Long Island I 170 Keyland Court I Bohemia, NY 11716 I Tel: 631.269.8800 Fax: 631.269.1599
Manhattan I 1560 Broadway, Suite1024 I New York, NY 10036 I Tel: 212.201.7905 Fax: 212.202.4079
www.impactenvironmental.com

November 12, 2009

Mr. Bernard Franklin
New York State Department of Environmental Conservation
Divison of Enviromental Remediation
Remedial Bureau C, 11th Floor
625 Broadway, Albany, New York 12233-0714

Re: 256 S Little Tor Road New City, New York

Dear Mr. Franklin:

This letter serves as a work plan for the 2nd round HRC injection at the abovementioned Site.

1. Summary of the 1st Round HRC Injection Results

The 1st round HRC injection was completed on the Site from May 30, 2006 through June 1, 2006 under the supervision of the NYSDEC. A total of 39 injection points and 4 cesspool locations were completed as part of the injection procedures in accordance with the NSDEC approved work plan. The 1st round HRC injection locations can be referenced with **Plate 2**.

Since the completion of the 1st HRC injection, accelerated reductive dechlorination has been observed in the groundwater. PCE concentration in MW-4 was reduced from 1400 ppb (4/6/2005) to 82 ppb (8/12/2009). Meanwhile, PCE breakdown products, trichlorethlyene (TCE), cis-1,2-dichlorethylene (DCE) and vinyl chloride (VC), were observed in elevated levels in the groundwater, which is further evidence for accelerated reductive dechlorination. Accordingly, it was concluded that HRC injection is an available remedial alternative for the Site.

Table 1 and **Figure 1** presented the summary of the historical levels of contaminants in the monitoring wells.

2. Proposed 2nd Round HRC Injection Plan

It has been more than 3 years since the 1st round HRC injection, and it is anticipated that the injected HRC has been consumed by now. In order to mitigate the residual groundwater contamination, a 2nd HRC injection is proposed. The proposed HRC injection will further support the on-going enhanced anaerobic bioremediation and help to accelerate the remediation process toward site closure.

The proposed 2nd injection will utilize HRC-X™, which is a thicker and more viscous version of HRC. Compared with the standard HRC, HRC-X has greater longevity and is capable of treating potential DNAPL without the need to identify the exact location of the residual DNAPL, which is particularly helpful for this project because of the potential source near the northwestern corner of the building.

HRC-X has greater longevity (periods of 36 - 48 months) than standard HRC as it takes more time for microbial action to free-up the lactic acid for fermentation. Once injected into the general vicinity of the residual source area or DNAPL, HRC-X goes to work releasing lactic acid and cost-effectively producing anaerobic conditions with optimal amounts of hydrogen throughout the area. HRC-X has been shown to produce reducing conditions for periods of 3-5 years. The newly available and controlled release hydrogen supply is then distributed as diffusive and advective forces achieving penetration into the full aquifer volume. Because of its longevity, the hydrogen resulting from HRC-X drives the long-term desorption, dissolution, and degradation of bound residual DNAPL which can otherwise be difficult to remove using traditional techniques.

Technical details regarding HRC-X can be referenced with **Appendix A**.

The proposed 2nd HRC injection will be focused on areas in vicinity of northwestern corner of the building. A permeable reductive barrier (PRB) will be established. The PRB consists of 3 rows, with 30 ft interval. Each row will consist of 8 injection points.

Within each row, the horizontal interval between neighboring points will be 10 ft. Each injection point will be installed from grade to 10 ft below water table or until bedrock, whichever is encountered first. The injection will be performed using “bottom-up” technique. HRC-X will be injected from the bottom of the injection point to the top of the capillary fringe. Approximately 70 lbs of HRC-X will be injected for each injection point.

The proposed injection points (number and spacing of points) and HRC-X injection volumes is a function of the extent of groundwater contamination based on the latest investigation. Calculations were accomplished utilizing application software and physical access to the proposed locations. A life span of 3 years was utilized to represent the longevity of HRC-X. A microbial demand factor of 300% and a safety factor of 200% were utilized for conservative estimation. Detailed calculation can be referenced with **Appendix B**.

The proposed injection points are depicted on **Plate 3**.

3. Groundwater Monitoring

Prior to the 2nd round HRC injection, groundwater sampling will be acquired from monitoring well MW-4, MW-5, MW-7, MW-8 and MW-14, to establish the baseline condition.

Upon completion of the 2nd round HRC injection, groundwater sampling will be performed on a quarterly basis. Groundwater samples will be acquired from monitoring wells MW-4, MW-5, MW-7, MW-8 and MW-14, to evaluate the effectiveness of the 2nd round HRC injection. The locations of the monitoring wells to be sampled can be referenced with **Plate 4**.

All groundwater samples will be analyzed via USEPA Test Method 8260. Additional testing parameters may include acquisition of such data, but not limited to oxygen and nitrate depletion, iron and manganese dissolved and the presence of methane.

