Final Basis of Design
Revised Groundwater Recovery and Treatment System
Non-Time Critical Removal Action
Liberty Industrial Finishing Site, Farmingdale, New York

June 25, 2003

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URS Project 20242267.00005

TABLE OF CONTENTS

FIGURES

ATTACHMENTS

1.0 INTRODUCTION AND OBJECTIVES

This document describes the basis of design for a conventional groundwater extraction system using shallow recovery wells at the Liberty Industrial Finishing Site (the Site). The document describes current conditions and Remedial Action Objectives (Section 2.0), the layout and design of recovery wells (Section 3.0), and a description of the anticipated treatment technology for VOCs and metals removals (Section 4.0).

2.0 CURRENT CONDITIONS

2.1 Physical Description

The Site is located in the unincorporated Village of Farmingdale, in the Town of Oyster Bay, Nassau County, New York. The site is bordered on the north by railroad tracks, on the east by Main Street, on the west by Ellsworth Allen Park, and on the south by Motor Avenue (Figure 1). The Site includes Lots 326 and 327 of Block 518, Section 48, as recorded by the Nassau County Clerk's office. The surrounding area is primarily residential, with several commercial properties along Motor Avenue and Main Street. The Site is currently divided into a western area (generally unpaved and inactive) and an eastern area (paved and limited activity). Commercial operations in the western area have ceased and only the foundations of some former structures and industrial facilities remain. The western area also includes three excavated former disposal basins that previously received metal finishing wastewaters. The eastern area of the Site is developed and includes several large warehouses and the remains of past industrial operations, including foundations of former process buildings.

The current groundwater remediation system (GRS, operated under the NTCRA), consists of one active recovery well (RW-1), three inactive groundwater circulation wells (GCW-1, GCW-2, and GCW-3), associated monitoring points, and the treatment building with adjacent parking lot and occupies the southern portion of the western site area (see Figure 2).

2.2 Hydrogeologic Conditions

The principal aquifers beneath the Site are the Upper Glacial aquifer (UGA) and the Magothy aquifer (MA). The UGA extends from the surface to about 90 feet below ground surface (bgs), and is separated locally from the subjacent MA by a clay unit. The current groundwater is table is 24 feet bgs (equivalent to 40 ft msl). As recently as 1999, the groundwater table elevation was 50 feet msl. Groundwater flow in both aquifers is toward the south-southwest (see Figure 3). Relative to the current GRS, the UGA is the aquifer of interest where site-related constituents exceed site-specific cleanup criteria for groundwater (see Section 2.3 and 2.5). Within the UGA, there does not appear to be a vertical hydraulic gradient, and groundwater flow is documented to be horizontal.

Figure 1: Site Vicinity Map

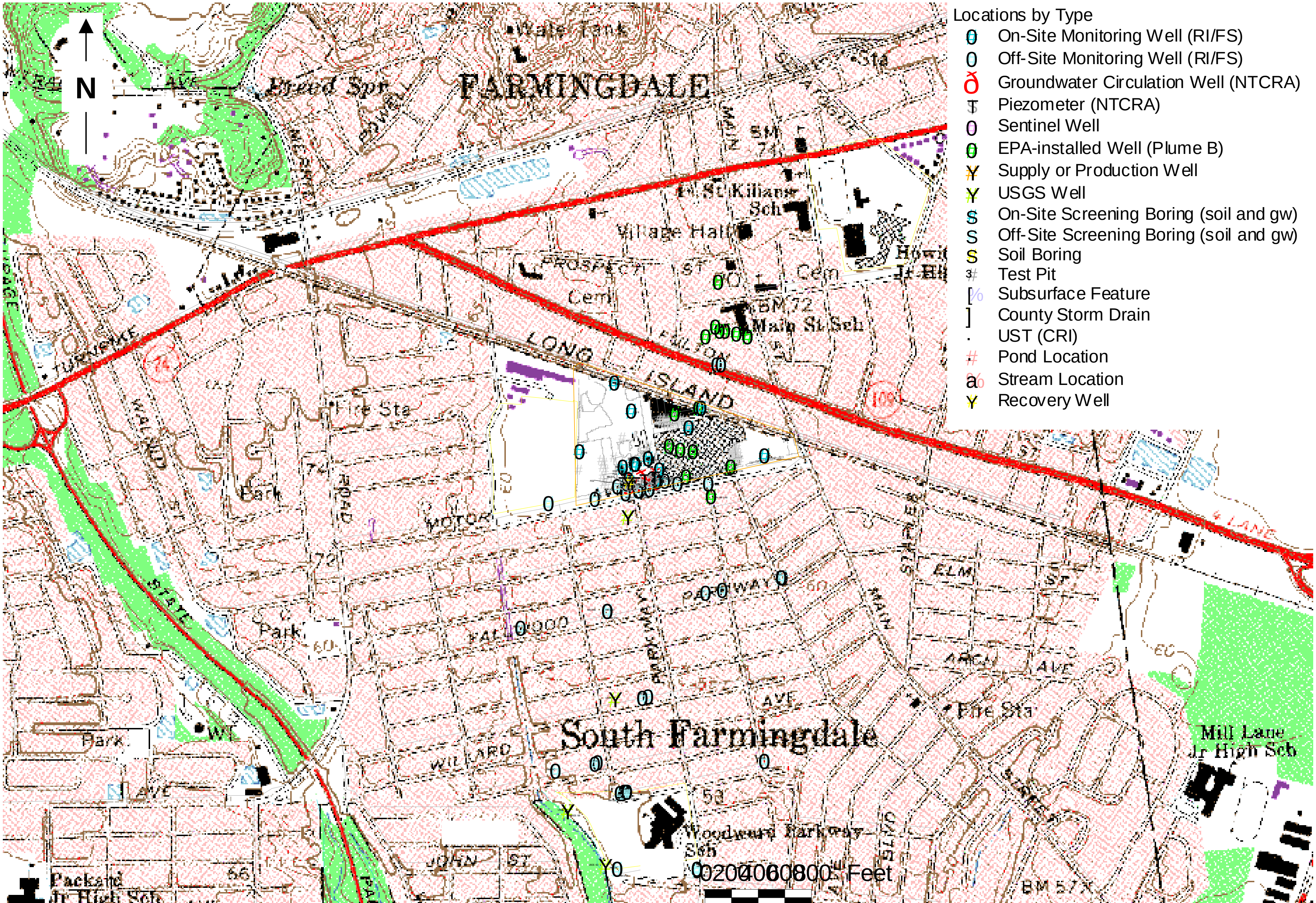
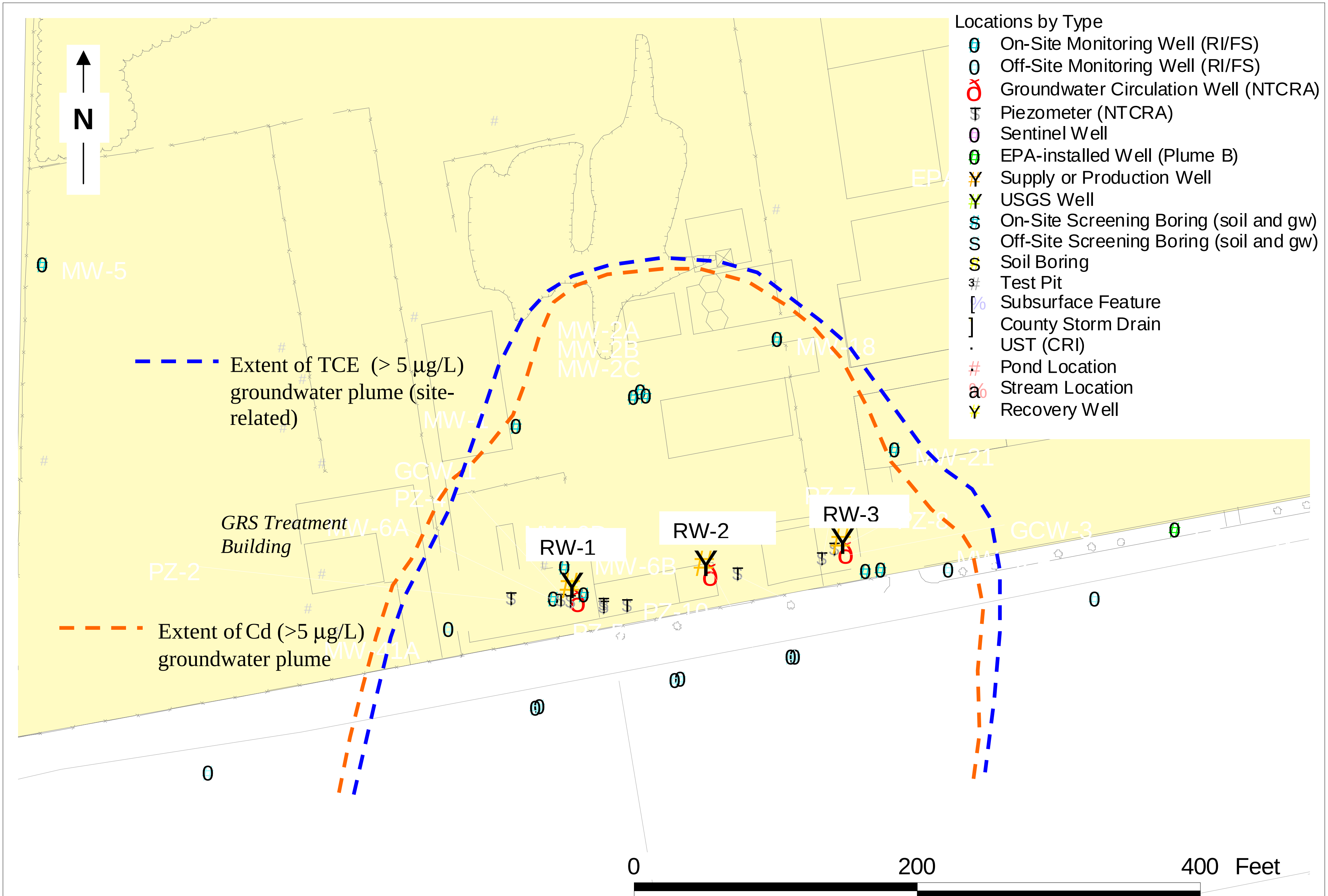


Figure 2: Well Location Map and Extent of Groundwater Plumes



2.3 Constituents of Interest

The constituents of interest are those volatile organic constituents (VOCs) and metal constituents that are present at the site boundary at concentrations greater than the state or federal groundwater standards or maximum contaminant levels (MCLs) and that are related to historic activities at the Site. Of the VOCs detected in on-site groundwater, these constituents are chlorinated ethenes (trichloroethene [TCE], cis-1,2-dichloroethene (cis-1,2-DCE), and chlorinated ethanes (1,1,1-trichloroethane [1,1,1-TCA] and 1,1-dichloroethane [1,1-DCA]). Of the metals detected in on-site groundwater, these constituents are cadmium and chromium. Note that chromium in on-site groundwater is present as hexavalent chromium (chromate CrO_4). The extent of the on-site TCE and cadmium groundwater plumes are shown in Figure 2.

On-site groundwater quality was evaluated during the 1992 remedial investigation (RI), the 1998 continued RI (CRI), the 1999 NTCRA pilot test, and the NTCRA compliance sampling program (July 2000 through to date). The NTCRA compliance sampling reports are submitted to the EPA on a quarterly basis and document the current (tables) and historic results (trend plots) for on-site and off-site monitoring wells. The chart below summarizes the groundwater quality data (September 2000 through August 2002) that were collected under the NTCRA compliance program. Note that these data were obtained during low groundwater conditions. The data summary on the next page shows that there are distinct areas of groundwater impacts at the southern boundary of the Site. Specifically:

Constituents	Western Area (Downgradient of Basins)	Central Area	Eastern Area (Bldg B Basement)
Chlorinated Ethenes	Shallow: not detected to 130 ug/L, with greatest concentrations near RW-1 Intermediate: moderate concentrations < 57 ug/L Deep: very low concentrations < 1.6 ug/L	Shallow: < 43 ug/L, with greatest concentrations upgradient Intermediate: low concentrations < 11 ug/L Deep: not detected	Shallow: 1.2 – 1300 ug/L, with greatest concentrations downgradient of Basement B Intermediate: low concentrations < 7.5 ug/L Deep: very low concentrations < 2.0 ug/L
Chlorinated Ethanes	Shallow: not detected Intermediate: very low concentrations < 2.2 ug/L Deep: very low concentrations < 2.0 ug/L	Shallow: very low concentrations < 0.6 ug/L Intermediate: not detected Deep: very low concentrations < 0.5 ug/L	Shallow: low to moderate concentrations < 110 ug/L Intermediate: not detected Deep: very low concentrations < 2.3 ug/L
Cadmium	Shallow: increasing concentrations from west (34.6 ug/L) to east (up to 1600 ug/L) Intermediate: moderate concentrations < 26 ug/L Deep: low concentrations < 7.8 ug/L	Shallow: increasing from east (54.7 ug/L) to west (507 ug/L) Intermediate: moderate concentrations < 101 ug/L Deep: low concentrations < 10.4 ug/L	Shallow: low to moderate concentrations < 62 ug/L Intermediate: low to moderate concentrations < 25.7 ug/L Deep: not detected
Chromium	Shallow: generally increasing from east (140 ug/L) to west (161 ug/L) Intermediate: generally less than 80 ug/L Deep: very low concentrations < 3.8 ug/L	Shallow: moderate concentrations < 196 ug/L Intermediate: low concentrations < 13.3 ug/L Deep: low concentrations < 26.2 ug/L	Shallow: decreasing conc. from west (< 415 ug/L) to east (< 49.4 ug/L) Intermediate: moderate to low concentrations < 81.6 ug/L Deep: low concentrations < 33.4 ug/L

Detailed Data Summary (September 2000 through October 2002):

