Olin

P.O. BOX 248, 1186 LOWER RIVER ROAD, NW, CHARLESTON, TN 37310-0248
(423) 336-4000 FAX: (423) 336-4183

August 31, 1998

Mr. James Craft
Engineering Geologist
New York State Department of Environmental Conservation
Region 8 Office - Division of Hazardous Waste Remediation
6274 East Avon - Lima Road
Avon, New York 14414-9519

Re: Olin Rochester RI/FS Quarterly Report No. 19
Olin Chemicals (Site #628018a) 100 McKee Rd, Rochester, NY

Dear Mr. Craft:

This is the nineteenth quarterly report of progress on the Olin Rochester RI/FS, covering the period from April 1, 1998 through June 30, 1998.

Surface water and seep sampling:

- Second quarter 1998 surface water sampling was done at seven locations: the original three Barge Canal locations near the groundwater plume, and at one additional location. The quarry outfall and one nearby canal point were also sampled to monitor the chloropyridine input to the canal and its level of dilution near the input point. One quarry seep point (QS4, the historically most contaminated location) was also sampled.

- Generally, the second quarter surface water sampling results were consistent with prior monitoring episodes or showed decreases.
  - The second quarter results indicated the presence of 2-chloropyridine at trace (detected but below practical quantitation limit) levels of 1 to 4 ug/l at the quarry outfall. This represents a continued decreasing trend at this point.
  - No pyridines or chloropyridines were detected at surface water sampling points SW1,2,3 and 12. This is consistent with seasonal monitoring trends.
  - The quarry seep contained just over 500 ug/l of chloropyridines, consistent with previously detected levels, and maintaining a trend of decreasing levels since monitoring was initiated.
  - No chloropyridines were detected at the monitoring point 100 feet from the quarry outfall.
- Canal and quarry monitoring results are documented in ***attachment 1*.**

groundwater monitoring:

- Piezometric plots were developed for June, 1998. Plots and piezometric data are included as ***attachment 2***. Plots for shallow bedrock reflect less capture than is actually being achieved, since measurements coincided with maintenance down-time for several pumping wells. Olin will avoid this conflict in future monitoring events.
- A revised proposal for groundwater sampling is presented in ***attachment 3***. This proposal supercedes the proposal in Olin's letter of May 11, 1998 (***attachment 4***) and reflects comments and concerns of NYSDEC made since that time. Olin feels that this proposal provides adequate monitoring for the current phase of study, but allows information development in a cost effective manner. The proposal consists of :
  - a] annual sampling of all offsite wells to confirm offsite plume location and to identify any trends as they develop, prior to finalization of the FS and
  - b] annual sampling of selected onsite wells to serve as a baseline against which to compare remedial progress after finalization of the FS.

  The sampling program may, of course, be revised following finalization of the FS to reflect data needs at that time. Olin plans to implement the annual 1998 sampling as proposed, sometime in the early fourth quarter of 1998.

Feasibility Study Issues:

- As noted in the prior quarterly report, Olin has developed and submitted a letter (Mr. Michael J. Bellotti to Mr. James Craft, May 11, 1998) summarizing a revised FS strategy. This revised FS strategy reflects our February 27 work session and the investigations made by Olin as a result of NYSDEC requests at that work session. The letter is included as ***Attachment 4***. Olin has had informal communication with the Agency on some key issues, but a final consensus has not yet been reached. After all parties concur on the Rochester site FS approach and strategy, Olin will submit a revised FS to the Agencies.

Miscellaneous issues:

- Olin's consultant, formerly ABB Environmental Services, has been purchased, and is now Harding Lawson Associates (HLA). I will refer to them as HLA, and will submit consultant's letter reports on HLA letterhead. The project staff will remain the same. Olin will continue to retain HLA as our RI/FS consultant, and anticipates that they will provide the same highly professional service as they have throughout the RI/FS process.
- The Olin Rochester plant has initiated a project to enhance its capability for treatment of all plant wastewater streams, including the groundwater stream. The project consists of upgrading the efficiency and capacity of the plant's steam condenser unit. This project involves passing all wastewater streams through a steam condenser to "pre-treat" for volatile compounds, prior to sending the stream to carbon filters, where semivolatile compounds and inorganics will be removed. The project will provide significant long term savings in carbon treatment costs. The condenser works by heating (not boiling) wastewater streams in a column using steam input. The water is heated to just below boiling, and volatiles are driven off as vapors. The vapors are cooled and condensed, creating a more concentrated liquid for proper disposal. The process creates a minimal volume of uncondensed vapor release. I have provided design input re: environmental issues, and have incorporated a carbon vapor unit into the design to treat these uncondensed vapors.
- For the second quarter of 1998, the interim groundwater remediation system has collected and treated approximately 2,300,000 gallons of groundwater, removing approximately 207 pounds of organic contaminants.

Olin will continue to communicate progress and issues with NYSDEC. Please direct any questions to me at 423 / 336-4587.

Sincerely,

Michael J. Bellotti

Michael J. Bellotti
Olin Corporation

Attachments

List of Attachments:

1] HLA report: Second Quarter 1998 Erie Barge Canal Water and Quarry Sampling Results

2] Piezometric Plots and supporting data: –June, 1998

3] Summary table: proposed groundwater and surface water monitoring

4] Letter to Mr. James Craft from Mr. Michael J. Bellotti, May 11, 1998, re: Olin Rochester Feasibility Approach Summary.

cc:
Mr. Joseph Ryan
New York State Department of Environmental Conservation
Division of Environmental Enforcement
600 Delaware Avenue
Buffalo, New York 14202-1073

Mr. Joseph White
New York State Department of Environmental Conservation
Division of Hazardous Waste Remediation
50 Wolf Road
Albany, New York 12433-1010

Mr. Steven Shost
New York State Department of Health
Bureau of Environmental Exposure Investigation
2 University Place
Albany, New York 12203

Mr. Rick Gahagan: Olin Rochester, NY
Ms. Monica L. Fries Esq.: Husch & Eppenberger, St. Louis, MO
Mr. Thomas Eschner: HLA, Portland, ME

Harding Lawson Associates
August 28, 1998

Mr. Michael Bellotti
Olin Chemical Corporation
P.O. Box 248, Lower River Road
Charleston, TN 37310

Subject: **Olin Rochester Site - Second Quarter 1998**
Erie Barge Canal Water and Quarry Sampling Results

Dear Mr. Bellotti:

Sampling results for the water samples collected during the second quarter of 1998 from the Erie Barge Canal (Canal) and the Dolomite Products Company quarry (quarry) are enclosed. Canal and quarry sampling are conducted as part of the on-going quarterly monitoring program for the Olin Rochester site. The sampling program, analytical procedure, data review findings, and validated data for the June 1998 monitoring event are discussed below.

Sampling

Seven canal and quarry surface water samples were collected by and submitted to Recra Environmental, Inc. (Recra) for selected pyridine analysis on June 26, 1998. The locations sampled during this quarter are listed below and are shown on the maps in Attachment 1.

Canal Samples	Quarry Samples
SW-1	QS-4 (Quarry Seep)
SW-2	QO-2 (Quarry Outfall)
SW-3	QO-2S1 (100 ft south of QO-2)
SW-12	

Analytical Procedures and Data Review

All water samples were analyzed and reviewed in accordance with 1995 New York State Category B Analytical Services Protocols (ASP95) for the Olin suite of selected pyridines (pyridine, 2-chloropyridine, 3-chloropyridine, 4-chloropyridine, 2,6-dichloropyridine, and p-fluoroaniline). The reporting limit for the selected pyridines is 10 micrograms per liter (µg/L).

A preliminary review of the quality control sample results associated with the analytical results was performed for data quality assurance purposes. Sample results were reviewed for holding time compliance; instrument calibration; surrogate standard recoveries; blank contamination; and matrix spike blank (MSB) and matrix spike/matrix spike duplicate (MS/MSD) accuracy and precision. The results of the data review are discussed in the quality control section of this letter. Overall, the data quality appears to be very good based on the information reviewed.

Engineering and
Environmental Services

511 Congress Street, P.O. Box 7050, Portland, ME 04101   207/775-5401   Fax 207/772-4762

Analytical Results

The results from the June 1998 canal and quarry monitoring event are presented in Attachment 2. Samples which were observed to contain one or more of the selected pyridines are summarized below; all results are expressed in µg/L.

Sample ID	2,6-DCPYR	2-CPYR	3-CPYR
QO-2	1 J	4 J	ND
QS-4	79/66	440/460	3 J/3 J

Notes: ND = Not Detected
J = Estimated value below reporting limit, but greater than zero.
CPYR = chloropyridine
DCPYR = dichloropyridine

As has been seen in the past, selected pyridines were not detected in any of the canal monitoring locations sampled during June 1998. Results reported for the sample collected from the quarry seep (QS-4) continue to show elevated selected pyridine results relative to canal concentrations; however, results observed this quarter continue to indicate a decreasing trend in concentrations for the detected pyridines. Results reported for the quarry outfall (QO-2) were consistent with historical results, and chloropyridines were not detected 100 feet south of the outfall (QO-2S1).

