Karst Hydrogeology Investigations in the Cambrian St. Lawrence Aquitard

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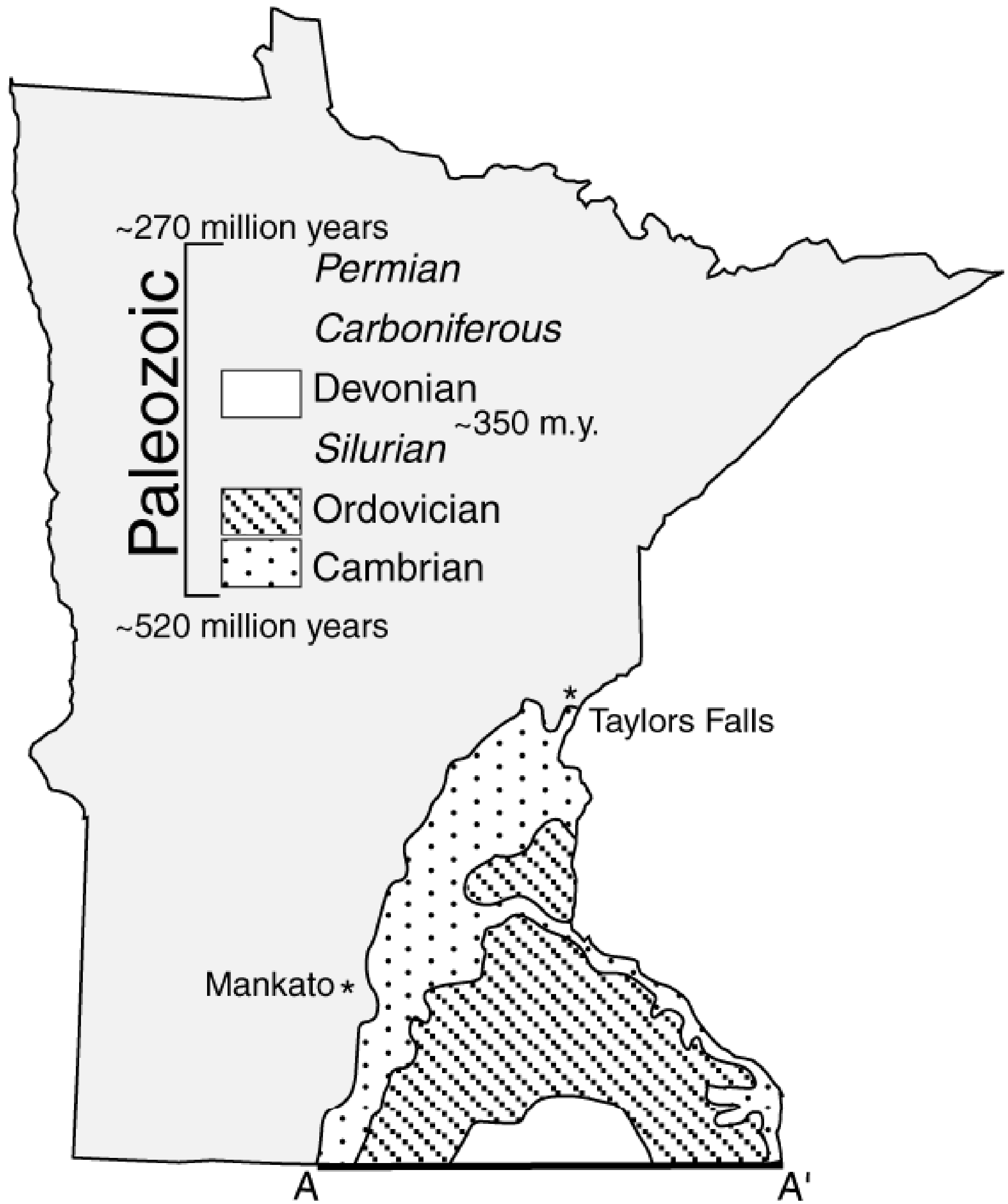
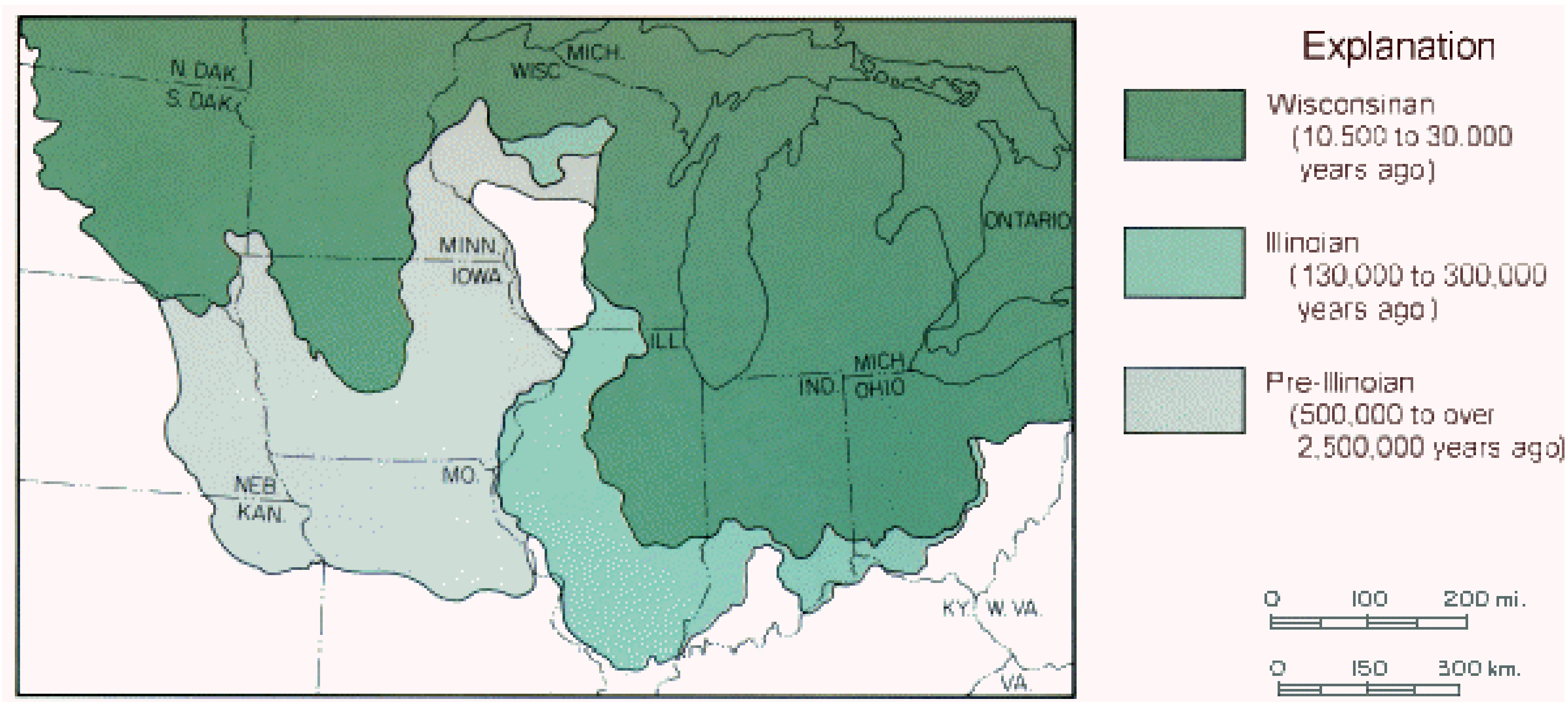
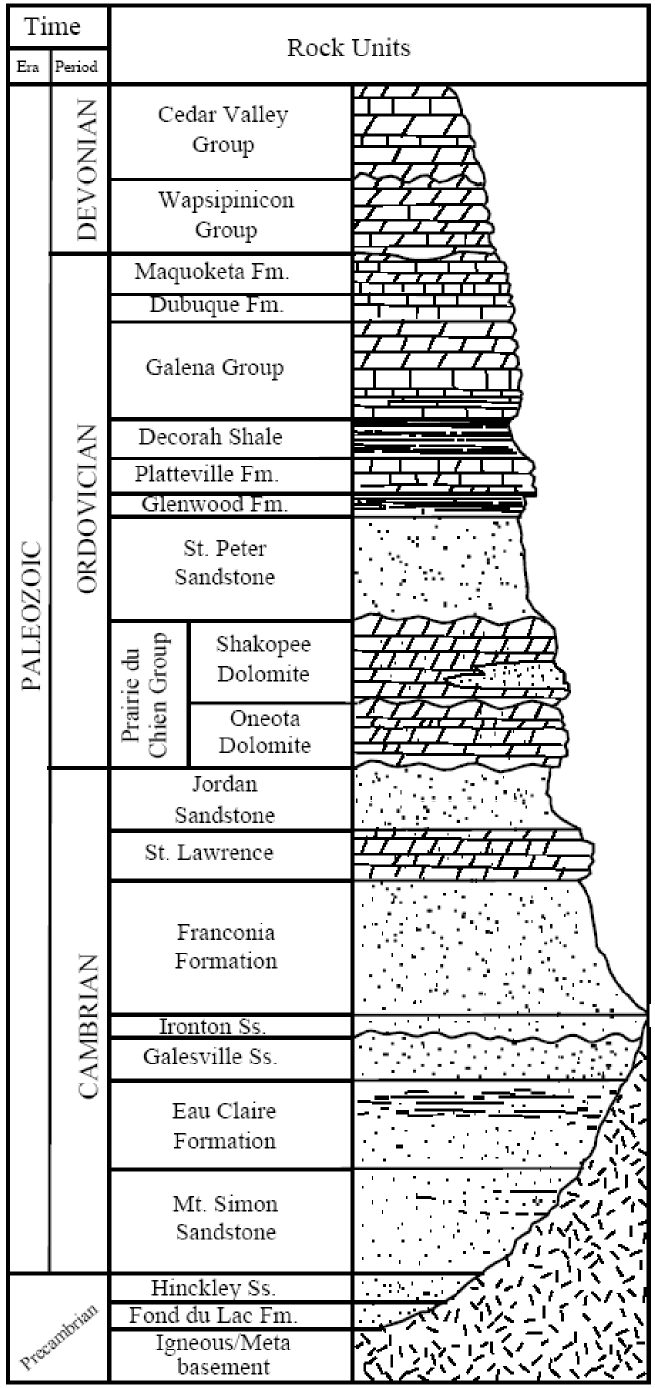
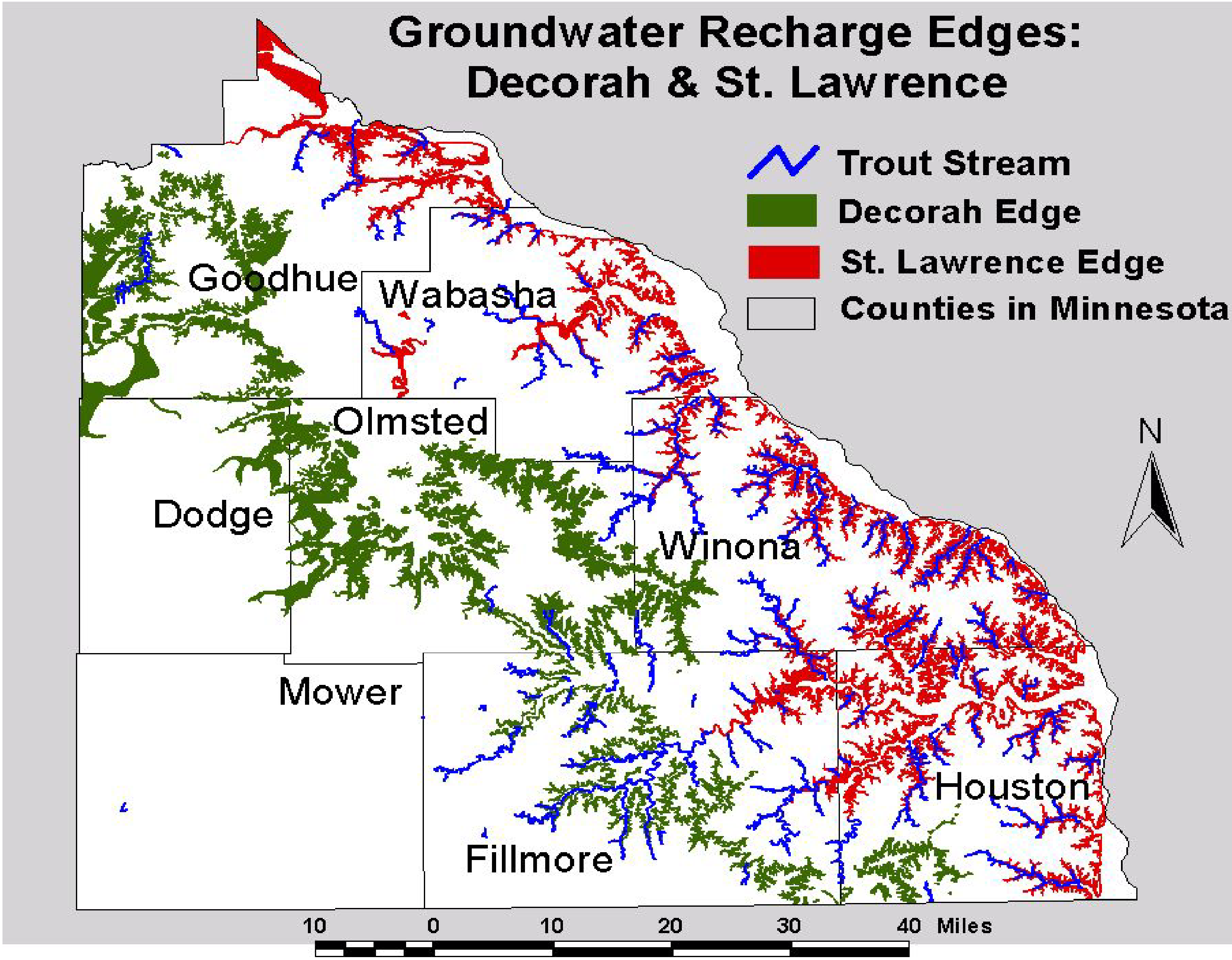