	Downgradient of Basins (West)							*Center*			*Downgradient of Building B Basement (East)*				
shallow	MW-41A	MW-1	MW-38A	MW-6A	PZ-9A	PZ-10A	MW-2A	MW-39A	PZ-6A	MW-18	MW-40A	PZ-7A	MW-7A	MW-21	MW-42A
TCE	1.0 - 13	3.7 - 47.0	3.9 - 110	34 - 44	ND - 66	6.8 - 68	86 - 130	ND - 37	ND - 36	13 - 43	ND - 230	ND - 130	0.7 - 810	3.1 - 1300	4.8 - 12
cis-1,2-DCE	ND - 5.3	ND - 16.0	ND - 98	14 - 28	ND - 8.9	ND - 10	17 - 52	ND	ND - 2.2	ND - 0.8	ND - 49	ND - 59	ND - 85	13 - 150	1.2 - 7.8
1,1,1-TCA	ND	ND	ND	ND	ND	ND	ND	ND	ND - 0.6	ND	ND - 38	2.4 - 73	ND - 80	14 - 110	ND - 2.5
1,1-DCA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND - 5.8	ND - 9.1	ND - 16	ND - 20	ND - 0.8
Cadmium	19.4 - 34.6	3.5 - 19.5	107 - 173	74.5 - 186	96.5 - 312	119 - 1600*	203 - 327	273 - 507	9.5 - 73.4	15.7 - 54.7	6.9 - 14.2	1.2 - 5.8	1.1 - 12.2	1.7 - 5.9	28.7 - 61.7
Chromium (tot)	105 - 161	106 - 159	9.3 - 77	14.6 - 106	32.1 - (1480)	25.7 - (1820)	110 - 140	56 - 123	18.5 - 135	55.1 - 196	164 - 415	55.2 - 266	25.8 - 135	5.2 - 93.4	ND - 49.4
int.			MW-38B	MW-6B	PZ-5B		MW-2B	MW-39B			MW-40B		MW-7B		
TCE			ND - 57	ND - 6.7	ND - 1.6		ND	ND - 11			ND		ND - 7.5		
cis-1,2-DCE			ND - 0.5	ND - 21	ND - 0.8		ND	ND			ND		ND - 2.1		
1,1,1-TCA			ND - 2.2	ND - 0.4	ND		ND - 1	ND			ND		ND		
1,1-DCA			ND - 1.6	ND	ND		ND - 1	ND			ND		ND		
Cadmium			16.4 - 25.9	11.9 - 16.1	ND - 21		7.4 - 13.8	12.9 - 101			14.1 - 25.7		0.62 - 7.4		
Chromium (tot)			2.8 - 83.4	ND - 3.5	ND - 1.6		7.1 - 35.8	ND - 13.3			4.4 - 24.1		2.8 - 81.6		
deep				MW-6D	PZ-5C		MW-2C		PZ-6C			PZ-7C			
TCE				NS	ND		NS		ND			ND - 0.8			
cis-1,2-DCE				NS	ND - 1.6		NS		ND			ND - 2.0			
1,1,1-TCA				NS	ND - 2		NS		ND			ND - 0.6			
1,1-DCA				NS	ND - 2.0		NS		ND - 0.5			ND - 2.3			
Cadmium				NS	ND - 7.8		NS		0.57 - 10.4			ND			
Chromium (tot)				NS	ND - 3.8		NS		ND - 26.2			ND - 33.4			

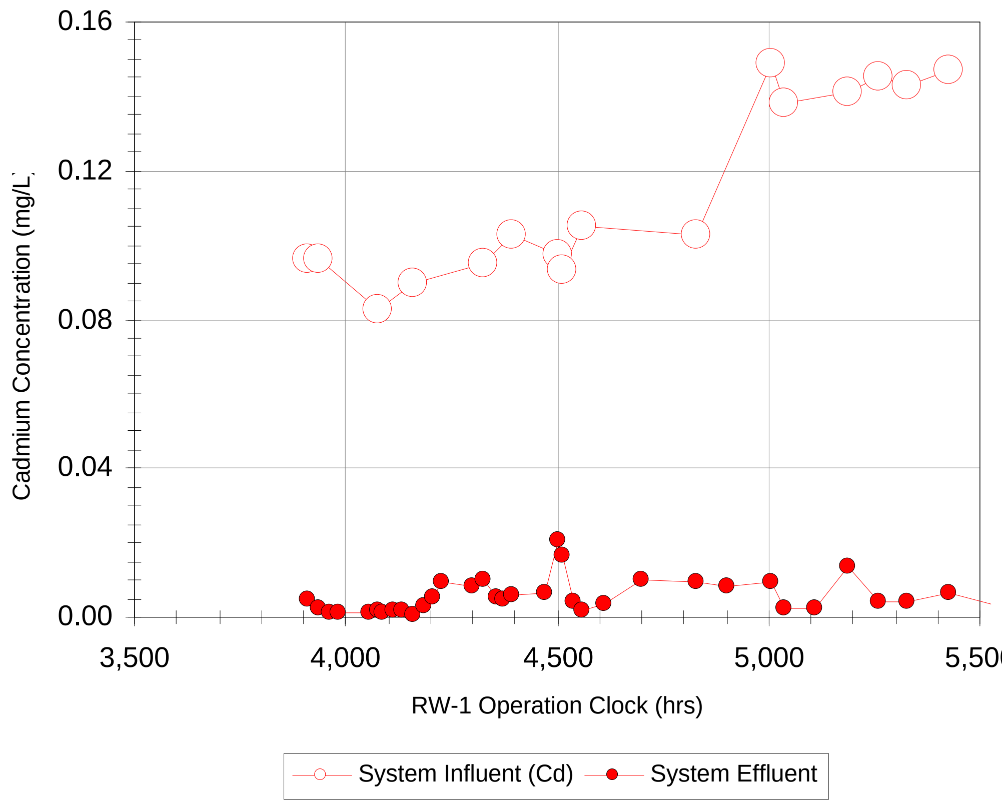
2.4 Non-Time Critical Response Action (NTCRA)

Administrative Order CERCLA-98-0208 (the Order) discusses the objectives and components of the current GRS that is operated under a Non-Time Critical Removal Action (NTCRA). Following a set of bench- and field-scale pilot tests, a GRS consisting of groundwater circulation wells and treatment of VOCs (by activated carbon) and metals (by chelation technology) was constructed between March 2000 and January 2001. The objective of the NTCRA is to address site-related constituents in groundwater at the site boundary. The operation of the GRS between 2000 and 2001, specifically the groundwater circulation system yielded unconvincing evidence that plume containment and constituent reductions (as defined in Articles 27 and 42(a)(vi)(1-2) of the Order) were achieved. Accordingly, by January 2002 the U.S. EPA and the Liberty Group agreed to discontinue the use of the GCW technology and instead construct a traditional groundwater extraction system, with recovery wells that penetrate the impacted aquifer zones. By May 2002, the Liberty Group had completed the construction of one recovery well (RW-1), implemented an aquifer pumping test to evaluate the capture zone effected by the operation of RW-1, and compiled a focused groundwater flow model that is used in this document to determine the required pumping rate to contain the on-site plume in the western site area. The GRS is currently operated by pumping 60 gallons per minute (gpm) from RW-1. The recovered groundwater is being treated via activated carbon and chelating technology and re-injected (by equal proportions) into the lower screen zones of GCW-2 and GCW-3. During the week of September 30, 2002, the automated pH-adjustment system was activated (following receipt of the

Nassau County permits to operate chemical holding tanks on the first floor of the treatment building). Also starting during the week of September 30, 2002, additional activities (see Attachment B) were initiated to determine the long-term loading rate of the Octolig resin under optimal pH conditions. Performance samples collected between October 2 and January 18, 2003 indicate that the total system treatment efficiency for cadmium is between 78.8 and 99.3%, and the treatment efficiency across the Octolig media is between 76.3 and 99.4%. The average treatment efficiencies for cadmium were 93.5% (total system) and 94.3% (Octolig only). Additional details were reported in the October 24, 2002 *Treatability Report – Octolig*, the January 28, 2003 *Period 02 Operations Summary*, and the February 12, 2003 *Period 03 Operations Summary*.

The chart below summarizes the measured system influent (from RW-1) concentrations and system effluent concentrations for cadmium between October 2, 2002 and January 18, 2003.

Figure 3: System Influent and Effluent Concentrations



The table below presents the individual analytical observations for Periods 01 through 03 (October 2, 2002 through January 18, 2003).

Meas #	Date	Time (hr)	Σ Time (hr)	Flow (gpm)	SYS-IN	post-GAC	post-OCT	Comment	Eff-Avg (pd)	ERR (pd)	Eff-Avg (tot)	ERR (tot)
1	10/2/2002	3,908	0	60	0.0961	0.100	0.0045	start-up	0.0045	0.0000	0.0045	0.0000
2	10/9/2002	3,935	27	60	0.0960	0.0950	0.0024		0.0035	0.0011	0.0035	0.0011
3	10/10/2002	3,961	53	60		0.0880	0.0013		0.0027	0.0009	0.0027	0.0009
4	10/11/2002	3,985	77	60		0.0927	0.0011		0.0023	0.0008	0.0023	0.0008
5	10/14/2002	4,056	148	60		0.0831	0.0011		0.0021	0.0007	0.0021	0.0007
6	10/15/2002	4,077	169	60	0.0826	0.0822	0.0019		0.0021	0.0005	0.0021	0.0005
7	10/16/2002	4,087	179	60		0.0825	0.0011		0.0019	0.0005	0.0019	0.0005
8	10/17/2002	4,111	203	60		0.0849	0.0015		0.0019	0.0004	0.0019	0.0004
9	10/18/2002	4,132	224	60		0.0828	0.0018		0.0019	0.0004	0.0019	0.0004
10	10/22/2002	4,160	252	60	0.0896	0.0909	0.00059		0.0017	0.0003	0.0017	0.0003
11	10/23/2002	4,185	277	60		0.0893	0.0027		0.0018	0.0003	0.0018	0.0003
12	10/24/2002	4,209	301	60		0.0890	0.0051		0.0021	0.0004	0.0021	0.0004
13	10/25/2002	4,229	321	60		0.0910	0.0097		0.0027	0.0007	0.0027	0.0007
14	10/28/2002	4,302	394	60		0.0949	0.0082		0.0031	0.0008	0.0031	0.0008
15	10/29/2002	4,328	420	60	0.0952	0.0924	0.0100		0.0035	0.0008	0.0035	0.0008
16	10/30/2002	4,356	448	60		0.0957	0.0053		0.0036	0.0008	0.0036	0.0008
17	10/31/2002	4,375	467	60		0.0937	0.0050		0.0037	0.0007	0.0037	0.0007
18	11/1/2002	4,392	484	60	0.103	0.0917	0.0059		0.0038	0.0007	0.0038	0.0007
19	11/4/2002	4,472	564	60		0.0902	0.0063		0.0040	0.0007	0.0040	0.0007
20	11/5/2002	4,500	592	60	0.0976	0.0873	0.0207		0.0048	0.0011	0.0048	0.0011
21	11/6/2002	4,512	604	60	0.0932	0.0928	0.0168	down for regeneration	0.0054	0.0012	0.0054	0.0012
	11/12/2002	4,524	0	60				start-up				
22	11/13/2002	4,541	17	60		0.0940	0.0042		0.0042	0.0000	0.0053	0.0011
23	11/19/2002	4,561	37	60	0.105	0.0923	0.0019		0.0031	0.0012	0.0052	0.0011
24	11/21/2002	4,612	88	60		0.0970	0.0037		0.0033	0.0007	0.0051	0.0010
25	11/25/2002	4,702	178	60		0.0932	0.0103		0.0050	0.0018	0.0053	0.0010
26	12/2/2002	4,831	307	60	0.103	0.101	0.0093		0.0059	0.0017	0.0055	0.0010
27	12/5/2002	4,902	378	60		0.108	0.0085		0.0063	0.0014	0.0056	0.0009
28	12/9/2002	5,004	480	60	0.149	0.131	0.0093		0.0067	0.0013	0.0057	0.0009
	12/10/2002	5,023	499	60				down for regeneration				
	12/26/2002	5,024	0	60				start-up				
29	12/27/2002	5,039	15	60	0.138	0.103	0.0025		0.0025	0.0000	0.0056	0.0009
30	12/30/2002	5,112	88	60		0.165	0.0021		0.0023	0.0002	0.0055	0.0009
31	1/2/2003	5,189	165	60	0.141	0.172	0.0138		0.0061	0.0038	0.0058	0.0009
32	1/6/2003	5,263	239	60	0.145	0.122	0.0042		0.0057	0.0028	0.0057	0.0009
33	1/9/2003	5,329	305	60	0.143	0.137	0.0043		0.0054	0.0022	0.0057	0.0008
34	1/13/2003	5,425	401	60	0.147	0.141	0.0065		0.0056	0.0018	0.0057	0.0008
35	1/18/2003	5,525	501	60		0.125	0.0037		0.0053	0.0015	0.0056	0.0008
				60				down for regeneration				

From the data shown above, average concentrations for the periodic effluent and for the cumulative effluent were calculated, along with the standard deviations. It is proposed that compliance with the sitewide cleanup criteria for groundwater should be based on periodic average effluent concentrations, as bracketed by the standard error of the mean. The data shown indicate that periodic average cadmium effluent concentrations were 5.4 µg/L ± 1.2 µg/L (Period 01), 6.7 µg/L ± 1.3 µg/L (Period 02), and 5.3 µg/L ± 1.5 µg/L (Period 03). The cumulative cadmium effluent concentration for the system was 5.6 µg/L ± 0.79 µg/L (Period 01 through 03). Therefore, the average cumulative effluent concentration and the individual average concentrations during the Period 01 and Period 03 were compliant with the sitewide cleanup criterion for cadmium. The average effluent concentration during Period 02 was slightly greater than the stated criterion for cadmium.

2.5 Remedial Action Objectives

The remedial action objectives are as follows:

(1) Hydraulically contain the groundwater plume of site-related constituents (chlorinated ethenes, ethanes, cadmium, and chromium) on the western site area and limit the potential for off-site migration of site-related constituents.

(2) Treat site-related constituents to concentrations that meet the ARARs discussed in the Final Feasibility Study for the Site (September 2000). The ARARs include New York State Groundwater Standards and Ambient Water Quality Criteria (as per T.O.G.S 1.1.1 or 6 NYRCC Part 703) and federal maximum contaminant levels (MCLs). Additional ARARs include surface water quality standards (6 NYRCC Part 701 and 703) and SPDES Permit, monitoring, reporting, and record keeping requirements (6 NYRCC Parts 750-756). The site-specific cleanup levels are as follows:

TCE	5.0 µg/L
cis-1,2-DCE	5.0 µg/L
1,1,1-TCA	5.0 µg/L
1,1-DCA	0.6 µg/L
Cadmium	5.0 µg/L
Chromium	50 µg/L

Note that a separate and not site-related groundwater plume (‘Plume B’) with dissolved concentrations of tetrachloroethene (PCE) and TCE exists to the east of the site-related groundwater plume. The source area of Plume B is located upgradient and to the north of the Site. Plume B is not specifically addressed by the NTCRA. However, it is anticipated that the capture zone of the full-scale on-site recovery system (see Section 3.2, below) will include a portion of the Plume B footprint.

(3) The objective of the treatment system is to produce a system effluent that meets the requirements for discharge to groundwater (average system effluent should be equivalent to or less than the site-specific cleanup levels, as bracketed by the standard error of the mean) or that of other discharge options (such as discharge to a surface water body).

3.0 GROUNDWATER EXTRACTION SYSTEM

3.1 Focused Groundwater Model

On March 8, 2002, a technical memorandum was submitted to the U.S. EPA that summarized proposed activities for a long-term pumping test of RW-1 at the Site. On May 31, 2002, the *Recovery Well Installation, Aquifer Pumping Test and Groundwater Modeling Report* was submitted to the U.S. EPA that, together with the results of the pumping test, presented a focused groundwater flow model for the Site. The purpose of the focused groundwater flow model was to serve as a tool for predicting the capture effect of extracting groundwater from recovery wells along the southern boundary of the Site. The calibration of the focused flow model was accomplished by adjusting aquifer parameters such as hydraulic conductivity and storage coefficient in all layers of the model until the aquifer response to pumping observed during the pumping test was closely matched in the model. The model calibration and prediction runs were completed using the 3-D finite difference modeling environment Groundwater Vistas (GWV). GWV is a Windows-based pre- and post-processor for MODFLOW (MODFLOW is the industry standard 3-D finite difference groundwater flow simulator).

On July 26, 2002, the U.S. EPA conditionally approved the May 31, 2002 report, and therefore, indicated agreement with the set-up, calibration, and conclusions of the focused groundwater model. Comments provided by the U.S. EPA to the focused groundwater flow model are addressed in Attachment A to this document. In this document, the focused groundwater flow model is being used to evaluate the optimal locations and pumping rates for three (3) recovery wells that are proposed along the southern Site boundary (see Section 3.2).