Quality Control

As part of the June 1998 Canal and quarry water sampling program, one matrix spike/matrix spike duplicate (MS/MSD) sample and a field blank sample were collected as quality control samples. Laboratory matrix spike blank (MSB) and field MS/MSD results indicated poor percent recovery (less than 10 percent) for p-fluoroaniline. As a result, all p-fluoroaniline results were considered unusable and flagged as rejected (R). All other quality control results were acceptable.

Conclusions

Results from the second quarter 1998 canal surface water sampling program indicated chloropyridines were not present in surface water locations monitored during June 1998, with the exception of trace concentrations (reported above zero but below the reporting limit of 10 µg/L) in the quarry outfall for 2-chloropyridine and 2,6-dichloropyridine. Chemical results reported for the quarry seep sample indicate selected pyridine concentrations appear to be decreasing from concentrations reported previously.

The next quarterly sampling event is scheduled for September 1998.

If you have any questions or comments on the material described in this letter, please do not hesitate to contact me at (207) 828-3437.

Sincerely,

Harding Lawson Associates

Thomas R. Eschner, R.G.
Associate Project Manager

TRE/jpc

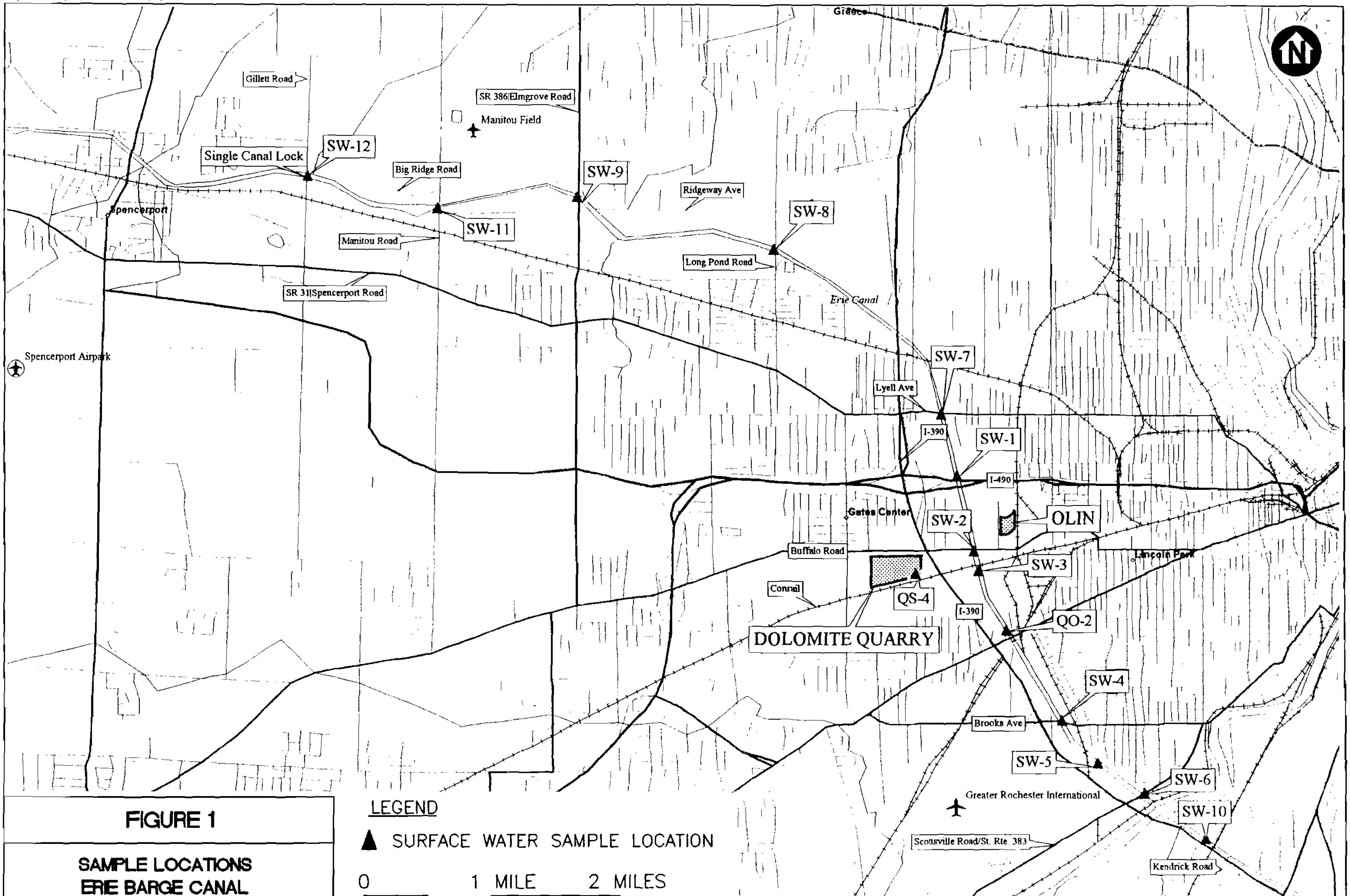
Attachments: Sample Location Maps - Attachment 1
Laboratory Data Summary Tables - Attachment 2
Chain of Custody Forms - Attachment 3

cc: N. Breton
J. Connolly
file 10.1

ATTACHMENT 1

SAMPLE LOCATION MAPS

T:\7311-34\7311F501 C&P 4/1/97



LEGEND

▲ SURFACE WATER SAMPLE LOCATION

0 1 MILE 2 MILES

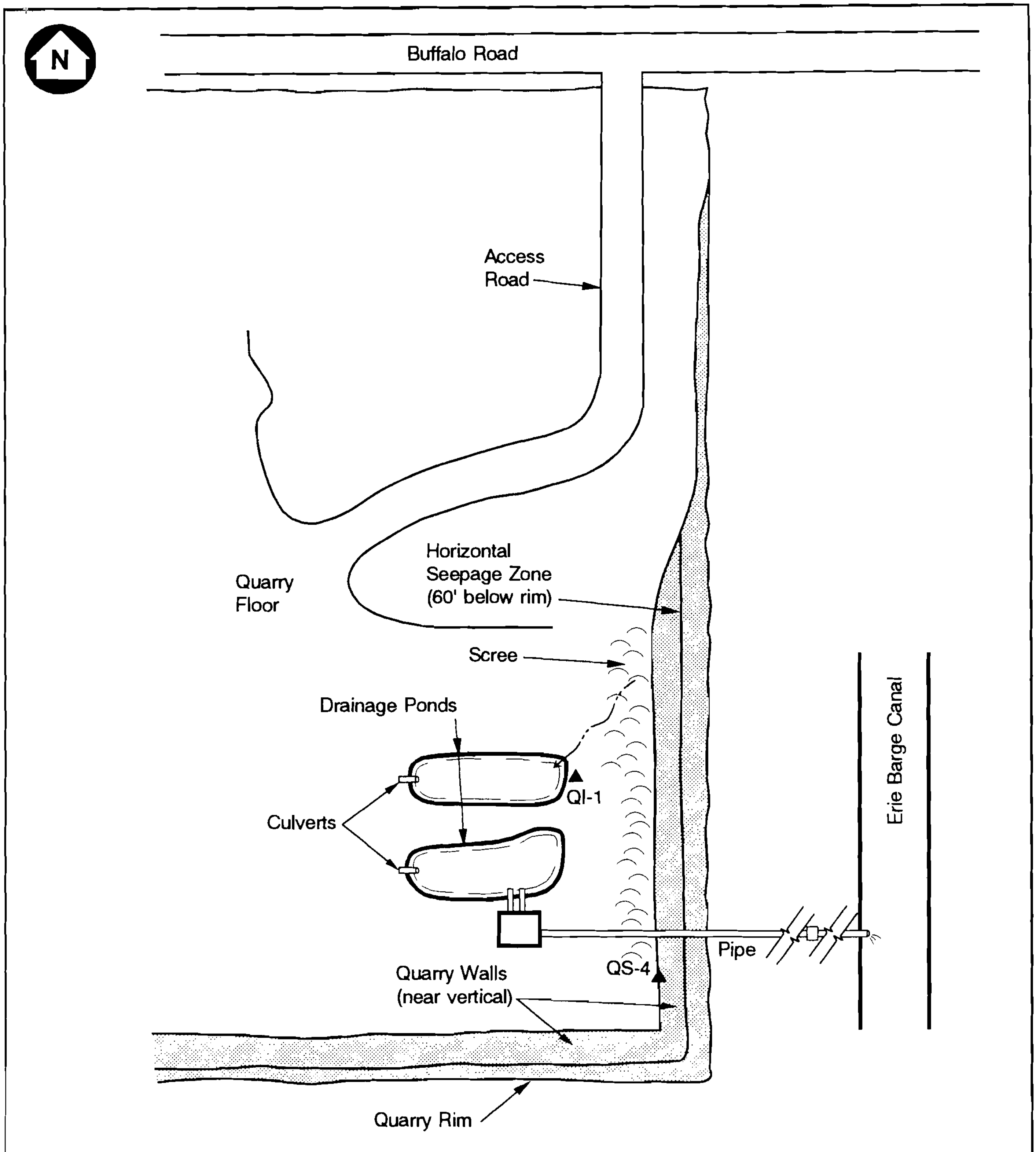
SCALE: 1" = 1 MILE

SOURCE: DeLorme Mapping 1995

FIGURE 1

SAMPLE LOCATIONS
ERIE BARGE CANAL

OLIN CHEMICALS
ROCHESTER, N.Y.