~270 million years
Paleozoic
Permian
Carboniferous
Devonian
~350 m.y.
Silurian
Ordovician
Cambrian
~520 million years
Taylors Falls
Mankato
A
A'


N. DAK.
S. DAK.
WISC.
MICH.
MINN.
IOWA
ILL.
ONTARIO
MICH.
IND.
OHIO
NEB.
KAN.
MO.
KY.
W. VA.
VA.
Explanation
Wisconsinan (10.500 to 30.000 years ago)
Illinoian (130,000 to 300,000 years ago)
Pre-Illinoian (500,000 to over 2,500,000 years ago)
0 100 200 mi.
0 150 300 km.


Time
Era
Period
Rock Units
PALEOZOIC
DEVONIAN
Cedar Valley Group
Wapsipinicon Group
ORDOVICIAN
Maquoketa Fm.
Dubuque Fm.
Galena Group
Decorah Shale
Platteville Fm.
Glenwood Fm.
St. Peter Sandstone
Prairie du Chien Group
Shakopee Dolomite
Oneota Dolomite
CAMBRIAN
Jordan Sandstone
St. Lawrence
Franconia Formation
Ironton Ss.
Galesville Ss.
Eau Claire Formation
Mt. Simon Sandstone
Precambrian
Hinckley Ss.
Fond du Lac Fm.
Igneous/Meta basement

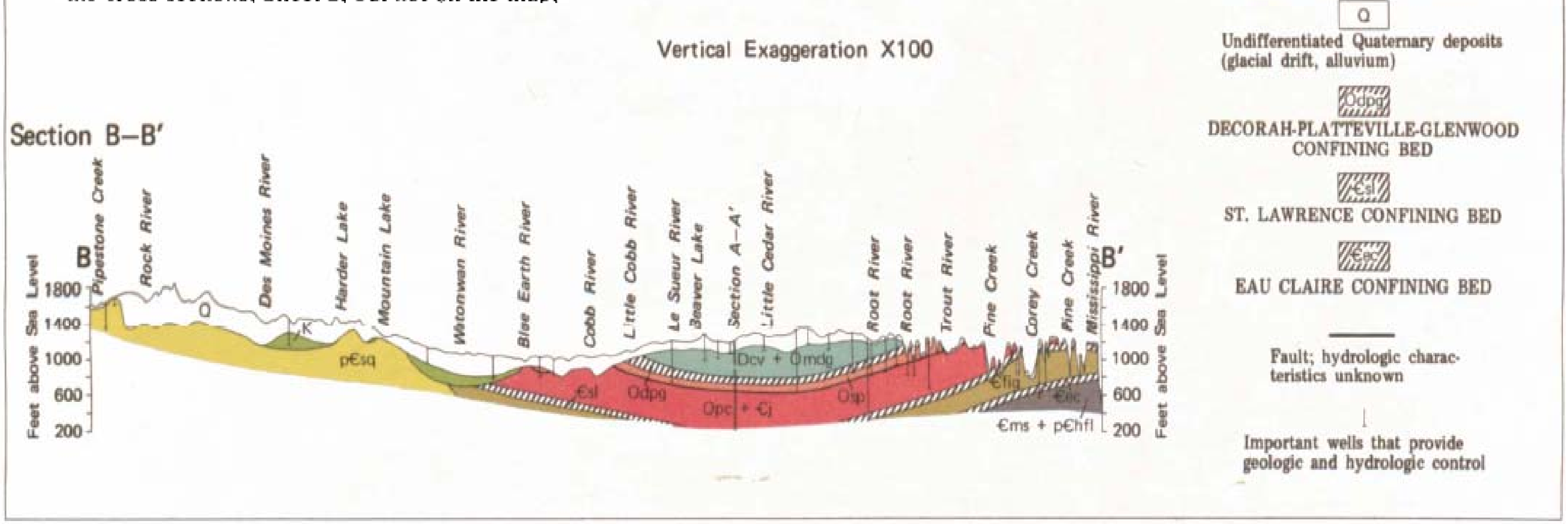


Numerous springs discharge from the Cambrian St. Lawrence formation. These springs help create a world-class trout fishery