3.2 Recovery Well Locations and Capture Zone Analysis

Recovery well RW-1 was installed during the week of March 25, 2002, approximately 10 feet north of existing well GCW-1. Based on the flow model solutions, the Liberty Group plans to install two additional (2) recovery wells at the locations shown in Figure 2. The locations of the recovery wells and their proposed extraction rates were chosen to meet the objectives stated in Section 2.5. Although two recovery wells would be sufficient to yield the necessary flow of 100 to 120 gpm, the presence of three (3) recovery wells will allow for periodic maintenance of each well while maintaining capture across the site boundary, as discussed in Section 2.5.

Recovery Well Details

It is proposed to install recovery wells RW-2 and RW-3 in an identical fashion to existing well RW-1, as follows (the dimension are to be ± 0.5 feet):

	Description	Top	Bottom
Well Depth	12-in ID Hollow Stem Augers	0 ft bgs	42 ft bgs
Well Sump	8-inch stainless steel	40.0 ft bgs	42.0 ft bgs
Well Screen	8-inch stainless steel 0.030-inch opening	10.0 ft bgs	40.0 ft bgs
Well Casing	8-inch stainless steel	+1.5 ft above grade	10.0 ft bgs
Filter pack	No. 1 Sand	8 ft bgs	42 ft bgs
Bentonite Seal	Hydrated Bentonite	6 ft bgs	8 ft bgs
Cave-In	To facilitate manhole construction	0 ft	6 ft bgs

The proposed well completion will ensure that both high- or low-groundwater conditions will not interfere with the normal operation of the extraction system.

The general layout for recovery wells RW-1 through RW-3 (surface and subsurface completion and connection to existing piping to GRS) is discussed in Attachment D.

Proposed Design Flow from the Recovery Wells

Seven overall pumping scenarios are possible with the well set-up shown in Figure 2. One scenario (#1) assumes that all wells are running, three scenarios (#2, #3, #4) assume that two wells are running and one well is shut down, and three scenarios (#5, #6, and #7) assume that only one well is running and two wells are shut down. The chart below summarizes the pumping configurations that were evaluated using the focused on-site groundwater model, as presented in the May 31, 2002 *Recovery Well Installation, Aquifer Pumping Test and Groundwater Modeling Report.*

Scenario	RW-1		RW-2		RW-3	
	status	Flow (gpm)	status	Flow (gpm)	status	Flow (gpm)
#1	**ON**	60	**ON**	20	**ON**	20
#2	**ON**	80	OFF	0	**ON**	40
#3	OFF	Not evaluated	**ON**	Not evaluated	**ON**	Not evaluated
#4	**ON**	80	**ON**	40	OFF	0
#5	OFF	0	**ON**	250	OFF	0
#6	**ON**	Not evaluated	OFF	Not evaluated	OFF	Not evaluated
#7	OFF	Not evaluated	OFF	Not evaluated	**ON**	Not evaluated

Of these scenarios, scenario #1 through #4 represent routine situations wherein either all wells are operating or one of the wells is being shut down for maintenance. Scenarios #5 through #7 are non-routine, wherein only one well would be operating. The focused groundwater flow model was used to develop capture zone analysis for scenarios #1, #2, and #5. In general, the capture zone analysis for scenarios with well RW-1 = OFF does not yield practical solutions due to the direction of groundwater flow (south-southwest) relative to the site boundary (east-northeast): in other words, RW-1 is always located 'downgradient' of any other on-site recovery well and as a result, with RW-1 not pumping, only very large amounts of pumping from RW-2 (or RW-3), as shown for Scenario #5, would yield a capture zone that extends sufficiently beyond RW-1 to the west. Scenario #6 and #7 are not practical either, as the asymmetry of the capture zone would result in a large portion of recovered groundwater that would not have site-related constituent loading.

The Liberty Group proposes to use Scenario #2 (RW-1 = 80 gpm and RW-3 = 40 gpm) as the default pumping situation (Figure 4B). For that scenario, RW-2 would be used only on an as-needed basis (e.g., during well maintenance). Another effective scenario of capturing groundwater across the site boundary includes three recovery wells (RW-1, RW-2, RW-3) as shown for Scenario #1 (total flow of 100 gpm). Note that RW-3 is always located 'upgradient' of both RW-1 and RW-2, and therefore the model solution shown in Figure 4A does not require pumping at the full rate of 100 gpm from the three wells. However, in order to 'shorten' flow lines from the Building B basement area, RW-3 would be assigned a pumping rate greater than the nominal flow rate shown in Figure 4A. Finally, Figure 4C shows a capture zone solution for an impractical single-well approach (Scenario #5, total of 250 gpm from RW-2 only), which barely captures groundwater on the west side, while providing too much capture on the east side. The groundwater recovery system design will meet the flow conditions discussed above (Scenario #2). The total flow from the recovery wells will be between 100 and 120 gpm.

Figures 4A through 4C below demonstrate the relation of modeled groundwater elevations, interpreted capture zone (black dotted lines) and the approximate plume boundaries (light blue lines) for pumping scenarios #1, #2, and #4. Scenario #2 is the proposed default pumping configuration.

Scenario 1:

RW-1 at 60 gpm
RW-2 at 20 gpm
RW-3 at 20 gpm
Plume boundary

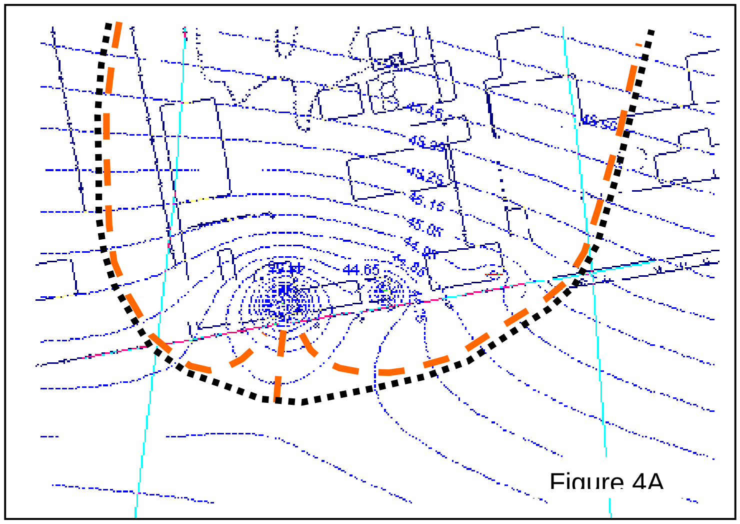


Figure 4A

Scenario 2:

RW-1 at 80 gpm
RW-2 off
RW-3 at 40 gpm
Plume boundary

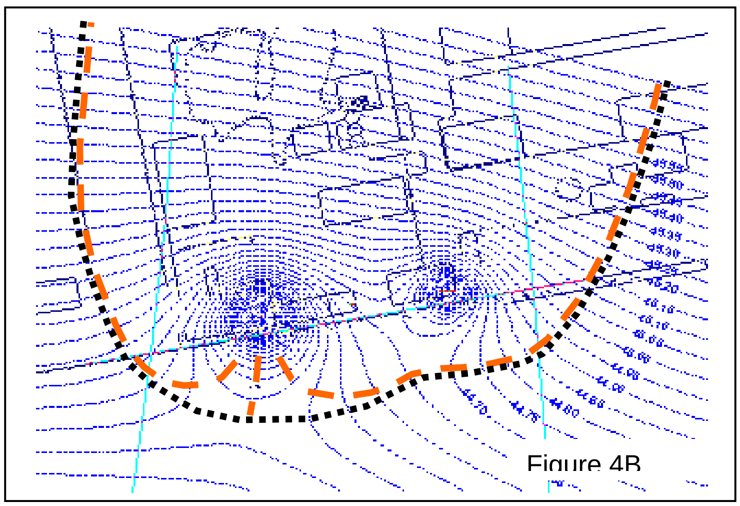


Figure 4B

Scenario 5:

RW-1 off
RW-2 at 250 gpm
RW-3 off
Plume boundary

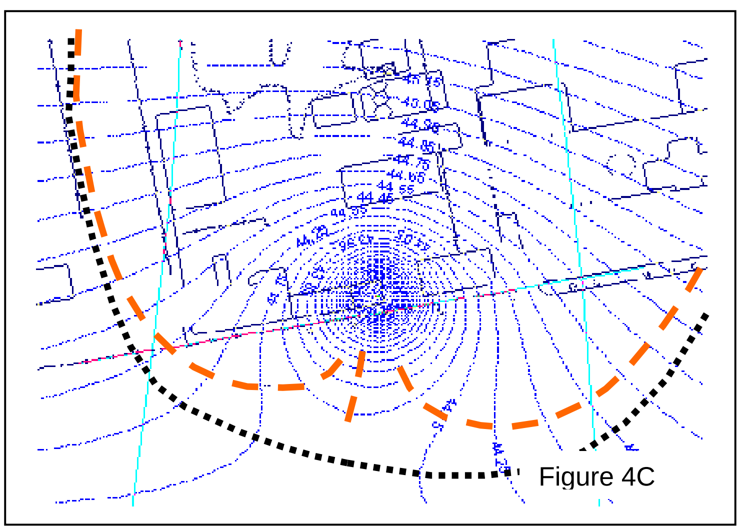


Figure 4C

4.0 GROUNDWATER TREATMENT SYSTEM

4.1 Volatile Organic Constituents

The current treatment system for VOC removal consists of six 2,000 lbs vessels with activated carbon that are arranged in three (3) parallel sets (lead and lag units). Testing results of the system influent and effluent have repeatedly shown that VOC concentrations are reduced to non-detect (less than 0.5 µg/L) subsequent to treatment with GAC. The current capacity of the GAC treatment system is 300 gpm, which is more than adequate to handle the proposed design flow of 100 to 120 gpm from the groundwater extraction system.

4.2 Metals

The current treatment system of the GRS for metals removals consists of two parallel banks of five (5) HDPE vessels that are designed to hold as much as approximately 240 kg of Octolig™ immobilized on silica gel (Octolig resin). The Octolig is manufactured by Metre General, Inc. of Frederick, Colorado. Metal removal and retention is a result of chelation of cations (e.g., cadmium, chromium, copper iron, nickel, zinc) and certain anions (e.g., chromate CrO_4^{2-}) on the surface of Octolig™. The effluent data collected to date indicates that cadmium, chromium, copper, iron, nickel, and zinc are chelated, whereas barium, manganese, and major metals (calcium, potassium, magnesium, sodium) pass through the Octolig resin. Both bench-scale and field-scale treatability tests of the Octolig resins were performed. The bench-scale tests were conducted at Metre General's facilities and the results reported in the 1999 Pilot Test Report, which indicate that chromium was removed to better than 99% and cadmium was removed to better than 90% of the influent concentrations (with pH adjustment).

A short-term field-scale test to evaluate the performance of the Octolig resins was performed during the week of January 28, 2002, and the results were reported in the April 30, 2002 memorandum *Short-Term Treatability Test – Octolig Resins*. The short-term test processed approximately 9,200 gallons of water through <u>one</u> vessel (vessel 500E) at normal groundwater pH and also at adjusted pH values between 8.0 and 9.0. The flow through the vessel was between 13 and 24 gpm, at a minimal pressure drop across the unit. There was no treatment of VOCs prior to bleeding the groundwater through the 500E vessel. The measured influent and effluent concentrations of cadmium and chromium are summarized on the next page:

Cadmium		INFLUENT ug/L	EFFLUENT ug/L	Cd/Cr Ratio prior to treatment
pH = 6.2	*Test #1*	287	1.2	4.45
		280	2.0	4.40
pH = 8.0	*Test #2*	270	0.88	3.77
		275	0.73	3.70
pH = 9.0	*Test #3*	284	0.49	4.50
		277	0.54	4.38
pH = 8.2	*Test #4*	165	0.52	4.95
		163	0.42	5.36
pH = 8.5	*Test #5*	159	<0.4	6.26
		158	<0.4	6.15
pH = 8.0	*Test #6*	57.3	<0.4	5.79
		60.6	<0.4	5.83
pH = 8.5	*Test #7*	59.2	<0.4	6.30
		58.7	<0.4	5.81

Chromium		INFLUENT ug/L	EFFLUENT ug/L
pH = 6.2	*Test #1*	64.5	<2.8
		63.7	<2.8
pH = 8.0	*Test #2*	71.6	<2.8
		74.3	<2.8
pH = 9.0	*Test #3*	63.1	<2.8
		63.2	<2.8
pH = 8.2	*Test #4*	33.3	<2.8
		30.4	<2.8
pH = 8.5	*Test #5*	25.4	<2.8
		25.7	<2.8
pH = 8.0	*Test #6*	9.9	<2.8
		10.4	<2.8
pH = 8.5	*Test #7*	9.4	<2.8
		10.1	<2.8

The results of the short-term treatability test indicated that cadmium and chromium are efficiently removed from the groundwater to concentrations that are less than the likely discharge limits (5 μg/L for cadmium and 50 μg/L for chromium).

The Liberty Group has continued to evaluate the performance of the entire metals removal system (see Attachment B). The groundwater is derived from existing recovery well RW-1. The system operations have been summarized in Section 2.4 of this document (Period 01 through 03), and also in the *November 24, 2002 Treatability Test Report – Octolig* (which includes Period 01), the January 28, 2003 *Period 02 Operations Summary* and the February 12, 2003 *Period 03 Operations Summary.*

The following tabulation shows the 10-month average [April – January 2003] and maximum observed concentrations from RW-1, as well as, projected influent concentrations from the entire groundwater extraction system (based on the on-site groundwater quality data collected during the year 2002 [February 2002, May 2002, August 2002, and October 2002]), to determine the approximate loading that could be expected to the Octolig resins:

		Concentrations				*Loading from*		
		RW-1 (avg.)	RW-1 (max)	Expected	Loading	RW-1 (avg.)	RW-1 (max)	Expected
	gram/mole	ug/L	ug/L	ug/L	Factor	mole/L	mole/L	mole/L
Barium	137	58.1	69.9	65	0.01	4.24E-09	5.10E-09	4.74E-09
Cadmium	112	109.7	149	100	0.95	9.30E-07	1.26E-06	8.48E-07
Chromium	52	26.9	44.5	10	0.50	2.58E-07	4.28E-07	9.62E-08
Copper	64	37.1	55	5	0.95	5.51E-07	8.16E-07	7.42E-08
Iron	56	294.1	1510	40	0.95	4.99E-06	2.56E-05	6.79E-07
Manganese	55	65.3	152	120	0.25	2.97E-07	6.91E-07	5.45E-07
Nickel	59	37.5	60.3	50	0.98	6.22E-07	1.00E-06	8.31E-07
Zinc	65	134.9	158	150	0.95	1.97E-06	2.31E-06	2.19E-06
						9.62E-06	3.21E-05	5.27E-06

average:	calculated from measured concentrations (Apr 2002 through Nov 2002)
maximum:	maximum observed concentration (Apr 2002 through Nov 2002)
expected:	based on long-term trends and removal of constituents in GAC (prior to octolig)
	purple = not detected after GAC
Loading Factor:	observed efficiency of Octolig (Nov 2002)

No. Vessels	10	
Octolig/Vessel	240	kg

			mole/day (avg.)	mole/day (max)	mole/day (exp.)
		L/day	mole/day (avg.)	mole/day (max)	mole/day (exp.)
Flow Rate (gpm)	80	435,456	4.19E+00	1.40E+01	2.29E+00
	100	544,320	5.24E+00	1.75E+01	2.87E+00
	120	653,184	6.29E+00	2.10E+01	3.44E+00
			days/kg	days/kg	days/kg
Loading (mole/kg)	0.05	at 80 gpm	1.19E-02	3.57E-03	2.18E-02
		at 100 gpm	9.55E-03	2.86E-03	1.74E-02
		at 120 gpm	7.95E-03	2.38E-03	1.45E-02
	0.1	at 80 gpm	2.39E-02	7.15E-03	4.36E-02
		at 100 gpm	1.91E-02	5.72E-03	3.49E-02
		at 120 gpm	1.59E-02	4.76E-03	2.90E-02
			days	days	days
Resin Mass (kg)	1,200 (1 bank)	80 gpm/0.05	14	4	26
		80 gpm/0.1	29	9	52
		100 gpm/0.05	11	3	21
		100 gpm/0.1	23	7	42
		120 gpm/0.05	10	3	17
		120 gpm/0.1	19	6	35
	2,400 (2 banks)	80 gpm/0.05	29	9	52
		80 gpm/0.1	57	17	105
		100 gpm/0.05	23	7	42
		100 gpm/0.1	46	14	84
		120 gpm/0.05	19	6	35
		120 gpm/0.1	38	11	70

According to Metre General, loading capacities of between 0.1 and 0.2 mole/kg resin are possible with pH adjustment to pH = 8.0-8.5. However, practical experience during system operations Periods 01 through 03 (October 2, 2002 through January 18, 2003) showed that cadmium removal efficiency appears to decrease at around 0.05 mole/kg Octolig. Thus, using the expected total influent concentrations (right-most column) and using both banks of Octolig vessels, the regeneration frequency will be approximately every 35 days (based on a flow of 120 gpm and effective binding capacities of 0.05 mole/kg Octolig).

