

# *Frego Creek Spring 2009 Dye Trace*

March 6, 2009 to May 5, 2009

Jeffrey A. Green, Andrew J. Peters<sup>1</sup>, Andrew J. Luhmann<sup>2</sup>,  
E. Calvin Alexander, Jr.<sup>2</sup> and Scott C. Alexander <sup>2</sup>

<sup>1</sup> Minnesota Department of Natural Resources, Division of Waters, 2300 Silver Creek Road NE,  
Rochester, Minnesota, 55906; Phone (507) 285-7430; Fax (507) 285-7144;  
emails: jeff.green@dnr.state.mn.us & andrew.peters@dnr.state.mn.us

<sup>2</sup> Geology & Geophysics Department, University of Minnesota, 310 Pillsbury Drive. SE.,  
Minneapolis, Minnesota, 55455; Phone (612) 624-3517; Fax (612) 625-3819;  
emails: luhm0031@umn.edu, alexa001@umn.edu & alexa017@umn.edu

## Introduction

A dye trace was conducted in an area near the city of Canton, Minnesota from March 6, 2009 to May 5, 2009. Dye traces have been completed in this area in the past and this effort was made to further refine delineation the springsheds in this area due to the close proximity of Frego Creek, a Minnesota designated trout stream. Much of the city of Canton's stormwater flows to sinkholes throughout the city limits and some just outside of city limits. Achieving a better understanding of the connection of these sinkholes receiving this stormwater flow and their connectivity to springs that provide a cold water source for Frego Creek was the goal of this trace.

Dye tracing entails using fluorescent dyes to track groundwater flow directions and travel times. The dye is poured into a sinkhole or sinking stream; from there, it flows through the karst conduit system until it re-emerges at a spring. For this project, the dyes used were Uranine, Eosine, and Rhodamine WT. Both direct water samples and passive dye detectors were used for sample collection and all the samples were analyzed at the University of Minnesota Geology Department using a scanning spectrofluorophotometer. The traces were designed and executed by Jeff Green and Andrew Peters of MNDNR Waters. E. Calvin Alexander, Jr., Andrew Luhmann, and Scott Alexander of the University of Minnesota Geology Department performed the sample analysis and interpretation.

## Results

The MNDNR Waters and the Fillmore County SWCD had previously contacted the landowners who owned the relevant sinkholes and springs. Prior to dye injection, bugs had been placed at all the sampling points to determine background levels of dyes. The dye trace was run on March 6, 2009, using runoff from melting snow. Table 1 summarizes the dye input information.

Dye Inputs				
Dye Input Point	Dye (type, quantity)	Time	Runoff (Est.)	Dye Detection Point
Sinkhole 23:D7964	Eosine, 509.96 grams	15:46 hrs.	8-16 G.P.M.	Spring A445 (A632)
Sinkhole 23:D7648	Rhodamine WT, 485.96 grams	15:26 hrs.	10-15 G.P.M.	Spring A445 (A632)
Sinkhole 23:D7963	Uranine, 506.14 grams	15:04 hrs.	10-20 G.P.M.	Spring A445 (A632)

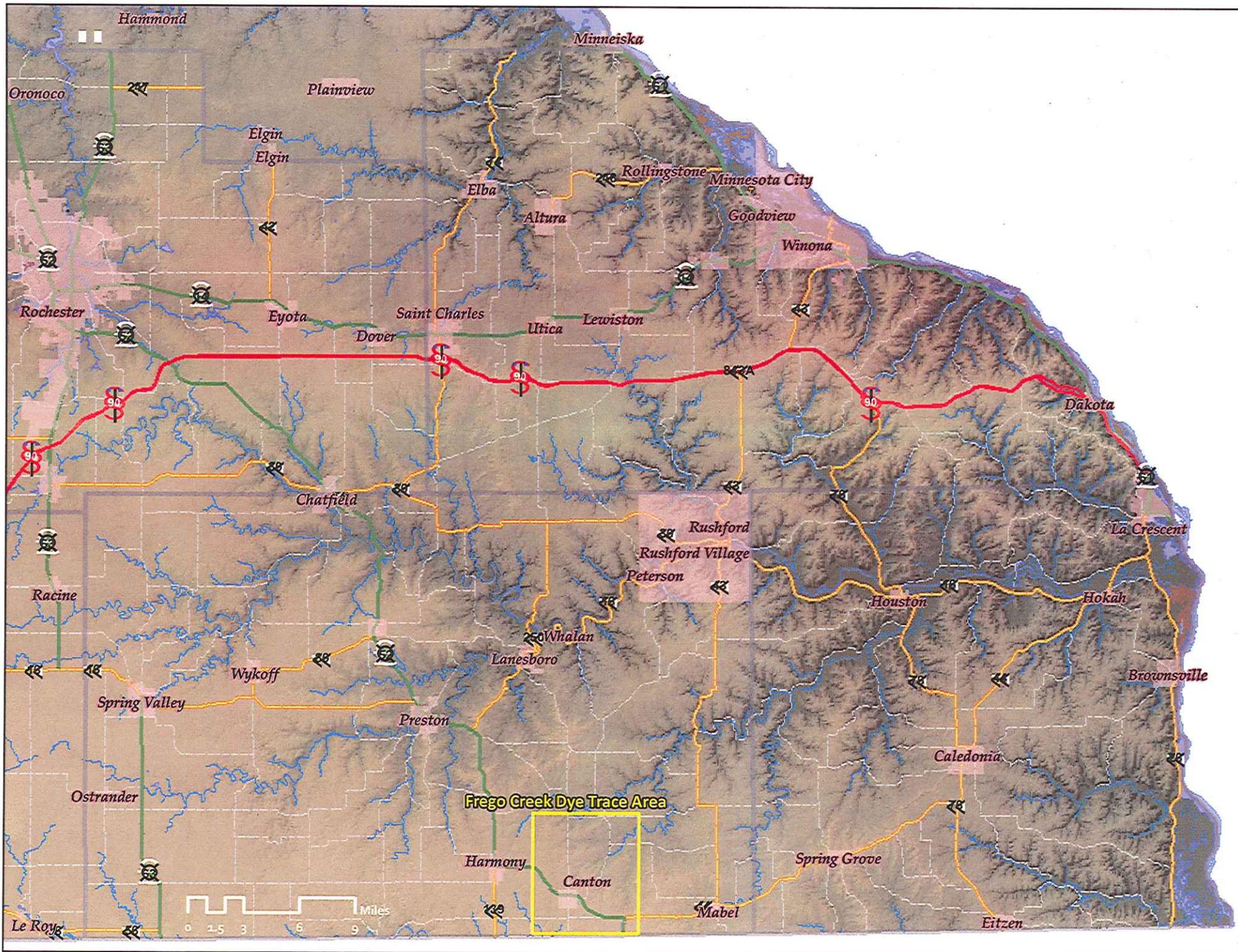
**Table 1: Dye Inputs, Frego Creek Dye Trace, Canton, Minnesota**

