Harmony Fall 2008 Dye Trace

October 28, 2008 to May 4, 2009

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Trace Name: Harmony Fall 2008
Trace Purpose: The sinkholes traced from lie near a springshed divide and were traced from in an effort to better delineate the boundary between three separate springsheds.
County: Fillmore
Cooperators: City of Harmony Fire Department, Earth Systems Class - Fillmore Central High School

Introduction

A dye trace was conducted in an area in the City of Harmony, Minnesota, and an area located just west of the City of Harmony, Minnesota from October 28, 2008 to May 4, 2009 (Figure 1). Numerous dye traces have been completed in this area in the past and this effort was made in order to better delineate the springsheds in this area due to the close proximity of numerous State of Minnesota designated trout streams. Achieving a better understanding of the connection of these sinkholes receiving surface water flow and their connectivity to springs that provide a cold water source for the designated trout streams in the area 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 or springs. For this project, the dye used was Uranine. Both direct water samples and passive dye detectors were used and all the samples were analyzed at the University of Minnesota Geology Department using a scanning spectrofluorophotometer. The trace was designed and executed by Jeff Green and Andrew Peters of MNDNR Waters with help from the City of Harmony Fire Department which provided water for the trace and the Earth Systems Class from Fillmore Central High School. E. Calvin Alexander, Jr., Andrew Luhmann, and Scott Alexander of the University of Minnesota Geology Department performed the sample analysis and interpretation.

Results

Prior to dye injection, dye receptors had been placed at all the sampling points to determine background levels of dyes. The dye trace began on October 28, 2008. Table 1 summarizes the dye input information.

Dye Inputs				
Dye Input Point	Dye (type, quantity)	Time	Water Input (Est.)	Dye Detection Point
Sinkhole 23:D6080	Uranine C, 726 grams	1427 hrs.	450 Gallons	Spring 23:A0024 & Monitoring Point "Quarry Overflow" which monitors waters leaving nearby quarry and Spring 23:A0237
Sinkhole 23:D7963	Rhodamine WT, 758 grams	1500 hrs.	450 Gallons	Spring 23:A0024 & Monitoring Point "Quarry Overflow" which monitors waters leaving nearby quarry and Spring 23:A0237

Table 1: Dye Inputs, Harmony Fall 2008 Dye Trace

Direct water samples were collected and charcoal dye detectors were in placed at all sampling locations from the start of the trace until early May of 2009. Both dyes were detected at levels high enough for positive identification. The Uranine dye was detected in the carbon samples from Spring 23:A0024 & "Quarry Overflow" no more than 15 days after dye input. This translates to a groundwater flow rate of no greater than approximately 800-feet per day. This rate is consistent with previous traces in this geologic setting (Ordovician Galena limestone).

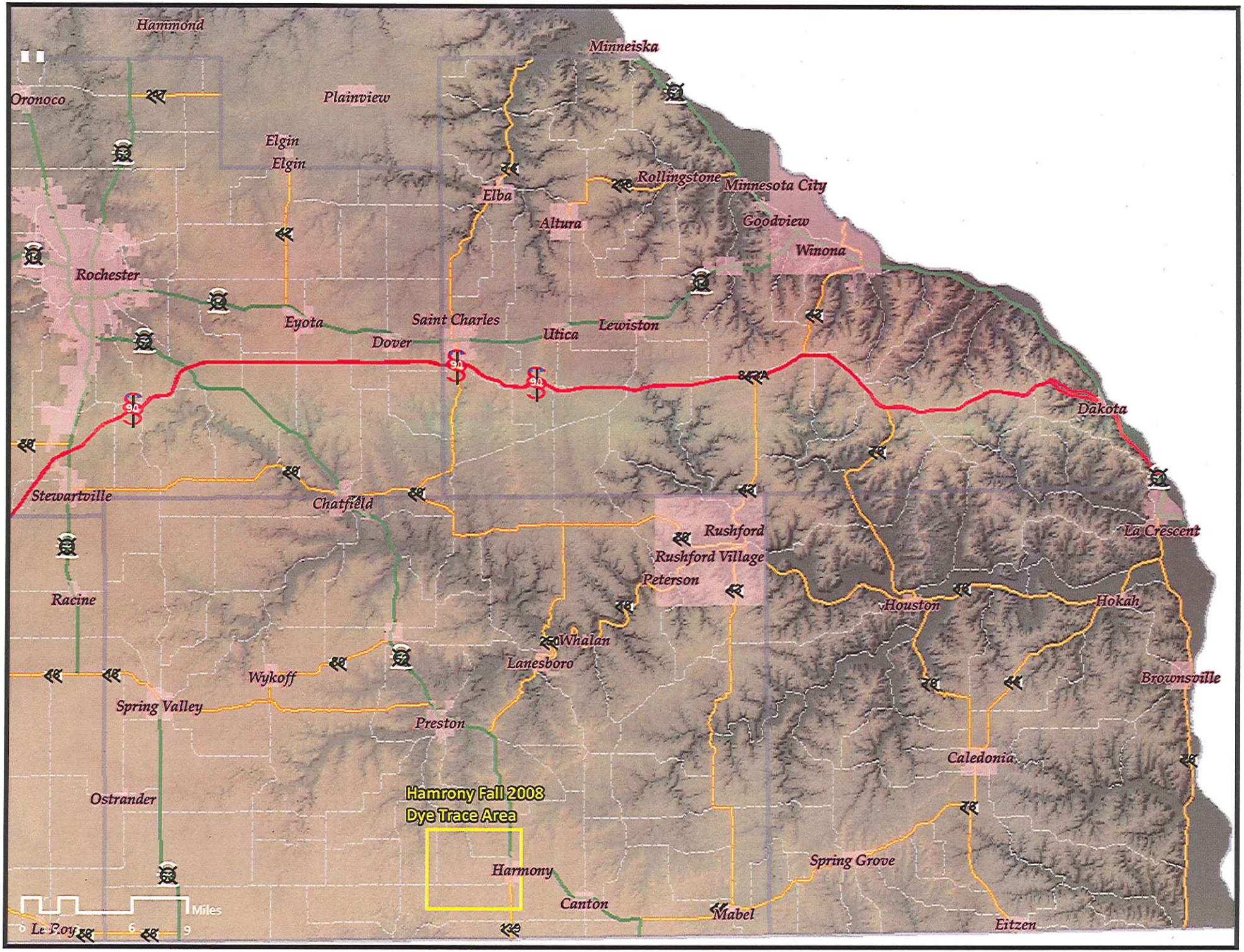
The Rhodamine WT dye was also detected in the carbon samples from the same locations but later than the Uranine dye, no more than 86 days after dye input. This translates to a groundwater flow rate of no greater than approximately 75 feet per day. This rate is not consistent with previous traces in this geologic setting (Ordovician Galena limestone) which is often much faster. We believe that during the Rhodamine WT dye input there was not enough water introduced to properly flush the dye into the groundwater system. In December of 2008 there were atypically warm winter temperatures that did melt snow cover in the area. We feel the water flow from this runoff event provided enough water to properly flush the dye into the groundwater system. If indeed our conclusions are correct and the dye was introduced into the system in mid-to-late December groundwater flow rates would be estimated at

approximately 165 to 248 feet per day. This groundwater flow rate would be more consistent with previous traces in this geologic setting (Ordovician Galena limestone).

The dye input points and their known connection from this dye trace in addition to previously completed traces are shown in Figure 2. Through this trace, we have further delineated the springsheds feeding springs 23:A0237, 23:A0024, 23:A0358 & 23:A0479. This new trace has expanded the known boundaries of the 23:A0237 springshed.