The current treatability testing for metals strongly suggests that the desired performance (i.e., meeting discharge criteria) and the desired practical performance (reasonable regeneration cycles of no less than 20-25 days) of the Octolig resins are being achieved.

ATTACHMENT A

<u>Responses to Comments by the U.S EPA (July 26, 2002) – Enclosure I</u>

<u>General Comments:</u>

1) No response necessary.

2) Recovery data compared favorably with pumping data, however, no formal analysis was performed using the recovery data. The May 31, 2002 report presents the raw data (hydrographs and drawdown cures) of both phases (pumping and recovery) of the aquifer pumping test.

3) No gradation analysis was performed during the March 2002 installation of RW-1. However, the CRI Report (July 2000) presents gradation data from pilot boring PB-1, which was located within about 25 feet of RW-1. Further, the middle screen (extraction screen) opening of the existing (and currently un-used) circulation wells was also 0.030 inches.

4) The model grid layers are thinner than the screened interval in RW-1 and observation wells, so the model can simulate three-dimensional flow in the vicinity of the pumping and observation wells

5) Figure A-1 shows a sitewide map of the potentiometric surface immediately prior to the pumping test (April 1, 2002). Figure A-2 shows a close-up map of the potentiometric surface near RW-1 immediately prior to the pumping test (April 1, 2002). Figure A-3 shows a close-up map of the potentiometric surface near RW-1 immediately prior to the termination of the pumping test (April 4, 2002), and Figure A-4 shows the corresponding cone of depression just prior to the end of the test, based on the drawdown data shown in Table A-1.

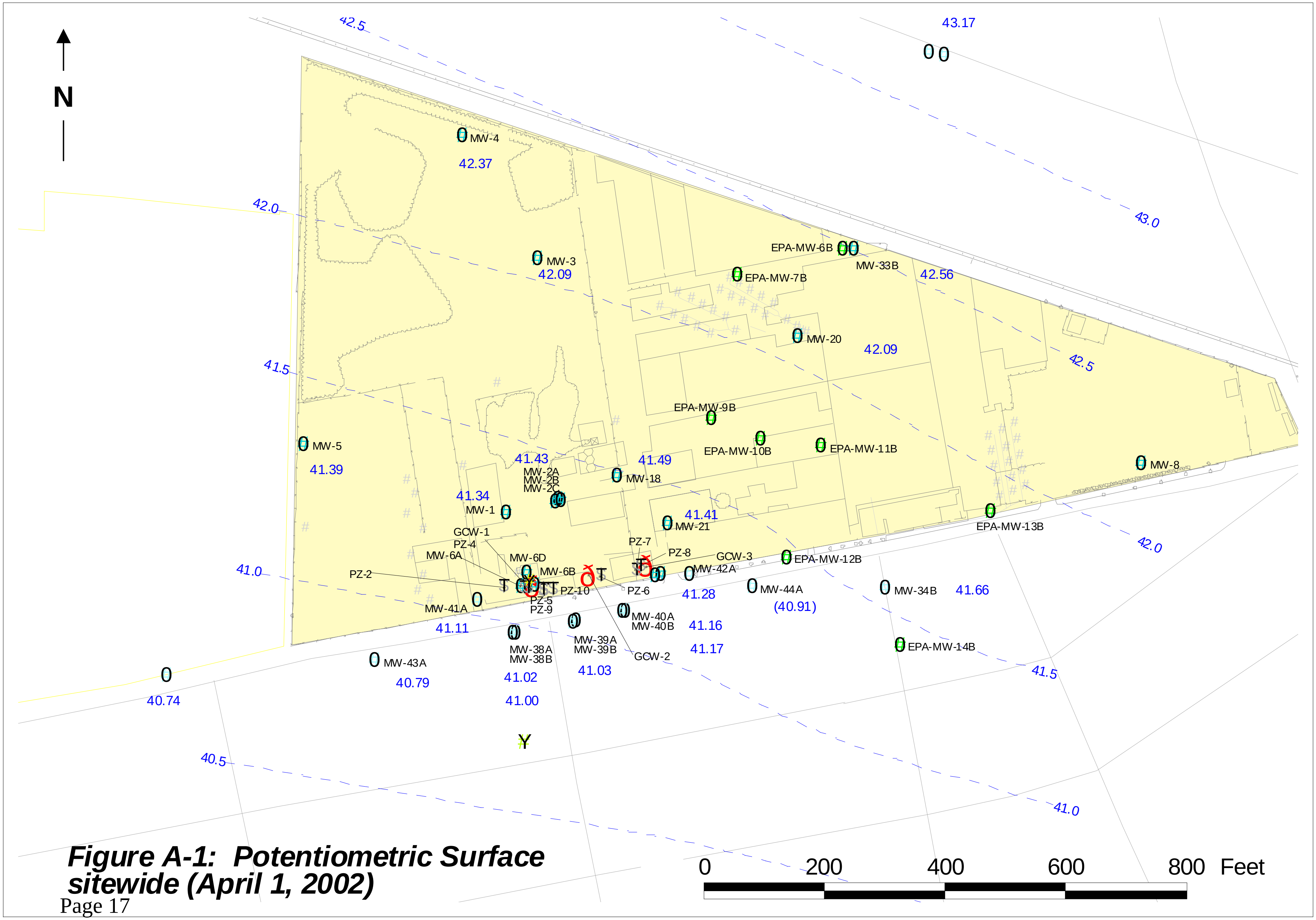


Figure A-1: Potentiometric Surface sitewide (April 1, 2002)

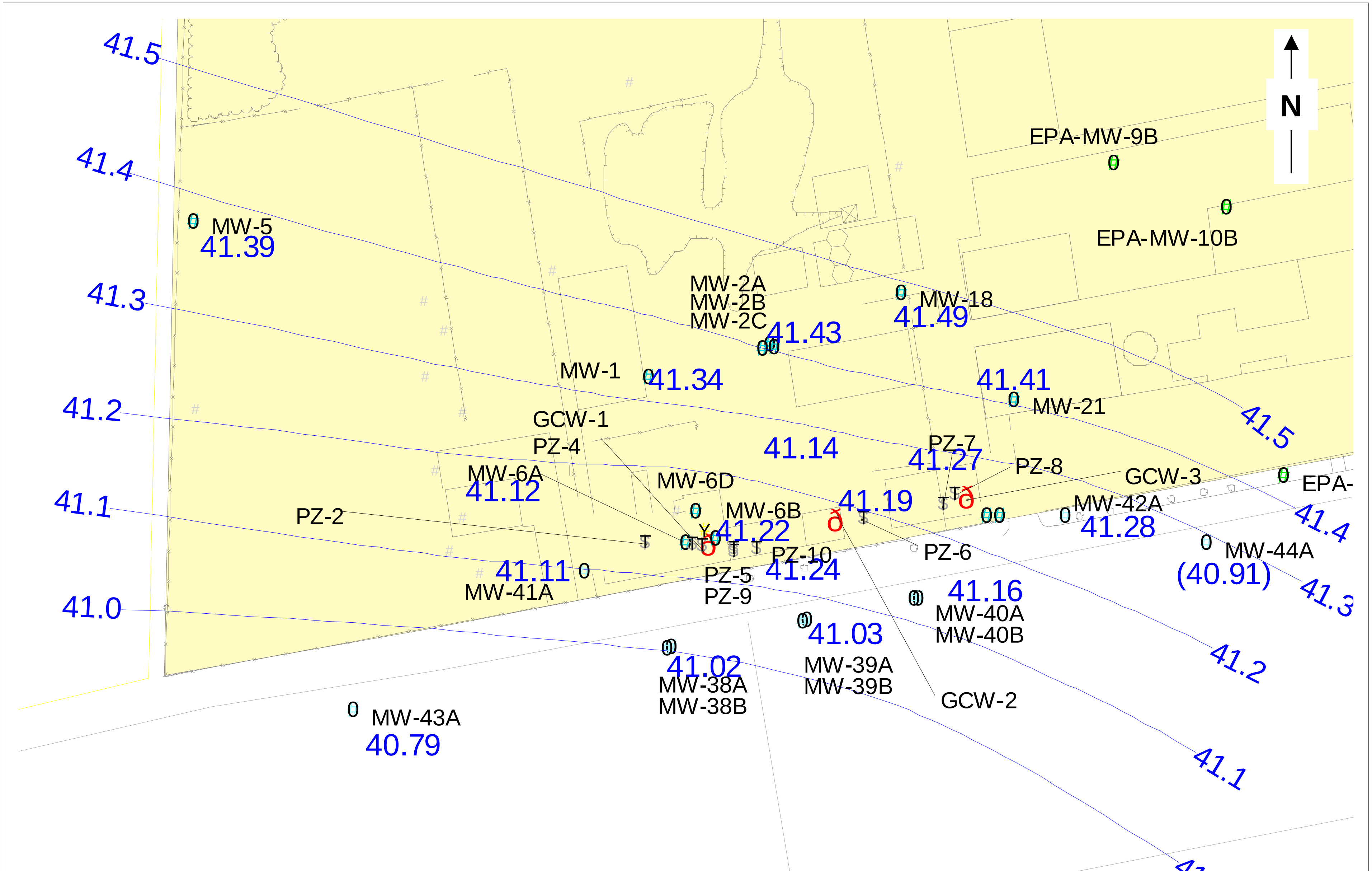


Figure A-2: Potentiometric Surface Near GCW-1 (April 1, 2002)

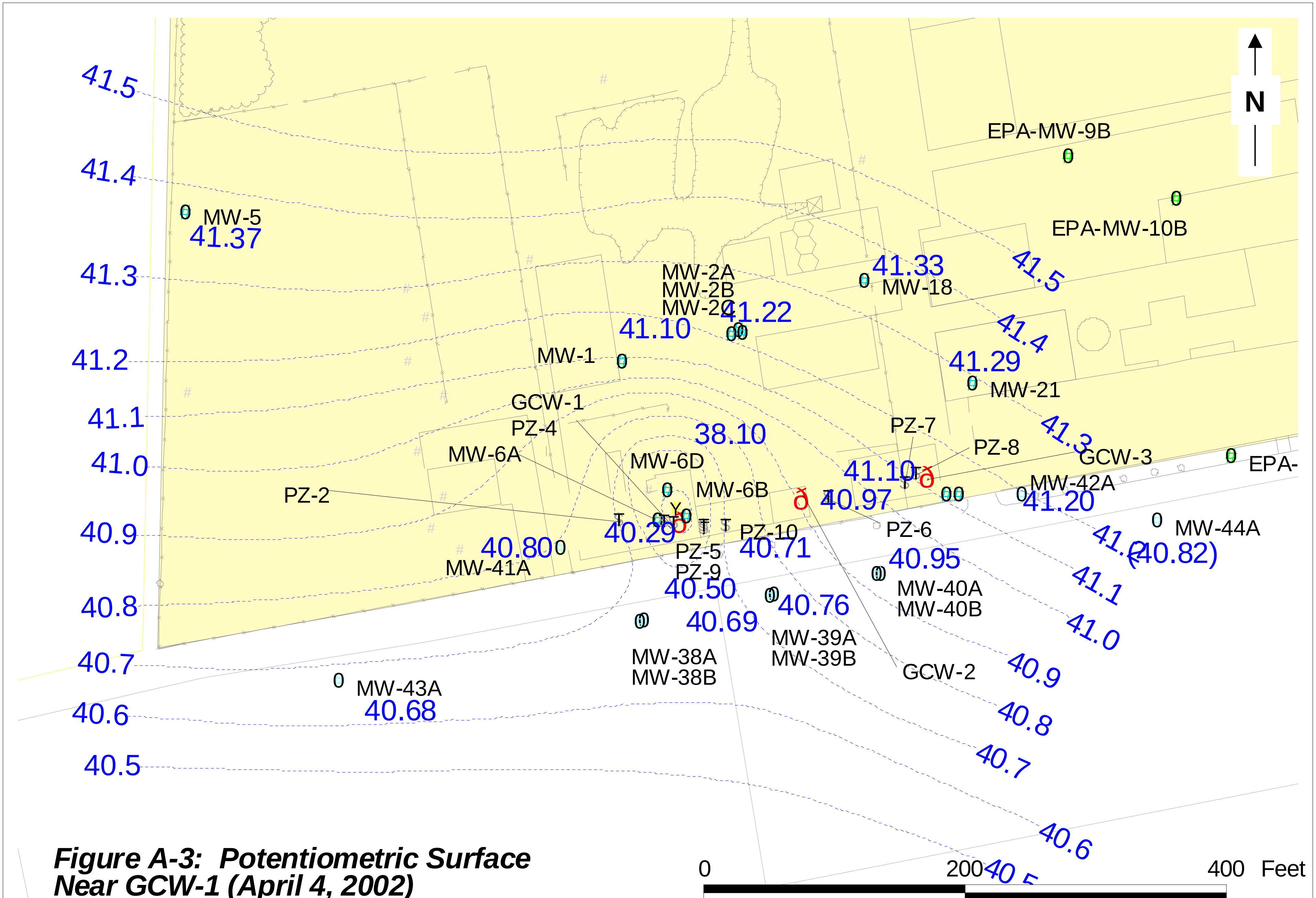


Figure A-3: Potentiometric Surface Near GCW-1 (April 4, 2002)