Dye receptors were in place at all sampling locations from March 6<sup>th</sup> until May 5<sup>th</sup>. All three dyes were detected at levels high enough for positive identification. The dyes, Eosine, Rhodamine WT and Uranine, were detected in the charcoal detectors no more than 10 days later. This translates to a groundwater flow rate range of no greater than approximately 775 feet to 988 feet per day. This is consistent with previous traces in this geologic setting (Ordovician Galena limestone).

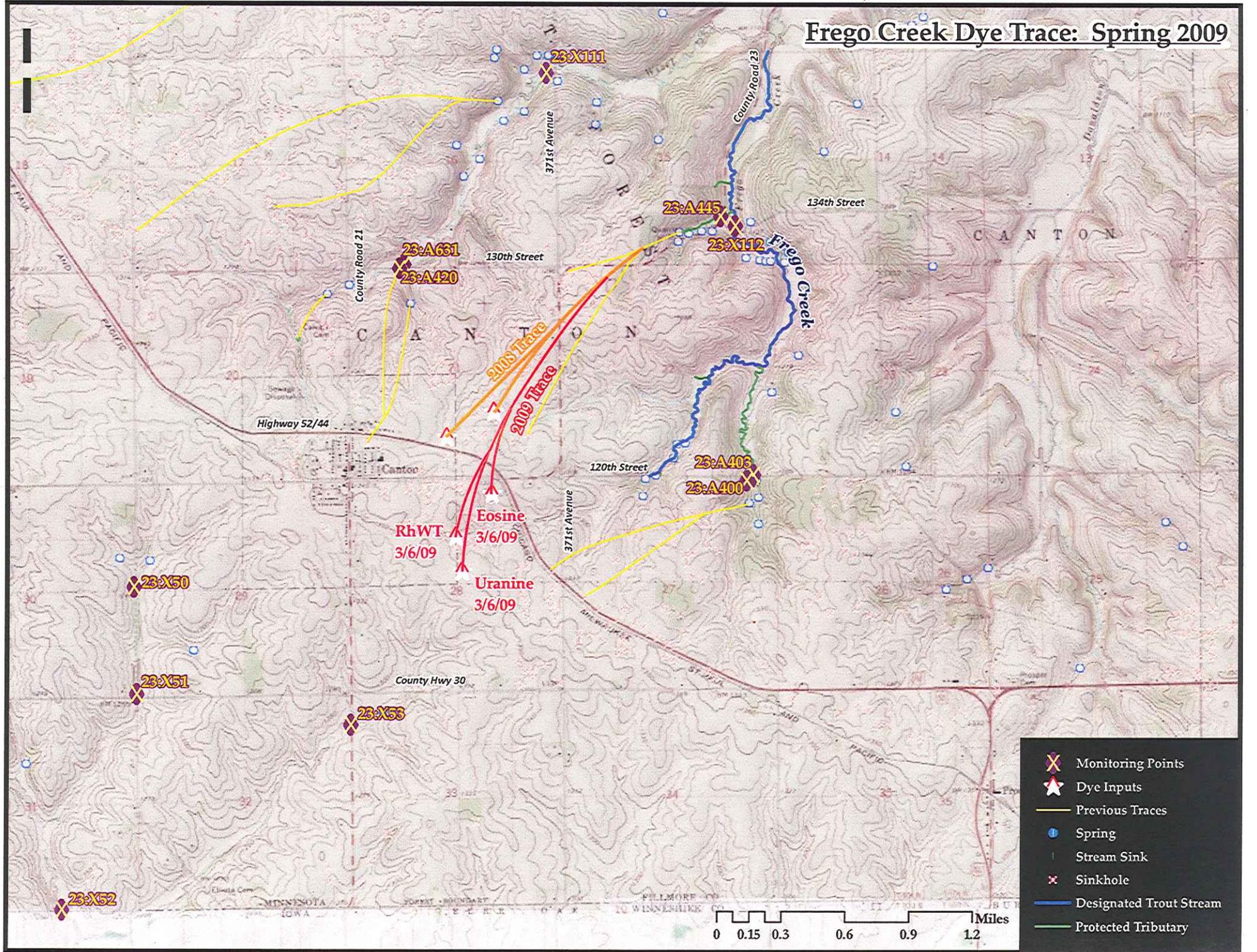
The dye points and connections from this dye trace in addition to previously completed traces are shown in Figure 2. Through this triple trace, we have further delineated the springshed feeding Spring A445 (A632). There are several springs visible in the immediate area of A445 (A632) but they all feed the same coldwater tributary to Frego Creek. The new trace from these sinkholes that was detected in the flow from the springs in this area has expanded the known boundaries of that springshed.

## Appendix 1

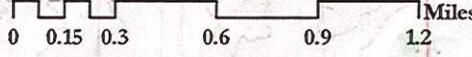
### Figures



# Frego Creek Dye Trace: Spring 2009



-  Monitoring Points
-  Dye Inputs
-  Previous Traces
-  Spring
-  Stream Sink
-  Sinkhole
-  Designated Trout Stream
-  Protected Tributary



## Appendix 2

### Dye Input

## *Frego Creek Spring 2009 Dye Trace: March 6, 2009 to May 5, 2009*

### *Dye Input Points:*

#### Input Point #1:

Sinkhole D:7964

Minnesota Karst Feature Database Number - MN23:D7964

UTM:

587,581 E, 4,820,094 N

Township, Range, Section:

NW ¼ of the NE ¼ of Section 28, T101N, R9W

Elevation:

~1320 feet

At 1546 CDT on 3 March 2009, approximately 510 grams of Eosine dye solution was introduced into an open swallow hole in D7964 during flow of approximately 8-16 gallons per minute of snow melt runoff into the swallow hole.