Appendix 1

Figures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Oronoco
Plainview
Elgin
Elgin
Elba
Rollingstone
Minnesota City
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Goodview
Winona
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Saint Charles
Dover
Utica
Lewiston
Dakota
Stewartville
Chatfield
Rushford
Rushford Village
Peterson
La Crescent
Racine
Houston
Hokah
Whalan
Lanesboro
Wykoff
Brownsville
Spring Valley
Preston
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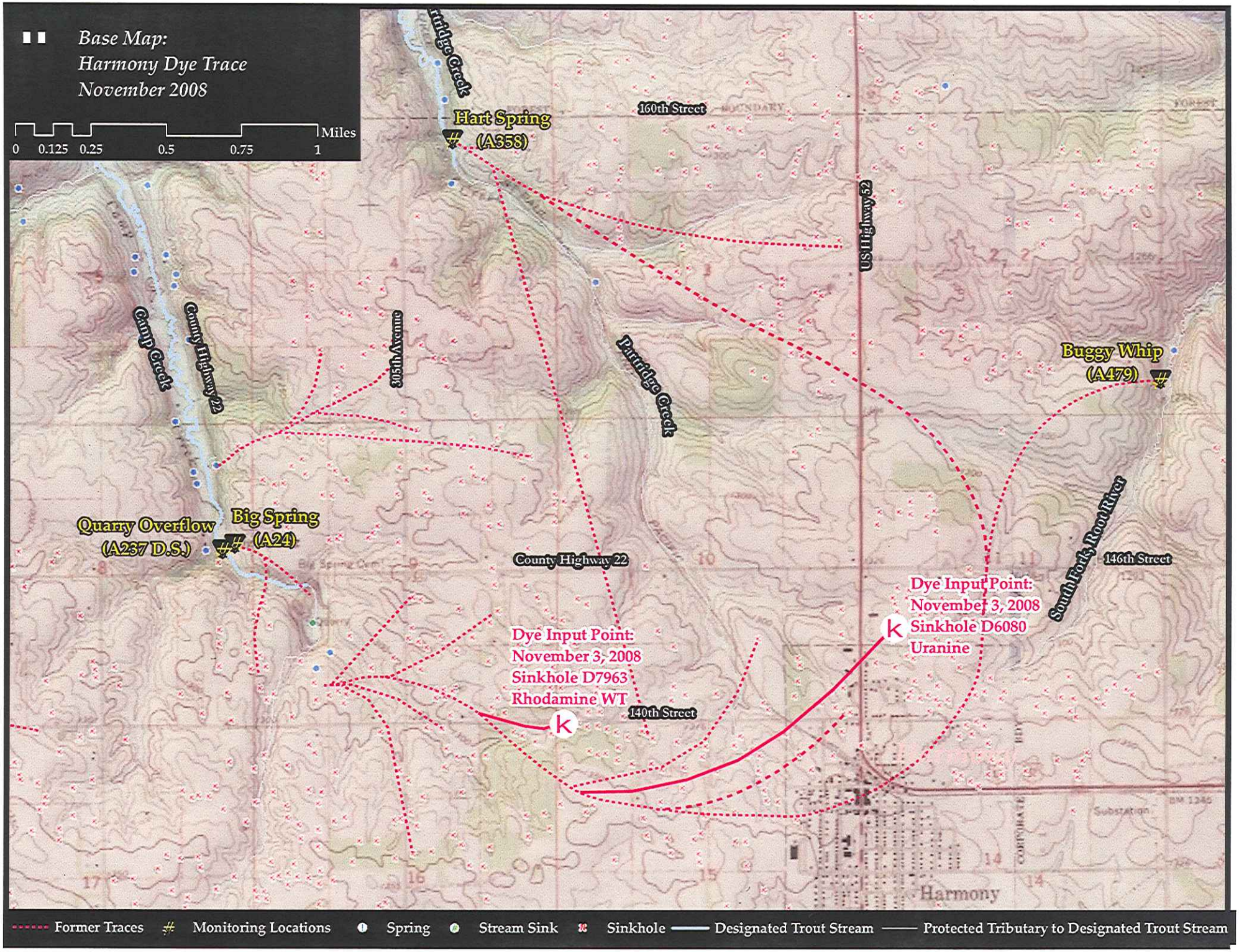
Dye Trace Area
Harmony
Spring Grove
Canton
Mabel
Eitzen
Le Roy
Miles


Base Map:
Harmony Dye Trace
November 2008
0 0.125 0.25 0.5 0.75 1 Miles
Hart Spring
(A358)
160th Street
US Highway 52
Partridge Creek
Camp Creek
County Highway 22
305th Avenue
Buggy Whip
(A479)
Quarry Overflow
(A237 D.S.)
Big Spring
(A24)
County Highway 22
South Fork Root River
146th Street
Dye Input Point:
November 3, 2008
Sinkhole D6080
Uranine
Dye Input Point:
November 3, 2008
Sinkhole D7963
Rhodamine WT
140th Street
Harmony
Former Traces
Monitoring Locations
Spring
Stream Sink
Sinkhole
Designated Trout Stream
Protected Tributary to Designated Trout Stream

Appendix 2

Dye Input

Harmony Fall 2008 Dye Trace: October 28, 2008 to May 4, 2009

Dye Input Points:

Input Point #1:

Sinkhole D6080:	**Minnesota Karst Feature Database Number - MN23:D6080**
UTM:	**580,154 E, 4,823,769 N**
Township, Range, Section:	**SW ¼ of the SW ¼ of Section 11, T101N, R10W**
Elevation:	**~1328 feet**

At 1427 CDT on 28 October 2008, approximately 726 grams of Uranine dye solution was introduced into an open swallow hole in D6080 with approximately 450 gallons of water.

Input Point #2:

Sinkhole D7963:	**Minnesota Karst Feature Database Number - MN23:D7963**
UTM:	**578,335 E, 4,823, 253 N**
Township, Range, Section:	**NE ¼ of the NE ¼ of Section 16, T101N, R10W**
Elevation:	**~1325 feet**

At approximately 1530 CDT on 28 October 2008, approximately 758 grams of Rhodamine WT dye solution was introduced into multiple open swallow holes in D7963 with approximately 450 gallons of water.

Harmony Fall 2008 28 Oct 2008

Set background bugs @ BJ Spring Quarry overflow, Buggywhip & Hart

Target sinkhole @ Gordons B D7963

BJ Sp- (A24) Quarry overflow (A237)

Hart Sp- (A358) Buggywhip A479

Sinkhole #'s - HECO D6080, Gordon D7963

D6080 450 gal H_2O

dye @ 1427 Chromatint Orange C lot 0401808C

725.54 gms 35% soln

Slight ponding water drained rapidly into a 16m swallow hole

water ended @ 1433

~~?~~ 9m round sinkhole

4m deep

Sinkhole D7963 swallow hole on W. end of sink Harmony F.D.

Dye @ 1500 ~ 450 gal

758.47 gm Rh WT 4m swallet

no ponding 25m long x 25 w x 5m deep

20% soln

several swallow holes

D7963

578335/4823253

± 4m

Garmin 76CSX

Appendix 3

Dye Receptors

Harmony Fall 2008 Dye Trace: October 28, 2008 to May 4, 2009

Dye Receptor Locations:

Dye Receptor #1:

Big Spring Minnesota Karst Feature Database Number - MN23:A0024
UTM: 576,647 E, 4,824,238 N
Notes: Receptor located 10 feet upstream of confluence with Quarry Overflow near steel debris

Dye Receptor #2:

Hart Spring Minnesota Karst Feature Database Number - MN23:A0358
UTM: 577,803 E, 4,826,382 N
Notes: Receptor located on south side of road on the west bank of the stream just south of bridge

Dye Receptor #3:

Buggy Whip Minnesota Karst Feature Database Number - MN23:A0479
UTM: 581,549 E, 4,825,118 N
Notes: Receptor located in the culvert discharge on the east side of road

Dye Receptor #4:

Quarry Overflow Minnesota Karst Feature Database Number - MN23:X???
UTM: 576,581 E, 4,824,208 N
Notes: Receptor located 10 feet upstream from confluence with Big Spring flow

Appendix 4

Summary of Analytical Results

Harmony Fall 2008 Dye Trace: Summary of Analytical Results of Carbon Samples									
Sampling Location	**10/28/08 to 11/3/08**	**11/3/08 to 11/12/08**	**11/12/08 to 11/24/08**	**11/24/08 to 12/8/08**	**12/8/08 to 1/22/09**	**1/22/09 to 3/4/09**	**3/4/09 to 3/16/09**	**3/16/09 to 4/8/09**	**4/8/09 to 5/4/09**
Big Spring	None	Uranine	Uranine	Uranine	Uranine, RhWT	Uranine, RhWT	Uranine	Uranine, RhWT	Uranine, RhWT
Quarry Overflow	None	Uranine	Uranine	Uranine	Uranine, RhWT	Uranine, RhWT	Uranine, RhWT	Uranine, RhWT	Uranine, RhWT
Buggy Whip	None	-	None	None	None	None	None	None	None
Hart Spring	None	None	None	-	Uranine	None	None	None	None

Harmony Fall 2008 Dye Trace: Summary of Analytical Results of Water Samples					
Sampling Location	**11/4/08**	**11/5/08**	**11/6/08**	**11/7/08**	**11/12/08**
Buggy Whip	None	None	None	-	None
Johnson Well	-	-	-	None	-

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[2] and Scott C. Alexander[2]. Interpretation of the analytical results was completed by Jeffrey A. Green[1], Andrew J. Peters[1], Andrew J. Luhmann[2], E. Calvin Alexander, Jr.[2] and Scott C. Alexander[1].

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Archived file source: Andrew Peters – D:/Documents/Final Trace Reports/Harmony Fall 2008/HarmonySpringTrace All Curves

Scanning Spectrofluorophotometer Results – Shimadzu RF-5000 and PeakFit V4.0
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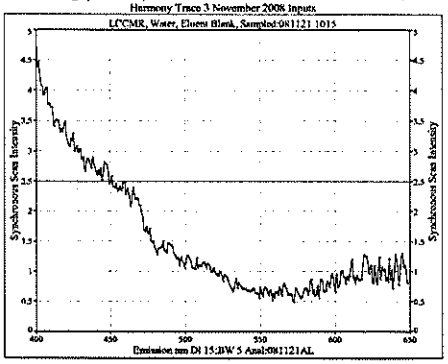

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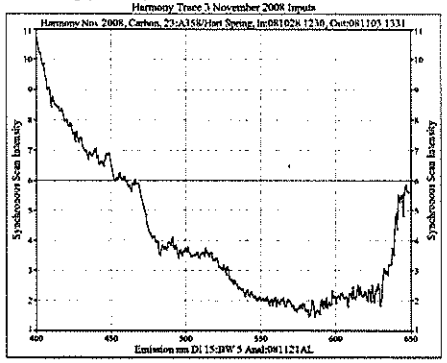

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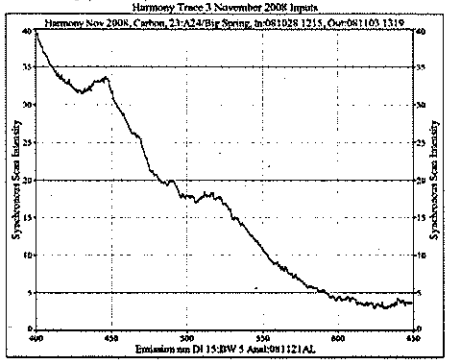

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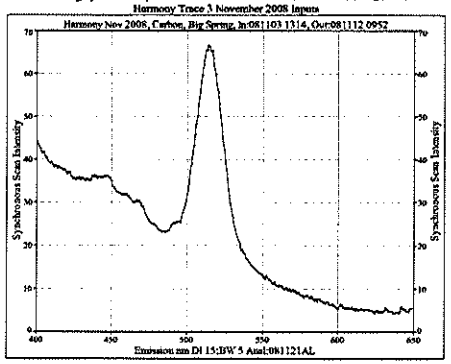