The monitoring of said wells is proposed on a quarterly basis until it can be demonstrated that the remediation was effective and/or no further action is required by the New York State Department of Environmental Conservation.

The development and sampling procedures conformed to NYSDEC protocol. A field log protocol will be conducted to record sampling data including; date, time, location, sample identification code, depth to water, total depth of the well, method of well development, and sampling technique. The monitoring wells will be developed by purging a minimum of three (3) static well volumes utilizing a peristaltic pump. A static well volume is defined as *Static well volume = height of water column x (well radius)*^{2} *x* π *x 7.48* (7.48 is the conversion factor for cubic feet to gallons). Following development, one water sample will be acquired from each of the monitoring wells utilizing a dedicated disposable bailer to prevent cross-contamination. All of the samples will be transferred with minimal disturbance into the appropriate vessels. The development wastewater will be containerized for subsequent disposal.

4. Work Schedule

Upon approval of this work plan, baseline sampling and the 2nd round HRC injection will be performed within 4-6 weeks.

If you have any questions or comments regarding this matter, please feel free to contact me.

Sincerely,
IMPACT ENVIRONMENTAL

Wenqing Fang
Environmental Engineer

Enclosure

CC: Scott Milich, Tor Valley Inc.

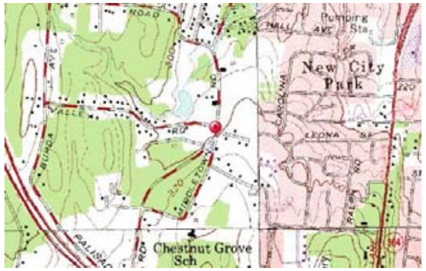
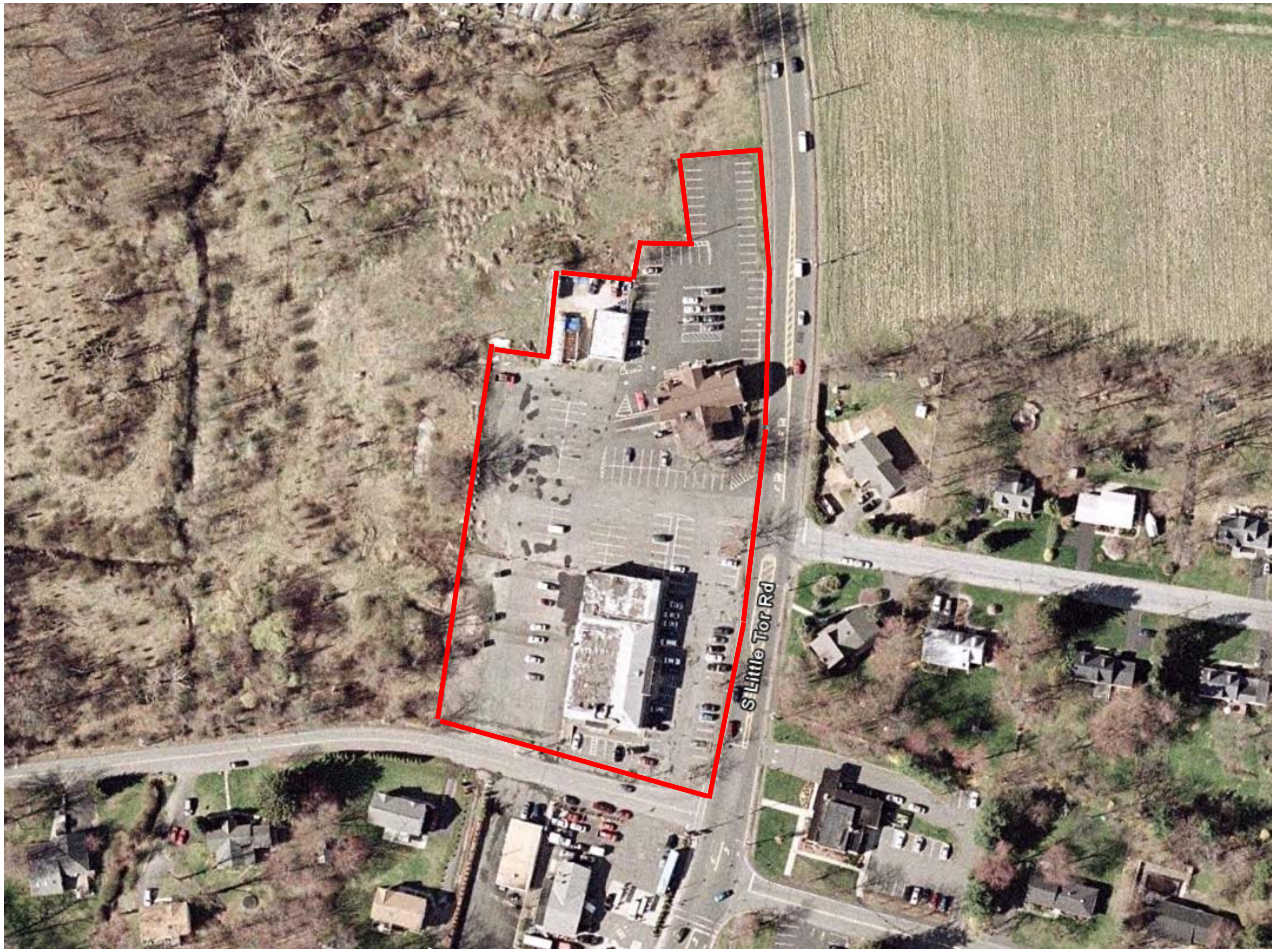