#### Input Point #2:

Sinkhole D7648:

Minnesota Karst Feature Database Number - MN23:D7648

UTM:

587,308 E, 4,819,765 N

Township, Range, Section:

SW ¼ of the NE ¼ of Section 28, T101N, R9W

Elevation:

~1330 feet

At approximately 1526 CDT on 3 March 2009, approximately 486 grams of Rhodamine WT dye solution was introduced into an open swallow hole in D7648 during flow of approximately 10-15 gallons per minute of snow melt runoff into the swallow hole.

#### Input Point #3:

Sinkhole D7963:

Minnesota Karst Feature Database Number - MN23:D7963

UTM:

587,357 E, 4,819,503 N

Township, Range, Section:

SW ¼ of the NE ¼ of Section 28, T101N, R9W

Elevation:

~1345 feet

At approximately 1504 CDT on 3 March 2009, approximately 506 grams of Uranine dye solution was introduced into an open swallow hole in D7963 during flow of approximately 10-20 gallons per minute of snow melt runoff into the swallow hole.

3/6/09: Fuge Pow - 50°F, Sunny

Powr #1: Uranine 4819503, 587357

Lot: 041808C 506.14 gm

1504 poured

10-20 gpm

Chromatint, Uranim-HS \*into swallet.

Powr #2: Rh WT 4819765, 587308

Lot: 041807E 485.96 gm

1526 poured

10-15 gpm

Chromatint, Rh WT \*into ran above swallet

Powr #3: Eosine

4820094, 587581

Lot: 020706

509.96 gm

1546 poured

8-16 gpm

Chromatint Red D143 Liquid

\*into swallet under snow and ice

## Appendix 3

Dye Receptors

## Frego Creek Dye Trace: March 3, 2009 to May 5, 2009

### *Dye Receptor Locations:*

#### Dye Receptor #1:

23:A631

Minnesota Karst Feature Database Number - MN23:A631

UTM:

586,868 E, 4,821,780 N

Notes: Receptor located on north side of spring. Accessed through farm.

#### Dye Receptor #2:

23:A420

Minnesota Karst Feature Database Number - MN23:A420

UTM:

586,841 E, 4,821,756 N

Notes: Receptor located south side of road on the east side of culvert

#### Dye Receptor #3:

23:A445

Minnesota Karst Feature Database Number - MN23:A445

UTM:

589,265 E, 4,822,137 N

Notes: Receptor located on west side of county road 23 along the north side of the culvert

#### Dye Receptor #4:

23X112

Minnesota Karst Feature Database Number - MN23:X112

UTM:

589,375 E, 4,822,077 N

Notes: Receptor located on the south side of the road tied to small tree on the west side of the east culvert

#### Dye Receptor #5:

23:A403

Minnesota Karst Feature Database Number - MN23:A403

UTM:

589,514 E, 4,820,195 N

Notes: Receptor located in culvert and is tied to debris on the south side of 120th street

#### Dye Receptor #6:

23:A400

Minnesota Karst Feature Database Number - MN23:A400

UTM:

589,551 E, 4,820,220 N

Notes: Receptor located just upstream of 23:A403 along the west side of the stream

**Dye Receptor #7:**

23:X111

Minnesota Karst Feature Database Number - MN23:X111

UTM:

588,000 E, 4,823,275 N

Notes: Receptor located on the west side of the road dangling from a tree above the south culvert

**Dye Receptor #8:**

23:X50

Minnesota Karst Feature Database Number - MN23:X0050

UTM:

584,873 E, 4,819,376 N

Notes: Receptor is tethered to a sign post on the west side of the road in a culvert

**Dye Receptor #9:**

23:X51

Minnesota Karst Feature Database Number - MN23:X0051

UTM:

584,894 E, 4,818,567 N

Notes: Receptor is tethered to a tree branch on the east bank of the stream approximately 30 feet upstream of the road crossing

**Dye Receptor #10:**

23:X52

Minnesota Karst Feature Database Number - MN23:X0052

UTM:

584,337 E, 4,816,942 N

Notes: Receptor is tethered to a bridge post near the southeast corner of the bridge

**Dye Receptor #11:**

23:X53

Minnesota Karst Feature Database Number - MN23:X0053

UTM:

586,518 E, 4,818,341 N

Notes: Receptor is on the east, upstream side of crossing. The receptor is buried under a large limestone rock near other large limestone slabs in the waterway, approximately 30 feet upstream of the road crossing.

## Appendix 4

### Summary of Analytical Results

**Frego Creek Spring 2009 Dye Trace: Summary of Analytical Results**

<b>Sampling Location</b>	<b>3/6/09 to 3/16/09</b>	<b>3/16/09 to 3/23/09</b>	<b>3/23/09 to 4/8/09</b>	<b>4/8/09 to 5/4/09</b>
23:A400	ND	ND	-	ND
23:A403	ND	ND	-	ND
23:A420	ND	ND	ND	ND
23:A631	ND	ND	ND	ND
23:A445	E*, WT*, U*	E*, WT*, U*	E*, WT*, U*	E*, WT*, U*
23:X111	-	-	-	-
23:X112	ND	ND	ND	ND
23:X50	ND	ND	ND	ND
23:X51	ND	ND	ND	ND
23:X52	ND	ND	ND	ND
23:X53	ND	ND	ND	ND

\* E – Eosine, WT – Rhodamine WT, U – Uranine

ND – No Detections

## Appendix 5

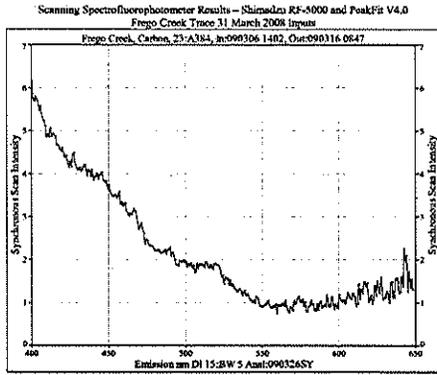
### Scanning Spectrofluorophotometer Results

The following analytical results were completed by project participants associated with the Geology & Geophysics Department at the University of Minnesota. Analysis of the samples was completed by Andrew J. Luhmann<sup>2</sup> and Scott C. Alexander<sup>2</sup>. Interpretation of the analytical results was completed by Jeffrey A. Green<sup>1</sup>, Andrew J. Peters<sup>1</sup>, Andrew J. Luhmann<sup>2</sup>, E. Calvin Alexander, Jr.<sup>2</sup> and Scott C. Alexander<sup>1</sup>.