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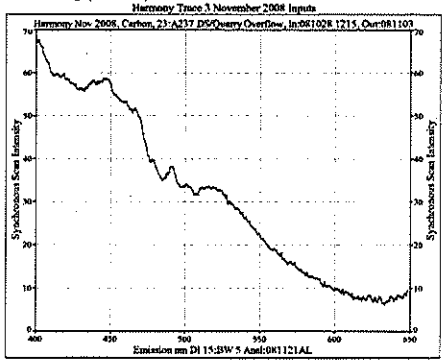

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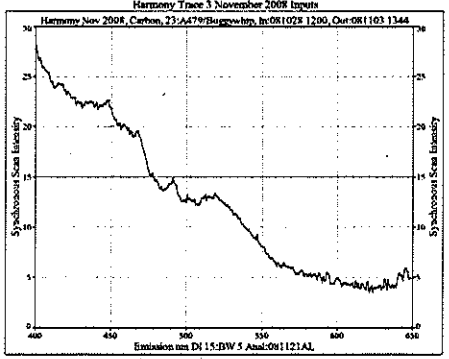

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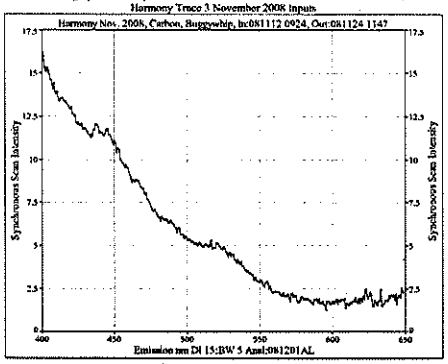

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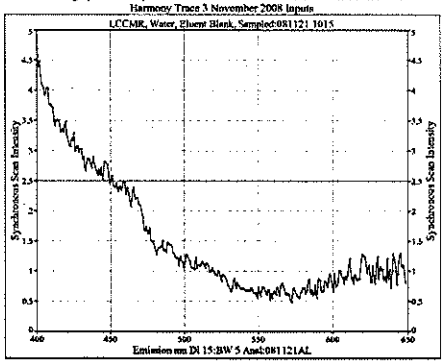

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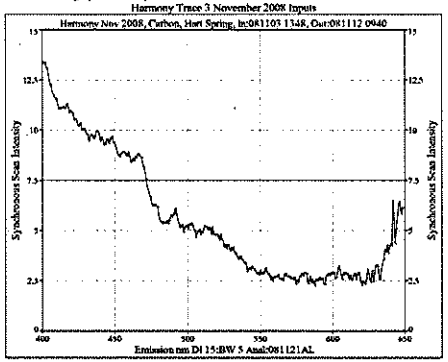

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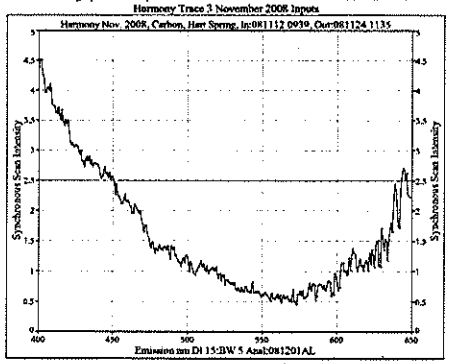

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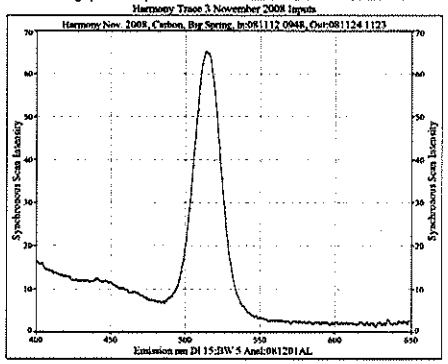

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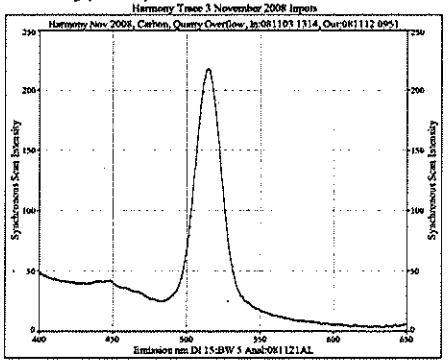

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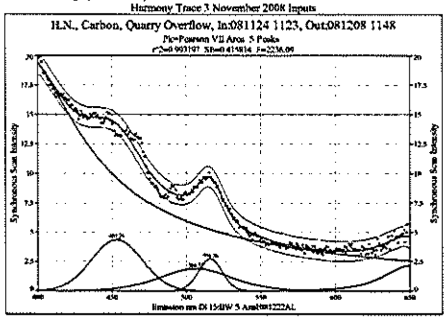

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Y Variable: Synchronous Scan Intensity
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Fitted Parameters

r² Coef Det	DF Adj r²	Fit Std Err	F-value
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Peak	Type				
1	Pearson VII Area	44857.0673	389.607000	119.374138	0.51635622
2	Pearson VII Area	185.236998	453.248897	39.9582102	167.917669
3	Pearson VII Area	119.575759	506.522891	56.6300944	4.44258782
4	Pearson VII Area	54.3047019	516.260632	18.6090944	18.6500837
5	Pearson VII Area	111.511711	650.484281	41.7625819	1.80072864

Measured Values

Peak	Type	Amplitude	Center	FWHM	Asym50	FW Base	Asym10
1	Pearson VII Area	20.2173408	389.606999	119.374138	1.00000002	0.00000000	0.00000000
2	Pearson VII Area	4.34976725	453.248897	39.9582102	1.00000000	80.1832333	1.00000000
3	Pearson VII Area	1.88349055	506.522889	56.6300944	1.00000016	125.102582	1.00000008
4	Pearson VII Area	2.71104063	516.260631	18.6090944	1.00000008	38.1005256	1.00000004
5	Pearson VII Area	2.12525409	648.399987	42.0671966	1.21998633	108.802511	1.08843542

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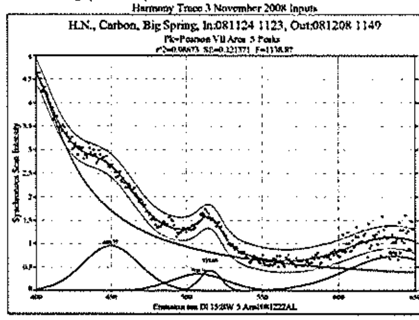

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Y Variable: Synchronous Scan Intensity
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Fitted Parameters

r² Coef Det	DF Adj r²	Fit Std Err	F-value
0.98673028	0.98581513	0.12137104	1138.87497

Peak	Type				
1	Pearson VII Area	7077.59531	393.217418	74.2808815	0.51545165
2	Pearson VII Area	44.5268074	449.770854	43.5900449	27.1858101
3	Pearson VII Area	16.3084937	508.164368	43.2757070	82.7069061
4	Pearson VII Area	7.50385521	515.651235	16.6551015	167.919233
5	Pearson VII Area	56.3218647	636.898882	72.5984750	103.082839

Measured Values

Peak	Type	Amplitude	Center	FWHM	Asym50	FW Base	Asym10
1	Pearson VII Area	4.85628892	393.405963	74.2845542	0.98989867	0.00000000	0.00000000
2	Pearson VII Area	0.95242622	449.770854	43.5900449	1.00000000	88.6110362	1.00000000
3	Pearson VII Area	0.35315953	508.164366	43.2757070	1.00000000	87.0631290	1.00000000
4	Pearson VII Area	0.42274679	515.651235	16.6551015	0.99999996	33.4214134	0.99999998
5	Pearson VII Area	0.72738237	636.898882	72.5984750	0.99999999	145.909592	1.00000000

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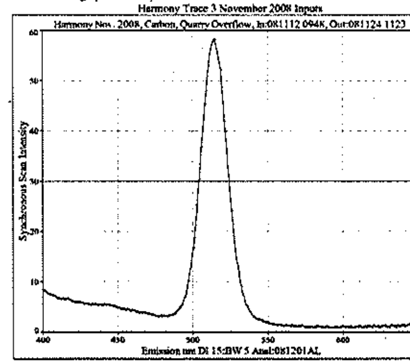

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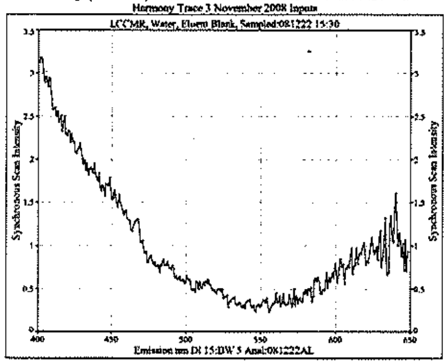

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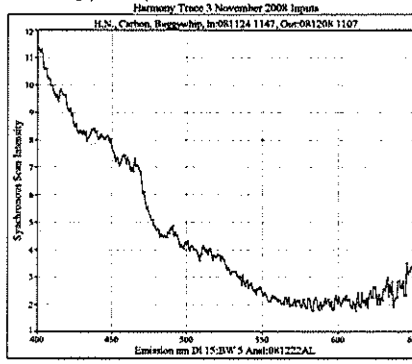