Plate 1: Project Location Map

Little Tor Road Site
New City, New York



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New York State Geographic Information System
2001 Half Foot Natural Color Long Island Zone

Legend

- Monitoring Well
- HRC Injection Well

Note:
Contours were based on the data collected in 1999.

PROJECT # 04-268

PLATE # 02

Scale in Feet
20 0 20 40 100

TITLE:
1st Round HRC Application

Little Tor Road Site
New City, New York

DRAWN BY:	WF
CHECKED BY:	KK
DATE:	3/5/2007
SCALE:	1" = 80'

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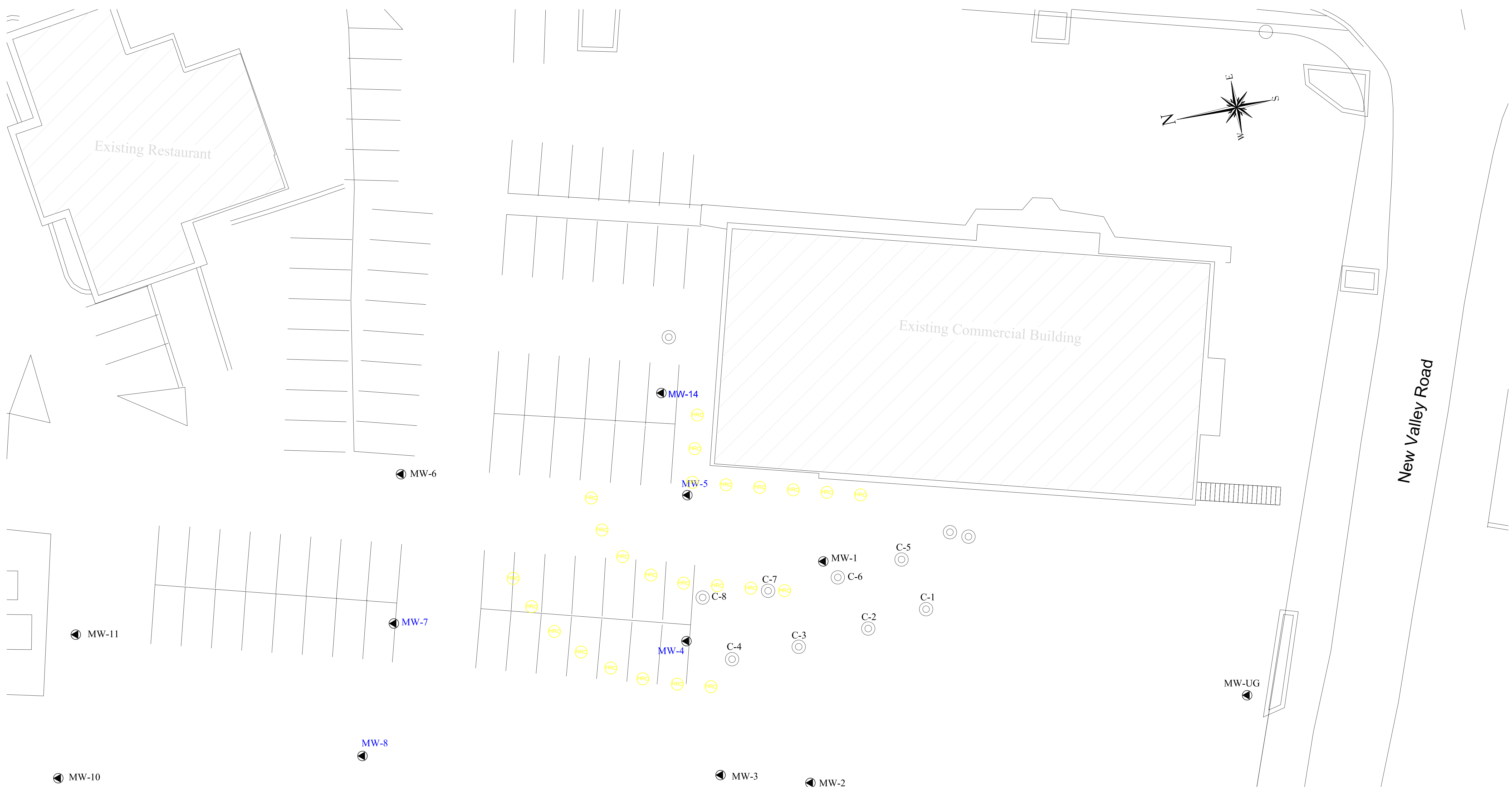