St. Lawrence Confining Bed (€sl)

The St. Lawrence confining bed underlies the Prairie du Chien-Jordan aquifer. It is composed of dolomitic shale and siltstone, interfingered with fine-grained, quartzose sandstone, some of which is dolomitic and glauconitic. The formation contains some beds of dolomite. In some localities this formation yields a small amount of water (from 1 gpm to 25 gpm), but the sandstone in the formation is very fine grained and silty, and in general it acts as a confining bed. The maximum thickness of the St. Lawrence Formation is approximately 60 feet (18 m) (6). It is shown on the cross sections, Sheet 2, but not on the map,

The St. Lawrence was viewed as a confining unit (aquitard) based on its geology & the head differences in the units above & below it

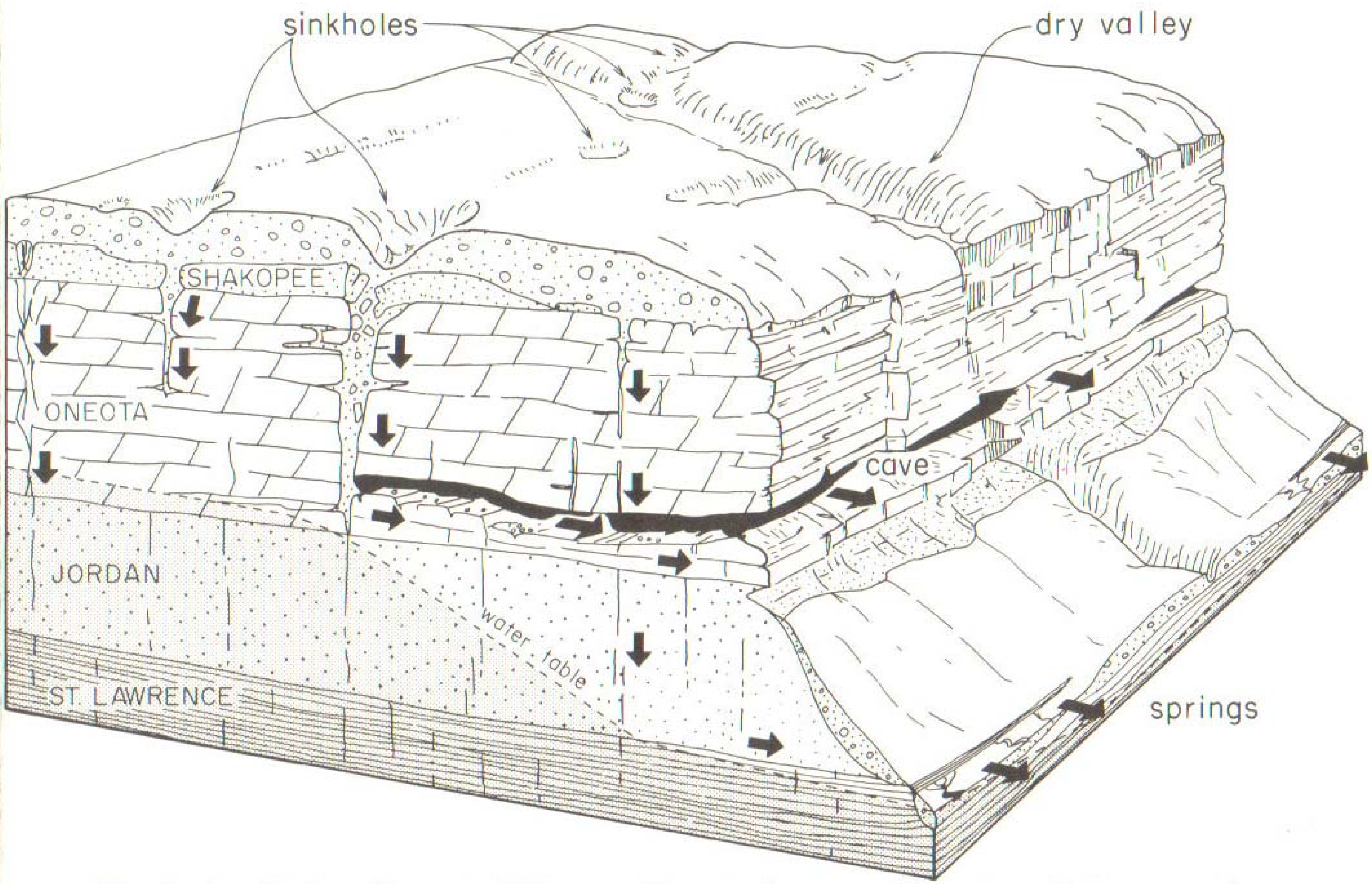


Hydrogeologic Map of Minnesota Bedrock Hydrogeology, Kanivetsky & Walton, 1978. Minnesota Geological Survey

Subp. 24a. **Confining layer.** "Confining layer" means a stratum of a geologic material that restricts vertical water movement. A confining layer includes:

C. a stratum at least ten feet in vertical thickness of the St. Lawrence or Eau Claire sedimentary bedrock formation, or a stratum at least two feet in vertical thickness of the Decorah or Glenwood sedimentary bedrock formation, as described in "Geology of Minnesota: A Centennial Volume" by Sims, P.K., and Morey, G.B., pages 459-473, "Paleozoic Lithostratigraphy of Southeastern Minnesota" by George Austin, which is incorporated by reference. The publication is available at the Minnesota Geological Survey, Minnesota Department of Health, or through the Minitex interlibrary loan program.

St. Lawrence Formation consists of interbedded dolostone, siltstone and shale. Considered to be a confining unit.

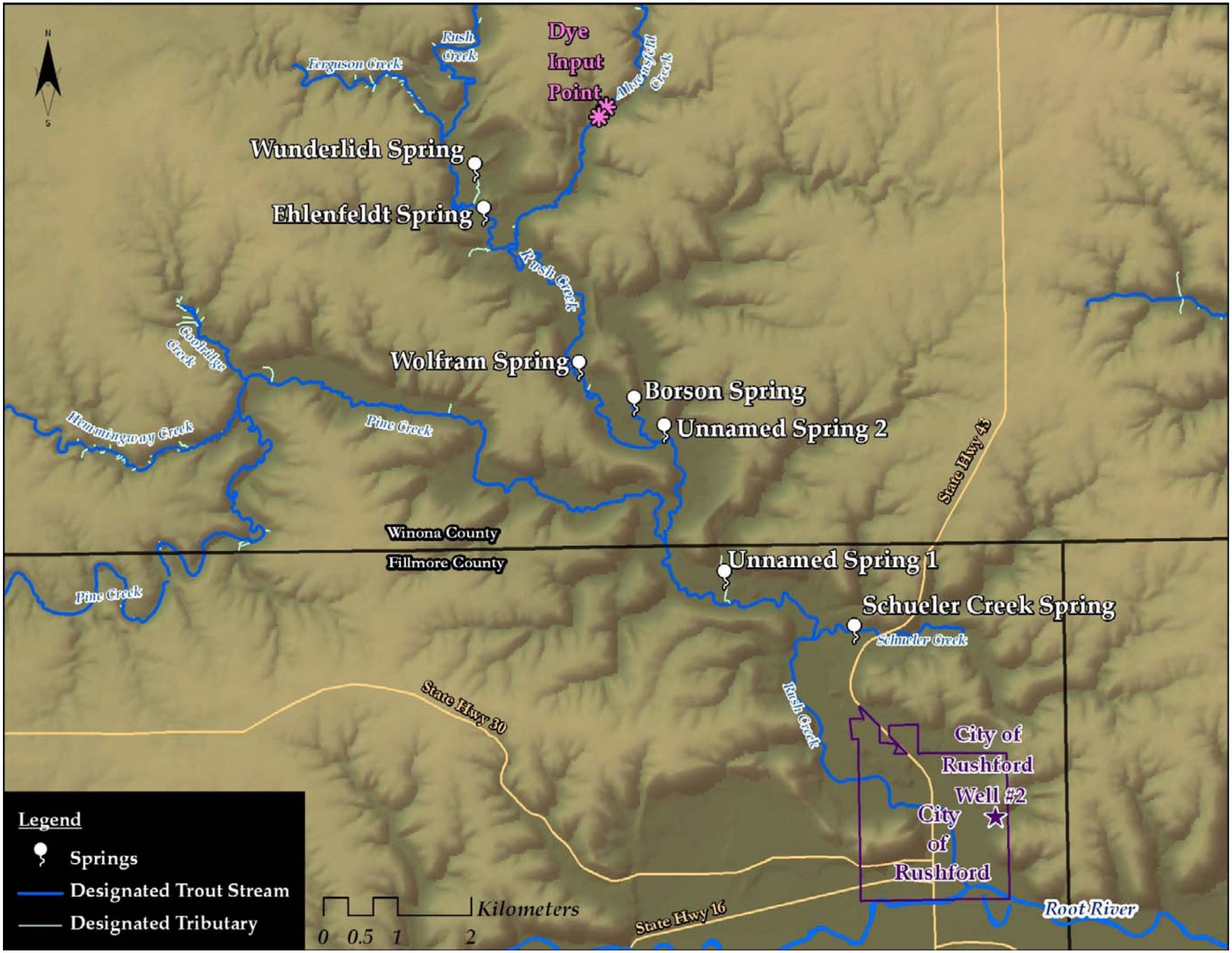


Typical relationships in Winona County between karst and topography

The fact that springs discharge from the St. Lawrence has been known for several decades. This block diagram is from the Winona County Geologic Atlas karst plate published by the MGS in 1984.