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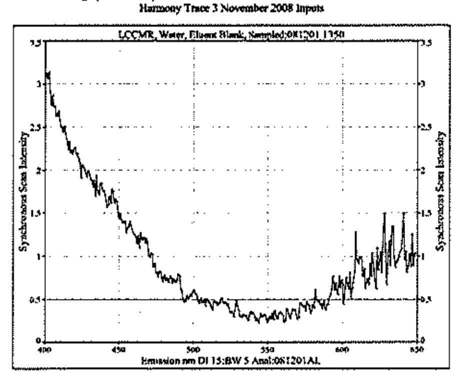

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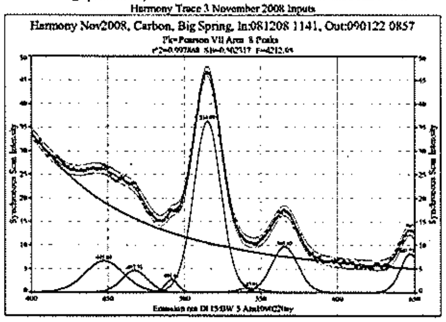

Description: Harmony Nov2008, Carbon, Big Spring, In:081208 1141, Out:090122 0857
X Variable: Emission nm Δλ 15:BW 5 Anal:090220sy
Y Variable: Synchronous Scan Intensity
File Source: g:\dyetracing\harmony081103\harmony091208-090122\hsbs0122

Fitted Parameters

r² Coef Det	DF Adj r²	Fit Std Err	F-value
0.99786028	0.99762291	0.50231659	4212.94952

Peak	Type	a0	a1	a2	a3
1	Pearson VII Area	21836.6379	361.247753	142.772809	0.61900308
2	Pearson VII Area	213.959891	447.639504	29.5189648	8.29565936
3	Pearson VII Area	97.7199474	467.510877	19.6846612	10.2727798
4	Pearson VII Area	29.1375754	491.606146	9.27277790	3.87221756
5	Pearson VII Area	818.318144	514.892994	20.7325781	9.67791149
6	Pearson VII Area	18.7626948	542.946177	19.4428007	167.744296
7	Pearson VII Area	210.810776	565.420730	20.0963345	10.3771461
8	Pearson VII Area	136.468519	647.371132	15.4438704	12.4769338

Measured Values

Peak	Type	Amplitude	Center	FWHM	Asym50	FW Base	Asym10
1	Pearson VII Area	45.2364762	361.247753	142.772809	1.00000000	0.00000000	0.00000000
2	Pearson VII Area	6.63400982	447.639504	29.5189648	1.00000000	62.2146146	1.00000000
3	Pearson VII Area	4.56775454	467.510877	19.6846612	1.00000000	41.0488730	1.00000000
4	Pearson VII Area	2.77826466	491.606146	9.27277790	0.99999995	20.8017995	0.99999998
5	Pearson VII Area	36.2683974	514.892994	20.7325781	1.00000001	43.3680775	1.00000000
6	Pearson VII Area	0.90548271	542.946177	19.4428007	1.00000000	39.0155269	1.00000000
7	Pearson VII Area	9.65426092	565.420732	20.0963345	0.99999967	41.9099131	0.99999983
8	Pearson VII Area	8.16190176	647.371132	15.4438704	1.00000000	31.9819268	1.00000000

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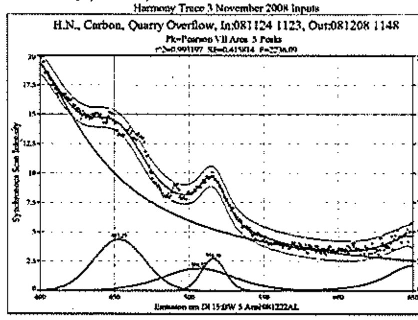
Scanning Spectrofluorophotometer Results – Shimadzu RF-5000 and PeakFit V4.0
Harmony Trace 3 November 2008 Inputs



Description: H.N., Carbon, Quarry Overflow, In:081124 1123, Out:081208 1148
X Variable: Emission nm Δλ 15:BW 5 Anal:081222AL
Y Variable: Synchronous Scan Intensity
File Source: g:\dyetracing\harmony081103\harmony081124-081208\hnqo1208

Fitted Parameters

r² Coef Det	DF Adj r²	Fit Std Err	F-value
0.99319723	0.99272807	0.41581433	2236.06830

Peak	Type	a0	a1	a2	a3
1	Pearson VII Area	44857.0673	389.607000	119.374138	0.51635622
2	Pearson VII Area	185.236998	453.248897	39.9582102	167.917669
3	Pearson VII Area	119.575759	506.522891	56.6300944	4.44258782
4	Pearson VII Area	54.3047019	516.260632	18.6090944	18.6300837
5	Pearson VII Area	111.511711	650.484281	41.7625819	1.80072864

Measured Values

Peak	Type	Amplitude	Center	FWHM	Asym50	FW Base	Asym10
1	Pearson VII Area	20.2173408	389.606999	119.374138	1.00000002	0.00000000	0.00000000
2	Pearson VII Area	4.34976725	453.248897	39.9582102	1.00000000	80.1832333	1.00000000
3	Pearson VII Area	1.88349055	506.522989	56.6300944	1.00000016	125.102582	1.00000008
4	Pearson VII Area	2.71104063	516.260631	18.6090944	1.00000008	38.1005256	1.00000004
5	Pearson VII Area	2.12523409	648.399987	42.0671966	1.21998633	108.802511	1.08843542

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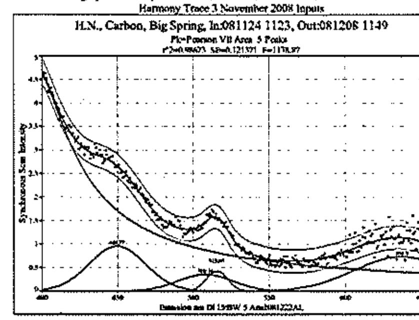
Scanning Spectrofluorophotometer Results – Shimadzu RF-5000 and PeakFit V4.0
Harmony Trace 3 November 2008 Inputs



Description: H.N., Carbon, Big Spring, In:081124 1123, Out:081208 1149
X Variable: Emission nm Δλ 15:BW 5 Anal:081222AL
Y Variable: Synchronous Scan Intensity
File Source: g:\dyetracing\harmony081103\harmony081124-081208\hnbs1208

Fitted Parameters

r² Coef Det	DF Adj r²	Fit Std Err	F-value
0.98673028	0.98581513	0.12137304	1138.87497

Peak	Type	a0	a1	a2	a3
1	Pearson VII Area	7077.59551	393.217418	74.2808815	0.51545165
2	Pearson VII Area	44.5280874	449.770854	43.5900449	27.1858101
3	Pearson VII Area	16.3084937	508.164368	43.2757070	82.7069061
4	Pearson VII Area	7.50583521	515.651235	16.6551015	167.919233
5	Pearson VII Area	56.3218647	636.898882	72.5984750	103.082839

Measured Values

Peak	Type	Amplitude	Center	FWHM	Asym50	FW Base	Asym10
1	Pearson VII Area	4.83628892	393.405963	74.2845542	0.98989867	0.00000000	0.00000000
2	Pearson VII Area	0.95242622	449.770854	43.5900449	1.00000000	88.6110362	1.00000000
3	Pearson VII Area	0.35315953	508.164368	43.2757070	1.00000000	87.0631290	1.00000000
4	Pearson VII Area	0.42274679	515.651235	16.6551015	0.99999996	33.4214134	0.99999998
5	Pearson VII Area	0.72730237	636.898882	72.5984750	0.99999999	145.909592	1.00000000

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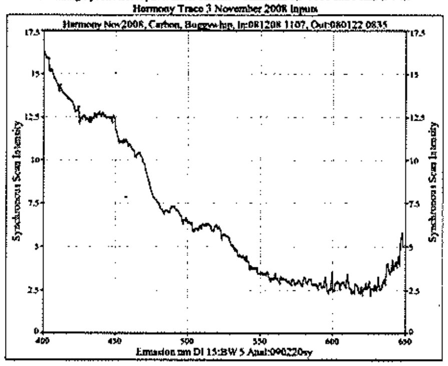
Scanning Spectrofluorophotometer Results – Shimadzu RF-5000 and PeakFit V4.0
Harmony Trace 3 November 2008 Inputs



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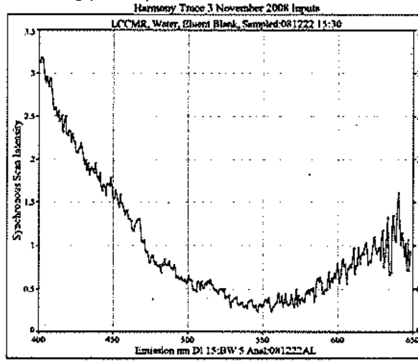
Scanning Spectrofluorophotometer Results – Shimadzu RF-5000 and PeakFit V4.0
Harmony Trace 3 November 2008 Inputs



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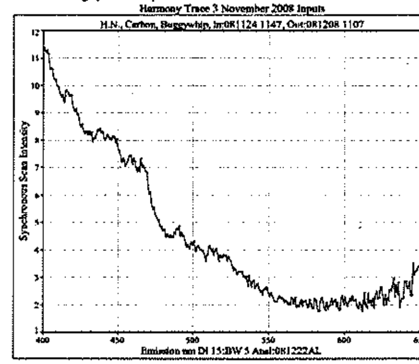
Scanning Spectrofluorophotometer Results – Shimadzu RF-5000 and PeakFit V4.0
Harmony Trace 3 November 2008 Inputs



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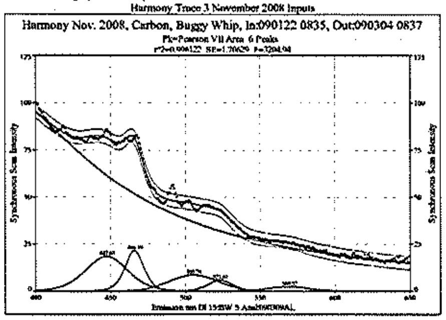
Scanning Spectrofluorophotometer Results – Shimadzu RF-5000 and PeakFit V4.0