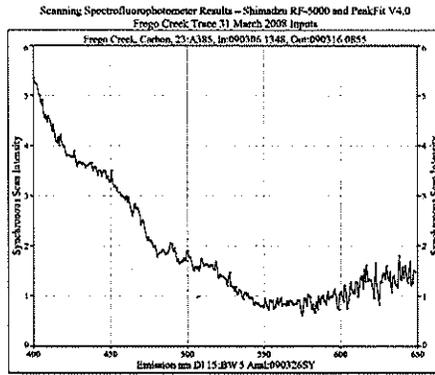
<sup>1</sup> Minnesota Department of Natural Resources, Division of Waters, 2300 Silver Creek Road NE, Rochester, Minnesota, 55906; Phone (507) 285-7430; Fax (507) 285-7144; emails: [jeff.green@dnr.state.mn.us](mailto:jeff.green@dnr.state.mn.us) & [andrew.peters@dnr.state.mn.us](mailto:andrew.peters@dnr.state.mn.us)

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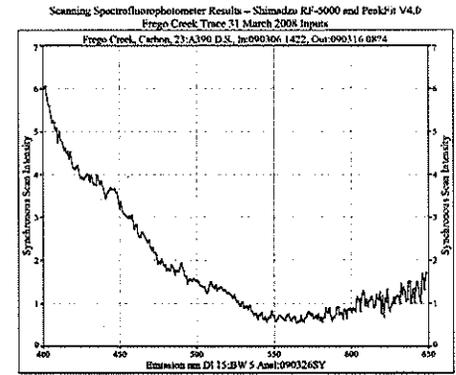
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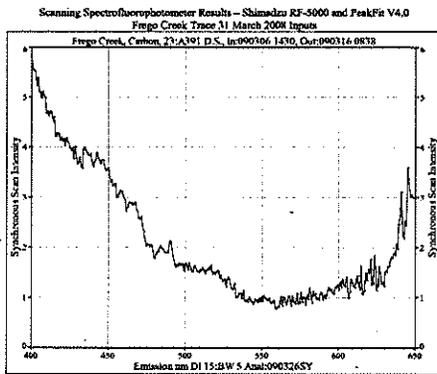
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 Dept. of Geology & Geophysics, University of Minnesota  
 alexa017@umn.edu



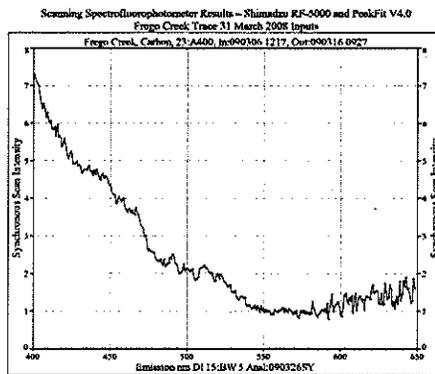
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 Dept. of Geology & Geophysics, University of Minnesota  
 alexa017@umn.edu



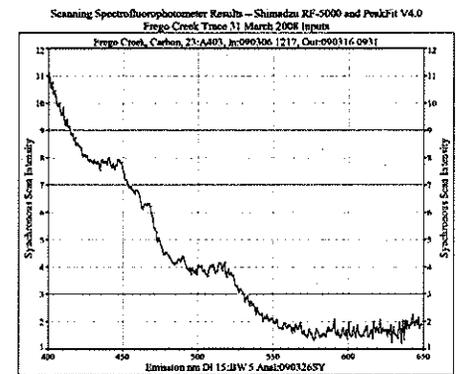
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 Dept. of Geology & Geophysics, University of Minnesota  
 alexa017@umn.edu



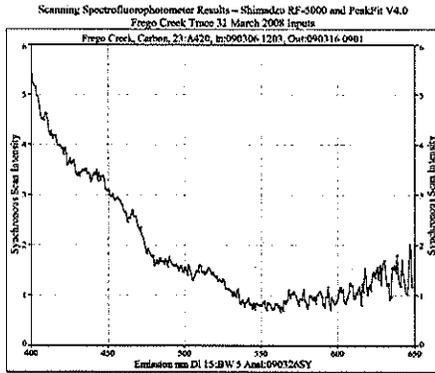
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 alexa017@umn.edu



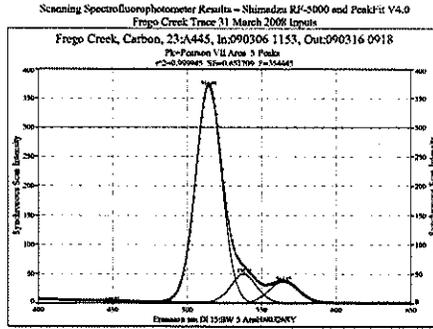
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 Dept. of Geology & Geophysics, University of Minnesota  
 alexa017@umn.edu



Hydrogeochemistry Laboratory  
 Dept. of Geology & Geophysics, University of Minnesota  
 alexa017@umn.edu



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 Dept. of Geology & Geophysics, University of Minnesota  
 alexa017@umn.edu



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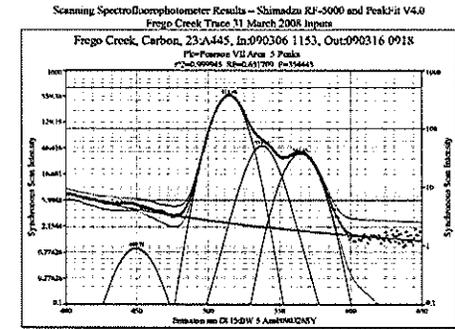
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Peak	Type	Amplitude	Center	FWHM	Area%	FW Base	Area%
1	Peakem VII Area	7883.89858	331.882412	199.212443	0.58153718		
2	Peakem VII Area	24.9229600	449.712640	23.2873540	10.0000000		
3	Peakem VII Area	7899.65302	514.678789	19.8220610	17.7307058		
4	Peakem VII Area	3114.91282	538.155000	20.0721097	5.66115020		
5	Peakem VII Area	899.756819	564.839532	23.0028107	32.6896177		