Legend

HRC Injection Point

Groundwater Monitoring Well

TITLE:

2nd Round HRC Injection Plan

Little Tor Road Site
New City, New York

DRAWN BY:	WF
CHECKED BY:	KK
DATE:	11-10-2009
SCALE:	1" = 30'

PROJECT # 04-268

PLATE # 03

Scale in Feet

10 5 0 10 20 50

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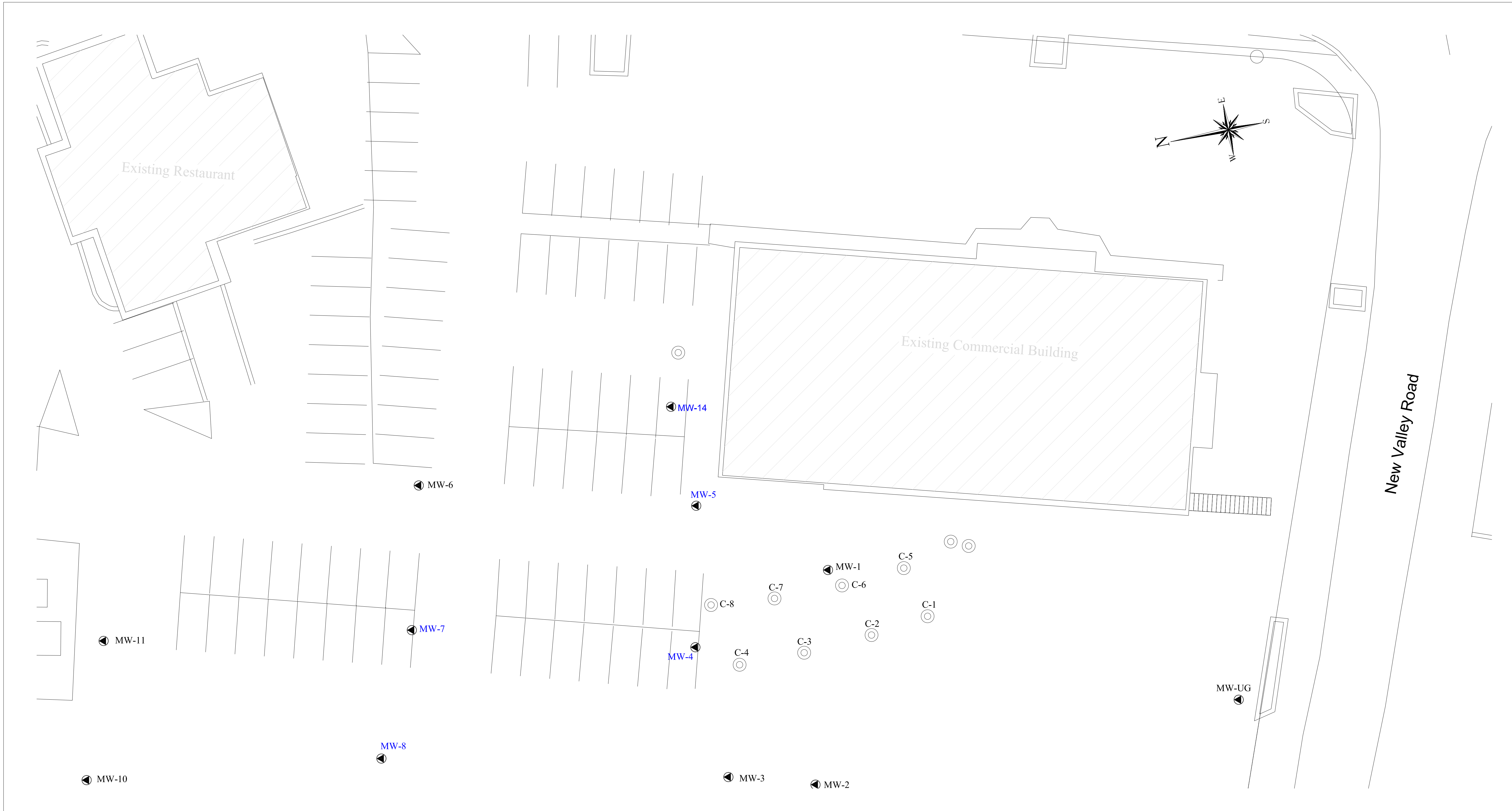

Legend

Groundwater Monitoring Well

TITLE:

Groundwater Sampling Plan

Little Tor Road Site
New City, New York

DRAWN BY:	WF
CHECKED BY:	KK
DATE:	11-10-2009
SCALE:	1" = 30'