Harmony Trace 3 November 2008 Inputs



Description: Harmony Nov. 2008, Carbon, Buggy Whip, In:090122 0835, Out:090304 0837
X Variable: Emission nm Δλ 15:BW 5 Anal:090309AL
Y Variable: Synchronous Scan Intensity
File Source: g:\dyetracing\harmony081103\harmony090122-090304\hab-0304

Fitted Parameters

r² Coef Det	DF Adj r²	Fit Std Err	F-value
0.99612165	0.99579619	1.70628501	3204.93717

Peak	Type	a0	a1	a2	a3
1	Pearson VII Area	45356.8315	362.190254	191.985044	0.75283032
2	Pearson VII Area	461.975411	447.631570	32.8941904	4.33712347
3	Pearson VII Area	364.264820	466.189345	14.7286522	3.04448723
4	Pearson VII Area	354.535926	505.738088	38.9446201	167.905214
5	Pearson VII Area	130.281934	523.607436	19.6882356	3.69360209
6	Pearson VII Area	98.3058978	569.515151	34.6440585	2.54729359

Measured Values

Peak	Type	Amplitude	Center	FWHM	Asym50	FW Base	Asym10
1	Pearson VII Area	111.743916	362.190255	458.182776	0.00000000	0.00000000	0.00000000
2	Pearson VII Area	18.4668897	447.631569	32.8941904	1.00000016	72.8566194	1.00000008
3	Pearson VII Area	21.4362900	466.189345	14.7286522	0.99999992	34.1576369	0.99999996
4	Pearson VII Area	8.54195054	505.738088	38.9446201	1.00000000	78.1492994	1.00000000
5	Pearson VII Area	5.53075224	523.607436	19.6882356	1.00000006	44.4257686	1.00000003
6	Pearson VII Area	2.41164721	569.515148	34.6440585	1.00000031	82.8677995	1.00000014

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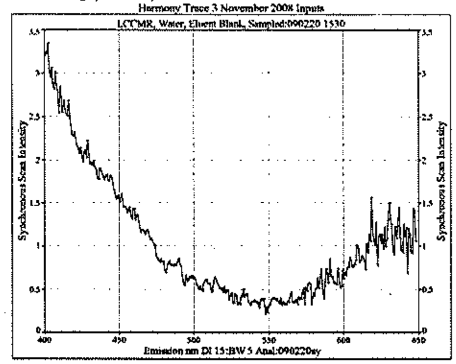
Scanning Spectrofluorophotometer Results – Shimadzu RF-5000 and PeakFit V4.0

Harmony Trace 3 November 2008 Inputs



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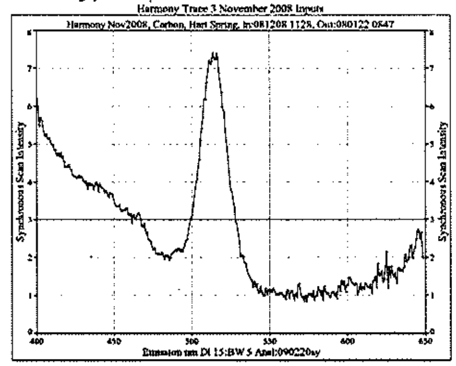
Scanning Spectrofluorophotometer Results – Shimadzu RF-5000 and PeakFit V4.0

Harmony Trace 3 November 2008 Inputs



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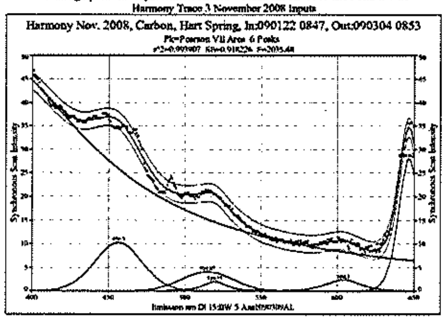
Scanning Spectrofluorophotometer Results – Shimadzu RF-5000 and PeakFit V4.0

Harmony Trace 3 November 2008 Inputs



Description: Harmony Nov. 2008, Carbon, Hart Spring, In:090122 0847, Out:090304 0853
X Variable: Emission nm Δλ 15:BW 5 Anal:090309AL
Y Variable: Synchronous Scan Intensity
File Source: g:\dyetracing\harmony081103\harmony090122-090304\hab-0304

Fitted Parameters

r² Coef Det	DF Adj r²	Fit Std Err	F-value
0.99390698	0.99339568	0.91822593	2035.48010

Peak	Type	a0	a1	a2	a3
1	Pearson VII Area	20020.7111	368.308294	178.946715	0.73602522
2	Pearson VII Area	398.529528	456.502189	36.3455394	18.6355438
3	Pearson VII Area	170.854340	514.866301	39.2413615	167.352279
4	Pearson VII Area	47.1528727	519.748873	18.0028068	1.38800665
5	Pearson VII Area	76.6532340	604.100039	27.0212534	2.11042427
6	Pearson VII Area	491.860662	646.624868	15.7150996	4.61583757

Measured Values

Peak	Type	Amplitude	Center	FWHM	Asym50	FW Base	Asym10
1	Pearson VII Area	51.0011936	368.308293	178.946715	1.00000003	0.00000000	0.00000000
2	Pearson VII Area	10.1866016	456.502189	36.3455394	1.00000000	74.4157040	1.00000000
3	Pearson VII Area	4.08530501	514.866301	39.2413615	1.00000000	78.7454099	1.00000000
4	Pearson VII Area	1.95876529	519.748873	18.0028068	1.00000000	51.1049434	1.00000000
5	Pearson VII Area	2.35930862	604.100039	27.0212534	1.00000000	66.7925394	1.00000000
6	Pearson VII Area	27.9799500	646.624869	15.7150996	0.99999984	34.5120581	0.99999992

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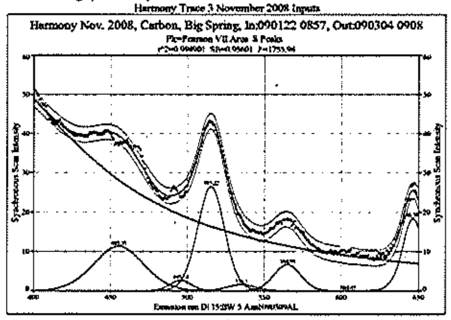
Scanning Spectrofluorophotometer Results – Shimadzu RF-5000 and PeakFit V4.0

Harmony Trace 3 November 2008 Inputs



Description: Harmony Nov. 2008, Carbon, Big Spring, In:090122 0857, Out:090304 0908
X Variable: Emission nm Δλ 15:BW 5 Anal:090309AL
Y Variable: Synchronous Scan Intensity
File Source: g:\dyetracing\harmony081103\harmony090122-090304\hab-0304

Fitted Parameters

r² Coef Det	DF Adj r²	Fit Std Err	F-value
0.99490067	0.99431370	0.95600962	1755.93809

Peak	Type	a0	a1	a2	a3
1	Pearson VII Area	22209.8544	360.355445	179.242274	0.75883335
2	Pearson VII Area	464.757740	455.346978	38.1199939	12.2523750
3	Pearson VII Area	47.0238226	495.735137	16.5065765	19.9451493
4	Pearson VII Area	588.471284	515.219588	20.4447818	9.82777079
5	Pearson VII Area	38.5359725	535.098809	22.1259598	11.0063007
6	Pearson VII Area	148.552052	564.860516	20.3694544	13.2017290
7	Pearson VII Area	19.5990322	604.445606	11.7994165	0.51000000
8	Pearson VII Area	321.771069	646.381386	15.6489127	4.66100352

Measured Values

Peak	Type	Amplitude	Center	FWHM	Asym50	FW Base	Asym10
1	Pearson VII Area	59.3314499	360.355445	449.976582	0.00000000	0.00000000	0.00000000
2	Pearson VII Area	11.2576485	455.346978	38.1199939	1.00000000	78.9908440	1.00000000
3	Pearson VII Area	2.64855120	495.735139	16.5065765	0.99999952	33.7457096	0.99999974
4	Pearson VII Area	26.4580308	515.219588	20.4447818	1.00000000	42.7566065	1.00000000
5	Pearson VII Area	1.60488771	535.098810	22.1259598	0.99999981	46.0123381	0.99999990
6	Pearson VII Area	6.74272915	564.860517	20.3694544	0.99999967	42.1021087	0.99999982
7	Pearson VII Area	0.05573247	604.445606	11.7994165	0.99999991	73.7772633	0.99999998
8	Pearson VII Area	18.3916422	646.381387	15.6489127	0.99999989	34.4032948	0.99999995

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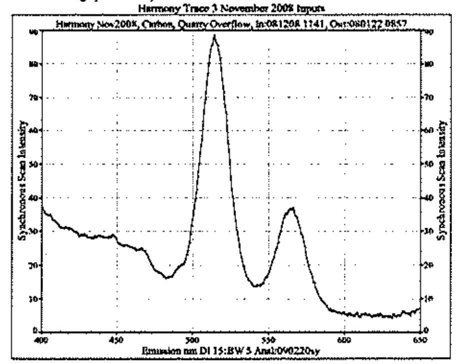
Scanning Spectrofluorophotometer Results – Shimadzu RF-5000 and PeakFit V4.0