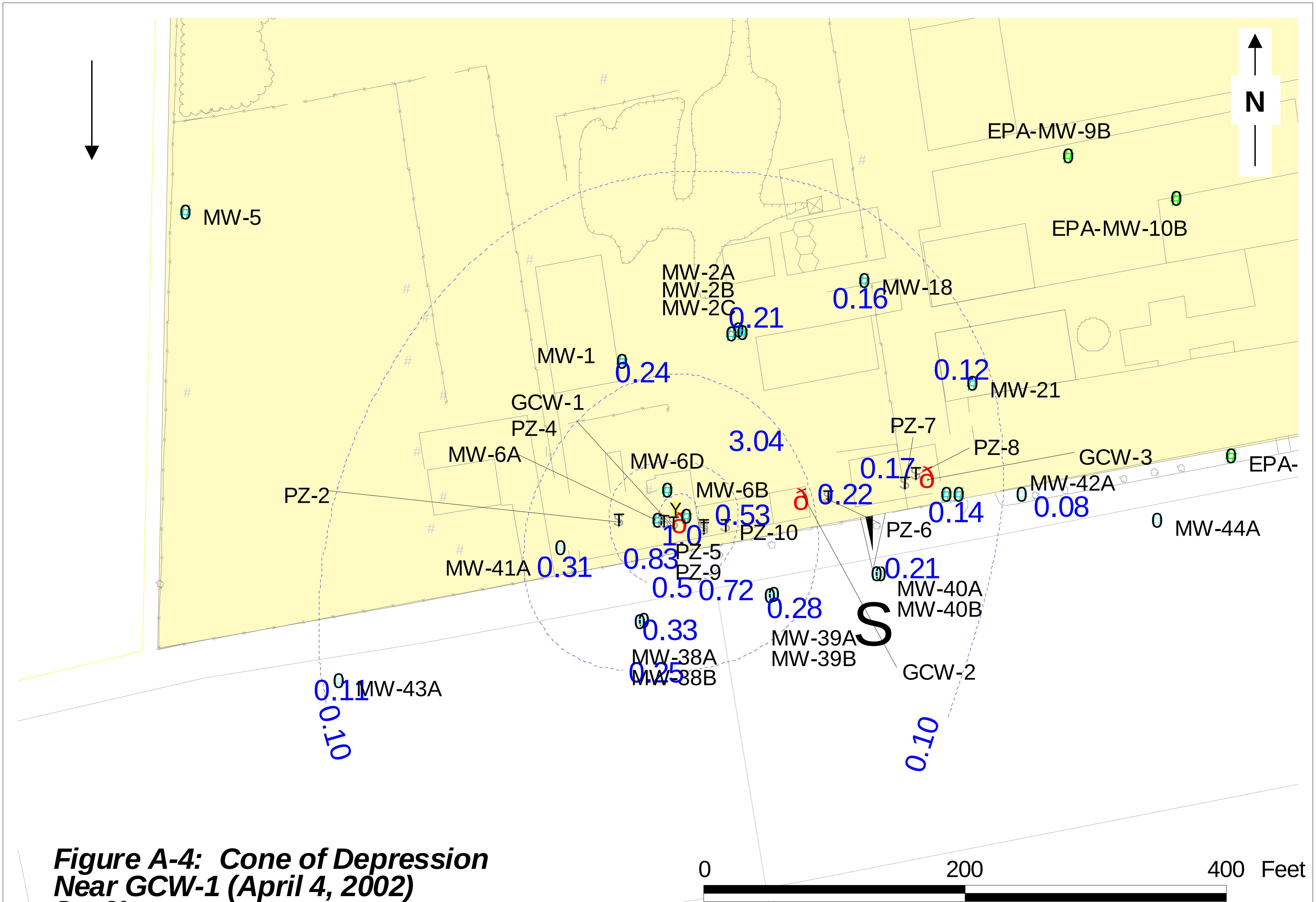


Figure A-4: Cone of Depression Near GCW-1 (April 4, 2002)

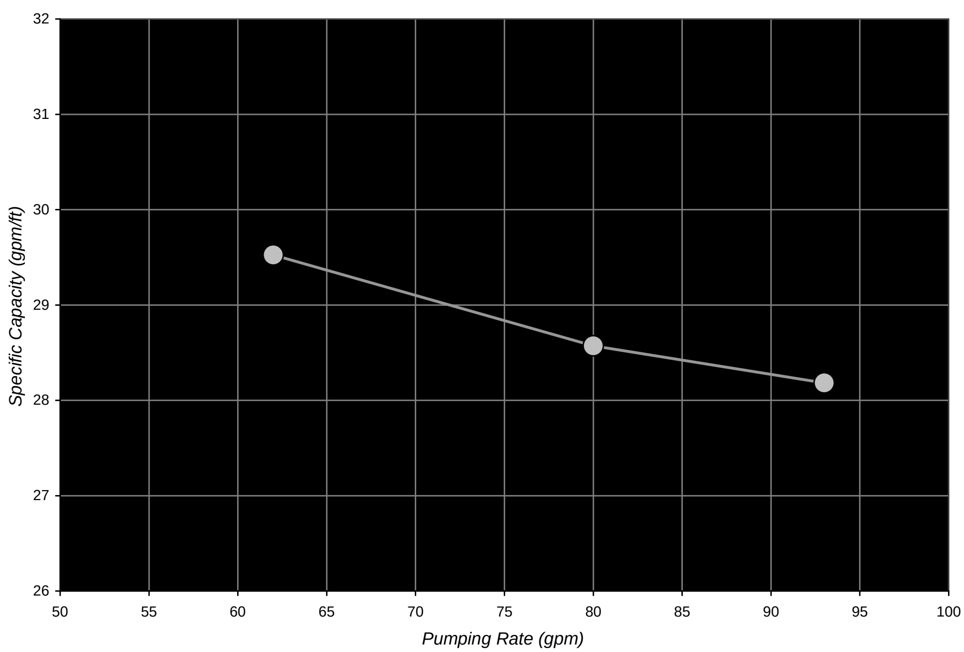
Well_ID	Level	TOC	Dist_RW-1	position	Transducer	Screen Interval		Groundwater Elevations				Groundwater Change		Drawdown	Recovery	Residual
						top	bottom	2/21/2002 12:00	4/1/2002 15:00	4/4/2002 8:00	4/5/2002 10:00	2/21 to 4/1	4/1 to 4/5	4/1 to 4/4	4/4 to 4/5	
		ft msl	ft			ft bgs	ft bgs	ft msl	ft msl	ft msl	ft msl	ft/day	ft/day	ft	ft	ft
RW-1	A	65.74	1	pumping	YES	10	40	NM	41.14	38.10	41.10	NM	-0.0100	3.04	-3.00	-0.04
MW-6A	A	65.99	12	side	YES	11	26	41.34	41.12	40.29	41.10	-0.0056	-0.0050	0.83	-0.81	-0.02
PZ-9A	A	66.04	19	side	YES	18	28	41.44	41.22	40.50	41.19	-0.0056	-0.0075	0.72	-0.69	-0.03
PZ-10A	A	66.85	47	side	YES	18	28	41.46	41.24	40.71	41.20	-0.0056	-0.0100	0.53	-0.49	-0.04
MW-38A	A	62.37	100	down	NO	15	30	41.23	41.02	40.69	40.97	-0.0054	-0.0125	0.33	-0.28	-0.05
MW-39A	A	63.08	110	down	NO	15	30	41.22	41.03	40.75	40.99	-0.0049	-0.0100	0.28	-0.24	-0.04
MW-41A	A	62.82	120	side	YES	14	29	41.32	41.11	40.80	41.07	-0.0054	-0.0100	0.31	-0.27	-0.04
MW-1	A	64.62	145	up	NO	14	29	41.62	41.34	41.10	41.28	-0.0072	-0.0150	0.24	-0.18	-0.06
PZ-6A	A	66.74	150	side	YES	18	28	41.42	41.19	40.97	41.19	-0.0059	0.0000	0.22	-0.22	0.00
MW-2A	A	64.44	180	up	NO	10	25	41.64	41.43	41.22	41.36	-0.0054	-0.0175	0.21	-0.14	-0.07
MW-40A	A	63.14	190	down	NO	15	30	41.32	41.16	40.95	41.10	-0.0041	-0.0150	0.21	-0.15	-0.06
PZ-7A	A	66.37	230	side	NO	13	28	41.48	41.27	41.10	41.24	-0.0054	-0.0075	0.17	-0.14	-0.03
MW-7A	A	66.03	255	side	NO	11	26	41.43	41.23	41.09	41.20	-0.0051	-0.0075	0.14	-0.11	-0.03
MW-18	A	66.04	275	up	NO	12	27	41.68	41.49	41.33	41.44	-0.0049	-0.0125	0.16	-0.11	-0.05
MW-21	A	64.32	295	side	NO	14	29	41.60	41.41	41.29	41.38	-0.0049	-0.0075	0.12	-0.09	-0.03
MW-42A	A	64.11	315	side	NO	14	29	41.43	41.28	41.20	41.27	-0.0038	-0.0025	0.08	-0.07	-0.01
MW-43A	A	62.20	350	side	NO	15	30	41.02	40.79	40.68	40.75	-0.0059	-0.0100	0.11	-0.07	-0.04
MW-5	A	66.89	525	up	YES	12	27	41.68	41.39	41.37	41.38	-0.0074	-0.0025	0.02	-0.01	-0.01
MW-6B	B	66.31	6	side	YES	48	58	41.30	41.10	40.39	41.06	-0.0051	-0.0100	0.71	-0.67	-0.04
PZ-4B	B	66.03	8	down	YES	50	60	41.39	41.21	40.75	41.18	-0.0046	-0.0075	0.46	-0.43	-0.03
PZ-3B	B	65.85	16	side	NO	50	60	41.36	41.15	40.61	41.14	-0.0054	-0.0025	0.54	-0.53	-0.01
PZ-5B	B	66.33	22	side	YES	50	60	41.67	41.10	40.53	41.07	-0.0146	-0.0075	0.57	-0.54	-0.03
MW-38B	B	62.26	100	down	NO	50	60	41.19	41.00	40.68	40.95	-0.0049	-0.0125	0.32	-0.27	-0.05
Mw-39B	B	62.85	110	down	NO	50	60	41.32	41.15	40.83	41.07	-0.0044	-0.0200	0.32	-0.24	-0.08
MW-2B	B	65.06	180	up	NO	50	60	41.60	41.40	41.18	41.36	-0.0051	-0.0100	0.22	-0.18	-0.04
MW-40B	B	63.36	190	down	NO	50	60	41.33	41.17	40.96	41.12	-0.0041	-0.0125	0.21	-0.16	-0.05
MW-7B	B	65.43	245	side	NO	50	60	41.13	41.19	41.03	41.16	0.0015	-0.0075	0.16	-0.13	-0.03
PZ-4C	C	66.04	8	down	YES	85	90	41.37	41.16	40.90	41.14	-0.0054	-0.0050	0.26	-0.24	-0.02
PZ-3C	C	65.81	16	side	NO	85	90	41.34	41.14	40.87	41.10	-0.0051	-0.0100	0.27	-0.23	-0.04
PZ-5C	C	66.32	22	side	YES	85	90	41.27	41.04	40.79	41.02	-0.0059	-0.0050	0.25	-0.23	-0.02
PZ-6C	C	66.69	150	side	YES	85	90	41.40	41.18	41.02	41.18	-0.0056	0.0000	0.16	-0.16	0.00
MW-2C	C	65.28	180	up	NO	130	140	41.43	41.22	41.15	41.19	-0.0054	-0.0075	0.07	-0.04	-0.03
PZ-7C	C	66.35	230	side	NO	80	90	41.43	41.22	41.09	41.20	-0.0054	-0.0050	0.13	-0.11	-0.02

Specific Comments:

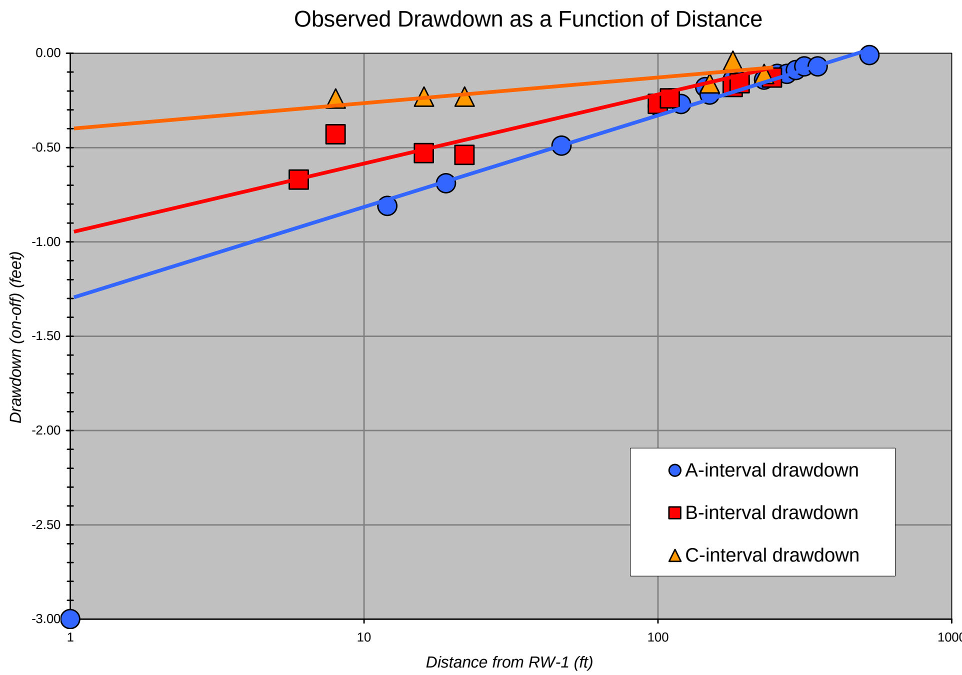
(6) The material in the annular space between the 8-in well sump and outer diameter of the borehole is No.1 sand.