Dye Tracing Investigations

- The tracing work was done begin to define the springsheds (contribution areas) of St. Lawrence springs
- The traces were run using passive charcoal detectors (bugs) for collecting samples
- The dyes used were Uranine C (Fluorescein), Eosin and Rhodamine WT
- Analysis of the bugs was done at the University of Minnesota Dept. Of Earth Science using a Shimadzu scanning spectrofluorophotometer

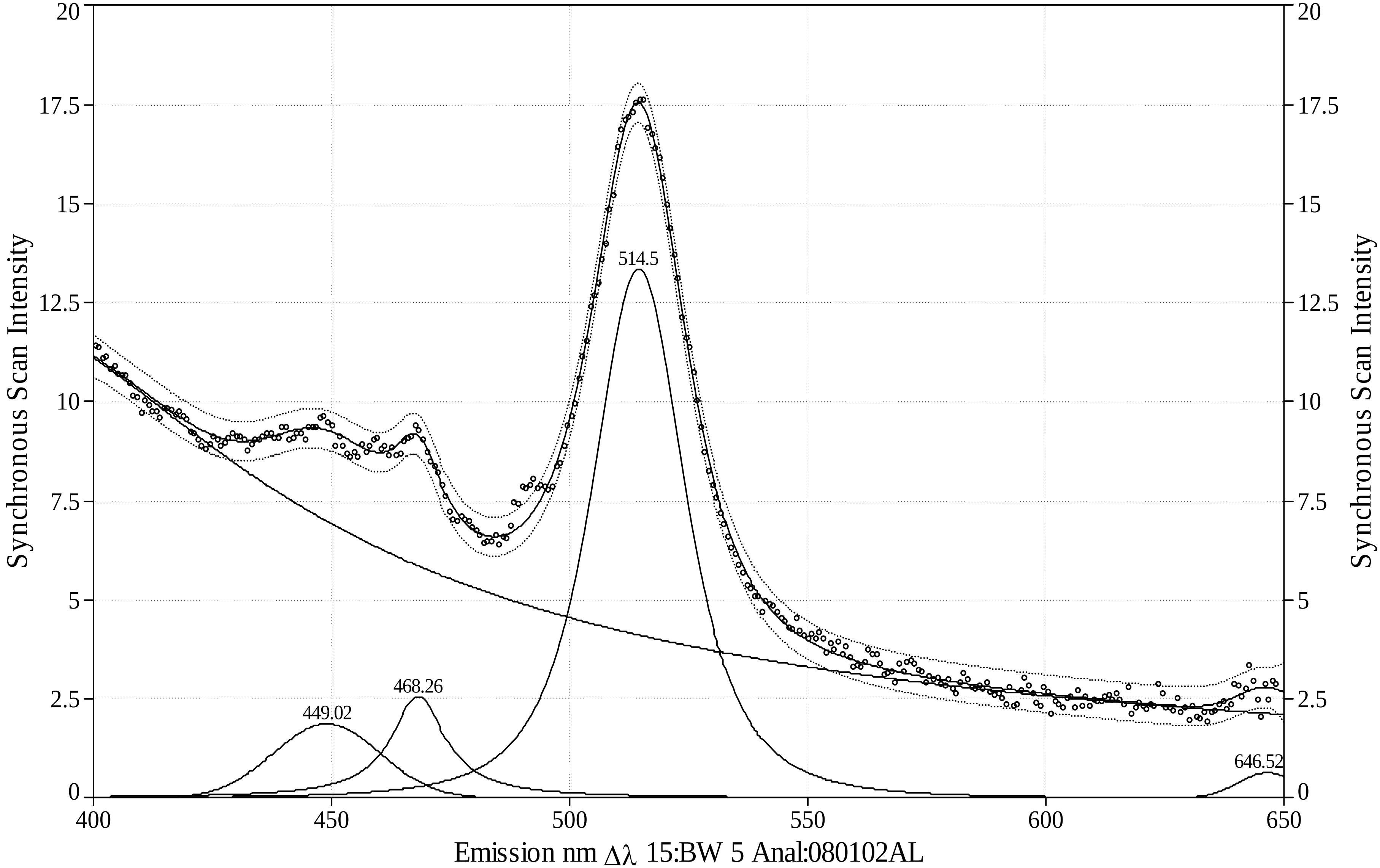

N
S
Dye
Input
Point
Rush
Creek
Ferguson Creek
Wunderlich Spring
Ehlenfeldt Spring
Rush Creek
Coolridge
Creek
Wolfram Spring
Borson Spring
Unnamed Spring 2
Hemmingway Creek
Pine Creek
State Hwy 43
Winona County
Fillmore County
Unnamed Spring 1
Pine Creek
Schueler Creek Spring
Schueler Creek
State Hwy 30
Rush Creek
City of
Rushford
Well #2
City
of
Rushford
Legend
Springs
Designated Trout Stream
Designated Tributary
Kilometers
0 0.5 1 2
State Hwy 16
Root River