PROJECT #	04-268
PLATE #	04

Scale in Feet
10 5 0 10 20 50

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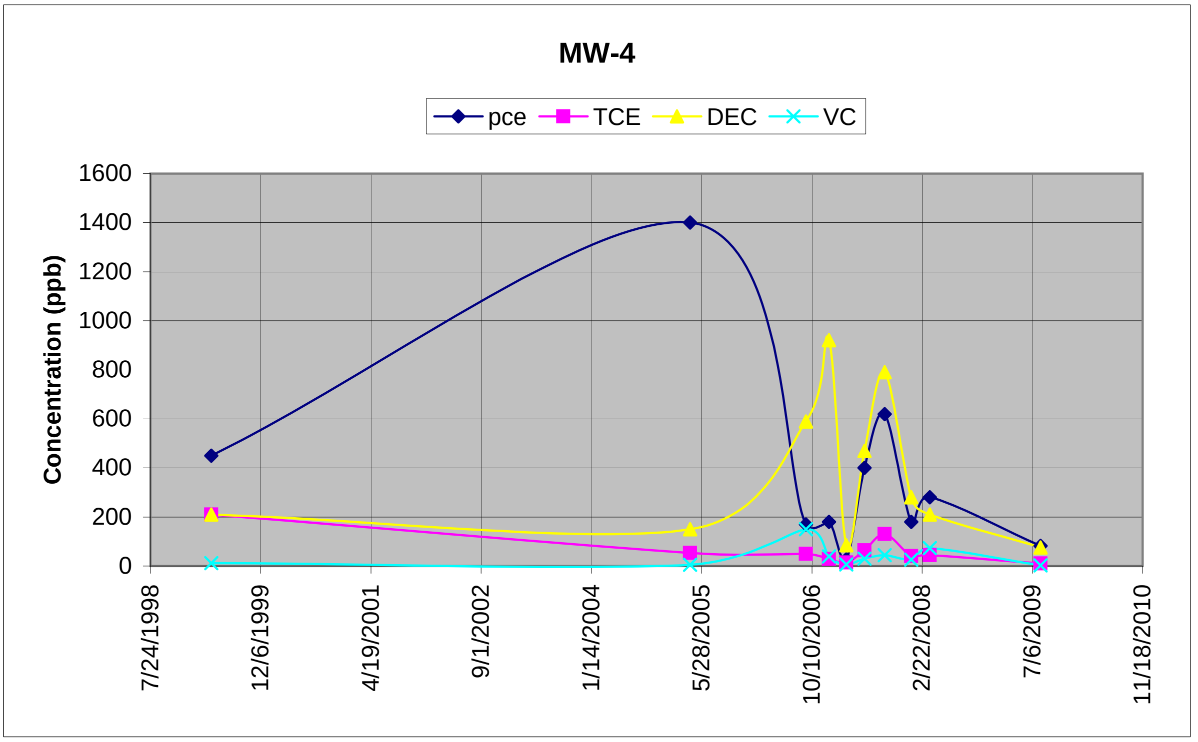
Figure 1: Contamination Trend Line