(7) The well was developed at a constant pumping rate of 66 gpm. No specific methods (such as evaluating well efficiency at various pumping rates) were employed to determine whether the well was fully developed. The chart below shows the calculated specific capacity of RW-1, as observed during the step test (April 1, 2002):

Pumping Rate (gpm)	Drawdown from Static (ft)	Specific Capacity (gpm/ft)
62	2.1	29.5
80	2.8	28.6
93	3.3	28.2

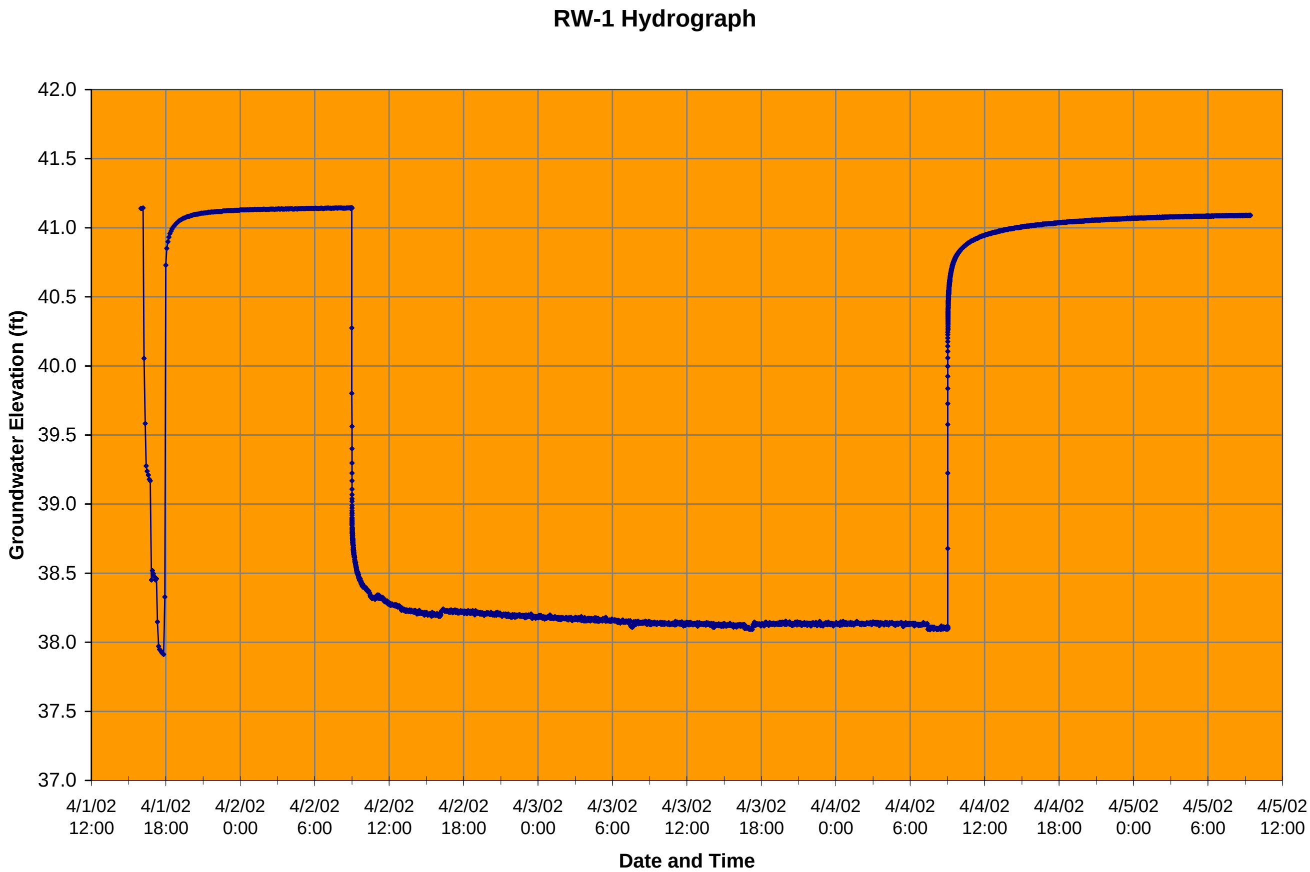


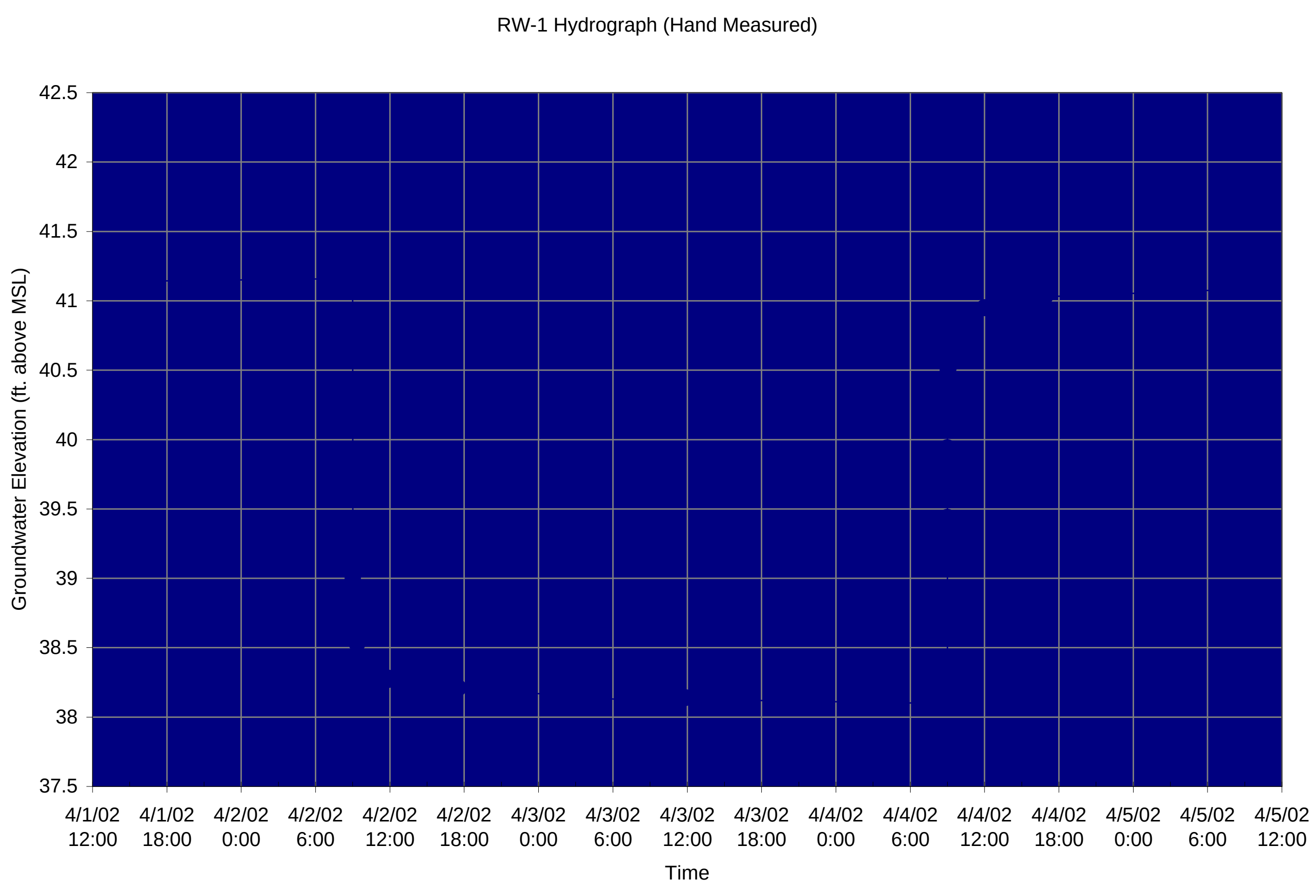
Based on the near-linear performance of the well during the step test, the well should be considered adequately developed. The overall well efficiency is on the order of 40%, as shown by the predicted (-1.3 feet) vs. observed (-3.0) feet) drawdown in recovery well RW-1 during the pumping test (see figure on the next page).



(8) The hydrograph of monitoring well MW-5 strongly suggests timed water withdrawal starting at 6:00 am each morning and ending at 12:00 noon. The water level fluctuations observed in MW-5 are in excess of one foot. Such changes are reminiscent of planned water withdrawals, such as those that would be occurring from the supply wells operated by the South Farmingdale Water District that are located to the northwest of MW-5. Note, however, that none of the other wells that were monitored continuously showed water level fluctuations anywhere near that magnitude; in fact, the hydrographs seem to indicate no influence whatsoever. The locations of the proposed recovery wells (see Figure 2) therefore appear to be outside the cone of influence potentially created by the water supply wells.

(9) The report erroneously stated that both transducer and hand measurements were systematically collected from PZ-3B and PZ-3C. In fact, only hand measurements were collected from these wells. The charts on the next page show the correspondence between the transducer data and the hand measured data for the pumping well RW-1.


RW-1 Hydrograph
Groundwater Elevation (ft)
42.0
41.5
41.0
40.5
40.0
39.5
39.0
38.5
38.0
37.5
37.0
4/1/02 12:00
4/1/02 18:00
4/2/02 0:00
4/2/02 6:00
4/2/02 12:00
4/2/02 18:00
4/3/02 0:00
4/3/02 6:00
4/3/02 12:00
4/3/02 18:00
4/4/02 0:00
4/4/02 6:00
4/4/02 12:00
4/4/02 18:00
4/5/02 0:00
4/5/02 6:00
4/5/02 12:00
Date and Time


RW-1 Hydrograph (Hand Measured)
Groundwater Elevation (ft. above MSL)
42.5
42
41.5
41
40.5
40
39.5
39
38.5
38
37.5
4/1/02 12:00
4/1/02 18:00
4/2/02 0:00
4/2/02 6:00
4/2/02 12:00
4/2/02 18:00
4/3/02 0:00
4/3/02 6:00
4/3/02 12:00
4/3/02 18:00
4/4/02 0:00
4/4/02 6:00
4/4/02 12:00
4/4/02 18:00
4/5/02 0:00
4/5/02 6:00
4/5/02 12:00
Time

(10) There's no evidence that the size or regeneration frequency of the Octolig resin units is or will be influenced by the change in observed chromium concentrations during the pumping test. The chart on page 13 of this document shows that chromium, in fact, does not play a major role in the anticipated loading to the Octolig resin.

(11) There was very minor rainfall recorded at the NOAA weather station immediately preceding the pumping test. The variations in the hydrograph of MW-5 are not due to precipitation, but are likely the result of timed water-withdrawal from the supply wells operated by the South Farmingdale Water District. These supply wells are located northwest of MW-5. The effects of rainfall were not considered during the pumping test, as the focused model assumes a constant head boundary.

(12) The distances of the observation wells and the screened intervals are shown in Table A-1.

(13) Allowing the model to simulate hydraulic connection across the transitional unit provides greater flexibility when matching predicted and observed water levels. The material properties of the bottom seven layers are similar to those specified for the transitional unit and the Magothy Aquifer in the November 2000 flow and transport model

(14) The average K-values were as follows:

Model Horizon	Jacob-Cooper Average K (ft/day)	Theis Solution Average K (ft/day)
A	222	233
B	225	245
C	381	416

The information was also presented in Attachment 7 to the May 30, 2002 report.

(15) The value of $k_h/k_v = 10$ is based on the commonly used literature value.

(16) In the model, the MODFLOW layer type is "three", which corresponds to "fully convertible". Every cell in the model can convert from confined to unconfined depending on the hydraulic head in a cell. Both storage coefficient and specific yield were specified in every model cell. In MODFLOW, when the hydraulic head in a cell

drops below the top of the cell, the specific yield is used in place of the storage coefficient. This gives the model greater flexibility to simulate what actually occurs in the aquifer.

.

(17) The regression yields the following results:

Zone A:

Regression Statistics		
Multiple R	0.978	y = 0.7136x + 0.053
R Square	0.957	
Adjusted R Square	0.954	
Standard Error	0.038	
Observations	14	

Zone B:

Regression Statistics		
Multiple R	0.942	y = 0.474x + 0.091
R Square	0.888	
Adjusted R Square	0.869	
Standard Error	0.035	
Observations	8	

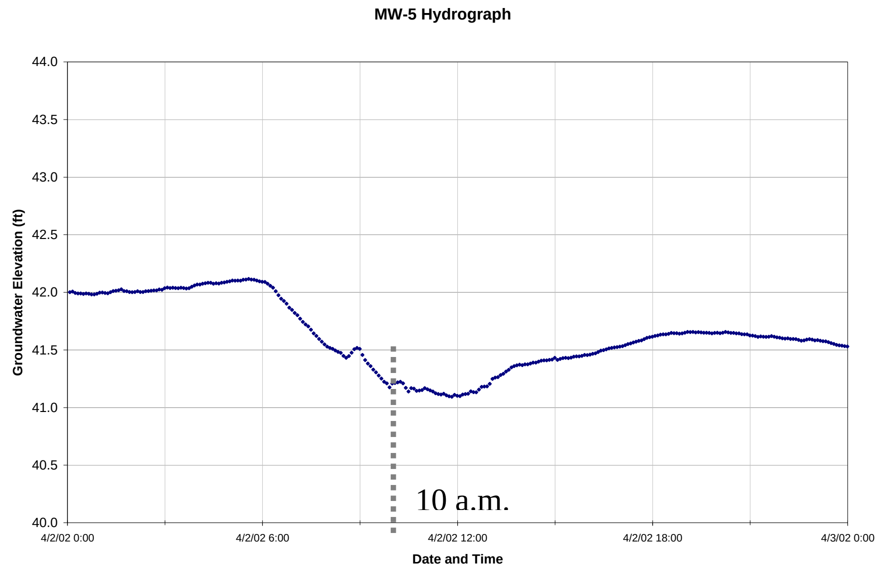
Zone C:

Regression Statistics		
Multiple R	0.757	y = 0.305x + 0.132
R Square	0.574	
Adjusted R Square	0.432	
Standard Error	0.020	
Observations	5	

As pointed out in the report and also by the reviewer, the model under-predicts the drawdown in the B-zone and C-zone of the aquifer.

(18) Yes, the results at the bottom of the page were cut-off accidentally by the printer.

(19) A similar "break" is noted in RW-1 and several other wells. The timing of the "break" may be related to the distance of the observation well from the pumping well and the position of the pumping well relative to the water table. For example, the "break" is much smaller in PZ-9A than PZ-5B because PZ-9A is screened at the water table where dewatering of pores occurs. Also, the “break” occurs approximately 0.04 days into the test (= 1 hour, corresponding to April 2, 2002, 10:00 a.m.). This the same time at which the hydrograph of MW-5 (the well that shows an apparent interference from timed pumping of supply wells to the northwest) indicates a similar break in drawdown.



(20) In any case the model predictions will always be conservative with regard to the size of the predicted capture zone and the rate at which it propagates.

<u>Responses relative to Enclosure II:</u>

(1) The analysis of the pumping test data included deriving first-order estimates of the aquifer parameters from straight-line Cooper-Jacob fitting and Theis-curve matching of the drawdown vs. time data. The model was calibrated to actually observed drawdown at various distances from the pumping well by varying these estimates of K values and S values within reasonable limits. The final calibration still produced a conservative model, as described in the report and repeated in the responses to comments (17) and (20) above.

(2) The turbidity measurements could have indeed benefited from periodic re-calibration. The measurements were collected with a Horiba U-22 multi-parameter probe (via flow-through cell), and basically indicate that the pumped water from RW-1 was less turbid than the ‘Zero turbidity’ calibration solution used.

(3) The boundaries of the site-related groundwater plumes for VOCs and metals are indicated on Figure 2 of the main document, and also as straight lines (light blue color) in Figures 3A through 3C of the main document. The position of the shown plume boundaries is consistent with the compliance monitoring data presented to the U.S. EPA in the quarterly reports.

(4) A similar extraction well construction and pumping test program would be implemented for the off-site shallow and deep groundwater extraction program. It is likely that such a testing program would be preceded by an off-site groundwater sampling event to determine the current off-site plume configuration.

ATTACHMENT B

Continued Activities to Determine the Effectiveness of Octolig Resin Media

In the past, the operation of the metals treatment system was limited by two main factors: (1) degradation of water transmitting properties through the Octolig resin and/or the holding vessels (pressure drop in some vessels increases from 2 psi to 10 psi over a period of 5-10 days); (2) lack of adequate cadmium removal due to either physical or chemical blinding of the Octolig resin. Spent Octolig removed from the vessels showed a substantial build-up of fines within the Octolig resin that consists of physically broken-down Octolig and very fine dark-gray material. The GRS was shut down on September 18, 2002 as a result of these operational issues. On October 2, 2002, the system was successfully re-started after replacing much of the Octolig resin in vessels 500A through 500D, further cleaning of the resin surfaces (physical removal of fine particulate build-up), and commencing the operation of the pH-adjustment system

The following activities are on-going or completed:

1. Installed a bench scale Octolig unit preceding the GAC units to observe the physical properties of Octolig resin and chemical removal efficiencies. This activity was conducted because the successful Octolig tests (bench-scale in 1999 and field-scale in 2002) were performed without passing the test water through the GAC units. The results of these tests were reported in the November 24, 2003 *Treatability Test Report- Octolig.*

2. Replacement of the 10 μm bag filter (post-pH adjustment, pre-Octolig) with a 3 μm bag filter, as it is likely that the build-up of fine particulates and the resulting drop in Octolig resin permeability was related to very fine iron oxide/iron hydroxide particles passing through the 10 μm bag filter. System sampling with the 3 μm bag filter unit installed indicates that iron particles are now adequately retained. In addition, iron is retained in the liquid-phase GAC units.