Harmony Trace 3 November 2008 Inputs



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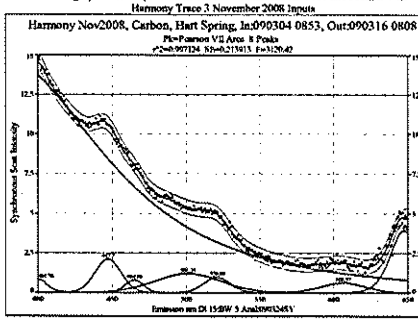
Scanning Spectrofluorophotometer Results -- Shimadzu RF-5000 and PeakFit V4.0
Harmony Trace 3 November 2008 Inputs



Description: Harmony Nov2008, Carbon, Hart Spring, In:090304 0853, Out:090316 0808
X Variable: Emission nm Δλ 15:BW 5 Anal:090324SY
Y Variable: Synchronous Scan Intensity
File Source: g:\dyetracing\harmony081103\harmony090304-090316\hshs0316

Fitted Parameters

r^2 Coef Det	DF Adj r^2	Fit Std Err	F-value
0.99712407	0.99679303	0.21391268	3120.42329

Peak	Type	a_0	a_1	a_2	a_3
1	Pearson VII Area	3322.64231	373.912943	164.123925	1.33462553
2	Pearson VII Area	12.5700766	401.380499	11.5243319	1.42425102
3	Pearson VII Area	46.1692057	447.203551	20.2952724	15.5569897
4	Pearson VII Area	12.3691805	464.875601	14.8450930	167.525934
5	Pearson VII Area	68.1417536	501.345032	53.2759617	15.5714968
6	Pearson VII Area	21.8219848	520.888522	21.1704127	25.2836800
7	Pearson VII Area	25.0640290	606.574763	35.4198537	5.40627992
8	Pearson VII Area	95.1376634	647.414153	21.4658540	4.04485981

Measured Values

Peak	Type	Amplitude	Center	FWHM	Asym50	FW Base	Asym10
1	Pearson VII Area	15.0158421	373.912943	164.123925	1.00000000	0.00000000	0.00000000
2	Pearson VII Area	0.82298533	401.380499	11.5243319	1.00000000	32.3763556	1.00000000
3	Pearson VII Area	2.10854240	447.203551	20.2952724	1.00000000	41.7426098	1.00000000
4	Pearson VII Area	0.78180977	464.875602	14.8450930	0.99999982	29.7894840	0.99999990
5	Pearson VII Area	3.18552980	501.345032	53.2759617	1.00000000	109.573332	1.00000000
6	Pearson VII Area	0.96048042	520.888524	21.1704127	0.99999958	43.0862378	0.99999977
7	Pearson VII Area	0.63770829	606.574761	35.4198537	1.00000023	76.8273604	1.00000012
8	Pearson VII Area	3.93113472	647.414153	21.4658540	1.00000000	47.9083064	1.00000000

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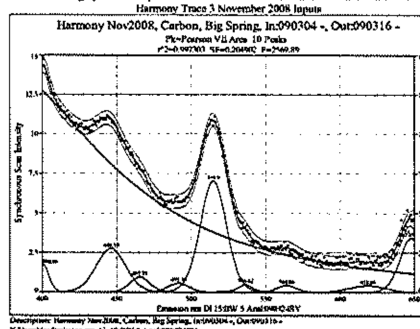
Scanning Spectrofluorophotometer Results -- Shimadzu RF-5000 and PeakFit V4.0
Harmony Trace 3 November 2008 Inputs



Description: Harmony Nov2008, Carbon, Big Spring, In:090304 -, Out:090316 -
X Variable: Emission nm Δλ 15:BW 5 Anal:090324SY
Y Variable: Synchronous Scan Intensity
File Source: g:\dyetracing\harmony081103\harmony090304-090316\hsbs0316

Fitted Parameters

r^2 Coef Det	DF Adj r^2	Fit Std Err	F-value
0.99730339	0.99690389	0.20490236	2569.80354

Peak	Type	a0	a1	a2	a3
1	Pearson VII Area	4004.06693	361.241430	184.306746	1.13090461
2	Pearson VII Area	16.4421878	400.860274	8.74315123	3.41998865
3	Pearson VII Area	68.5800011	446.176330	22.8043201	9.12412109
4	Pearson VII Area	16.1640058	465.548239	15.4474228	9.29132544
5	Pearson VII Area	10.2167576	491.448434	16.4931727	9.81890902
6	Pearson VII Area	157.353602	514.899955	20.5466511	10.0250964
7	Pearson VII Area	7.77824653	536.421659	10.4282218	1.18999968
8	Pearson VII Area	7.53591714	564.061943	15.0290910	4.14939933
9	Pearson VII Area	13.2788407	618.635468	29.2748044	167.306423
10	Pearson VII Area	67.2662854	647.845028	17.9001648	7.21608085

Measured Values

Peak	Type	Amplitude	Center	FWHM	Asym50	FW Base	Asym10
1	Pearson VII Area	14.9415880	361.241430	453.434404	0.00000000	0.00000000	0.00000000
2	Pearson VII Area	1.69978407	400.860274	8.74315123	0.99999978	18.9043320	0.99999999
3	Pearson VII Area	2.75940351	446.176330	22.8043201	1.00000010	47.8955858	1.00000005
4	Pearson VII Area	0.94938451	465.548239	15.4474228	0.99999999	32.7199571	1.00000000
5	Pearson VII Area	0.56939620	491.448434	16.4931727	0.99999993	34.4778409	0.99999996
6	Pearson VII Area	7.04284000	514.899955	20.5466511	1.00000001	42.9121751	1.00000000
7	Pearson VII Area	0.51373603	536.421660	10.4282218	0.99999965	32.3291787	0.99999987
8	Pearson VII Area	0.44539702	564.061941	15.0290910	1.00000056	33.4459998	1.00000028
9	Pearson VII Area	0.42560165	618.635467	29.2748044	1.00000013	56.7454414	1.00000007
10	Pearson VII Area	3.42493506	647.845028	17.9001648	0.99999997	38.0281788	0.99999999

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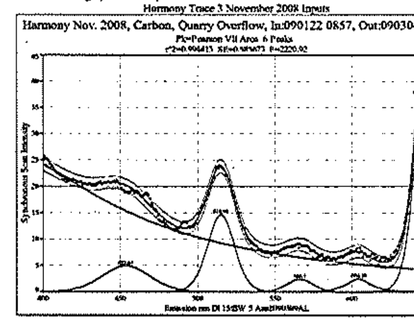
Scanning Spectrofluorophotometer Results -- Shimadzu RF-5000 and PeakFit V4.0
Harmony Trace 3 November 2008 Inputs



Description: Harmony Nov. 2008, Carbon, Quarry Overflow, In:090122 0857, Out:090304 0903
X Variable: Emission nm Δλ 15:BW 5 Anal:090309AL
Y Variable: Synchronous Scan Intensity
File Source: g:\dyetracing\harmony081103\harmony090122-090304\hsqo0304

Fitted Parameters

r^2 Coef Det	DF Adj r^2	Fit Std Err	F-value
0.99441289	0.99394404	0.58567312	2220.92325

Peak	Type	a_0	a_1	a_2	a_3
1	Pearson VII Area	12733.5469	361.053699	204.297955	0.73185891
2	Pearson VII Area	194.845216	453.626860	36.6351679	9.30980360
3	Pearson VII Area	324.261580	514.914345	20.3848153	8.62004848
4	Pearson VII Area	51.2735625	566.102038	19.9664565	37.3404395
5	Pearson VII Area	60.1334290	604.175981	18.7872383	1.47080165
6	Pearson VII Area	664.148442	646.705187	16.0518464	5.25757471

Measured Values

Peak	Type	Amplitude	Center	FWHM	Asym50	FW Base	Asym10
1	Pearson VII Area	28.1367276	361.053699	463.202676	0.00000000	0.00000000	0.00000000
2	Pearson VII Area	4.88253611	453.626860	36.6351679	1.00000000	76.7896868	1.00000000
3	Pearson VII Area	14.5743319	514.914345	20.3848153	1.00000000	42.8778354	1.00000000
4	Pearson VII Area	2.39926387	566.102038	19.9664565	0.99999997	40.4173626	0.99999998
5	Pearson VII Area	2.43862814	604.175980	18.7872383	1.00000024	52.1722277	1.00000010
6	Pearson VII Area	37.2302713	646.705187	16.0518464	0.99999995	34.8998018	0.99999997

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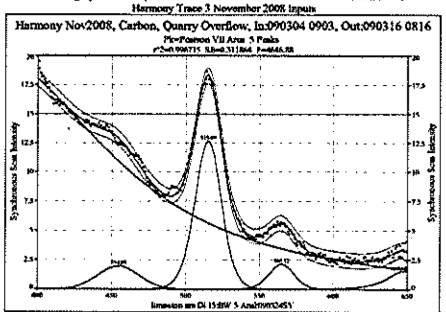
Harmony Trace 3 November 2008 Inputs



Description: Harmony Nov2008, Carbon, Quarry Overflow, In:090304 0903, Out:090316 0816
X Variable: Emission nm Δλ 15:BW 5 Anal:090324SY
Y Variable: Synchronous Scan Intensity
File Source: g:\dyetracing\harmony081103\harmony090304-090316\hsqo0316

Fitted Parameters

r^2 Coef Det	DF Adj r^2	Fit Std Err	F-value
0.99671490	0.99648004	0.31186443	4646.87873

Peak	Type	a_0	a_1	a_2	a_3
1	Pearson VII Area	5449.19421	368.028721	189.069552	1.15870128
2	Pearson VII Area	68.2199422	454.678612	32.4693192	167.720997
3	Pearson VII Area	290.253308	515.091804	20.8722734	6.87165370
4	Pearson VII Area	46.4876587	565.123453	19.9382718	8.57226009
5	Pearson VII Area	54.8393031	647.623762	26.2053064	1.32571232