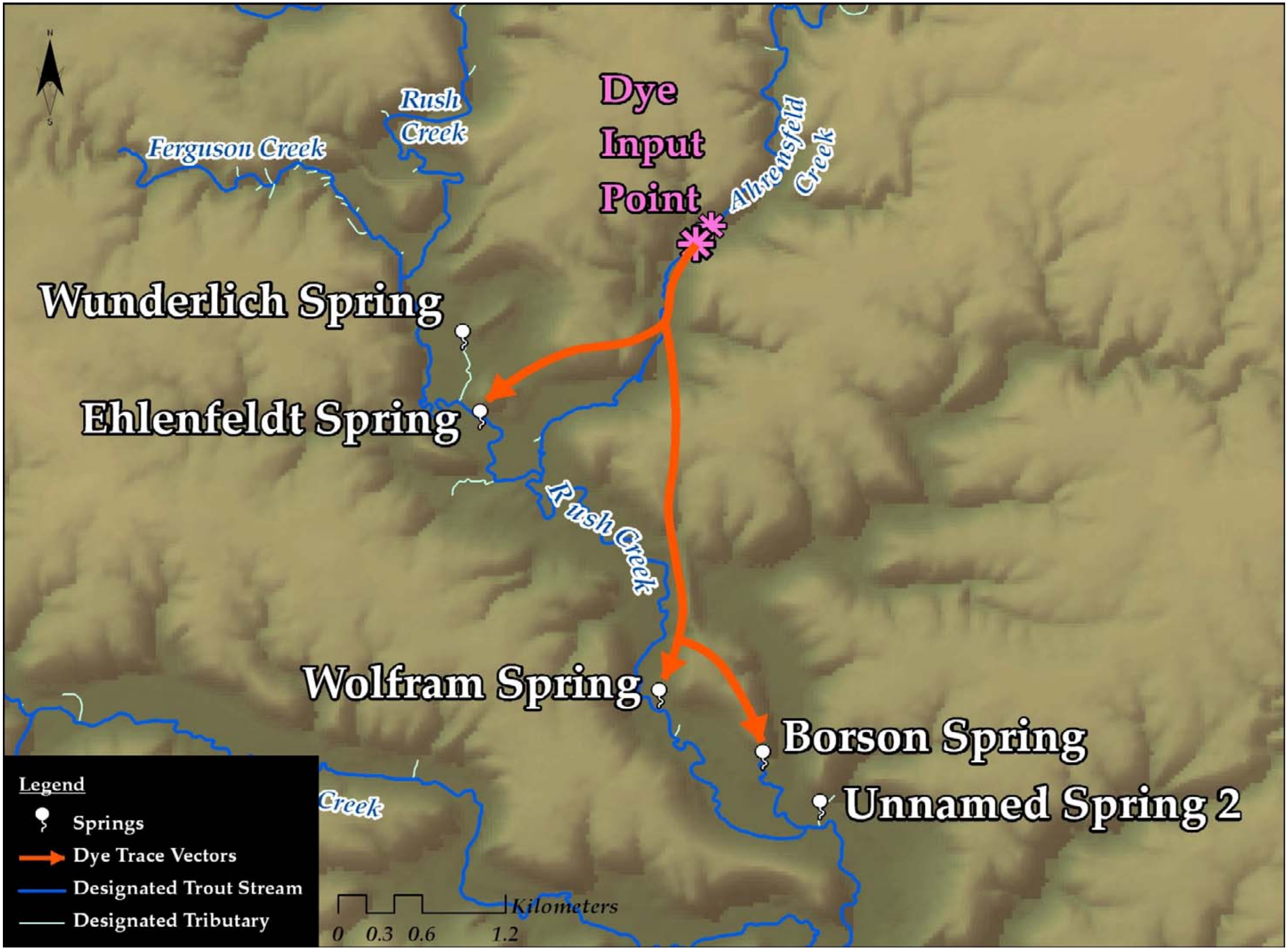

11. 1. 2007

LCCMR, Carbon, BorsonSpring(85:A255), In:071115 1200, Out:071123 1200

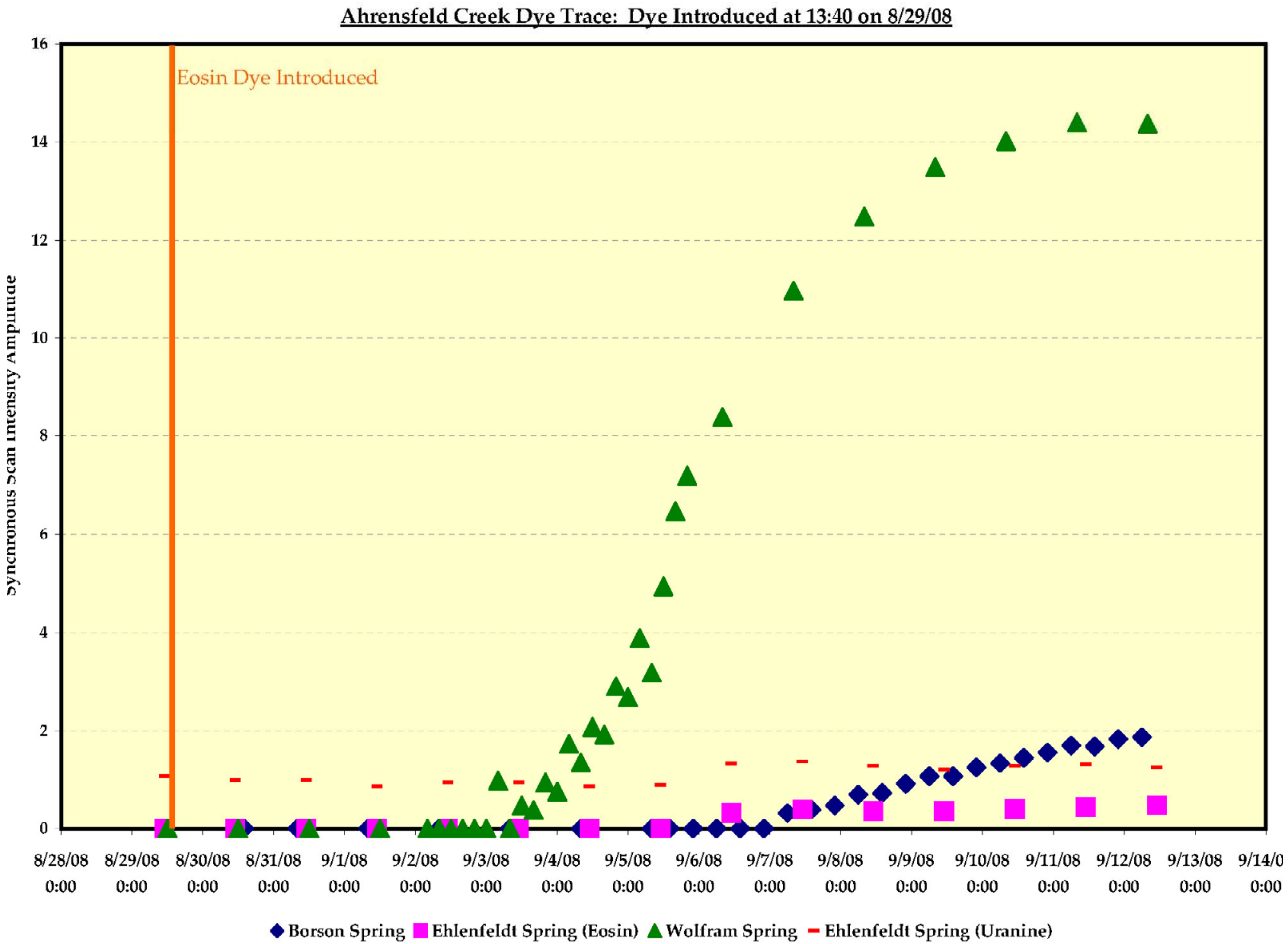
Pk=Pearson VII Area 5 Peaks

r^2=0.996509 SE=0.240411 F=4371.64





Dye
Input
Point
Rush
Creek
Ferguson Creek
Ahrensfeld
Creek
Wunderlich Spring
Ehlenfeldt Spring
Rush Creek
Wolfram Spring
Borson Spring
Unnamed Spring 2
Creek
Legend
Springs
Dye Trace Vectors
Designated Trout Stream
Designated Tributary
Kilometers
0
0.3
0.6
1.2

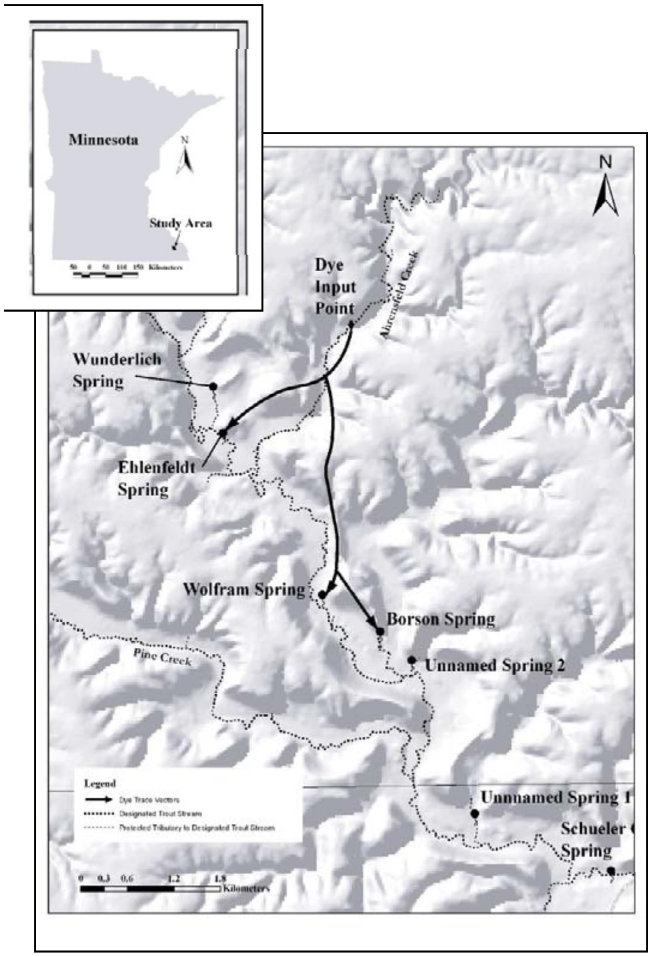

Ahrensfeld Creek Dye Trace: Dye Introduced at 13:40 on 8/29/08
Eosin Dye Introduced
Synchronous Scan Intensity Amplitude
16
14
12
10
8
6
4
2
0
8/28/08 0:00
8/29/08 0:00
8/30/08 0:00
8/31/08 0:00
9/1/08 0:00
9/2/08 0:00
9/3/08 0:00
9/4/08 0:00
9/5/08 0:00
9/6/08 0:00
9/7/08 0:00
9/8/08 0:00
9/9/08 0:00
9/10/08 0:00
9/11/08 0:00
9/12/08 0:00
9/13/08 0:00
9/14/0 0:00
Borson Spring
Ehlenfeldt Spring (Eosin)
Wolfram Spring
Ehlenfeldt Spring (Uranine)