3. Improve the operation of the pH adjustment and system controls for the automatic adjustment of the groundwater pH prior to and after the Octolig vessels. This system has been on-line since October 2, 2002. Improvements that were completed include the installation of anti-siphon valves in-line with the chemical feed pumps to better control the rate of chemical addition. The system operation is being monitored and the observed treatment effectiveness has been reported in the November 24, 2002 *Treatability Report – Octolig*, the January 28, 2002 *Period 02 Operations Summary*, and the February 12, 2003 *Period 03 Operations Summary*. The data reported therein are also discussed in the main text of the Final Design Document.

ATTACHMENT C

Responses to Comments by the U.S EPA (January 16, 2003) – Enclosure I (EPA's comments)

In the following sections, EPA comments are re-printed in italics, whereas responses are shown in normal print

General Comments

1. Overall, the analysis presented in the document is sound. The results of the modeling presented in this report are consistent with previous modeling efforts. While some information is presented in Attachment A, it would have been beneficial if the model input parameters were presented in a separate attachment. For example, a cross-section that represents the model layers and their associated parameters would provide a handy summary of the input parameters.

With regards to the proposed pumping scenario, scenario #2 is the preferred as it facilitate adjusting the pumping schedule in the field and provides a better capture zone.

Response: The model parameters and model layers were presented in detail in the May 31, 2002 Report *Recovery Well Installation, Aquifer Pumping Test, and Groundwater Modeling*. Specifically, Figure 7-2 of the referenced report shows a cross section of the model layers with associated parameters. Figure 7-2 is reproduced here to satisfy the comment:

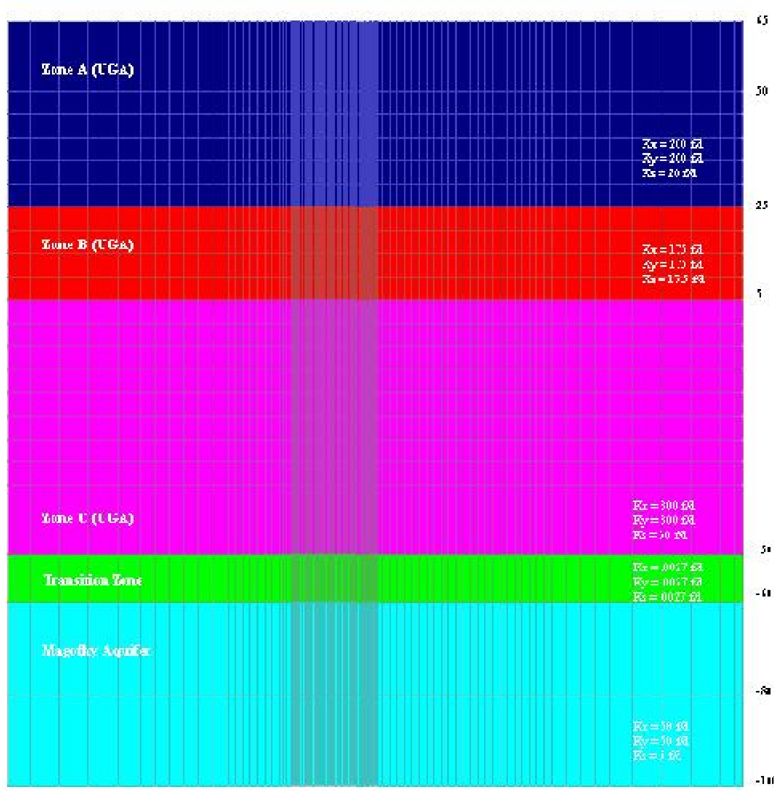


Figure 7-2
MODFLOW Layer

2. Due to concern over the amount of time the on-site groundwater treatment system has been out of service, EPA is requiring that every effort be made to operate the treatment system twenty-four hours a day and schedule maintenance on components of the treatment system so that the facility is in essentially continuous operation.

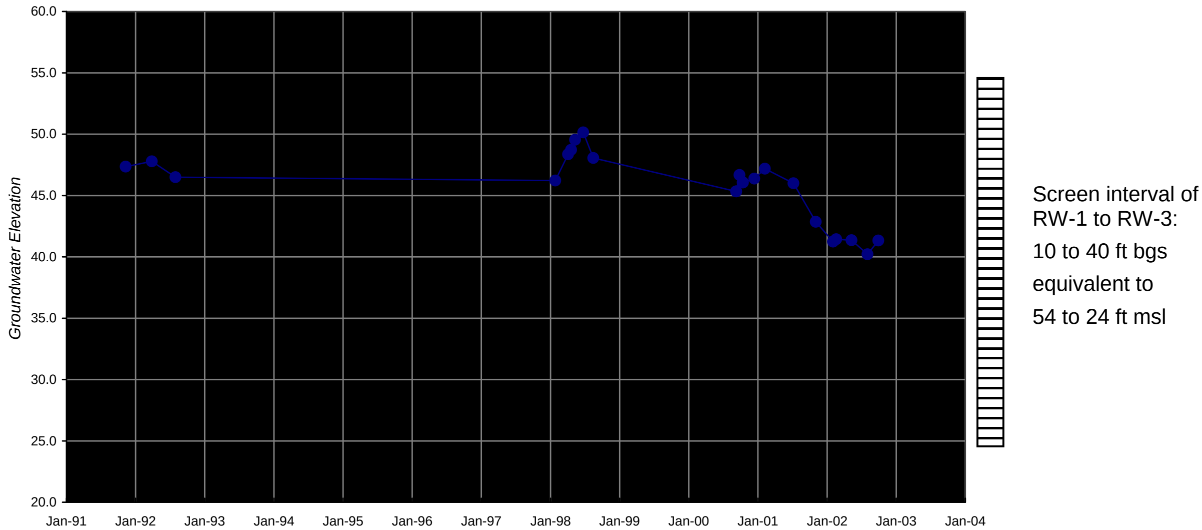
Response: Comment noted. The groundwater remediation system (GRS) at the Site is being run 24 hours per day, except during periods when a system shut-down occurs due to a fault condition, or at times when system maintenance (Octolig regeneration) is performed. At the present time (with the system running on RW-1 only, with a pumping rate of 60 gpm), Octolig regeneration is performed approximately every 25 to 30 days. Fault conditions (such as pH excursions in the balancing tanks) occur typically no more than once per week. During such occasions, the GRS may be down one to three days (if such faults occur on a Friday). Overall, during the time the GRS has operated with its automated pH adjustment system, the system efficiencies were as follows, shown for Periods 01 (October 9 through November 6, 2002), Period 02 (November 17 through December 10, 2002), and Period 03 (December 26 through January 17, 2003).

Period	Operation	Efficiency	Cum	Date		Total Flow	Cadmium	
	hrs	%	hrs	from	to	liter	kg	cum kg
01	604	89.9%	604	10/09/02	11/06/02	8.219E+06	0.699	0.699
02	499	74.3%	1103	11/12/02	12/10/02	6.799E+06	0.647	1.35
03	501	94.9%	1604	12/26/02	01/17/03	6.818E+06	0.917	2.26
04								
TOTAL	1,604	66.8%	1604	10/09/02	01/17/03	2.184E+07	2.263	

Specific Comments

3. Page 1: The report states that as recently as 1999, the groundwater table elevation was 50 ft msl. However, with the recent drought conditions water levels have declined. The report should discuss current and historic water levels, to aid in the selection of a proper screen interval.

Response: The chart below exemplifies the known historic groundwater table fluctuations at the Site, as observed in monitoring well MW-7A. The proposed screen intervals for RW-2 and RW-3 (10 feet to 40 feet below grade) are shown next to the chart. Based on historic observations, there will be at least 15 feet of available drawdown in the recovery wells. Note that the observed drawdown in existing recovery well RW-1 (screen interval is 10 to 40 ft bgs) is less than 4 feet at a pumping rate of 80 gallons per minute.



4. Page 4: In summarizing the site analytical data, the report states that the discussion is limited to the most recent data, which was collected under low groundwater elevations. The discussion should discuss historic data as they may impact system design criteria.

Response: The discussion on pages 4 and 5 of the Design Document was updated to include all groundwater quality data collected during the NTCRA well sampling program (September 2000 through October 2002). During that time, both high and low groundwater table conditions were observed (see chart above for well MW-7A: the observed water table ranged between approximately 47 feet bgs to 40 feet bgs).

In general, all quantitative discussions (such as the results of the continued treatability and loading evaluations, and the predictive evaluation of regeneration frequencies) were updated to reflect the most current analytical observations (through January 18, 2003).

5. Page 7: In discussing the treatment system goals, the report suggests the compliance with only the substantive requirements of a SPDES permit will be required. The need to obtain a SPDES permit or to only comply with the substantive requirements has not been determined.

Response: The document now contains a proposed derivation of system treatment goals that are consistent with the overall site cleanup criteria and are based on cumulative effluent averages (periodic and total system performance). This new section was added to the conclusion of Section 2.5 (Remedial Action Objectives).

6. Page 8: The recovery wells should be completed with a pitless adaptor or other approved system to avoid introduction of surface runoff into the well.

Response: The recovery wells will be completed with a pitless adapter and subsurface connection of the well effluent to the existing piping in the adjacent manhole vaults. Attachment D provides details of the general layout of the surface and subsurface completion of the recovery wells.

7. Page 10: The plume limits, as shown on Figure 2, should be superimposed on the figures illustrating the three pumping scenario.

Response: The light blue lines in Figures 3A through 3B (pumping scenarios) represent the plume limits, as explained in the legend to the figures.

Responses to Comments by the U.S EPA (January 16, 2003) – Enclosure II (H2M Group and Dvirka and Bartilucci)

In the following sections, H2M and Dvirka & Bartilucci comments are re-printed in italics, whereas responses are shown in normal print

1. The plan calls for utilizing a proposed flow rate of 100 gpm from RWI and 40 gpm from RW3 and to utilize RW2 on as needed basis during maintenance of one of the other wells. It is anticipated that well RW2 would need to be pumped in excess of 40 gpm if RW3 were to be out of service in order to have the same cone of influence to the east that RW3 has and, likewise , it would need to be pumped in excess of 100 gpm if RW1 were to be out of service in order to have the same cone of influence to the west that RW1 has. Please insure that the well pump in RW2 will be designed to have this capability and that the treatment system will have the capacity to handle the maximum potential flow rate of 250 gpm shown in the report. Please also insure that the treatment system will include the capability of parallel treatment paths so that the remediation can continue during periods of carbon change-out and Octolig regeneration.

Response: The proposed scenario #2 envisions a pumping rate of 80 gpm from RW-1 and 40 gpm from RW-3, with RW-2 as a standby well that would be utilized on an as needed basis. The discussion in the main text of this document clearly makes the point that RW-1 is the most critical well, the capture effect of which cannot be accomplished with reasonable withdrawal rates from either RW-2 or RW-3. Thus, it is not proposed that RW-2 (or RW-3) have the capacity of pumping a '*maximum potential flow rate of 250 gpm*'. Such a scenario was clearly labeled 'unrealistic' in Section 3.2 of the main document. The U.S EPA agrees with this evaluation (see their comment #1), and therefore no such provisions for excessive pumping from one well will be made. Instead, RW-2 and RW-3 will both be fitted with 7.5 hp submersible pumps that can safely and effectively operate between 40 and 80 gpm, at their given depths and distances from the treatment building (see Attachment D).

With respect to the capability of parallel treatment paths, both the GAC units and the Octolig units are currently built as parallel units, which will provide the means for continuous treatment during maintenance periods.

2. The document should include the disposal method and location for the treated groundwater.

Response: Attachment E to this document describes the disposal method and location for the treated groundwater (recharge trench to the west of the treatment building).

3. Please provide the testing and frequency requirements that the groundwater treatment facility must comply with.

Response: Section 2.5 of the main document summarizes the treatment goals for the GRS (periodic average effluent concentrations are to be or equal or less than the site cleanup criteria for groundwater, as bracketed by the standard error of the mean). The sampling frequency (system influent and system effluent) and the proposed treatment of the Octolig regeneration waste are described in detail in Attachment E.

4. The monitoring well network should be utilized to insure that the treatment system is effectively removing the constituents of concern. What are the monitoring requirements for the downgradient monitoring network that was specifically installed to monitor whether the treatment system is capturing the groundwater and thereby reducing the plume emanating from the site?

Response: The monitoring well network is being sampled on a quarterly basis for TCL VOCs, and total cadmium, chromium, hexavalent chromium, and iron. The monitoring requirements are described in detail in the quarterly monitoring well sampling reports that are submitted to the U.S. EPA.

5. It is requested that the treatment system data and monitoring well data be submitted on a monthly basis.

Response: Periodic summaries of the treatment system data are being submitted to the U.S. EPA (November 24, 2002 report; January 28, 2003 report, February 12, 2003 report). These Operations Summary reports detail the system data and treatment effectiveness for each operational period (as bracketed by regeneration events for the Octolig media, which occur on an approximately monthly basis). Monitoring well data are being submitted quarterly within the framework of the quarterly monitoring reports.

5. The time period indicated on page 5 in section 2.4 for construction of the treatment system is incorrect.

Response: the construction period for the GRS now reads “May 2000 through January 2001”.

ATTACHMENT D

Locations and General Arrangement for Recovery Wells RW-2 and RW-3

Two new recovery wells (RW-2 and RW-3) will be installed at the locations shown in Figure D-1 and according to the specifications shown in Section 3.2 (page 10) of the main document. As shown in Figure D-2, the recovery wells (including the existing well RW-1) will be fitted with a pitless adapter at a depth of about 3.5 feet below grade, connecting with 2-inch diameter PVC pipe to the existing GCW concrete vaults about 8-10 feet to the south. Within the concrete vaults, the new 2-inch PVC lines will be connecting to the existing PVC discharge lines to the treatment building. A separate conduit will supply power from the power hook-up within the existing concrete vault.

Each well will be fitted with a 7.5 horsepower submersible pump (capable of pumping between 40 to 100 gpm) supported by a stainless steel safety cable, with the pump intake set at approximately 34 feet below grade. Modifications within the treatment building will consist of adding flow control valves (FCV) to the influent lines from RW-2 and RW-3.