Measured Values

Peak	Type	Amplitude	Center	FWHM	Area%	FW Base	Area%
1	Peakem VII Area	12.6089563	370.402290	128.241797	0.55179789	0.00000000	0.00000000
2	Peakem VII Area	0.90843277	449.712639	23.2873540	1.00000003	52.8190100	1.00000007
3	Peakem VII Area	370.018703	514.678789	19.8220610	1.00000000	40.4311807	1.00000012
4	Peakem VII Area	50.1622795	538.155000	20.0721097	1.00000000	43.3715510	1.00000000
5	Peakem VII Area	36.5144160	564.839532	23.0028107	1.00000000	46.4430182	1.00000000

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 alexa017@umn.edu



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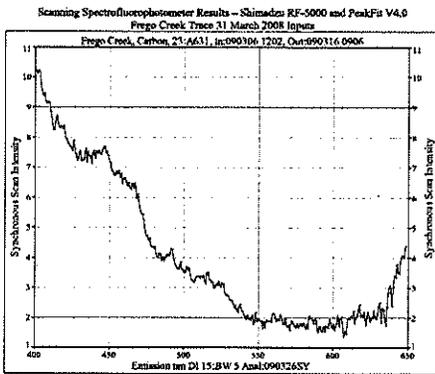
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1	0.00994452	0.00994450	0.651170879	3.2645e+05	

Peak	Type	Amplitude	Center	FWHM	Area%	FW Base	Area%
1	Peakem VII Area	7883.89858	331.882412	199.212443	0.58153718		
2	Peakem VII Area	24.9229600	449.712640	23.2873540	10.0000000		
3	Peakem VII Area	7899.65302	514.678789	19.8220610	17.7307058		
4	Peakem VII Area	3114.91282	538.155000	20.0721097	5.66115020		
5	Peakem VII Area	899.756819	564.839532	23.0028107	32.6896177		

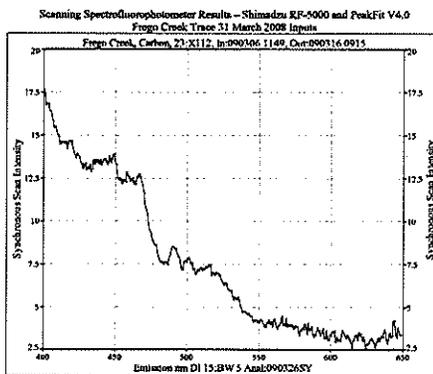
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Peak	Type	Amplitude	Center	FWHM	Area%	FW Base	Area%
1	Peakem VII Area	12.6089563	370.402290	128.241797	0.55179789	0.00000000	0.00000000
2	Peakem VII Area	0.90843277	449.712639	23.2873540	1.00000003	52.8190100	1.00000007
3	Peakem VII Area	370.018703	514.678789	19.8220610	1.00000000	40.4311807	1.00000012
4	Peakem VII Area	50.1622795	538.155000	20.0721097	1.00000000	43.3715510	1.00000000
5	Peakem VII Area	36.5144160	564.839532	23.0028107	1.00000000	46.4430182	1.00000000

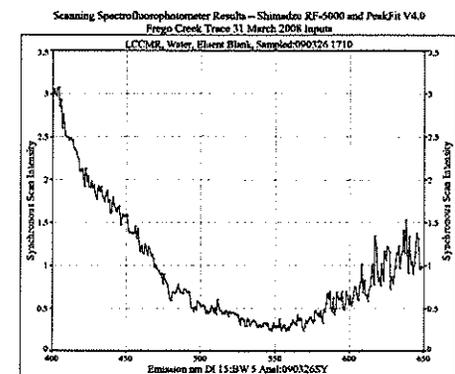
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 Dept. of Geology & Geophysics, University of Minnesota  
 alexa017@umn.edu



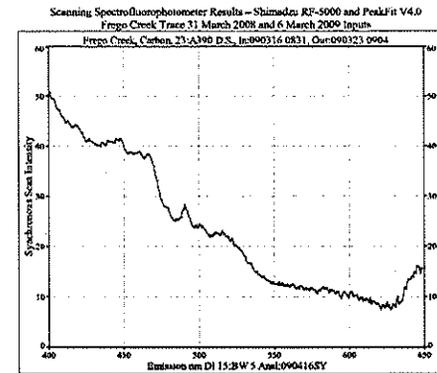
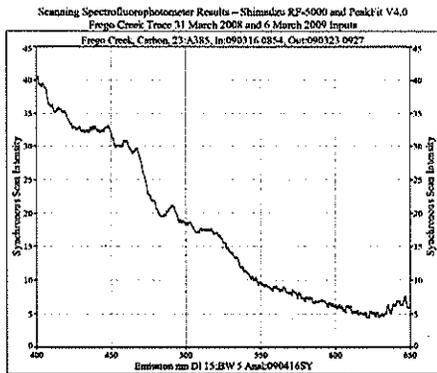
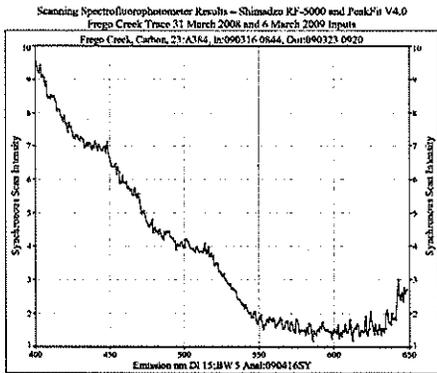
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 Dept. of Geology & Geophysics, University of Minnesota  
 alexa017@umn.edu



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 Dept. of Geology & Geophysics, University of Minnesota  
 alexa017@umn.edu