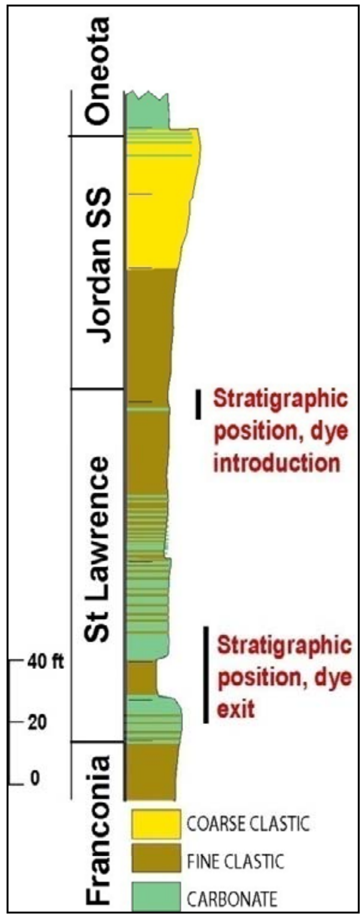
Site	Breakthrough Flow Speeds	Sample Type
Ahrensfeld 1	150-300 m/day Dye input 1 Nov. 2007- (dye detected at the springs 2+ years later)	Charcoal detector
Ahrensfeld 2	400-600 m/day Dye input 29 Aug. 2008. Dye detected with charcoal samplers 1+ year later	Direct Water Sample
Kiefer Valley	260-580 m/day	Charcoal detector
Daley Creek	180-360 m/day	Charcoal detector
Sullivan Creek	35-240 m/day	Charcoal detector
Borson Northeast	75-110 m/day	Charcoal detector
Indian Springs Creek	80-285 m/day	Charcoal detector

St. Lawrence Dye Trace Sites and Flow Speeds

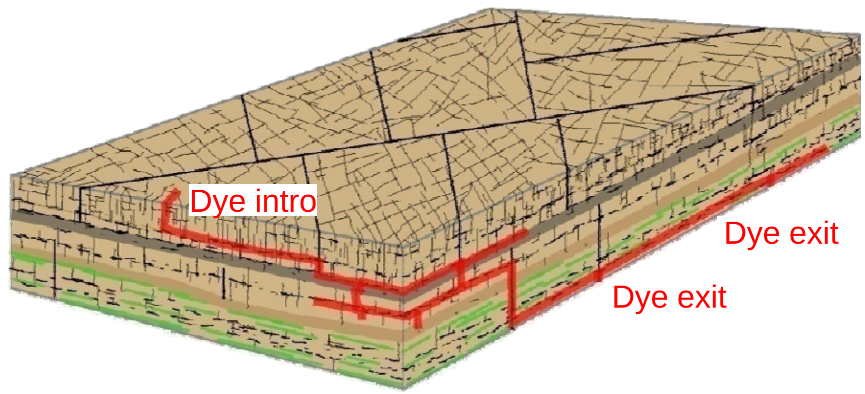
IMPLICATIONS OF VERTICAL AND BEDDING PLANE FRACTURES IN AQUITARDS:

ST LAWRENCE AQUITARD: RECENT DYE TRACE (Jeff Green, MNDNR; Green and others, 2008; and Green and others, in review)