Legend

QS-4 ▲ Seep Sample Location

QI-1 ▲ Pond Inflow Sample Location

Not to Scale

FIGURE 2

SAMPLE LOCATIONS DOLOMITE PRODUCTS QUARRY

OLIN CHEMICALS
PHASE II RI REPORT ADDENDUM
ROCHESTER, NEW YORK

W9801019

ATTACHMENT 2

LABORATORY DATA SUMMARY TABLES

Olin Chemicals
Rochester, NY
June 1998 Sampling Event

Selected Pyridine ASP 95 Analysis (ug/L)

LOCATION DATE SAMPLED SAMPLE TYPE		QO-2 6/26/98 FS	QO-2 S1 6/26/98 FS	QS-4 6/26/98 FS	QS-4 FD 6/26/98 FD	SW-1 6/26/98 FS	SW-12 6/26/98 FS	SW-2 6/26/98 FS	SW-3 6/26/98 FS	RINSE BLANK 6/26/98 RB
PARAMETER	**PQL**									
2,6-Dichloropyridine	10	1 J	10 U	79	66	10 U	10 U	10 U	10 U	10 U
2-Chloropyridine	10	4 J	10 U	440	460	10 U	10 U	10 U	10 U	10 U
3-Chloropyridine	10	10 U	10 U	3 J	3 J	10 U	10 U	10 U	10 U	10 U
4-Chloropyridine	10	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
p-Fluoroaniline	10	R	R	R	R	R	R	R	R	10 U
Pyridine	10	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U

Notes:

FS = Field Sample
FD = Field Duplicate
RB = Rinse Blank
U = Compound was analyzed, but not detected at or above the associated numerical value.
J = Estimated Value
R = Rejected (unusable) Value
ASP95 = New York State Analytical Services Protocol, 1995

ATTACHMENT 3

CHAIN OF CUSTODY FORMS

RECRA LABNET, a division of Recra Environmental, Inc. CTA0379 *CHAIN OF CUSTODY RECORD*

PROJECT NO	SITE NAME
NYSA5762	Olin Roch. RI

SAMPLERS (SIGNATURE): G. Bennett J. Hammer

STATION NO	DATE	TIME	COMP	GRAB	STATION LOCATION	NO OF CONTAINERS	SVOA - Anilines 1 L Amber						REMARKS
1	6-26-98	930			SW-1	2	2						
2		1130			SW-2	2	2						
3		1115			SW-3	2	2						
4		1000			QO-2	6	6						ms/msD
5		1014			QO-2S1	2	2						
6		1015			QS-4	4	4						Field Duplicate
7		1210			SW-12	2	2						
8	↓	1110			Bailer Rinse Blank	2	2						
						22							

RELINQUISHED BY (SIGNATURE)	DATE/TIME		RECEIVED BY (SIGNATURE)	RELINQUISHED BY (SIGNATURE)	DATE/TIME		RECEIVED BY (SIGNATURE)
[signature]	6-26-98	1330	[signature]				
RELINQUISHED BY (SIGNATURE)	DATE/TIME		RECEIVED BY (SIGNATURE)	RELINQUISHED BY (SIGNATURE)	DATE/TIME		RECEIVED BY (SIGNATURE)
RELINQUISHED BY (SIGNATURE)	DATE/TIME		RECEIVED FOR LABORATORY BY (SIGNATURE)	DATE/TIME		REMARKS	