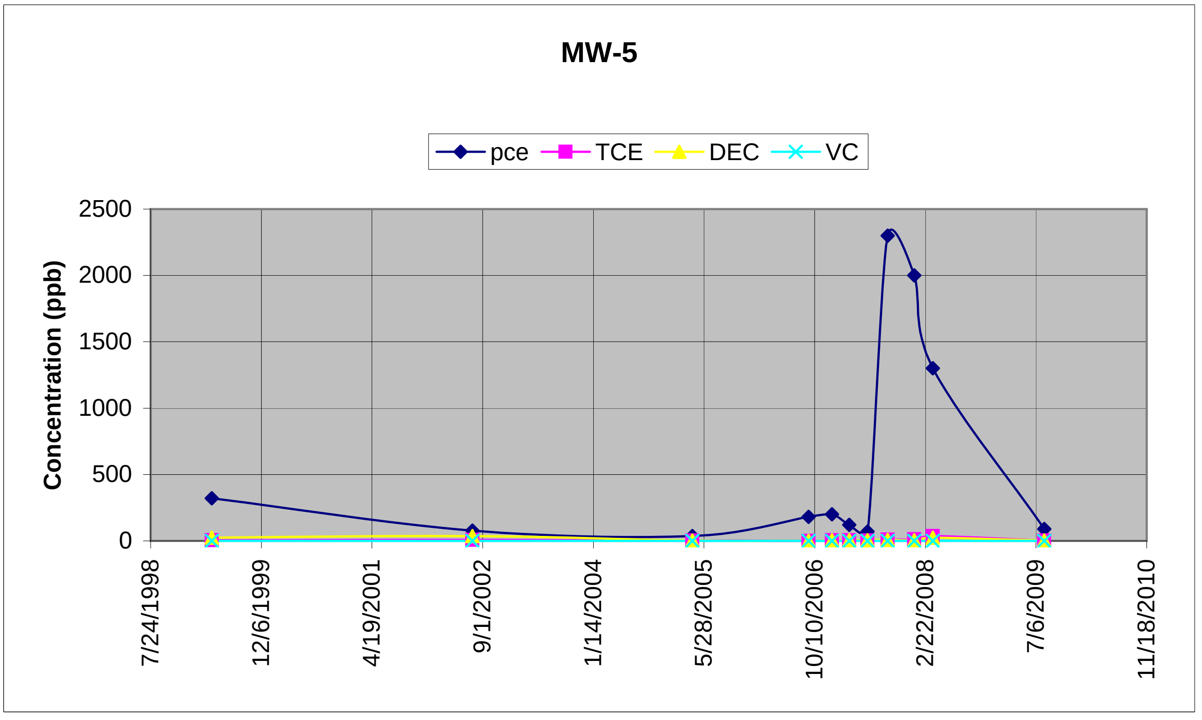
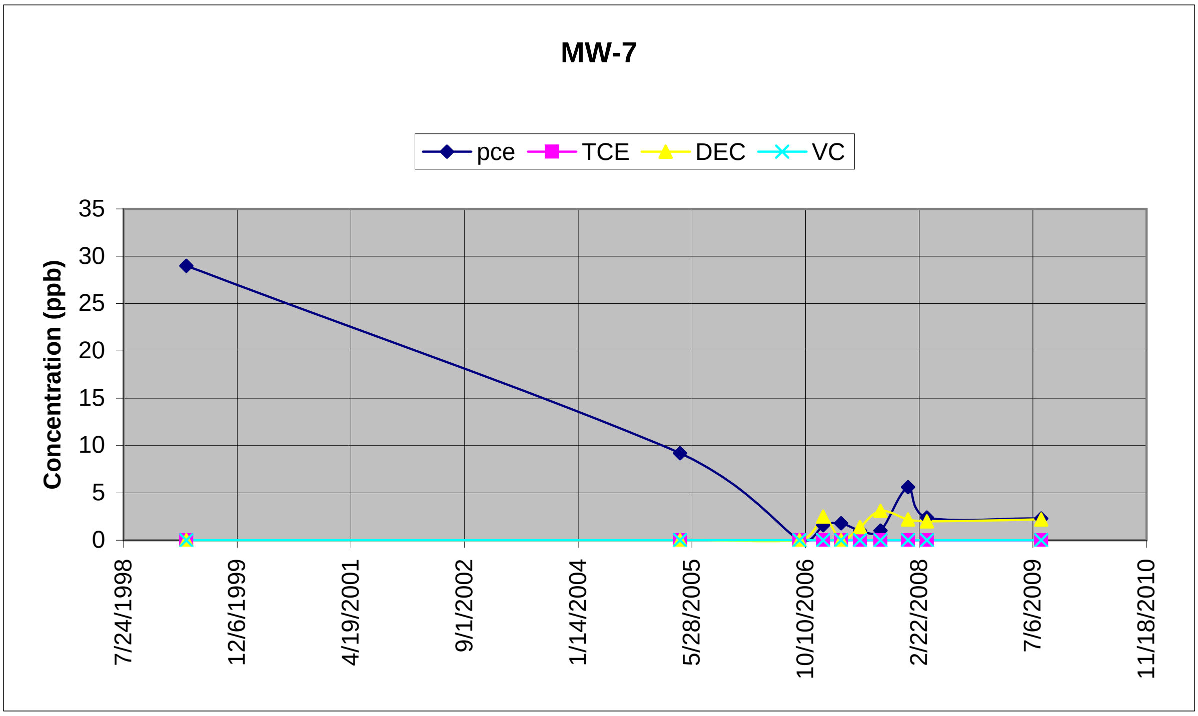