Measured Values

Peak	Type	Amplitude	Center	FWHM	Asym50	FW Base	Asym10
1	Pearson VII Area	20.0030125	368.028723	462.563498	0.00000000	0.00000000	0.00000000
2	Pearson VII Area	1.97143227	454.678612	32.4693192	1.00000001	65.1556355	1.00000000
3	Pearson VII Area	12.6332630	515.091803	20.8722734	1.00000006	44.4792198	1.00000003
4	Pearson VII Area	2.13593111	565.123455	19.9382718	0.99999995	41.9504694	0.99999997
5	Pearson VII Area	1.53916621	647.623762	26.2053064	0.99999999	75.8150312	1.00000000

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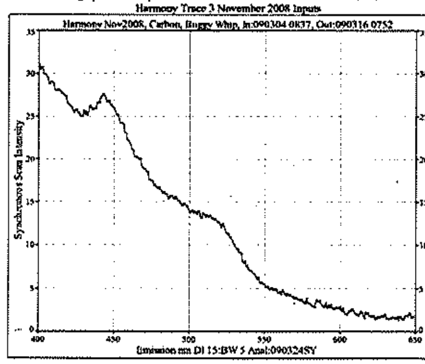
Harmony Trace 3 November 2008 Inputs



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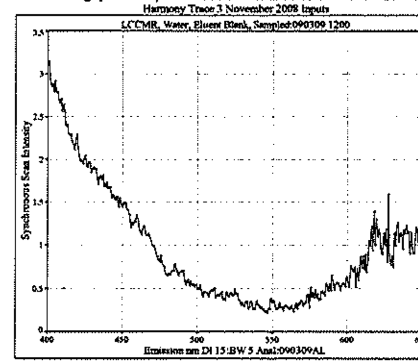
Scanning Spectrofluorophotometer Results -- Shimadzu RF-5000 and PeakFit V4.0
Harmony Trace 3 November 2008 Inputs



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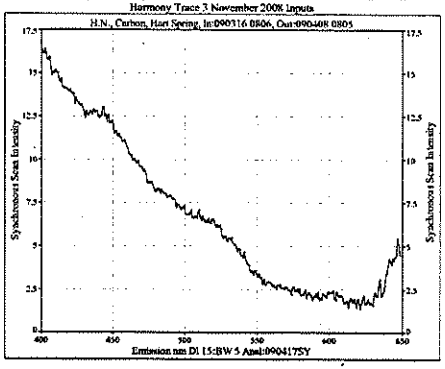
Scanning Spectrofluorophotometer Results – Shimadzu RF-5000 and PeakFit V4.0
Harmony Trace 3 November 2008 Inputs



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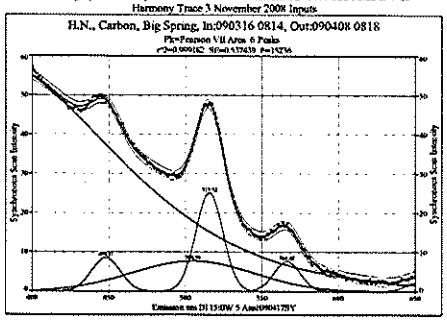
Harmony Trace 3 November 2008 Inputs



Description: H.N., Carbon, Big Spring, In:090316 0814, Out:090408 0818
X Variable: Emission nm Δλ 15:BW 5 Anal:090417SY
Y Variable: Synchronous Scan Intensity
File Source: g:\dyetracing\harmony081103\harmony090316-090408\hnb20408

Fitted Parameters

r² Coef Det	DF Adj r²	Fit Std Err	F-value
0.99918367	0.99911500	0.53743938	15235.9714

Peak	Type	a₀	a₁	a₂	a₃
1	Pearson VII Area	138998.6491	364.604792	204.369118	3.86686149
2	Pearson VII Area	199.052158	448.110872	21.9130286	167.890211
3	Pearson VII Area	765.009658	504.937215	93.0207323	109.559625
4	Pearson VII Area	553.738890	515.517085	20.7419612	99.2812488
5	Pearson VII Area	165.433348	566.420104	20.2791234	31.2064955
6	Pearson VII Area	40.6862692	650.363233	18.4328704	11.3093621

Measured Values

Peak	Type	Amplitude	Center	FWHM	Asym50	FW Base	Asym10
1	Pearson VII Area	60.0619529	364.942529	406.896019	0.00000000	0.00000000	0.00000000
2	Pearson VII Area	8.52331839	448.110872	21.9130286	1.00000000	43.9723949	1.00000000
3	Pearson VII Area	7.72079152	504.937210	93.0207323	1.00000021	186.999807	1.00000012
4	Pearson VII Area	54.9937222	515.517093	20.7419612	1.00000022	41.8127307	1.00000012
5	Pearson VII Area	7.61384441	566.420164	20.2791234	1.00000000	41.1994171	1.00000000
6	Pearson VII Area	2.02779935	649.712644	18.4816339	1.15147209	38.5270912	1.07752325

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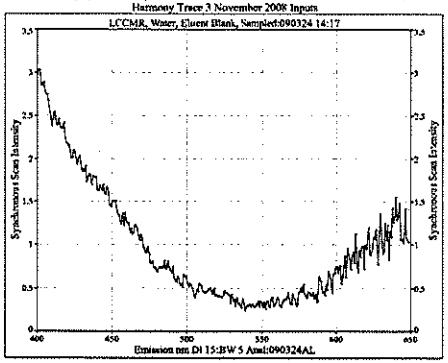
Scanning Spectrofluorophotometer Results – Shimadzu RF-5000 and PeakFit V4.0
Harmony Trace 3 November 2008 Inputs



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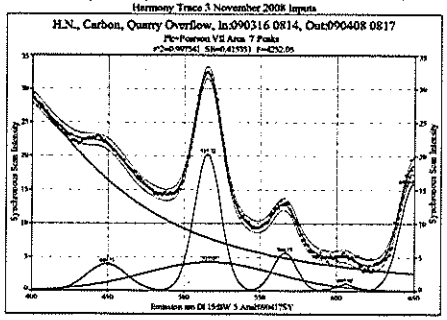
Harmony Trace 3 November 2008 Inputs



Description: H.N., Carbon, Quarry Overflow, In:090316 0814, Out:090408 0817
X Variable: Emission nm Δλ 15:BW 5 Anal:090417SY
Y Variable: Synchronous Scan Intensity
File Source: g:\dyetracing\harmony081103\harmony090316-090408\hnqo0408

Fitted Parameters

r² Coef Det	DF Adj r²	Fit Std Err	F-value
0.99934102	0.99729687	0.41535094	4252.04942

Peak	Type	a₀	a₁	a₂	a₃
1	Pearson VII Area	9192.58294	358.648478	168.648146	1.04070454
2	Pearson VII Area	130.356903	449.309196	30.7376243	159.481862
3	Pearson VII Area	460.959883	515.316390	20.2489953	20.0812659
4	Pearson VII Area	465.424166	517.976669	102.534966	167.916379
5	Pearson VII Area	110.129122	566.150957	18.4036526	102.465369
6	Pearson VII Area	23.8669514	605.919158	14.2572178	0.97289745
7	Pearson VII Area	353.783126	649.612013	20.0978412	14.9749704

Measured Values

Peak	Type	Amplitude	Center	FWHM	Asym50	FW Base	Asym10
1	Pearson VII Area	35.6342119	359.482759	462.980585	0.00000000	0.00000000	0.00000000
2	Pearson VII Area	5.97005974	449.309196	30.7376243	1.00000004	61.4685945	1.00000002
3	Pearson VII Area	20.2460476	515.316390	20.2489953	1.00000014	41.3896290	1.00000006
4	Pearson VII Area	4.26096365	517.976673	102.534966	0.99999985	205.7545905	0.99999992
5	Pearson VII Area	3.61056001	566.150958	18.4036526	0.99999969	36.9988624	0.99999983
6	Pearson VII Area	1.04993671	605.919158	14.2572178	1.00000000	48.3220528	1.00000000
7	Pearson VII Area	15.8345307	649.612010	20.0978412	1.00000059	42.6158105	1.00000032

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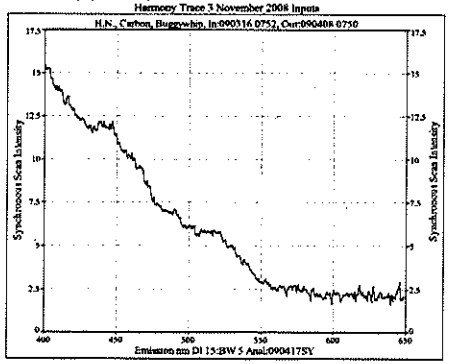

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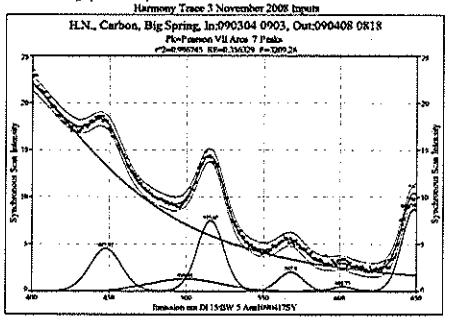
Scanning Spectrofluorophotometer Results – Shimadzu RF-5000 and PeakFit V4.0
Harmony Trace 3 November 2008 Inputs



Description: H.N., Carbon, Big Spring, In:090304 0903, Out:090408 0818
X Variable: Emission nm Δλ 15:BW 5 Anal:090417SY
Y Variable: Synchronous Scan Intensity
File Source: g:\dyetracing\harmony081103\harmony090316-090408\hnb10408

Fitted Parameters

r² Coef Det	DF Adj r²	Fit Std Err	F-value
0.99674462	0.99642139	0.53632852	3209.26194