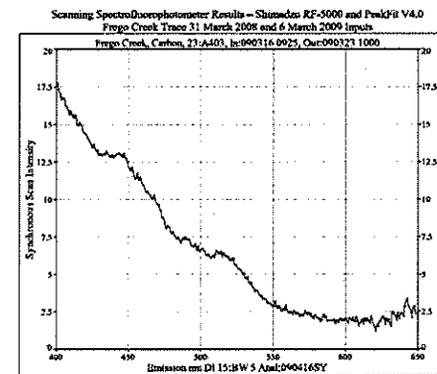
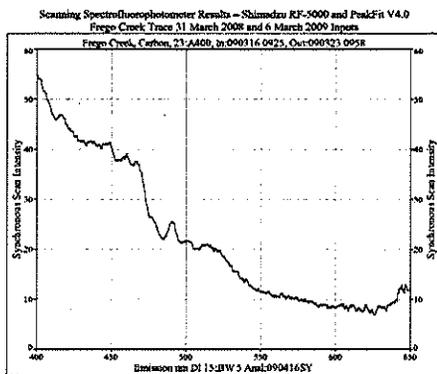
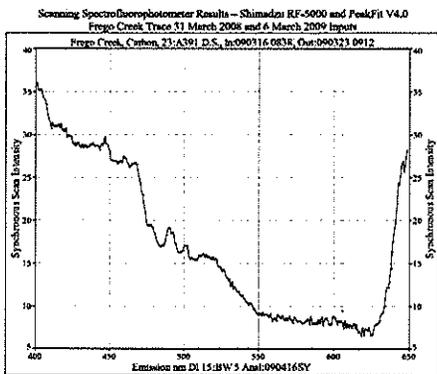
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 Dept. of Geology & Geophysics, University of Minnesota  
 alexa017@umn.edu



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 Dept. of Geology & Geophysics, University of Minnesota  
 alexa017@umn.edu

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 Dept. of Geology & Geophysics, University of Minnesota  
 alexa017@umn.edu

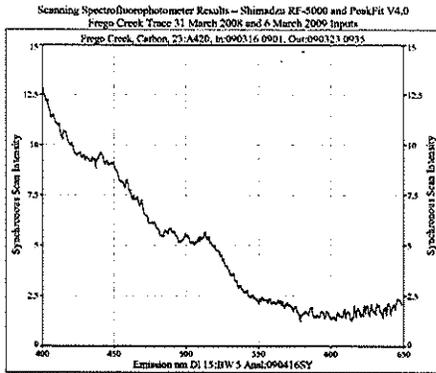
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 Dept. of Geology & Geophysics, University of Minnesota  
 alexa017@umn.edu



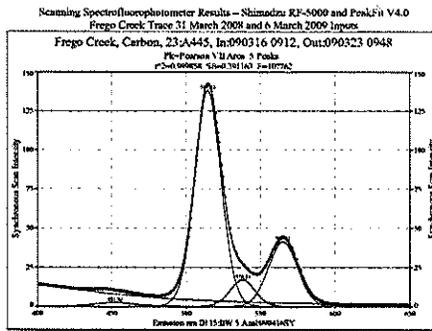
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 Dept. of Geology & Geophysics, University of Minnesota  
 alexa017@umn.edu

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 Dept. of Geology & Geophysics, University of Minnesota  
 alexa017@umn.edu

Hydrogeochemistry Laboratory  
 Dept. of Geology & Geophysics, University of Minnesota  
 alexa017@umn.edu



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 Dept. of Geology & Geophysics, University of Minnesota  
 alexa017@umn.edu



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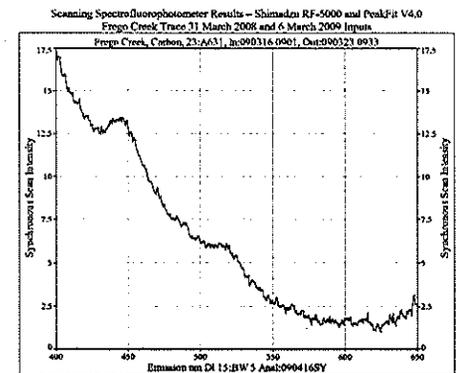
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3	Peak	480.00000	10.00000	1.00000	10.00000	10.00000
4	Peak	510.00000	10.00000	1.00000	10.00000	10.00000
5	Peak	540.00000	10.00000	1.00000	10.00000	10.00000

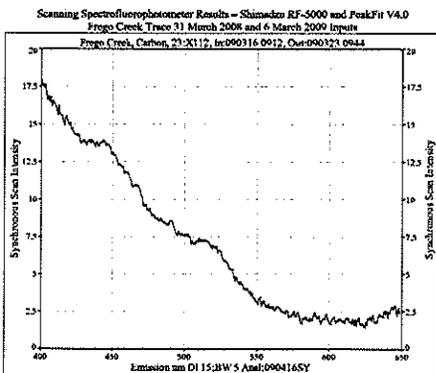
Measured Values

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2	Peak	2.57968170	451.921274	36.8140188	1.00000000	100.000000	1.00000000
3	Peak	1.37111110	516.840209	20.3022581	1.00000000	42.3084708	1.00000000
4	Peak	17.1856323	538.124262	19.7297765	1.00000000	41.9733254	1.00000000
5	Peak	41.2386227	565.314389	22.8154449	1.00000000	47.0009134	1.00000000

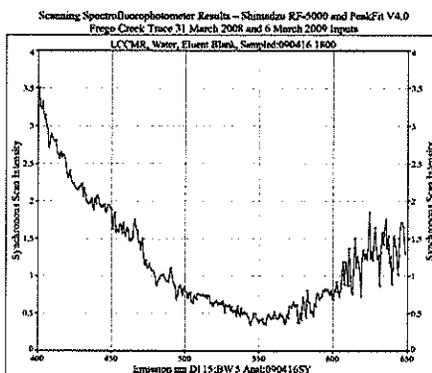
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 alexa017@umn.edu



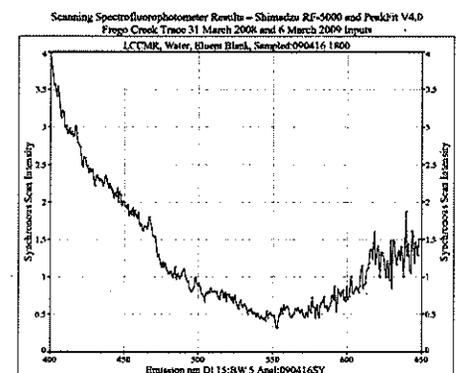
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 Dept. of Geology & Geophysics, University of Minnesota  
 alexa017@umn.edu