-Horizontal flow speed, 100’s meters/day
-Vertical flow speed, meters/day



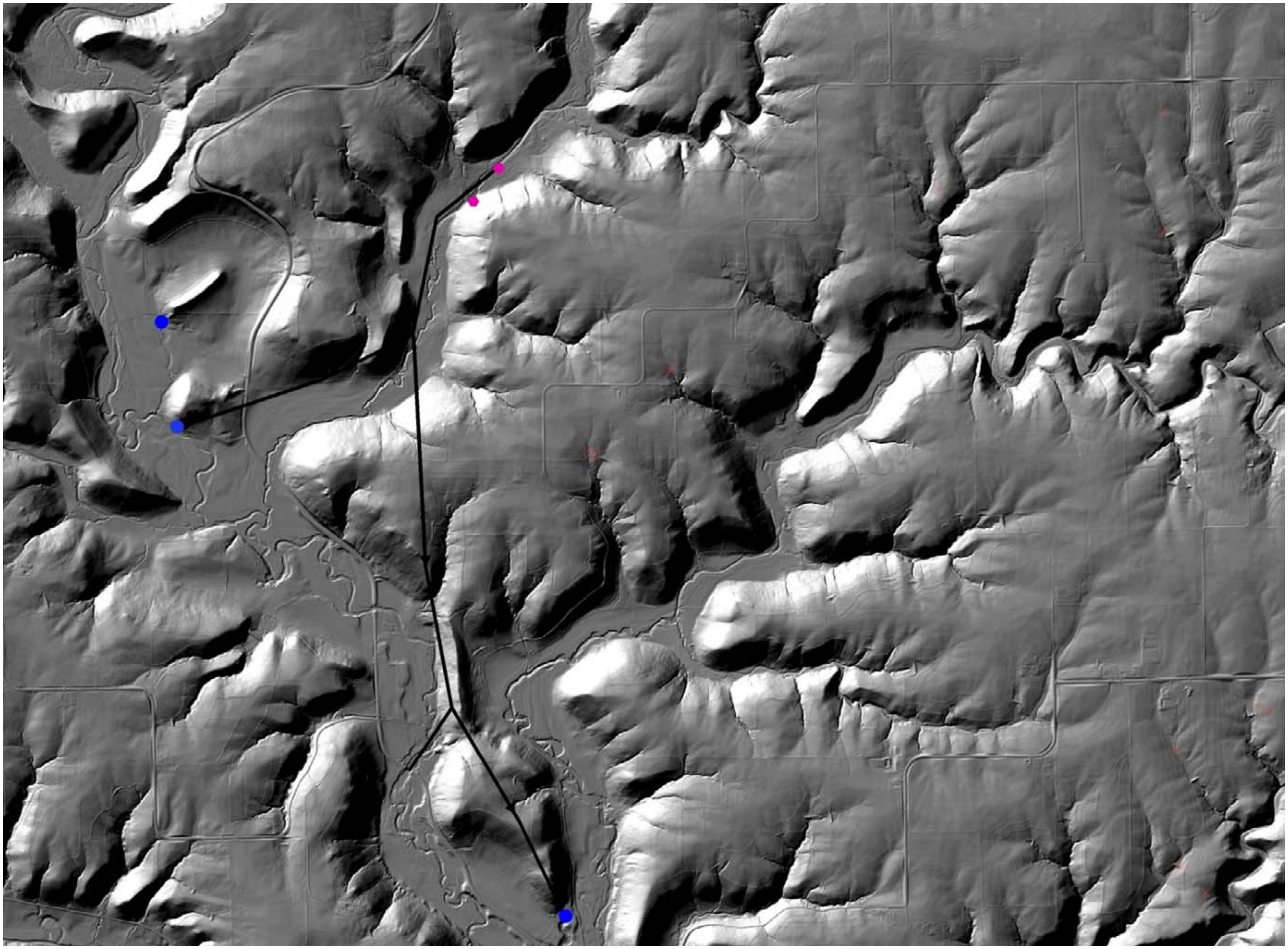
Wolfram spring

Borson spring

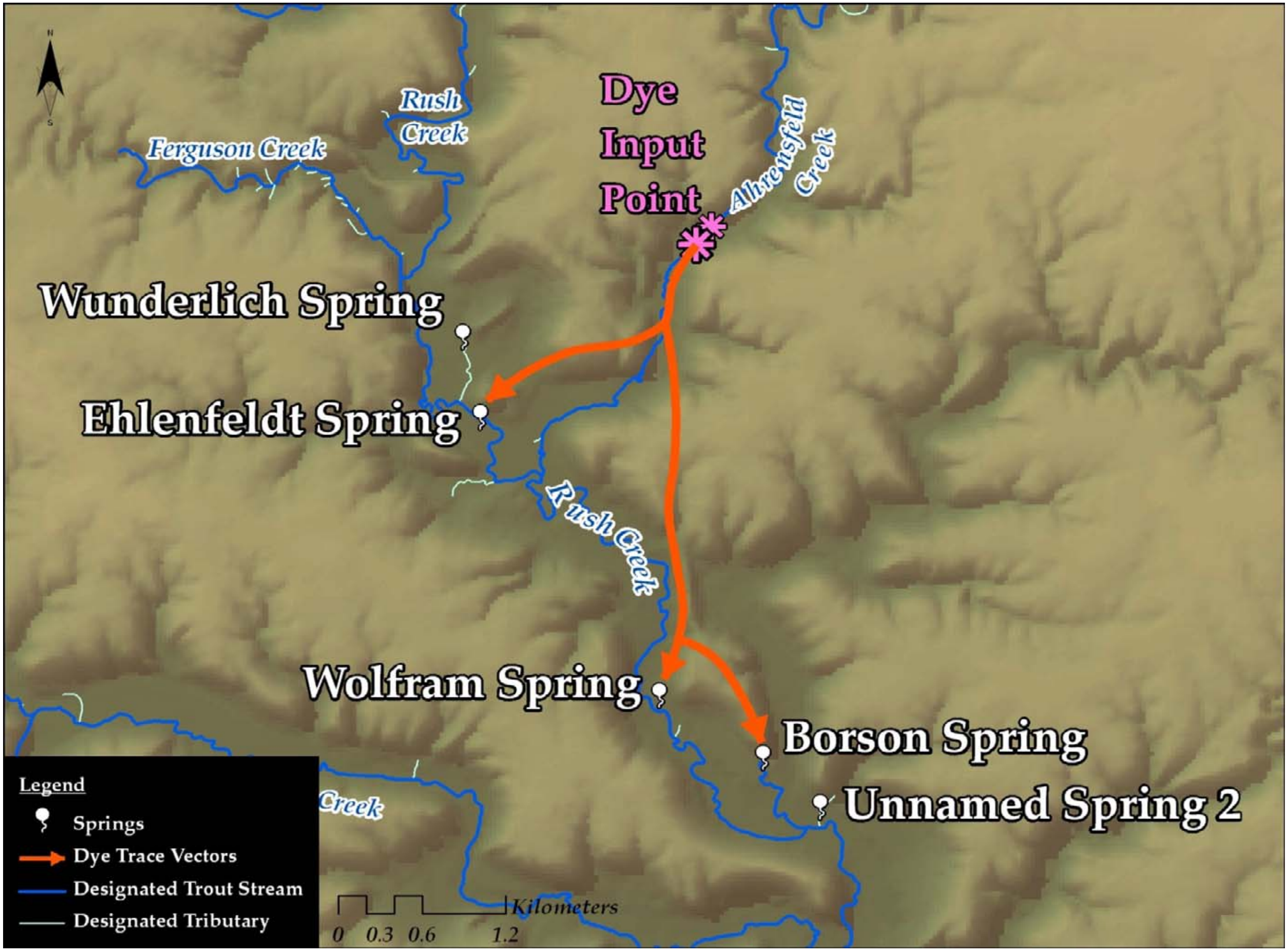
Classic Karst Stream Sink

St. Lawrence stream sinks do not look like classic karst features.

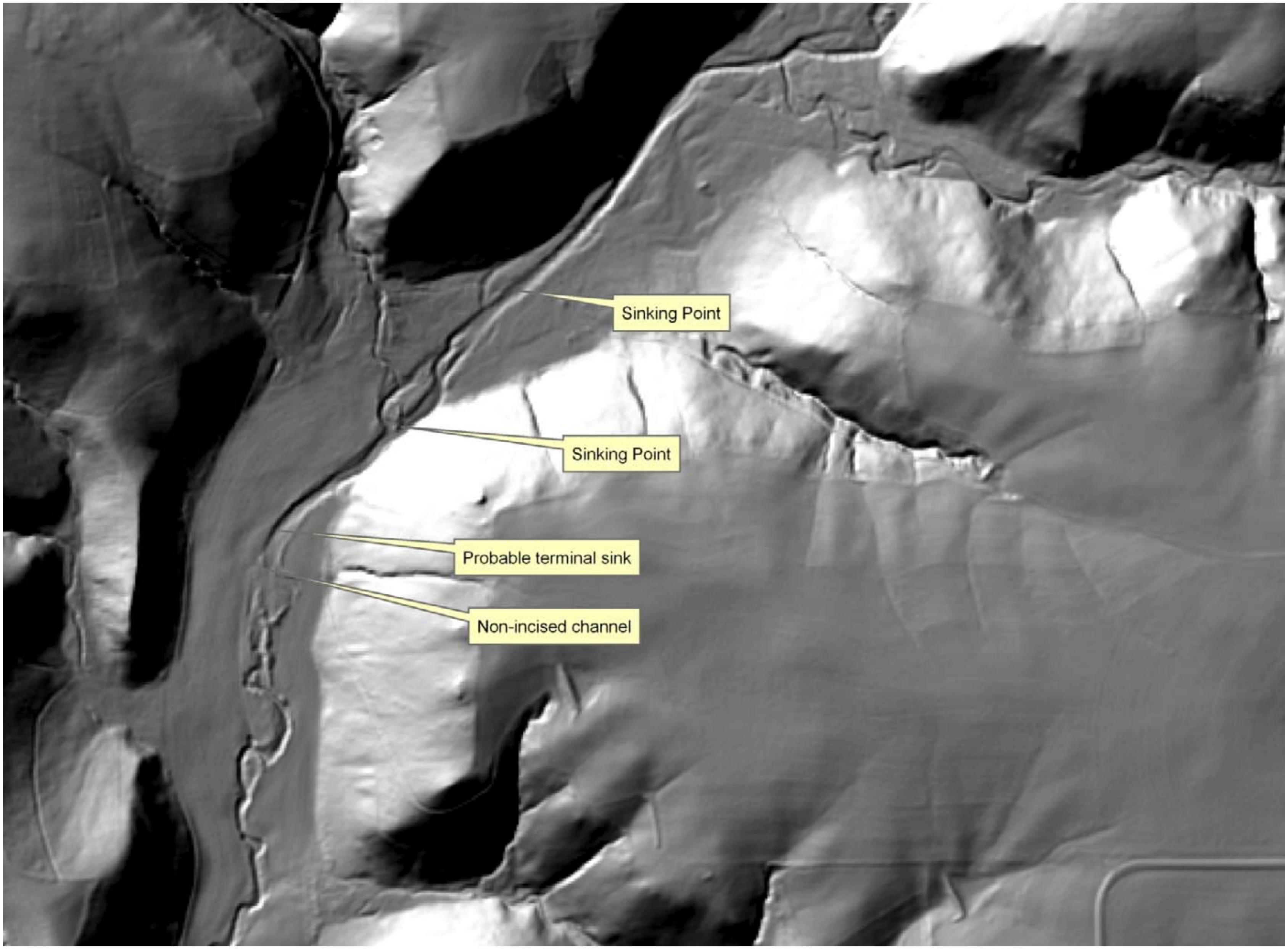
Kiefer Valley, Whitewater WMA



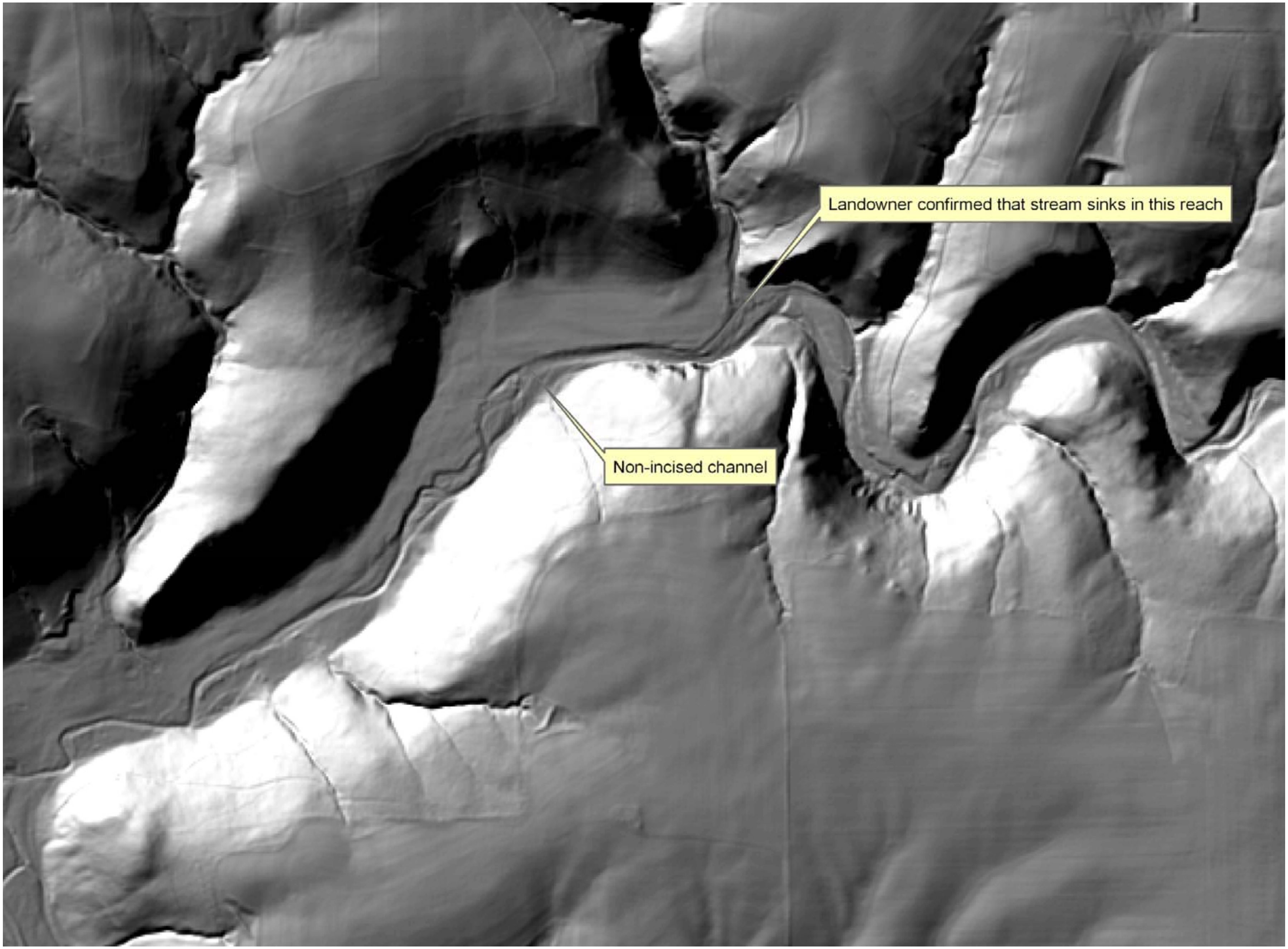
LiDAR imagery is being used to locate more sinking points