Distribution: Original accompanies shipment copy to coordinator field files

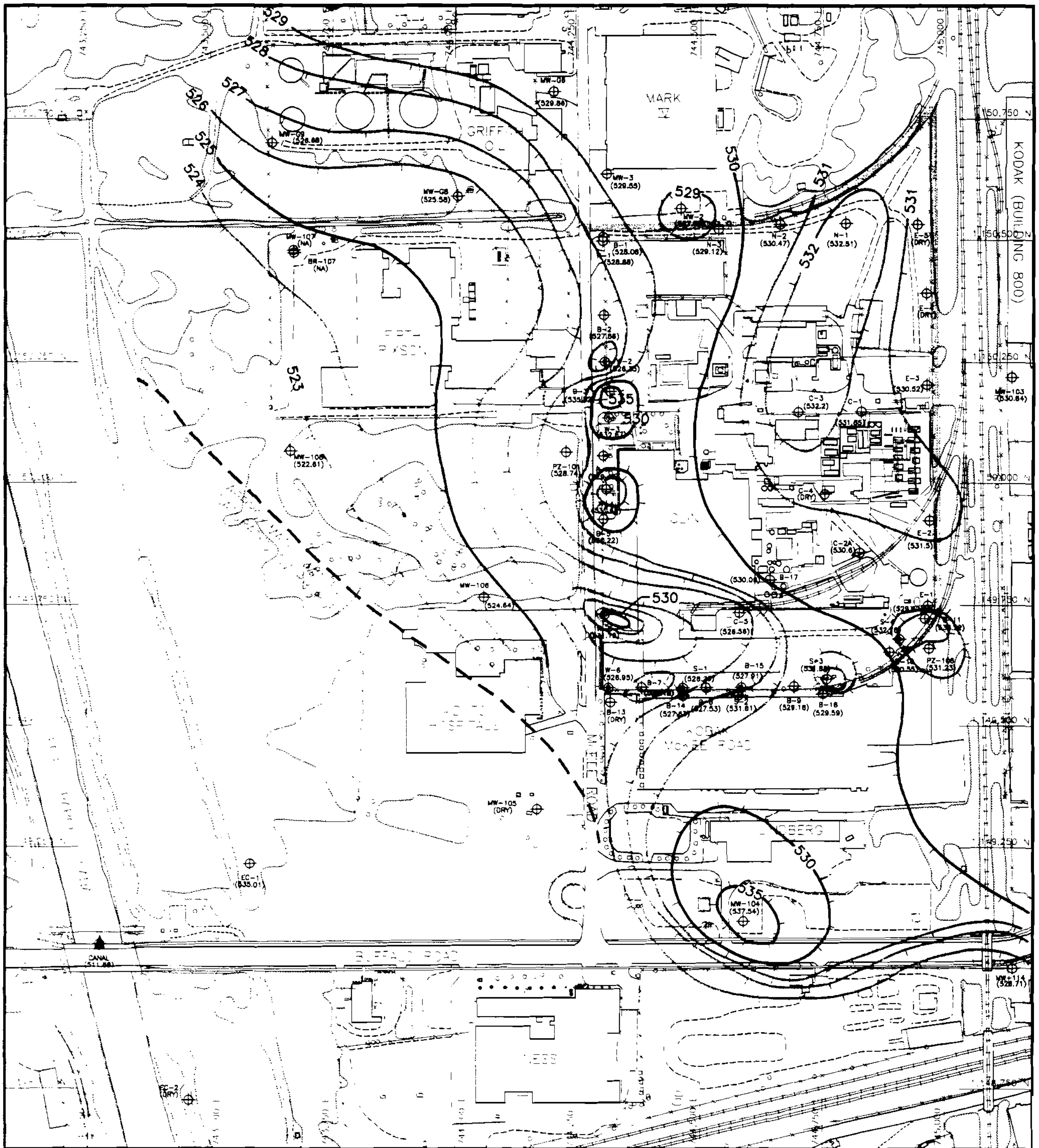
000032

Olin Rochester Piezometric Data: June-1998

WELL	ZONE	REF_ELEV ft-msl	WATER DEPTH ft	WATER_ELEV ft-msl	DATE	OBSERVATIONS
BR-1	Bedrock	537.11	8.02	529.09	6/25/98	
BR-101	Bedrock	540.65	9.2	531.45	6/25/98	
BR-102	Bedrock	540.21	22.6	517.61	6/25/98	
BR-103	Bedrock	533.19	4.2	528.99	6/25/98	
BR-104	Bedrock	537.56	9.27	528.29	6/25/98	
BR-105	Bedrock	536.9	23.67	513.23	6/25/98	
BR-106	Bedrock	535.74	21.52	514.22	6/25/98	
BR-107	Bedrock	536.32	0	NA	6/25/98	AREA REGRADED-UNABLE TO LOCATE WELL
BR-108	Bedrock	540.58	28.86	511.72	6/25/98	
BR-111	Bedrock	540.42	28.78	511.64	6/25/98	
BR-112A	Bedrock	547.72	31.07	516.65	6/25/98	
BR-113	Bedrock	543.02	31.69	511.33	6/25/98	
BR-114	Bedrock	539.77	14.44	525.33	6/25/98	
BR-116	Bedrock	545.38	28.92	516.46	6/25/98	
BR-117	Bedrock	547.61	36.5	511.11	6/25/98	
BR-118	Bedrock	547.79	52.22	495.57	6/25/98	
BR-2	Bedrock	538.97	11.4	527.57	6/25/98	
BR-2A	Bedrock	540.36	9.62	530.74	6/25/98	
BR-3	Bedrock	538.04	10.2	527.84	6/25/98	
BR-4	Bedrock	538.93	13.42	525.51	6/25/98	
BR-5	Bedrock	536.3	6.52	529.78	6/25/98	
BR-5A	Bedrock	536.35	5.97	530.38	6/25/98	
BR-6	Bedrock	538	10.51	527.49	6/25/98	
BR-6A	Bedrock	540.9	15.82	525.08	6/25/98	
BR-7	Bedrock	539.7	20.38	519.32	6/25/98	
BR-7A	Bedrock	539.26	29.59	509.67	6/25/98	
BR-8	Bedrock	540	9.6	530.40	6/25/98	
BR-9	Bedrock	539.31	31.25	508.06	6/25/98	
CANAL	Bedrock	544.79	32.91	511.88	6/25/98	
NESS-E	Bedrock	540.31	26.82	513.49	6/25/98	
NESS-W	Bedrock	543.04	32.16	510.88	6/25/98	
PZ-102	Bedrock	540.89	15.96	524.93	6/25/98	
PZ-103	Bedrock	540.22	11.74	528.48	6/25/98	
PZ-104	Bedrock	537.21	14.43	522.78	6/25/98	
PZ-105	Bedrock	536.93	11.25	525.68	6/25/98	
PZ-106	Bedrock	537.21	9.37	527.84	6/25/98	
PZ-107	Bedrock	538.39	9.08	529.31	6/25/98	
BR-105D	Deep Bedrock	536.49	25.08	511.41	6/25/98	
BR-111D	Deep Bedrock	540.34	28.82	511.52	6/25/98	
BR-112D	Deep Bedrock	547.91	36.49	511.42	6/25/98	
BR-113D	Deep Bedrock	542.93	31.42	511.51	6/25/98	
BR-116D	Deep Bedrock	545.22	36.41	508.81	6/25/98	
BR-117D	Deep Bedrock	547.16	49.54	497.62	6/25/98	
BR-118D	Deep Bedrock	547.93	47.9	500.03	6/25/98	
BR-119D	Deep Bedrock	567.06	67.02	500.04	6/25/98	
BR-120D	Deep Bedrock	557.43	60.5	496.93	6/25/98	
BR-121D	Deep Bedrock	554.79	58.3	496.49	6/25/98	
BR-122D	Deep Bedrock	552.34	44.8	507.54	6/25/98	NEW WELL LOCATED ON CANAL
BR-123D	Deep Bedrock	553.62	45.9	507.72	6/25/98	NEW WELL LOCATED ON CANAL
BR-124D	Deep Bedrock	537.45	31.52	505.93	6/25/98	NEW WELL LOCATED ON CANAL
BR-2D	Deep Bedrock	538	53.63	484.37	6/25/98	
BR-3D	Deep Bedrock	537	79.21	457.79	6/25/98	
B-1	Overburden	537.48	9.4	528.08	6/25/98	
B-10	Overburden	537.97	7.42	530.55	6/25/98	
B-11	Overburden	536	2.78	533.22	6/25/98	
B-13	Overburden	537.07	0	DRY	6/25/98	DRY AT 12.84 FT.
B-14	Overburden	537.95	10.32	527.63	6/25/98	
B-15	Overburden	535.29	7.38	527.91	6/25/98	
B-16	Overburden	536.21	6.62	529.59	6/25/98	
B-17	Overburden	538.84	8.78	530.06	6/25/98	

Olin Rochester Piezometric Data: June-1998

B-2	Overburden	538.91	11.05	527.86	6/25/98	
B-3	Overburden	541.62	5.7	535.92	6/25/98	
B-4	Overburden	542.87	13.42	529.45	6/25/98	
B-5	Overburden	540.1	9.88	530.22	6/25/98	
B-7	Overburden	540.68	15.5	525.18	6/25/98	
B-8	Overburden	538.21	10.68	527.53	6/25/98	
B-9	Overburden	537.67	8.51	529.16	6/25/98	
C-1	Overburden	539.05	7.2	531.85	6/25/98	
C-2A	Overburden	539.12	8.52	530.60	6/25/98	
C-3	Overburden	541.63	9.43	532.20	6/25/98	
C-4	Overburden	540.82	0	DRY	6/25/98	DRY AT 9.42 FT.
C-5	Overburden	536.35	9.79	526.56	6/25/98	
E-1	Overburden	534.32	4.7	529.62	6/25/98	
E-2	Overburden	538.32	6.82	531.50	6/25/98	
E-3	Overburden	536	5.48	530.52	6/25/98	
E-4	Overburden	538.58	0	DRY	6/25/98	DRY AT 2.84 FT.
E-5	Overburden	539.31	0	DRY	6/25/98	DRY AT 6.86 FT.
EC-1	Overburden	539.99	4.98	535.01	6/25/98	
EC-2	Overburden	542	0	DRY	6/25/98	DRY AT 12.75 FT.
MW-103	Overburden	533.25	2.41	530.84	6/25/98	
MW-104	Overburden	537.54	0	537.54	6/25/98	ROAD BOX UNDERWATER
MW-105	Overburden	536.91	0	DRY	6/25/98	DRY AT 18.95 FT.
MW-106	Overburden	535.44	10.8	524.64	6/25/98	
MW-107	Overburden	536.29	0	NA	6/25/98	AREA REGRADED UNABLE TO LOCATE WELL
MW-108	Overburden	540.69	18.08	522.61	6/25/98	
MW-114	Overburden	539.69	12.98	526.71	6/25/98	
MW-2	Overburden	535.5	7.82	527.68	6/25/98	
MW-3	Overburden	535.89	6.34	529.55	6/25/98	
MW-G6	Overburden	534.65	4.79	529.86	6/25/98	
MW-G8	Overburden	534.25	8.67	525.58	6/25/98	
MW-G9	Overburden	536.6	9.92	526.68	6/25/98	
N-1	Overburden	537.06	4.55	532.51	6/25/98	CASING BENT, BAILER LODGED
N-2	Overburden	536.92	6.45	530.47	6/25/98	
N-3	Overburden	537.16	8.04	529.12	6/25/98	
PZ-101	Overburden	542.95	14.21	528.74	6/25/98	
PZ-108	Overburden	536.56	5.33	531.23	6/25/98	
S-1	Overburden	536.76	10.51	526.25	6/25/98	
S-2	Overburden	536.31	4.5	531.81	6/25/98	NOT PUMPING
S-3	Overburden	536.4	4.52	531.88	6/25/98	NOT PUMPING
S-4	Overburden	536.68	4.5	532.18	6/25/98	
W-1	Overburden	536.98	8.1	528.88	6/25/98	
W-2	Overburden	539.53	13.18	526.35	6/25/98	
W-3	Overburden	541.91	9.24	532.67	6/25/98	
W-4	Overburden	540.35	8.73	531.62	6/25/98	
W-5	Overburden	537.69	6.5	531.19	6/25/98	
W-6	Overburden	538.25	11.3	526.95	6/25/98	