Figure 1: Contamination Trend Line



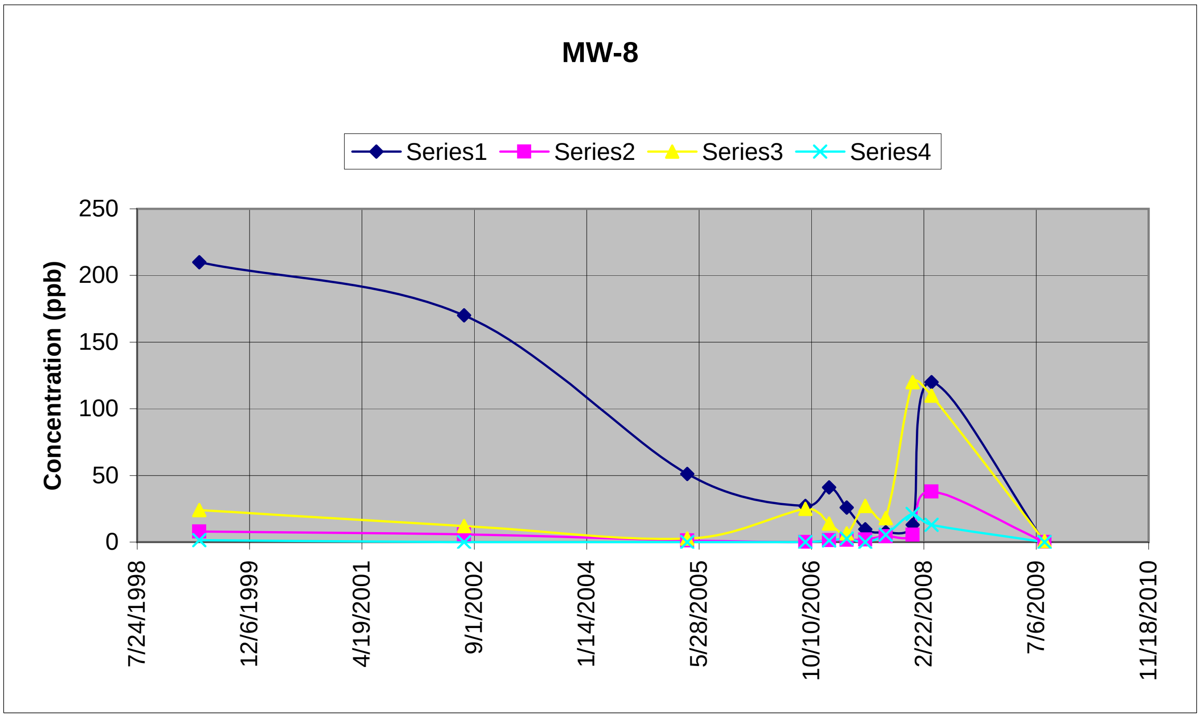


Table 1: Detected Analytes in Groundwater

Sample ID	Date	Depth to Water	Dissolved Oxygen	Tetrachloroethene	Trichloroethene	cis-1,2-Dichloroethene	Vinyl Chloride	trans-1,2-Dichloroethene	1,1-Dichloroethane	MTBE	1,1-Dichloroethene	2-Butanone	1,1,2-Trichloroethane	Acetone	2-Hexanone	1,2-Dichloroethane	1,1,1,2-Tetrachloroethane	Chloroform	Chloroethane	1,2,4-Trimethylbenzene
Unit		ft	mg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l
NYSDEC Ambient Water Quality Standards & Guidance Values (µg/l)				5	5	5	2	5	5	10	5	50	1	50	50	0.6	5	7	5	5
MW-4	4/26/1999	NA	NA	**450**	**210**	**210**	**12**	ND	ND	**110**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	4/6/2005	NA	NA	**1400**	**54**	**150**	**4.8**	1J	0.93J	1.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	9/13/2006	3.54	3.7	**170**	**49**	**590**	**150**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	12/27/2006	2.91	7.59	**180**	**29**	**920**	**39**	2.3	ND	ND	1.1	ND	**2.5**	ND	ND	ND	ND	ND	ND	ND
	3/15/2007	3.12	6.5	**28**	**14**	**85**	**7**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	6/6/2007	3.21	2.08	**400**	**64**	**470**	**30**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	9/5/2007	4.51	3.85	**620**	**130**	**790**	**44**	4.1	1.8	ND	ND	ND	**12**	ND	ND	ND	ND	ND	ND	ND
	1/3/2008	4.5	6.41	**180**	**40**	**280**	**26**	1	ND	1.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	3/27/2008	NA	6.87	**280**	**44**	**210**	**73**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	8/12/2009	NA	NA	**82**	**11**	**76**	**2.2**	ND	ND	ND	ND	ND	ND	8.1	ND	ND	ND	ND	ND	ND
MW-5	4/26/1999	NA	NA	**320**	**5.3**	**24**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	7/17/2002	NA	NA	**78**	**8**	**35**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	4/6/2005	NA	NA	**36**	1.5	2.4	ND	ND	ND	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	9/13/2006	NA	2.54	**180**	ND	7.5J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	12/27/2006	3.88	5.88	**200**	5.8	4.5	ND	ND	ND	ND	ND	ND	**3.1**	ND	ND	ND	ND	ND	ND	ND
	3/15/2007	4.02	6.4	**120**	4.7	**5.2**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	6/6/2007	4.21	1.59	**69**	3.1	4.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	9/5/2007	5.67	2.61	**2300**	**10**	**6.5**	ND	ND	ND	ND	ND	ND	ND	ND	ND	**2.8**	1.2	ND	ND	ND
	1/3/2008	NA	8.39	**2000**	**11**	**5.2**	ND	ND	ND	ND	ND	ND	ND	24	ND	ND	2	0.66	ND	ND
	3/27/2008	NA	5.06	**1300**	**35**	**25**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	8/12/2009	NA	NA	**90**	3.5	3.5	0.64	ND	ND	ND	ND	ND	ND	8	ND	ND	ND	ND	ND	ND
MW-7	4/26/1999	NA	NA	**29**	ND	ND	ND	ND	ND	1.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	4/6/2005	NA	NA	**9.2**	ND	ND	ND	ND	ND	**22**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	9/13/2006	6.89	3.62	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	12/27/2006	6.27	7.33	1.6	ND	2.5	ND	ND	ND	**11**	ND	**71**	ND	ND	ND	ND	ND	ND	ND	ND
	3/15/2007	6.53	5.7	1.8	ND	ND	ND	ND	ND	6.5	ND	**53**	ND	**240***	ND	ND	ND	ND	ND	ND
	6/6/2007	6.58	3.38	1	ND	1.4	ND	ND	ND	4.8	ND	**57**	ND	**290***	6.5	ND	ND	ND	ND	ND