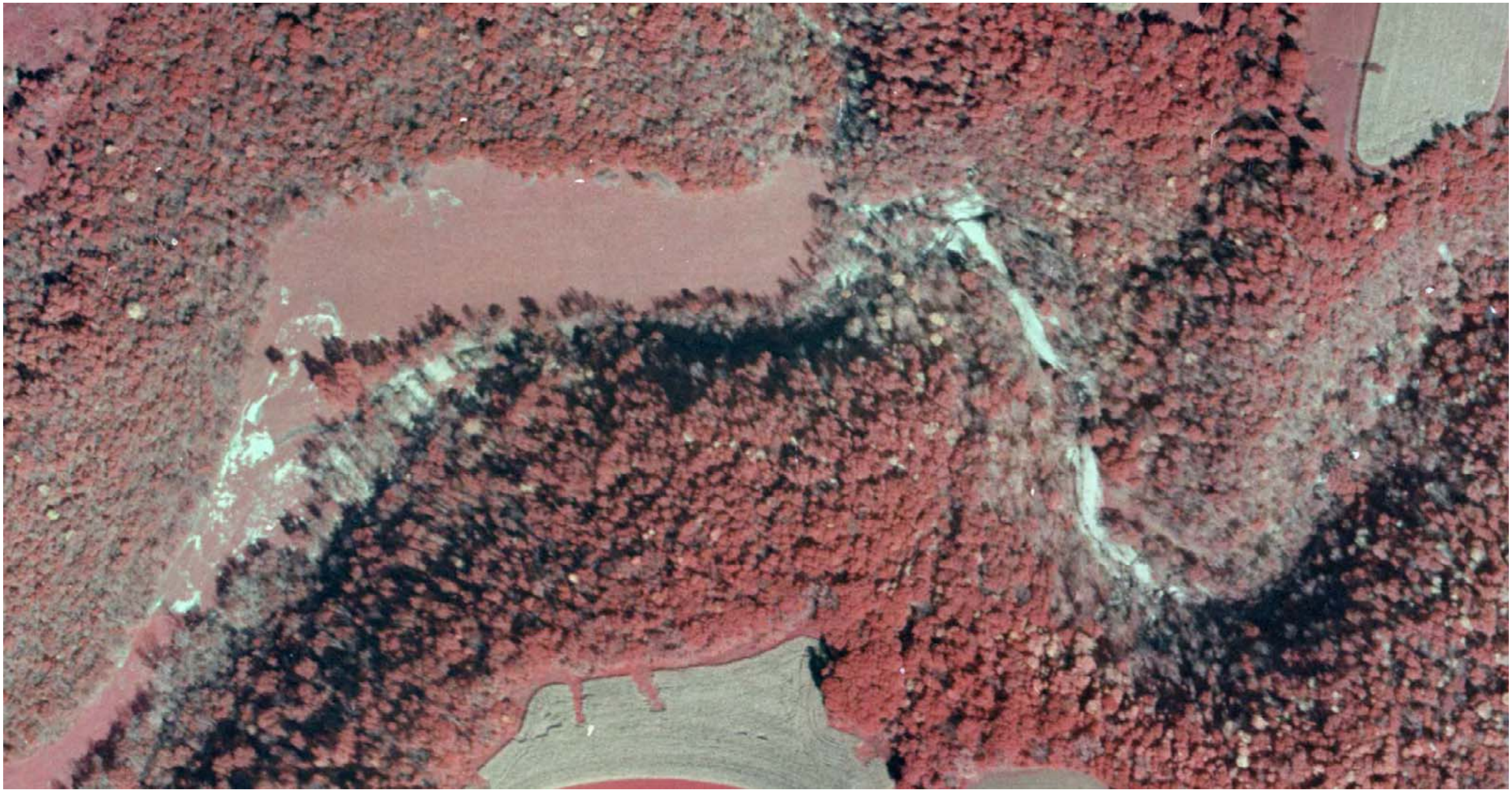


Large valley to the east with no flowing stream at valley mouth



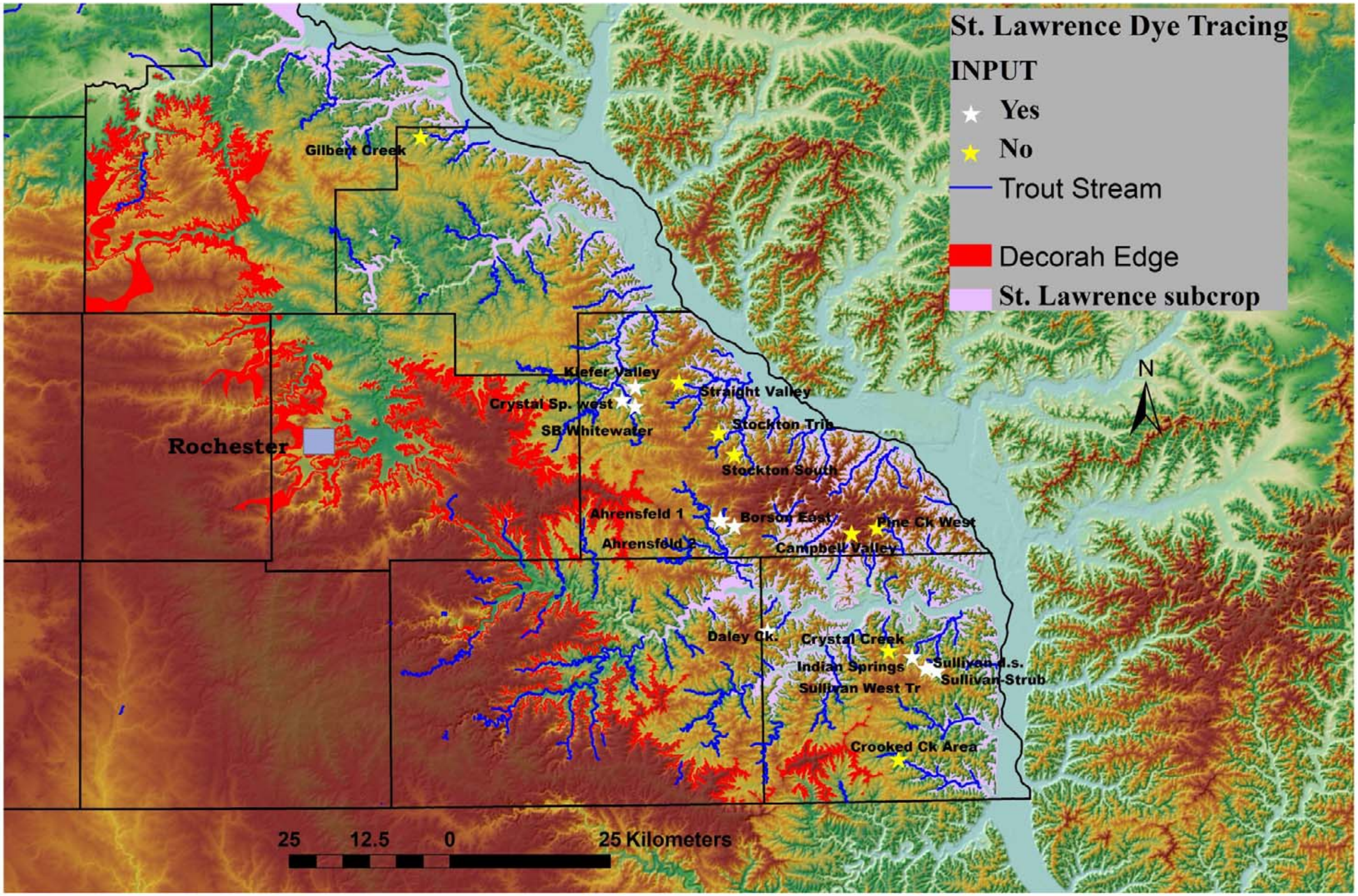
LiDAR at the first St. Lawrence dye tracing points


Landowner confirmed that stream sinks in this reach
Non-incised channel



Borson NE site. DNR CIR photo

2011 50 cm CIR



The geographic distribution of these sites indicate that this is a regional phenomenon

Conclusions

The St. Lawrence Formation has a conduit flow component

Our view that St. Lawrence springs had some measure of separation from direct surface impacts is not correct

Land and water management decisions in the uplands above the St. Lawrence sinking points will affect groundwater quality

The distribution of St. Lawrence sinking streams indicate that this is a regional phenomenon

LiDAR and Aerial Photographs (particularly CIR) are valuable tools for identifying distinctive St. Lawrence features


Questions?