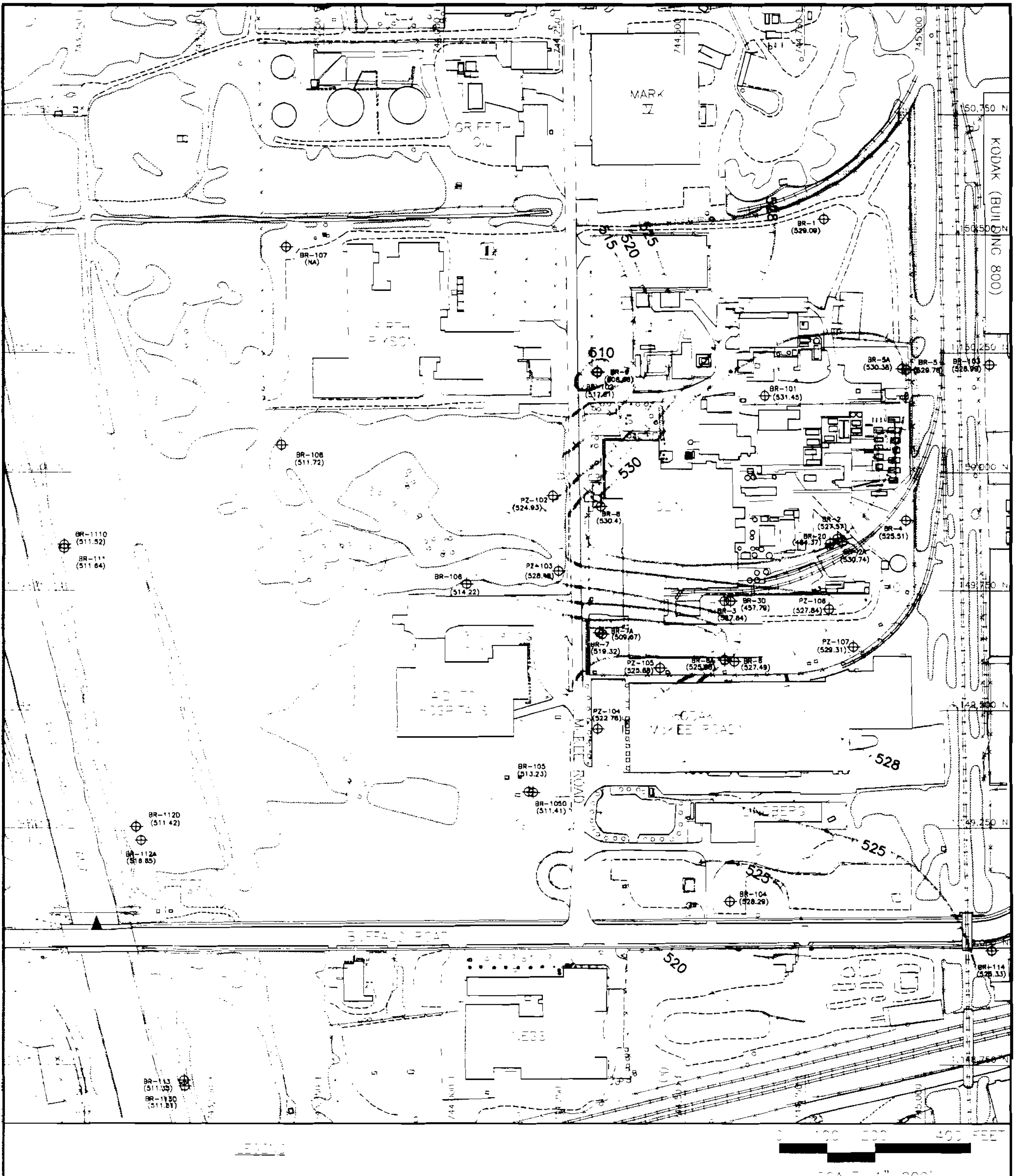
0 100 200 400 FEET

SCALE: 1"=200'

525

JUNE 1998
OVERBURDEN GROUNDWATER
INTERPRETED PIEZOMETRIC
CONTOURS

OLIN CHEMICALS
ROCHESTER, N.Y.



LEGEND

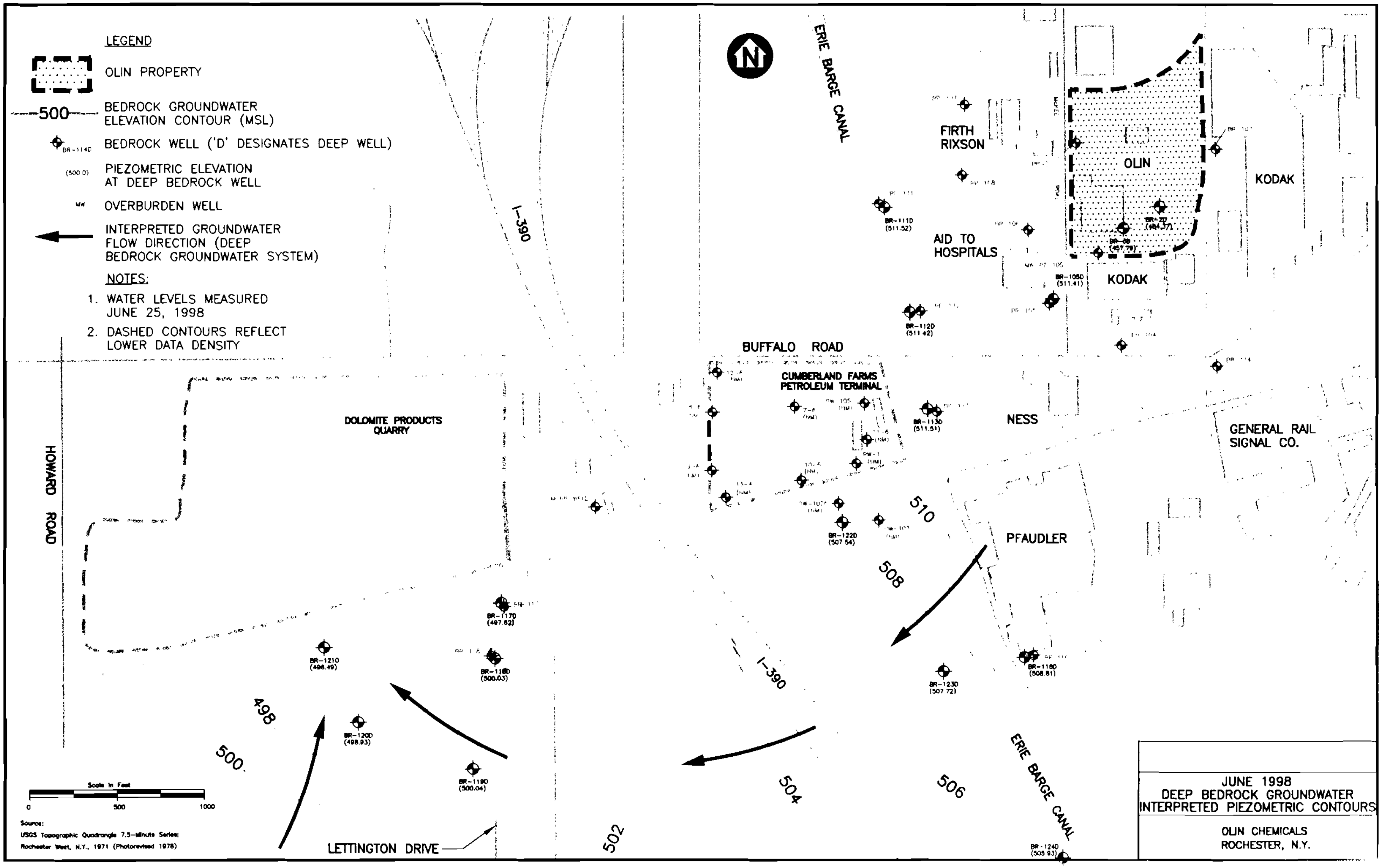
⊕ PIEZOMETRIC ELEVATION AT WELL OR PIEZOMETER, MSL

525

▲ PIEZOMETRIC ELEVATION AT SURFACE WATER MEASUREMENT POINT

JUNE 1998 BEDROCK GROUNDWATER INTERPRETED PIEZOMETRIC CONTOURS

OLIN CHEMICALS
ROCHESTER, N.Y.



JUNE 1998
DEEP BEDROCK GROUNDWATER
INTERPRETED PIEZOMETRIC CONTOURS

OLIN CHEMICALS
ROCHESTER, N.Y.