Peak	Type	a₀	a₁	a₂	a₃
1	Pearson VII Area	6149.189934	366.394589	171.677648	1.19884088
2	Pearson VII Area	116.650445	447.814233	23.7789236	122.353989
3	Pearson VII Area	76.4804470	499.412934	54.9520305	39.7197848
4	Pearson VII Area	163.580489	515.673663	20.3501233	16.9407192
5	Pearson VII Area	41.6520024	567.899242	19.1738821	32.7314625
6	Pearson VII Area	13.5914117	601.728403	15.8241501	0.92217759
7	Pearson VII Area	174.294733	648.382834	18.4494028	11.3628209

Measured Values

Peak	Type	Amplitude	Center	FWHM	Asym50	FW Base	Asym10
1	Pearson VII Area	25.26636454	366.394589	171.677648	1.00000000	0.00000000	0.00000000
2	Pearson VII Area	4.52069099	447.814233	23.7789236	1.00000006	49.2736347	1.00000003
3	Pearson VII Area	1.30075935	499.412934	54.9520305	1.00000014	111.162287	1.00000006
4	Pearson VII Area	7.45908281	515.673663	20.3501233	1.00000004	41.7609628	1.00000002
5	Pearson VII Area	2.05800360	567.899242	19.1738821	1.00000003	38.8742146	1.00000001
6	Pearson VII Area	0.51388338	601.728403	15.8241501	1.00000002	35.4864394	1.00000001
7	Pearson VII Area	8.71082014	648.382834	18.4494028	1.00000007	38.3359792	1.00000004

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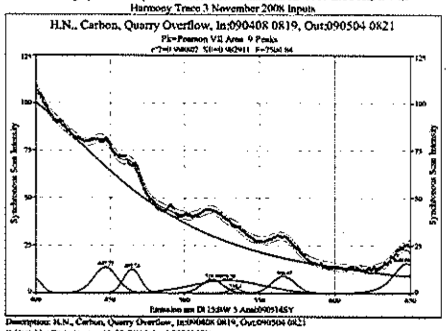
Scanning Spectrofluorophotometer Results – Shimadzu RF-5000 and PeakFit V4.0
Harmony Trace 3 November 2008 Inputs



Description: H.N., Carbon, Quarry Overflow, In:090408 0819, Out:090504 0821
X Variable: Emission nm Δλ 15:BW 5 Anal:090514SY
Y Variable: Synchronous Scan Intensity
File Source: g:\dyetracing\harmony081103\harmony090408-090504\hnqo0504

Fitted Parameters

r² Coef Det	DF Adj r²	Fit Std Err	F-value
0.99880225	0.99866434	0.98291134	7504.84389

Peak	Type	a0	a1	a2	a3
1	Pearson VII Area	29366.8761	369.385887	190.225466	1.22752236
2	Pearson VII Area	84.8085134	399.845649	10.7583061	121.039549
3	Pearson VII Area	272.725873	447.267641	18.3880647	9.27815727
4	Pearson VII Area	177.876502	465.236693	13.3406792	167.878249
5	Pearson VII Area	136.092840	518.880200	17.2614675	8.98773019
6	Pearson VII Area	429.943483	529.281529	56.6922376	9.53171389
7	Pearson VII Area	28.6447580	534.195400	10.9195400	10.0000000
8	Pearson VII Area	177.391163	566.421644	18.5376220	70.0554899
9	Pearson VII Area	406.716918	648.058901	21.3255989	2.15128883

Measured Values

Peak	Type	Amplitude	Center	FWHM	Asym50	FW Base	Asym10
1	Pearson VII Area	110.061306	369.385887	464.498420	0.00000000	0.00000000	0.00000000
2	Pearson VII Area	7.33222815	400.297356	10.7947234	0.84870635	21.8204334	0.91413704
3	Pearson VII Area	13.6147506	447.267641	18.3880647	1.00000002	38.5387077	1.00000001
4	Pearson VII Area	12.5107927	465.236693	13.3406792	0.99999999	26.7706537	1.00000000
5	Pearson VII Area	7.23154445	518.880200	17.2614675	0.99999999	36.2324833	1.00000000
6	Pearson VII Area	6.96411837	529.281529	56.6922376	1.00000000	118.669965	1.00000000
7	Pearson VII Area	2.41228076	534.195402	10.9195400	0.99999916	22.8082087	0.99999936
8	Pearson VII Area	8.97379404	566.421645	18.5376220	0.99999977	37.3285260	0.99999987
9	Pearson VII Area	15.8242922	648.058901	21.3255989	0.99999999	52.8962039	1.00000000

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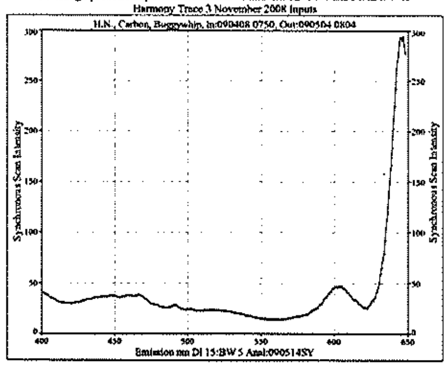
Scanning Spectrofluorophotometer Results – Shimadzu RF-5000 and PeakFit V4.0
Harmony Trace 3 November 2008 Inputs



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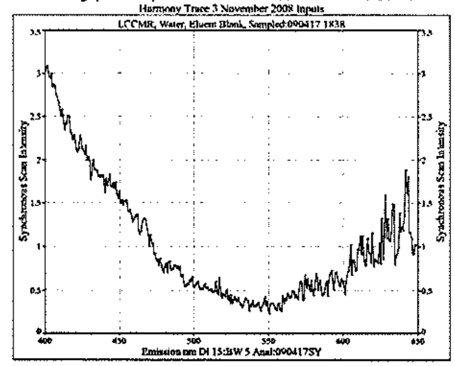
Harmony Trace 3 November 2008 Inputs



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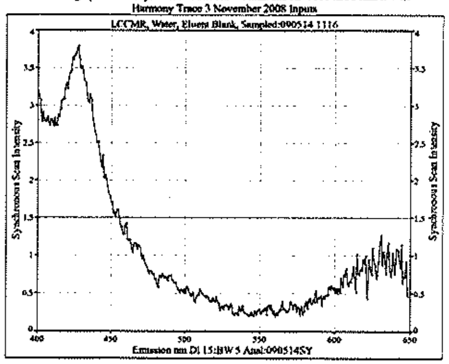
Scanning Spectrofluorophotometer Results – Shimadzu RF-5000 and PeakFit V4.0
Harmony Trace 3 November 2008 Inputs



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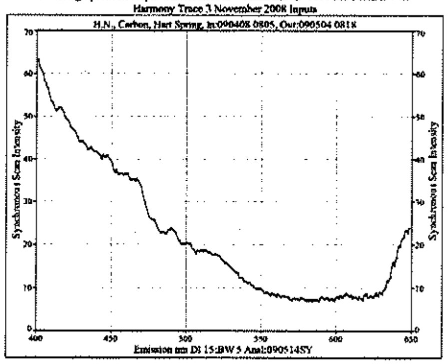
Harmony Trace 3 November 2008 Inputs



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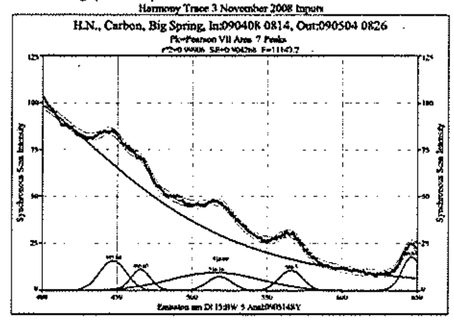
Harmony Trace 3 November 2008 Inputs



Description: H.N., Carbon, Big Spring, In:090408 0814, Out:090504 0826
X Variable: Emission nm Δλ 15:BW 5 Anal:090514SY
Y Variable: Synchronous Scan Intensity
File Source: g:\dyetracing\harmony081103\harmony090408-090504\hnbs0504

Fitted Parameters

r² Coef Det	DF Adj r²	Fit Std Err	F-value
0.99906026	0.99896696	0.90426829	11143.1700

Peak	Type	a0	a1	a2	a3
1	Pearson VII Area	29402.3247	361.085496	209.025643	1.30908719
2	Pearson VII Area	353.800585	447.643018	21.0382626	163.708082
3	Pearson VII Area	188.903885	466.069896	15.2593052	5.05947245
4	Pearson VII Area	735.436379	516.157548	71.2694956	27.8222002
5	Pearson VII Area	155.424077	518.888542	19.1526272	12.9543648
6	Pearson VII Area	215.307980	566.297138	18.6435285	41.2144120
7	Pearson VII Area	292.259498	646.633425	14.9743979	7.88287958

Measured Values

Peak	Type	Amplitude	Center	FWHM	Asym50	FW Base	Asym10
1	Pearson VII Area	110.989109	361.206897	465.098420	0.00000000	0.00000000	0.00000000
2	Pearson VII Area	13.7790002	447.643017	21.0382626	1.00000007	42.2196994	1.00000004
3	Pearson VII Area	11.1256143	466.069896	15.2593052	0.99999998	33.2890386	0.99999999
4	Pearson VII Area	9.62266108	516.157548	71.2694956	1.00000000	144.827033	1.00000000
5	Pearson VII Area	7.50046358	518.888542	19.1526272	1.00000004	39.6117007	1.00000002
6	Pearson VII Area	10.8095842	566.297140	18.6435285	0.99999962	37.6994529	0.99999980
7	Pearson VII Area	17.8372102	646.633425	14.9743979	0.99999996	31.6480921	0.99999998

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