Fillmore County, where conduit flow creates a positive feedback environment enlarging joints eventually into cave passages on flow paths which exit via springs.

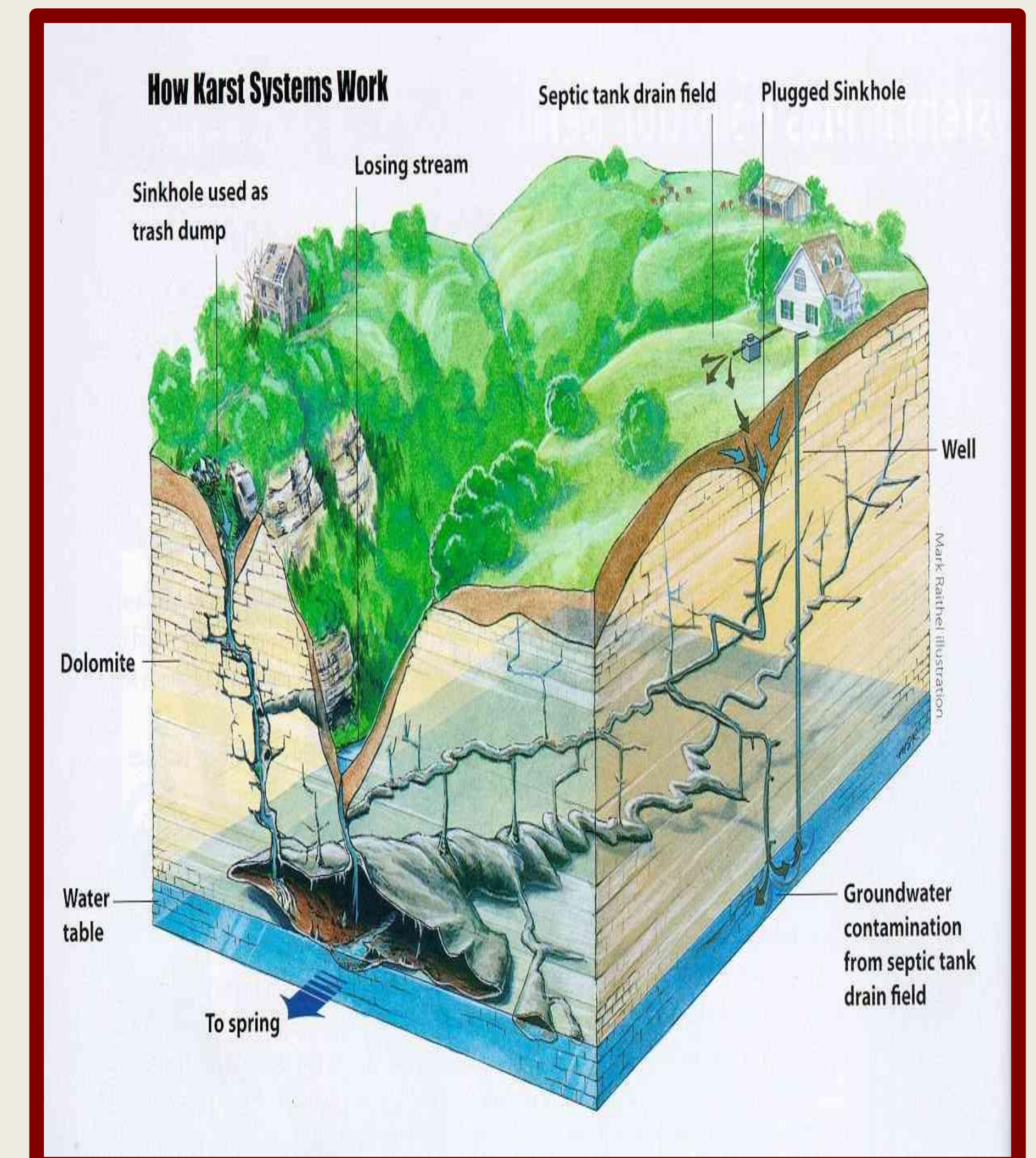
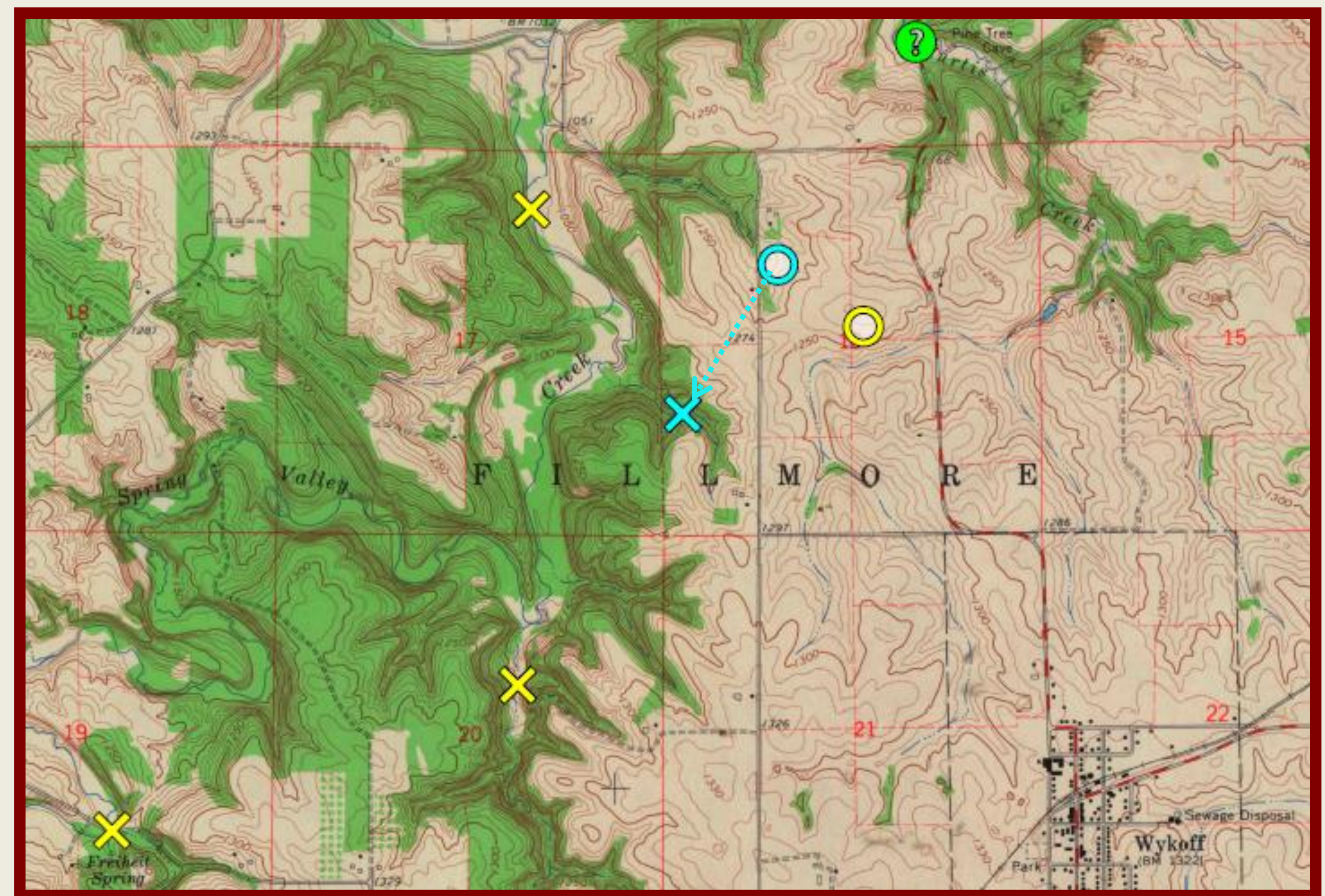


Illustration: Mark Raithe

Results



Legend

- Rhodamine WT dye input location
- Eosin dye input location
- × Rhodamine WT positive bug
- × Eosin dye positive bug
- ⊙ Detection of fluorescein from an unknown source

The Wykoff Northwest Dye trace that took place 20 July 2012 positively connected a springshed flow path shown in bright blue. The eosin dye shown in yellow has not yet been detected at a location where bugs are currently monitored. The bright green question mark is in reference to a bug that we were monitoring during the trace that tested positive for fluorescein dye. We did not use fluorescein during our dye trace. That detection is from another source of that dye, the source of which is currently unknown. Fluorescein is a dye widely used in automobile antifreeze and that could be the origin of the dye.

Acknowledgements

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