MONITORING PROGRAM: OLIN ROCHESTER: 1998 Annual Sampling

Well	zone	area	Pyridines	VOC's	Data Objective:
BR103	BR	KODAK EAST	1		shallow bedrock plume monitoring
BR104	BR	BUFFALO RD	1		shallow bedrock plume monitoring
BR105	BR	AID-HOSP	1		shallow bedrock plume monitoring
BR105D	BR deep	AID-HOSP	1		deep bedrock plume monitoring
BR106	BR	AID-HOSP	1		shallow bedrock plume monitoring
BR108	BR	AID-HOSP	1		shallow bedrock plume monitoring
BR111	BR	CANAL	1		shallow bedrock plume monitoring
BR111D	BR deep	CANAL	1		deep bedrock plume monitoring
BR112A	BR	CANAL	1		shallow bedrock plume monitoring
BR112D	BR deep	NYSDOT	1		deep bedrock plume monitoring
BR113	BR	CANAL	1		shallow bedrock plume monitoring
BR113D	BR deep	NYSDOT	1		deep bedrock plume monitoring
BR114	BR	BUFFALO RD	1		shallow bedrock plume monitoring
BR114D	BR deep	BUFFALO RD	1		deep bedrock plume monitoring
BR116	BR	PFAUDLER	1		shallow bedrock plume monitoring
BR116D	BR deep	PFAUDLER	1		deep bedrock plume monitoring
BR117D	BR deep	QUARRY	1		deep bedrock plume monitoring
BR118D	BR deep	QUARRY	1		deep bedrock plume monitoring
BR119D	BR deep	QUARRY	1		deep bedrock plume monitoring
BR120D	BR deep	QUARRY	1		deep bedrock plume monitoring
BR121D	BR deep	QUARRY	1		deep bedrock plume monitoring
BR122D	BR deep	QUARRY	1	1	deep bedrock plume monitoring
BR123D	BR deep	QUARRY	1	1	deep bedrock plume monitoring
BR124D	BR deep	QUARRY	1	1	deep bedrock plume monitoring
NESS-EAST	BR deep	NESS	1		deep bedrock plume monitoring
NESS-WEST	BR deep	NESS	1		deep bedrock plume monitoring
PZ101	BR	McKee Rd	1		shallow bedrock plume monitoring
PZ102	BR	McKee Rd	1		shallow bedrock plume monitoring
PZ103	BR	McKee Rd	1		shallow bedrock plume monitoring
collection	sump	onsite	12	12	monthly: track mass removed
PZ107	BR	onsite	1	1	onsite tracking of contam trends
PZ105	BR	onsite	1	1	onsite tracking of contam trends
BR101	BR	onsite	1	1	onsite tracking of contam trends
BR102	BR	onsite	1	1	onsite tracking of contam trends
BR3	BR	onsite	1	1	onsite tracking of contam trends
BR8	BR	onsite	1	1	onsite tracking of contam trends
BR9	pumping well	onsite	1	1	onsite tracking of removed contaminants
BR-5A	pumping well	onsite	1	1	onsite tracking of removed contaminants
BR-6A	pumping well	onsite	1	1	onsite tracking of removed contaminants
BR-7A	pumping well	onsite	1	1	onsite tracking of removed contaminants
B17	OB	onsite	1	1	onsite tracking of contam trends
B6	OB	onsite	1	1	onsite tracking of contam trends
S3	OB	onsite	1	1	onsite tracking of contam trends
E1	OB	onsite	1	1	onsite tracking of contam trends
E3	OB	onsite	1	1	onsite tracking of contam trends
QS4	quarry seep	quarry	4	1	track quarry seep quality
QO2	quarry outfall	canal	4	1	track wq input to canal
QO2S1	canal at outfall	canal	4		track dilution of input to canal
SW1	barge canal	canal	4		track canal water quality
SW2	barge canal	canal	4		track canal water quality
SW3	barge canal	canal	4		track canal water quality
SW6	barge canal	canal	4		track canal water quality
SW12	barge canal	canal	4		track canal water quality
TOTAL samples			88	32	

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Olin

P.O. BOX 248, 1186 LOWER RIVER ROAD, NW, CHARLESTON, TN 37310-0248
(423) 336-4000 FAX (423) 336-4183

May 11, 1998

Mr. James Craft
Engineering Geologist
New York State Department of Environmental Conservation
Region 8 Office - Division of Hazardous Waste Remediation
6274 East Avon - Lima Road
Avon, New York 14414-9519

Re: Olin Rochester RI/FS
Olin Chemicals (Site #628018a) 100 McKee Rd, Rochester, NY

Dear Mr. Craft:

This is a follow-up to our February 27 work session, re: Olin's responses to both written and verbal agency comments on the existing draft Feasibility Study (FS). As we agreed at our work session, Olin will address all agency comments by a re-issue of the FS, rather than by a point-by-point discussion.

Since the work session, we have developed and evaluated additional information pursuant to your comments. I have attached a letter from Olin's consultant, ABB Environmental Services, which describes additional evaluation of elements to be added to the FS, and which summarizes Olin's sitewide approach. I believe that a conceptual agreement on this summary letter will be the first step toward finalizing our FS. This is to request that you review the summary letter so we can move toward concurrence on the major issues. Our next step then will be to complete and re-submit the FS.

I would like to highlight two conclusions of the additional evaluation.

Mass removal: While significant mass removal is being achieved via the existing interim groundwater extraction and treatment system, Olin agrees to include a more aggressive mass removal approach in the FS. This approach will consist of enhanced groundwater withdrawal in the historic contaminant source area (B17 area). A likely mode of implementation would be the installation of an additional (fifth) bedrock extraction. This well would allow more mass to be removed at a faster rate, and will allow for some removal of any DNAPL present within its reach. This additional well would aid in our other objective of sitewide hydraulic containment. The well would screen both overburden and bedrock aquifers.

DNAPL treatment in-situ: Olin has pursued your request to further investigate the feasibility of in-situ treatment of any DNAPL. Per agency request, we have used our internal expertise to investigate and better understand the chemistry of chloropyridines; we have consulted a commercial vendor of in-situ chemical treatment techniques; and we have discussed the implementability of in-situ treatment with Ms. Olivia West of Oak Ridge National Labs in Oak Ridge, TN.

Olin has pursued your suggestions for determining the potential effectiveness of in-situ chemical treatment of DNAPL. All our inquiries universally indicate that in-situ chemical treatment of DNAPL is not a viable remedial option at our Rochester facility. Olin and our consultants, ABB, feel that any chemical application which we attempt to introduce to the subsurface would be ineffective due to limitations of chemical reactivity, ambient aquifer high pH and contact efficiency. A detailed documentation of this evaluation is included in the attached letter.

We look forward to developing a mutually satisfactory remedial plan and to finalizing the Olin Rochester FS so we can implement the necessary remediation. Please call me with any questions or discussion at 423/336-4587.

Sincerely,

Michael J. Bellotti

Michael J. Bellotti
Olin Corporation

cc:

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New York State Department of Environmental Conservation
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Mr. John Bums: Olin Charleston, TN
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Mr. Thomas Eschner: ABB, Portland, ME

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MICHAEL J. ...

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7311-48
May 8, 1998

Mr. Michael Bellotti
Olin Chemicals Corporation
P.O. Box 248, Lower River Road
Charleston, TN 37310

Subject: Olin Rochester On-Site/Off-Site FS Report Proposed Approach

Dear Mr. Bellotti:

The purpose of this letter is to outline an approach to completion of the Feasibility Study (FS) Report for Olin's Rochester site. This letter documents modifications to the approach and content in the previously-submitted FS Report. These modifications address the written comments from Mr. James Craft dated 6 January 1998 and comments and suggestions received from Mr. Craft and other New York State representatives at our meeting of 27 February 1998 in Rochester. This letter summarizes the approach for the entire remedial strategy for all media at the site.

The enclosed outline (Attachment 1) is a skeletal version of the table of contents for the report and also serves as the basis for the discussion of report contents that is presented in subsequent paragraphs of this letter. The discussion addresses the entire remedial strategy for the site, but includes greater detail for topics that previously have not been addressed in the FS report.

The **Executive Summary** will be a digest of the entire report. It will present findings and explain conclusions, plus describe the process of evaluation of remedial alternatives.

Section 1 - Introduction, will present a description of the plant and surrounding area, a discussion of site history, and summaries of findings from the Remedial Investigation (RI) and risk assessment (RA). Section 1 will be similar to the Introduction in the On-Site FS Report.

Section 2 - Identification and Screening of Technologies, will present the remedial action objectives (RAOs) and general response actions for the impacted media, which consist of on-site groundwater, on-site soil, and off-site groundwater. Risk assessment has not identified any unacceptable risk scenarios for exposure to impacted surface water. Because risks currently are at acceptable levels and because Olin intends to eliminate the discharge of contaminated groundwater (quarry seep) to surface water (Erie Barge Canal), no RAOs are required for surface water. Risk assessment also has not identified any unacceptable risk scenarios for exposure to impacted soil gas; consequently no RAOs are required for soil gas.

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The first part of Section 2 will be similar to corresponding sections in the On-Site FS Report. It will describe Olin's overall site remediation strategy, which consists of a combination of remedial actions for on-site soil, aggressive on-site groundwater remedial action, and passive remedial actions for off-site groundwater.

The remainder of Section 2 will identify and screen technology process options capable of meeting the general response actions. This evaluation of remedial technology types and process technologies will be more extensive than what has been presented to date.