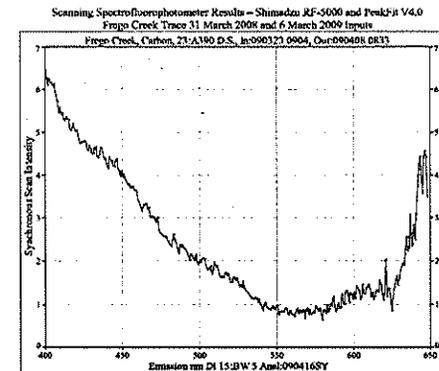
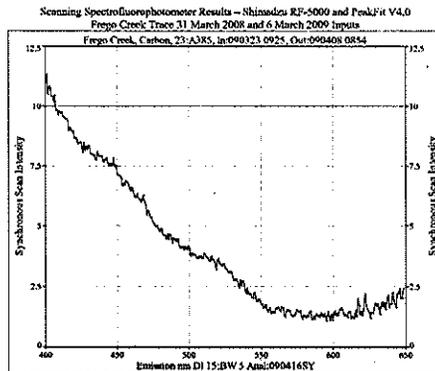
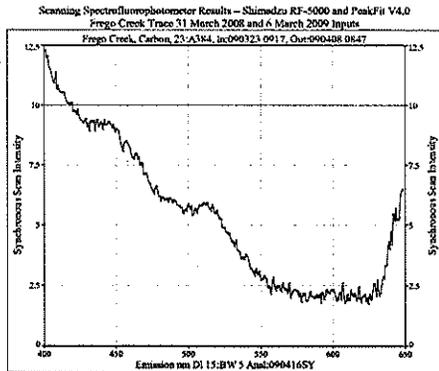
Hydrogeochemistry Laboratory  
 Dept. of Geology & Geophysics, University of Minnesota  
 alexa017@umn.edu



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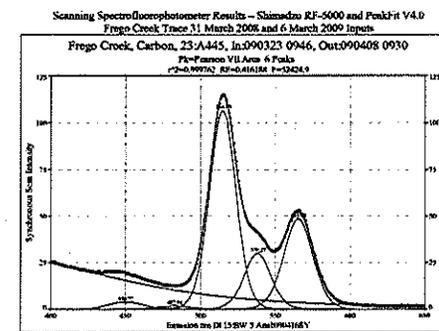
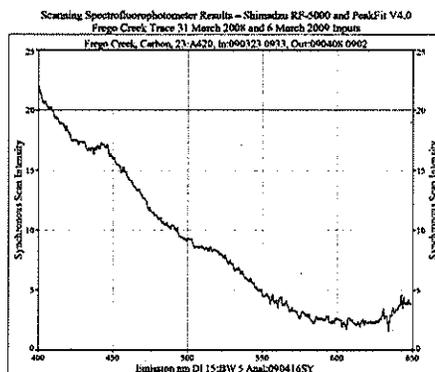
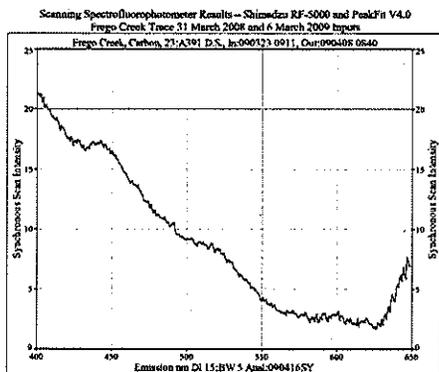
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Description: Frego Creek, Carbon, 23-A445, In:090323 0946, Out:090408 0930  
 X Variable: Emission nm DI 15:BW 5 Anal:090416SY  
 Y Variable: Synchronous Scan Intensity  
 File Source: g:\hydro\log\logreg\090321-090408\0450408

Fitted Parameters

Peak	Type	Amplitude	Center	FWHM	Asym50	PW Base	Asym10
1	Paramon VII Area	693.19469	361.945663	191.489103	1.81616007		
2	Paramon VII Area	118.163829	459.970318	28.22529602	167.827713		
3	Paramon VII Area	54.1055811	482.935181	28.4852922	20.8966989		
4	Paramon VII Area	2365.77307	514.959932	20.4997923	10.5123028		
5	Paramon VII Area	666.791841	538.21795	22.6894361	1.71536252		
6	Paramon VII Area	1700.84859	565.446682	22.6383519	7.76099638		

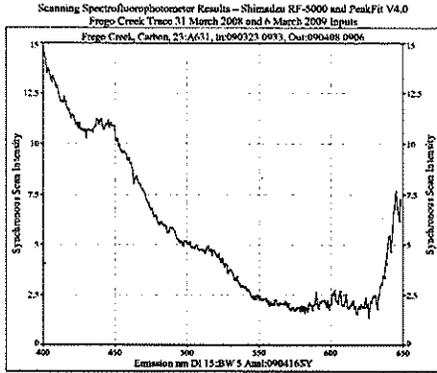
Measured Values

Peak	Type	Amplitude	Center	FWHM	Asym50	PW Base	Asym10
1	Paramon VII Area	28.4684834	361.945663	457.692215	0.00000000	0.00000000	0.00000000
2	Paramon VII Area	3358.02984	459.970318	28.22529602	1.00000011	56.8392722	1.00000009
3	Paramon VII Area	1.76659904	482.935181	28.4852922	1.00000000	58.1895406	1.00000000
4	Paramon VII Area	106.286747	514.959932	20.4997923	1.00000012	42.1199318	1.00000006
5	Paramon VII Area	29.9895768	538.21795	22.6894361	1.00000037	64.6782624	1.00000019
6	Paramon VII Area	48.4578371	565.446682	22.6383519	1.00000015	47.8946477	1.00000097