Figure D-1: Proposed Locations for RW-2 and RW-3

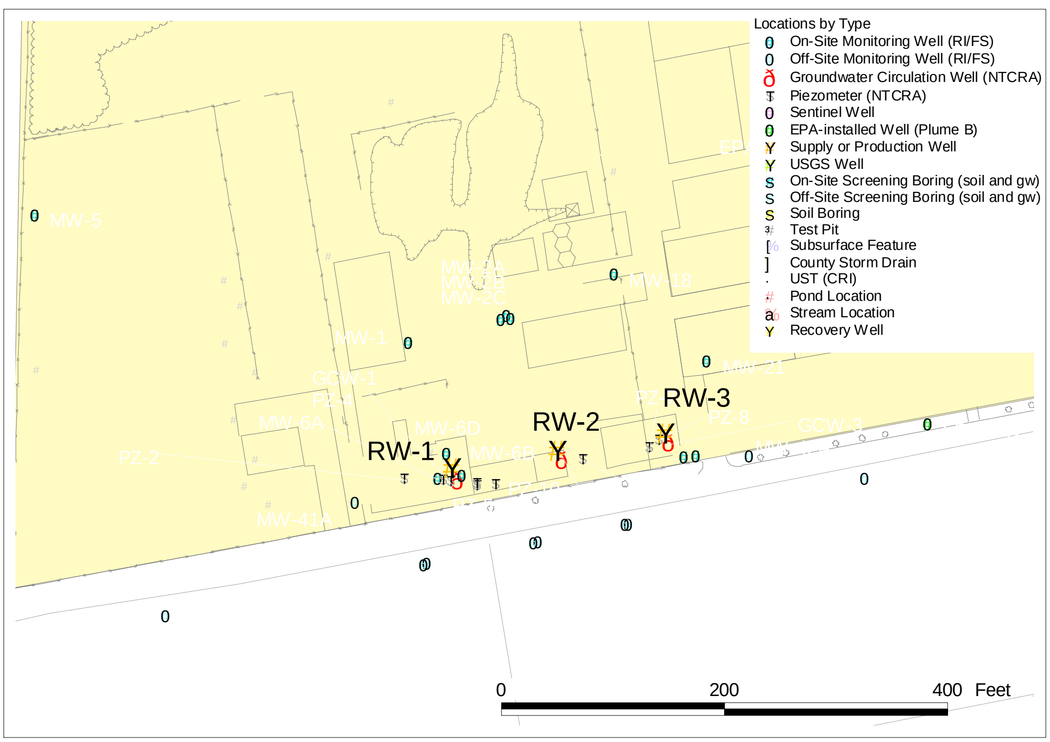


Figure D-2: (see next page) Proposed Recovery Well Layout (plan view and cross section)

ATTACHMENT E

Sampling Frequency of Groundwater Remediation System, Regeneration Procedure for Octolig Units, and Proposed Treatment and Disposal of Octolig Remediation Waste

Between October 2002 and January 2003, URS has been evaluating more efficient methods to conduct the regeneration of spent Octolig media and handling of the acidic wastewater generated during regeneration (successive acidic and aqueous rinses of the Octolig media). The acidic wastewater consists of the approximately 700 gallons of sulfuric acid solution (3-5%), which is used to mobilize the bound metals from the spent Octolig media, and several (up to four) subsequent clean water rinses (2,000 to 2,500 gallons) to remove residual acid (and dissolved metals therein) from the Octolig media.

<u>Regeneration of Octolig Media</u>

URS has revised the regeneration procedure of the Octolig in order to (1) improve the extent of metals removal through prolonged contact time of the Octolig media with the acid and clean water rinses, and (2) minimize the volume of acidic wastewater generated to less than approximately 3,000 gallons, due to storage limitations.

The first objective is being accomplished through the introduction of the acid rinse (AC-1) into the bottom of the Octolig units (at about 10 gpm per unit) for a soaking period of approximately 30 minutes, as is currently done, followed by closed-loop recirculation of the acid rinse by pumping the acid rinse from the bottom of the Octolig units and back to the top the units. After approximately 45 minutes of acid rinse circulation, the waste acid solution will be pumped to the holding tank V-750. An initial water rinse (AQ-1) of approximately 1,000 gallons (200 gallons per unit) will then be pumped from the V-300 balancing tank into the top of the Octolig units and circulated for approximately 45 minutes (at 15-20 gpm per unit). The objective of the first water rinse is to remove as much residual acid (and corresponding dissolved metals) as possible from the pore space of the Octolig, prior to discharging to the waste acid holding tank V-750. Based on the regeneration event for Period 03 (completed on January 29, 2003), the pH of the first acid rinse is buffered at around pH = 2.0

At least three (3) additional water rinses (AQ-2, AQ-3, and AQ-4) will be introduced and circulated in a similar fashion to remove more residual acid (with dissolved metals). However these rinses will have caustic added via metering pump P-310, to buffer the rinses at successively higher pH values. Rinses AQ-2 and AQ-3 would be circulated for approximately 45 minutes prior to discharge to the holding tank. The last water rinse (AQ-4_ will be circulated until the pH of the effluent from the Octolig units has reached approximately pH = 5.0, at which point the Octolig is reconditioned to allow removal of metals from groundwater under regular forward flow conditions ('treatment mode'). At this point, the forward flow recirculation will discontinue, the water rinse will be pumped to the V-750 tank, and the normal treatment process will resume, with discharge to the groundwater (via the proposed recharge trench, see Attachment F).

<u>Sampling Frequency</u>

During each recirculation event, samples will be collected from the first acid rinse AC-1, the final water rinse AQ-4, and the composite acidic wastewater. The composite sample will yield the mass of regenerated metals in the acidic waste water (mass = volume x concentration of metal), which will be compared to the Octolig mass loading, as observed and calculated during regular operations sampling. Therefore, the following sampling frequency (treatment mode and regeneration mode) is anticipated:

Sample ID	Source	Frequency	Cum Hours (per period)	Metals	VOCs
SYS-IN_xxxxx	System influent	1 per week	0 - END	X	X
OCT-IN_xxxxx	Octolig Influent (behind X-400 bag filter)	1 per week	0 -END	X	
SYS-EFF_xxxxx	System effluent	2 per week	0 - 500	X	
	System effluent	daily (M-F)	500 - END	X	
	System effluent	1 per week	0 - END		X
AC-1	Acid rinse	1 per reg. event		X	
AQ-4	Final Water Rinse	1 per reg. event		X	
REG-COMP	Composite V-750	1 per reg. event		X	

xxxxx = operation time of RW-1

In general, the Octolig media will be regenerated if either the periodic average discharge ($\pm$ the standard error of the mean) or the cumulative average discharge concentrations ($\pm$ the standard error of the mean) are greater than the site cleanup criteria of 5 µg Cd/L and 50 µg Cr/L. A summary of these periodic and cumulative average concentrations is presented in Section 2.5 of the main document. The Octolig mass loading will be calculated from the OCT-IN and SYS-EFF analytical results. The average concentrations of the system effluent (both cumulative and within each treatment period) will be calculated from the SYS-EFF samples. The mass of constituents treated, an evaluation of the regeneration effectiveness, and a discharge compliance evaluation will be reported in the periodic Operations Summary Reports.

The piping modifications to the GRS that are resulting from the modifications described above are highlighted in enclosed Figure E-1.

Treatment and Disposal of Octolig Regeneration Waste

Pilot testing determined that precipitation of the metals as hydroxide compound (by raising the pH to about 9.5) followed by filtration via bag filter X-760 produced insufficient metals removal, which would make reprocessing of the filtrate through the Octolig metals removal system inefficient and result in greater loading on the Octolig and premature breakthrough. In January 2003, URS evaluated alternate methods to reduce or eliminate the mass of metals that need to be reprocessed into the Octolig units.

Several options were evaluated on a bench-scale to achieve these goals. The most promising bench-scale test was performed by Aquachem, Inc. Aquachem's bench-scale test showed that dosing the waste acid with their proprietary compound AquaSil (a bentonite or zeolite plus polymer material, at a dosage of about 1,500 mg/L) from a starting pH of 4.5 produced excellent, fast-settling floc and high clarity water with a final pH of around 10.5. Analytical tests by Aquachem and verified by URS (using the contract laboratory STL) indicated that the supernate concentrations were significantly less than the initial concentration.

Bench-Scale Test Results:

Parameter	**REG-COMP (μg/L)**	Supernate (μg/L)	Supernate (μg/L)	Reduction
	(STL)	(Aquachem)	(STL)	rel. to STL
Cadmium	47,100	NA	743	98.4%
Chromium	485	< 50	25.6	94.7%
Copper	3,190	243	595	81.3%
Nickel	28,600	NA	655	97.7%
Zinc	58,900	< 50	232	99.6%
pH	4.5	10.5	11.2	----

where REG-COMP = composite sample of the regeneration acidic waste.
Supernate = supernate after precipitation of metals via AquaSil mineral-polymer.
NA = not analyzed.

Based on these results, a full-scale test was performed on approximately 2,900 gallons of acidic wastewater that was derived from the December 2002 Octolig regeneration. The pH was initially brought up to approximately 3.5. Then AquaSil (type AMX-5M) was slurried into the tank in small doses. The pH of the waste acid tank was monitored and the wastewater observed for signs of flocculation. After adding approximately 30 pounds of AquaSil (an effective dosage of about 1,250 mg/L or 80 percent of the bench-scale dosage), large floc formed and the pH slowly increased to approximately 11.2. The addition of AquaSil was discontinued and the mixer subsequently turned off. The floc settled rapidly, as was the case in the bench-scale jar test. A composite sample of the supernatant was collected after 2 hours and submitted for analysis.

<u>Full-Scale Test Results:</u>

Parameter	Wastewater (μg/L)	Supernate (μg/L)	Precipitate (mg/kg)	Reduction (wwtr to Supernate)
Cadmium	46,200	678	33,300	98.5%
Chromium	443	20.4	392	95.4%
Copper	3,050	819	1,850	73.1%
Iron	3,660	< 80	8,800	97.8%
Manganese	4,270	43.4	3,890	99.0%
Nickel	27,600	1,070	21,200	96.1%
Zinc	56,000	263	21,600	99.5%

where Wastewater = composite sample of the regeneration acidic waste (at pH = 3.5)
Supernate = supernate after precipitation of metals via AquaSil mineral-polymer.
Precipitate = filter cake of precipitate (dry wt.)

As the data indicates, the AquaSil additive was able to reduce metals concentrations (except copper) by more than 95 percent. Specifically, cadmium concentrations were reduced by 98.5%. Therefore, the supernate will be disposed by slowly bleeding it into the treatment system (V-300 tank) for reprocessing through the Octolig units. The proposed bleed rate is about 2 gpm, such that the net effect of supernate addition (assume approx. 700 μg Cd/L) into the groundwater influent (150 μg Cd/L at 120 gpm) results in a concentration increase of only about 10 μg/L over a 24-hour period. The reprocessing will not affect the ability of the Octolig media to meet the discharge criteria. Further, the operational time of the Octolig media between regeneration will be reduced only by about 1.5% (or less than 1 day).

ATTACHMENT F

Design and Location of Proposed Recharge Trench for Treated Groundwater

Groundwater Recharge Trench: Location and Model Results:

The objective of this memorandum is to discuss the location, construction details, and hydraulic properties of a proposed groundwater recharge trench at the Site. The objective of the recharge trench is to recharge treated groundwater from the on-site groundwater remediation system (GRS) to the upper portion of the Upper Glacial aquifer. The recharge trench is designed to meet the following requirements: (a) recharge treated groundwater at 120 gallons per minute (gpm) to the aquifer, (b) located outside and sidegradient of the anticipated capture zone for the full-scale groundwater recovery system (see Section 3.2 of the Final Design Document), (c) located outside the anticipated potential footprint of a GRS expansion due to the off-site groundwater remedy, and (d) result in acceptable mounding of groundwater as a result of the planned recharge.

Figure F-1 shows the proposed location of the recharge trench to the west of the existing GRS treatment building. Figure F-2 shows the result of a two-dimensional variably saturated steady-state model that was developed to predict the amount of mounding of the water table around a proposed recharge trench at the Site. The dimensions of the modeled trench are 100 feet long, 10 feet wide (footprint of 1,000 ft^2) and 10 feet deep, relative to a surface grade elevation of 64 feet msl. The computer code TARGET_2DU (URS/Dames & Moore, 1985) was used to simulate groundwater flow. TARGET_2DU is a block-centered finite difference model that can simulate transient or steady-state variably saturated groundwater flow and transport problems. The model simulates vertical and horizontal groundwater flow in a vertically oriented slice through the trench perpendicular to the long axis of the trench. The model assumes symmetric flow conditions lateral to this long dimension, so that the model simulates flow from the center of the trench out to a lateral distance of 400 feet. The simulated portion of the trench is five feet wide (one half of the modeled 10 foot width). The model cells are one foot in the horizontal and vertical directions, except at the water table and below, where cells thicken from 1 foot near the water table to 14.5 feet at the bottom of the Upper Glacial Aquifer (UGA).

The following assumptions were used in the model:

- The local water table is flat and occurs at a depth of 24 feet below ground surface (i.e., 40 feet msl). Note that the local water table has varied between 15 feet and 24 feet bgs in the recent past. The model assumes a minimum observed water table (24 feet bgs), which results in a maximum height of the modeled mounding.
- Only flow within and above the UGA is simulated. The base of the UGA (90 feet bgs) is specified as “no flow”.
- Background recharge is assumed to be about 20 inches/year (URS 2000)

- The hydraulic conductivity of the UGA is assumed to be 230 feet/day (horizontal) and 23 feet/day (vertical) (URS 2000).
- The porosity of the UGA is simulated at 23% (URS 2000).
- The unsaturated-zone properties of the UGA (area above the local water table) are assumed equivalent to a typical gravelly sand. This is based on grain-size analyses of the UGA, as presented in the Continued RI Report for the Site. In typical sand formations, relatively small changes in moisture content above the water table result in relatively large changes in pressure head (matric potential) and relative hydraulic conductivity.
- Along the vertical edges of the model "no flow" is specified above the water table, and a constant, static water level of 40 feet msl is specified below the water table.
- The infiltration rate in the trench is assumed to be 200 gpm (to be conservative) and uniformly distributed over the area of the modeled infiltration trench (10 feet wide by 100 ft long = 1,000 ft^2). Thus, the simulated rate of infiltration at the bottom the trench is 38.5 ft/day. Note that the modeled discharge rate of 200 gpm is 66% greater than the expected discharge from the on-site treatment system of 120 gpm.

Figure F-1 shows the proposed location of the infiltration trench relative to the treatment building of the GRS. The long-axis of the trench will be oriented perpendicular to the direction of groundwater flow (south-southwest). Four piezometers (P-1 through P-4) are proposed to monitor the extent of mounding within and at distances of 25 feet and 100 feet from the trench. These distances are chosen based on the model results (see below). The piezometers construction details are also shown in Figure F-1. Finally, Figure F-1 shows the general arrangement of the distribution piping from the west side of the treatment building to the center of the trench, where a header and manual valving system will distribute water along the long-axis of the recharge trench. The details of the proposed piping layout, valving and flow control system, and the proposed materials of construction are shown in Figure F-1 (plan view and cross section).

Figure F-2 shows the results of the model. At steady-state flow, mounding of water under the trench is predicted to be about 12 to 13 feet directly below the trench, indicating that there is the possibility of some free water in the trench. The mound extends laterally to about 200 feet, where the predicted rise of the water table is less than 1 foot. At a lateral distance of 25 feet, the mound is predicted to be about 9 feet high, and at 100 feet the mound will be about 1 foot high (or possibly a small amount higher). Note that the "zig-zag" nature of the simulated mound (as shown in Figure F-2) stems from the difficulty inherent in simulating variably saturated flow in sandy materials. Such flow is very difficult to simulate due to the extreme variation in hydraulic conductivity and matric potential that result from slight differences in the spatial distribution of moisture content.

Prior to the establishment of steady flow and a stable mound, isolated pockets of fully saturated soil may occur locally around the trench (but not at the water table). The amount of time required to achieve steady flow has not been estimated, but is likely to be small given the highly permeable nature of the UGA.

URS Corporation, 2000, Groundwater flow and solute transport modeling, Liberty Industrial Finishing Site, Technical Memorandum, November 13, 2000.

FIGURE F-1 (see separate pocket)

FIGURE F-2: Steady-State Groundwater Flow Prediction