This section will describe the elevated levels of groundwater concentrations for various parameters, and note that these are likely indicative of the presence of dense non-aqueous phase liquid (DNAPL) in the fractured bedrock in the area of well B-17 and beneath the Main Plant Building and associated infrastructure. Any DNAPL would consist of chloropyridines (primarily 2-chloropyridine, with lesser amounts of 2,6-dichloropyridine) and volatile organic compounds (VOCs) (primarily carbon tetrachloride, methylene chloride, tetrachloroethene, and trichloroethene, with some other VOCs).

Although Olin's existing groundwater extraction, containment and treatment system can achieve hydraulic containment, it is likely the system will continue to withdraw aqueous contaminants that would continuously dissolve from any present DNAPL. As a consequence, the FS will evaluate the feasibility of actively remediating DNAPL.

In a general sense, DNAPL can be dealt with using three approaches:

- Removal Technologies (e.g., excavation, extraction, enhanced extraction),
- In-Situ Destruction Technologies (i.e., thermal, chemical, biological), and
- Immobilization Technologies (isolation, encapsulation, conversion to less mobile form).

The FS will identify technologies for each of these categories, and then screen the technologies based on effectiveness and implementabilty. Although our evaluation of technologies is still underway, our preliminary conclusions are presented below by technology type.

Removal Technologies

DNAPL removal usually involves either excavation (if the location of the DNAPL is accessible and limited in extent) or pumping (either with or without enhancements to increase the mobility of the DNAPL). At the Olin site, any DNAPL would be difficult to remove in its entirety due to its limited accessibility in fractured bedrock and because the area of original sources is minimally accessible due to plant expansion over the intervening years. The original sources have been discontinued (underground chemical sewers plugged and abandoned, housekeeping practices for handling solvents improved). The presence of DNAPL in rock precludes digging as a removal technology, and its presence beneath the main plant building and tanks and piping of the operating plant area create access difficulties. Thus excavation approaches can be eliminated and the evaluation of removal technologies will focus on pumping options.

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The primary limitation to pumping options is the suspected presence of DNAPL in the fractured bedrock. There is a consensus in the groundwater literature that any attempts to recover DNAPL from fractured bedrock are not likely to be successful (Pankow and Cherry, 1996; Parker et al., 1994). DNAPL is difficult to remove from fractured bedrock because of different wetting phases, pore and fracture sizes, and diffusion into the rock matrix. Attempts at enhancing DNAPL mobility through the use of flushing agents (solvents, surfactants) have very limited effectiveness in that they primarily act in the larger connected fractures, whereas much of the DNAPL may be found in small and dead-end fractures, or even diffused into the bedrock matrix. Thermal enhancement, involving in-situ heating by electrical means or through steam injection, are subject to the same limitations as well as being difficult to implement beneath the water table. For these reasons, direct removal of DNAPL is not feasible at the Olin site.

Some mass removal currently is being accomplished at the Olin site through groundwater pumping. The current extraction system is recovering site-related contaminants at a calculated rate of approximately 4,000 lb/yr. Although this is a very significant removal rate, it may be possible to increase the mass removal rate by additional groundwater withdrawal at the B-17 area, closer to the historic source area. Despite the limitations associated with direct pumping of DNAPL, some small portion of DNAPL removal can likely be achieved in the act of aqueous phase withdrawal, as any DNAPL within the reach of the source area well would be extracted, and treated or disposed of. Therefore, an alternative consisting of expanded groundwater pumping and more aggressive mass removal will be developed and evaluated in the FS as a mass removal option.

Soil vapor extraction (SVE) is a removal technology that, although not directly acting on DNAPL, indirectly has the potential to remove mass by inducing flux from the aqueous phase. Four factors weigh heavily against SVE as an appropriate remedial technology at Olin's Rochester site:

1. The primary contaminants of concern, chloropyridines, are semivolatile organic compounds, and therefore have a low tendency to vaporize and be accessible for extraction.

2. Although VOCs are contaminants of concern and likely are a component of the DNAPL, the mass of VOCs in soil vapor under static conditions or induced to vaporize by removal of soil gas through an SVE system is small (approximately 1%) relative to the total contaminant mass present. The mass that potentially would be removed through the soil vapor medium also is low relative to the mass currently being removed with the existing groundwater extraction system.

3. Implementation of an SVE system capable of extracting the relatively small mass of soil gas would require installation of approximately 80 extraction points in the main area of plant operations. For reasons of access noted above, only a portion (perhaps 20 to 25%) of the target area would be accessible for installation of extraction points.

4. The cost for an SVE system would far exceed the benefit gained in mass removal.

For these reasons, and because no unacceptable risk scenarios were identified for soil gas, SVE is not considered a viable remedial technology and is not carried forward for inclusion in remedial alternatives.

In-Situ Destruction Technologies

Destruction technologies result in the decomposition or conversion of site-related contaminants into low-toxicity compounds. Destruction technologies generally fall into one of three categories: thermal, chemical, or biological.

In-situ thermal destruction would require that the subsurface environment be raised to sufficiently high temperatures to decompose the DNAPL components. The energy to accomplish this is generally introduced into the subsurface via electrodes, or through the use of radio-frequency or microwave energy. Thermal destruction technologies are not practical at the Olin site since the majority of any DNAPL present is expected to be found well below the groundwater table in bedrock, making the thermal approaches technically infeasible.

In-situ chemical destruction technologies are currently receiving increased attention in the field of site remediation, due to their potential effectiveness and relatively low cost when site conditions are favorable. There are two general factors that determine whether these approaches will be effective at a site: (1) whether the site-related contaminants can be chemically converted to non-toxic compounds under ambient subsurface conditions, and (2) whether the necessary chemical reagents can be contacted with the contaminants in-situ.

Regarding the effectiveness of the chemistry in-situ, several of the components of the suspected DNAPL at the Olin Site will be difficult to treat. Consultations with an expert in the chloropyridine chemistry field (Boudakian, 1998) indicate that chloropyridine compounds are very difficult to oxidize even under controlled laboratory conditions. Although Fenton's chemistry has not been tested specifically on chloropyridines, other potent oxidants, such as ozone, have been tested with no success. In addition, a leading vendor who uses the popular Fenton's chemistry for in-situ chemical oxidation reports that methylene chloride is not treatable by the process. Therefore, it is likely that substantial portions of the suspected DNAPL compounds will be resistant to in-situ chemical treatment, especially under uncontrolled subsurface conditions at ambient ground temperatures.

We have spoken at length about the Rochester site with Geo-Cleanse, one of the recognized leaders in application of Fenton's chemistry to site remediation. Their observations were that the high pH and high alkalinity resulting from the carbonate bedrock are severe limitations on the potential effectiveness of Fenton's chemistry. In addition, the vendor specifically reports that the technology should not be used in the presence of carbonate bedrock, because of potential

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interferences with the chemical reaction. The reaction requires acidic conditions to be effective and the carbonate bedrock would continue to buffer any attempts to reduce pH.

At Mr. Craft's request, we also spoke with Ms. Olivia West regarding application of Fenton's chemistry to the Rochester site. Ms. West is a managing research scientist and was technical lead for the recent full-scale demonstration of in-situ chemical oxidation conducted by Oak Ridge National Laboratory (West, et al. 1997). Ms. West had no specific knowledge of chloropyridines, but was of the opinion that if ozonation did not oxidize chloropyridine under laboratory conditions, Fenton's chemistry would not be successful, and certainly not under field conditions. The presence of soil or rock, particularly carbonate rock, adds another mode of chemical interference for the oxidant. She expressed surprise that we might apply Fenton's chemistry at a site with high pH and alkalinity, because the chemistry requires low pH. Ms. West stated that if we have studies indicating that peroxide does not oxidize chloropyridines, she would accept the studies and not proceed with further testing.

In regard to implementability, i.e., contacting the site-related contaminants reagents with applied reagents, the likely presence of DNAPL in the fractured bedrock zone again presents a significant obstacle. The Fenton's chemistry vendor reports that the technology is applicable primarily in unconsolidated deposits, and not bedrock. The presence of buildings, tanks, piping, and other infrastructure also present difficulties for injection of the chemistry. The application of the method is premised upon delivering the products to the contaminant. In many areas of the site, surface access is not possible for well installation. Angled and horizontal drilling technologies may be able to overcome some logistical impediments in overburden; however, the chemical would still be needed in the non-homogeneous medium of fractured bedrock, with little likelihood of uniform distribution in the subsurface.

Based on our discussions with experts in the fields of chloropyridine chemistry and Fenton's chemistry, and our review of published literature on the feasibility of conducting remedial actions within fractured bedrock, ABB-ES concludes that the limitations described above rule out the use of in-situ chemical destruction for DNAPL at Olin's Rochester site.