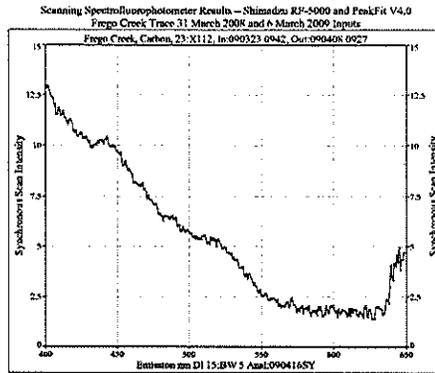
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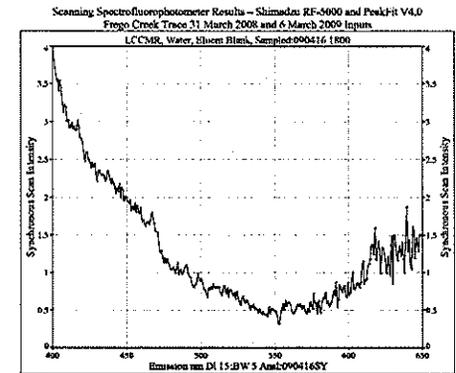
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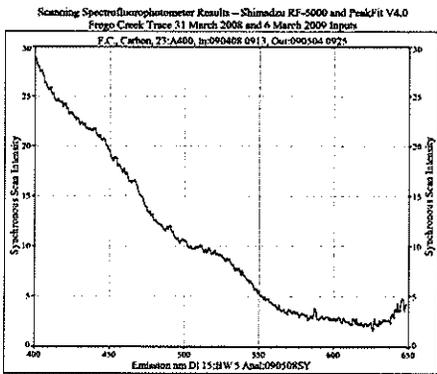
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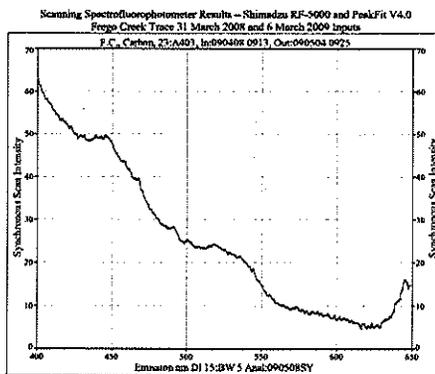
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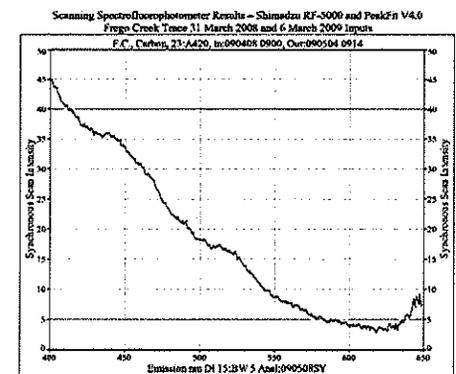
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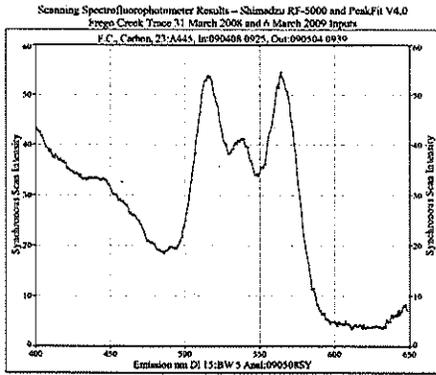
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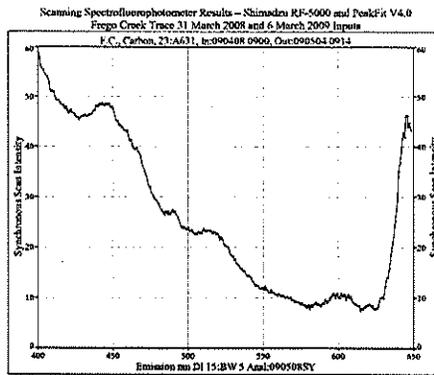
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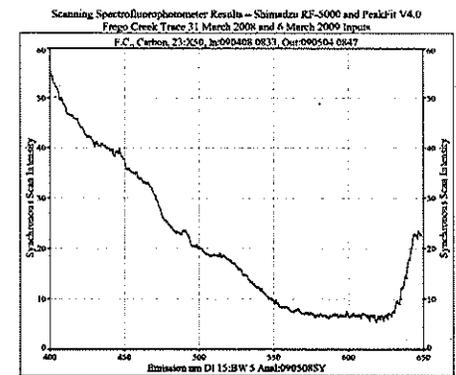
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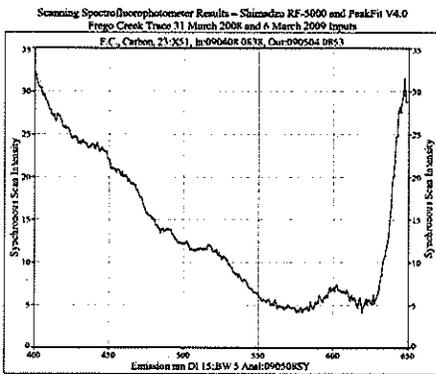
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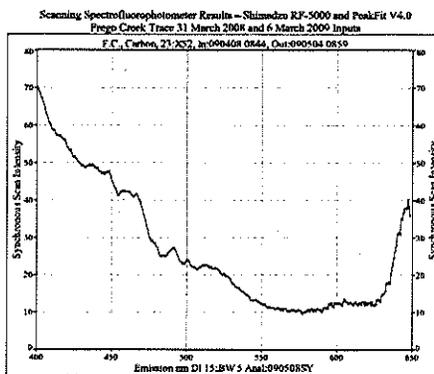
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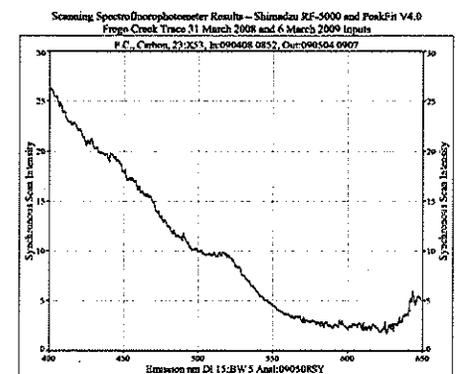
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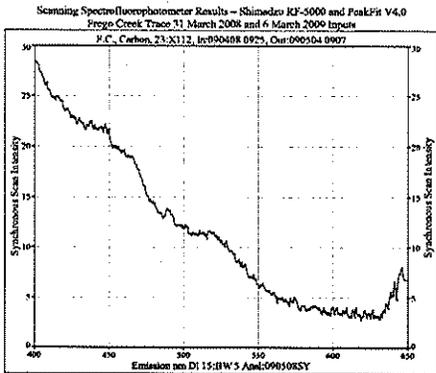
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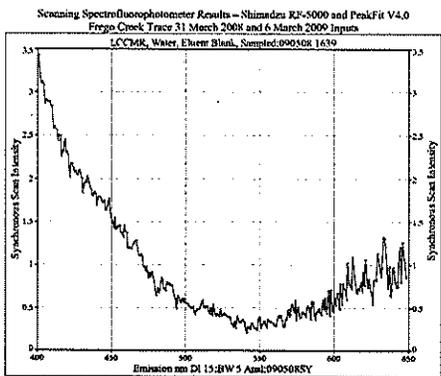
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