<u>In-situ biological destruction</u> technologies make use of microbial populations to metabolize or co-metabolize the undesired organic constituents present in the subsurface. The process can occur under existing conditions from native microbial populations, in which case it is termed intrinsic bioremediation. Alternatively, microbes and nutrients can be introduced into the subsurface to initiate, sustain, or enhance biodegradation. For this approach to be effective, conditions must be favorable (electron donors, electron acceptors, redox) for the particular microbes, and the organic constituents must be amenable to biological degradation processes.

Of the site-related contaminants detected at the Olin site, chlorinated VOCs are known to biodegrade under anaerobic conditions. Based on site groundwater data collected in March 1997, there is evidence to suggest on-going (intrinsic) biological degradation of chlorinated VOCs in the on-site wells. In off-site locations, conditions in the deeper bedrock wells appear favorable for

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anaerobic degradation of chlorinated VOCs, whereas shallow bedrock and overburden wells show limited potential for anaerobic degradation. The low concentrations of chlorinated VOCs in the quarry seep is another piece of evidence suggesting ongoing attenuation of the off-site VOC plume.

Few data are available on the degradability of chloropyridines; however, the presence of significant quantities of chloropyridines at the quarry suggests that these compounds are not readily degrading under local conditions. Treatability tests could determine whether biological degradation has any potential to be effective on chloropyridines; however, effective and implementable delivery of microbes and nutrients would remain as an issue. Modification of the subsurface environment (i.e., in fractured bedrock) to enhance biodegradation would face the same physical limitations as in-situ chemical oxidation. The subsurface is extremely heterogeneous, and the distribution of DNAPL likely also is heterogeneous. Delivery of materials to the subsurface would occur neither uniformly nor necessarily proportional to the presence of DNAPL.

Overall, biological degradation by itself does not appear to be a candidate technology for remediation of the Olin site. Although some of the site-related contaminants (i.e., chlorinated VOCs) appear to be undergoing sufficient biodegradation to limit the extent of their off-site migration, there is no evidence that biological treatment can be used to significantly reduce chloropyridine concentrations in the subsurface at the Olin site. Only intrinsic bioremediation will, therefore, be considered as a remedial technology, and only in conjunction with other technologies as part of a comprehensive sitewide remediation alternative.

Immobilization Technologies

Immobilization technologies are intended to reduce or eliminate groundwater impacts by reducing the solubility of the site-related contaminants, or by isolating them from the groundwater environment. Solubility reduction can be accomplished through chemical reactions with the contaminants that change their form (convert them to a solid) or reduce their solubility. Isolation technologies include modifying the matrix in which the contaminants are found (for example, soil stabilization), or by diverting groundwater flow around the area of contamination.

Because of their chemical stability, chloropyridines cannot easily be polymerized or converted into a less soluble form. (Boudakian, 1998). Also, because DNAPL is suspected to be present in the fractured bedrock, soil stabilization approaches are not applicable. Therefore, immobilization technologies potentially appropriate for the Olin site are limited to isolation techniques.

Isolation approaches generally consist of groundwater cutoff barriers, (slurry walls, grout curtains), diversion trenches, and impermeable surface barriers. Groundwater barriers are generally limited to overburden applications, and would not be applicable to the fractured bedrock aquifer at the Olin site. Diversion trenches are also most commonly used in overburden aquifers. Blasted bedrock trenches are not considered feasible for the Olin site due to the extensive active facility operations throughout the

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area and the distance into the rock that the trench would have to be advanced (nearly sixty feet below the top of rock to intercept the significant deep fracture in the bedrock). Installation of a surface barrier will be evaluated as an element of a site remediation alternative for on-site soils. The site is currently nearly completely covered by pavement, buildings and other structures, which results in minimal surface infiltration. Therefore, evaluation of a surface barrier would be applicable only to the few minor areas of the site that remain uncovered.

Because of site conditions and process limitations, we expect that Section 2 will conclude that extraction and treatment is the only groundwater technology that remains after screening. Olin currently has an extraction system at the site perimeter to achieve hydraulic containment. The FS will evaluate the existing system as well as an enhanced system to improve capture and increase mass removal.

Section 3 - Development and Screening of Remedial Alternatives, will present the remedial alternatives, appropriate to the source soils and groundwater, that are developed from the combination of technology process options. These assembled alternatives will be screened based on effectiveness, implementability, and cost. The technologies will be grouped by on-site groundwater, on-site soil, and off-site groundwater. We anticipate, pending results of technology screening, that no in-situ destruction technologies or immobilization technologies will be included in alternatives. Probable alternatives are listed in Table 1.

Table 1: Summary of Alternatives To Be Retained for Detailed Analysis

On-site Groundwater	Off-site Groundwater	On-site Soil
Alternative ONSITE-GW1: No Action	**Alternative OFFSITE-GW1:** No Action	**Alternative S1:** No Action
Alternative ONSITE-GW2: Institutional Controls and Monitoring	**Alternative OFFSITE-GW2:** Collection of Quarry Seepwater, Treatment or POTW Discharge, Institutional Controls, and Monitoring	**Alternative S2:** Zoning/Deed Restrictions, Institutional Controls, and Intrinsic Remediation
Alternative ONSITE-GW3: Existing Groundwater Extraction, Treatment, POTW Discharge, Institutional Controls and Monitoring		**Alternative S3:** Surface Barrier, Zoning/Deed Restrictions, and Institutional Controls
Alternative ONSITE-GW4: Expanded Groundwater Extraction, Treatment, POTW Discharge, Institutional Controls and Monitoring		

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Section 4 - Detailed Analysis of Alternatives, will individually analyze each of the alternatives that passes the screening in Section 3. Based on the limited number of alternatives likely to be developed and screened, we expect that all alternatives developed will be retained for detailed analysis in Section 4. The analysis will be based on the criteria identified in USEPA guidance on conducting RIs and FSs. The alternatives will also be evaluated in a comparative analysis and a recommended alternative identified.

Summary of Remedial Strategy

The FS approach presented in this letter is, in form and organization, similar to the On-Site FS previously presented to the NYSDEC. However, the revised FS is a substantial enhancement of the previous FS, both in terms of media considered and in rigor of technology evaluation. The remedial strategy is developed and articulated to a greater degree in response to Agency inquiries. The primary enhancements to the FS are evaluation of treatment strategies for DNAPL and evaluation of the aggressiveness of mass removal both in aqueous and non-aqueous phase.

One enhancement is the discussion in Section 2.4, Evaluation of Remedial Technology Types and Process Technologies. In that section the likelihood of the presence of DNAPL is discussed. The three general approaches to dealing with DNAPL (removal, in-situ destruction, and immobilization) are explained, and specific technologies within each category are identified and then screened based on effectiveness and implementability. The numerous difficulties associated with the remediation of DNAPL are widely acknowledged in the technical literature and within the technical community. The presence of chloropyridines as primary contaminants of concern creates additional uncertainty because of the lack of widely available information about the chemicals. Nonetheless, Olin's experience with, and understanding of, the chemicals presents a body of knowledge that suggests that the chemistry would likely render ineffective any in-situ chemical degradation. Technology vendors have expressed doubt about the remedial effectiveness of chemical degradation techniques due to ambient high pH and alkalinity in the carbonate bedrock. Finally, accessibility and implementability concerns are also present. In total, these factors suggest that the application of in-situ degradation technologies have extremely limited physical or chemical basis for success.

The additional evaluation undertaken for this FS develops Olin's overall remedial strategy of removing contaminant mass through groundwater pumping, resulting in both DNAPL and aqueous phase removal. Olin has included an alternative of additional extraction in the source area (B-17 area). This alternative would increase the rate of mass removal by pumping in the only accessible portion of the historic source area. In the implementation of this additional extraction, any fluid withdrawal would include the most highly contaminated groundwater, and likely would include any accessible DNAPL that might reside within the reach of the additional withdrawal well. Since other modes of addressing DNAPL are not implementable, this mode of DNAPL extraction is the best that can be achieved given the ambient site conditions.

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The primary component of the on-site remediation will be continued operation of the groundwater extraction and treatment system to accomplish contaminant mass removal and management of migration. With containment achieved at the plant boundary, remedial components for the off-site areas will be intrinsic remediation and institutional controls in the low-risk off-site areas, and seep collection and treatment/discharge at the quarry. This is an appropriate approach to risk reduction through the application of effective, implementable technologies.

Please call if you have questions on the approach to the FS proposed in this letter.

Sincerely,

ABB ENVIRONMENTAL SERVICES, INC.

Thomas R. Eschner

Thomas R. Eschner, R.G.
Project Manager/Principal Hydrogeologist

TRE/eg

cc: J. Brandow
S. Walbridge

REFERENCES

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Pankow, J.E., and Cherry, J.A., 1996. "Dense Chlorinated Solvents and Other DNAPLs in Groundwater", Waterloo Press, Portland, OR, 522 p.

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ATTACHMENT 1