	9/5/2007	7.93	2.45	1	ND	3.1	ND	ND	ND	6	ND	12	ND	**68**	ND	ND	ND	ND	ND	ND
	1/3/2008	6.65	5.84	**5.6**	ND	2.2	ND	ND	ND	2.9	ND	ND	ND	16	ND	ND	ND	ND	ND	ND
	3/27/2008	NA	5.45	2.4	ND	2	ND	ND	ND	4.3	ND	**15**	ND	20	ND	ND	ND	ND	ND	2
	8/12/2009	NA	NA	2.3	ND	2.2	ND	ND	ND	3.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW-8	4/26/1999	NA	NA	**210**	**8**	**24**	1.4	ND	ND	6.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	7/17/2002	NA	NA	**170**	**5.8**	**12**	ND	ND	ND	0.93J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	4/6/2005	NA	NA	**51**	1.1	**2.7**	ND	ND	ND	**24**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	9/13/2006	5.86	2.71	**27**	ND	**25**	ND	ND	ND	5.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	12/27/2006	5.24	5.61	**41**	1.4	**14**	1.2	ND	ND	2.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	3/15/2007	5.12	5.7	**26**	1.7	**6.4**	**2.6**	ND	ND	1.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	6/6/2007	5.62	1.72	**9.6**	2	**27**	ND	ND	ND	4.1	ND	ND	ND	21	ND	ND	ND	ND	ND	ND
	9/5/2007	6.91	2.45	**7.5**	4.2	**18**	**5.4**	ND	ND	3.2	ND	ND	ND	18	ND	ND	ND	ND	ND	ND
	1/3/2008	8.6	5.94	**13**	**5.4**	**120**	**21**	0.54	ND	1.6	ND	ND	ND	ND	ND	ND	ND	ND	2	ND
	3/27/2008	NA	5.72	**120**	**38**	**110**	**13**	ND	ND	2.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	8/12/2009	NA	NA	ND	ND	0.82	ND	ND	ND	ND	ND	ND	ND	6.1	ND	ND	ND	ND	ND	ND
MW-12	5/25/1999	NA	NA	**24**	1.7	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	7/17/2002	NA	NA	**48**	1.7	4.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	4/6/2005	NA	NA	**7**	ND	.93J	ND	ND	ND	1.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	9/13/2006	NA	5.28	.88J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	12/27/2006	6.06	9.6	1.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	3/15/2007	6.02	7.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	6/6/2007	6.26	4.31	0.45J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	9/5/2007**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND	ND
	1/3/2008	5.93	7.31	2	ND	1.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	3/27/2008	NA	7.95	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

HRC Design Software for Barrier Treatment

US Version 3.1

Regenesis Technical Support: USA (949) 366-8000, www.regenesis.com

Site Name: Little Tor Road
Location: 256 S Little Tor Road
Consultant: WF

Site Conceptual Model/Extent of Plume Requiring Remediation

Length of Barrier (intersecting gw flow direction)	70	ft		
Depth to contaminated zone	10	ft		
Thickness of contaminated saturated zone	10	ft		
Aquifer soil type	silty sand			
Effective porosity	0.25			
Hydraulic conductivity	10	ft/day =	3.5E-03	cm/sec
Hydraulic gradient	0.005	ft/ft		
Seepage velocity	73.0	ft/yr =	0.200	ft/day,

Dissolved Phase Electron Donor Demand

	Contaminant Loading		Stoich. (wt/wt)
	Conc (mg/L)	Mass (lb)	contam/H_2
Tetrachloroethene (PCE)	2.00	1.59	20.7
Trichloroethene (TCE)	0.10	0.08	21.9
cis-1,2-dichloroethene (DCE)	0.10	0.08	24.2
Vinyl Chloride (VC)	0.01	0.01	31.2
Carbon tetrachloride	0.00	0.00	19.2
Chloroform	0.00	0.00	19.9
1,1,1-Trichloroethane (TCA)	0.00	0.00	22.2
1,1-Dichlorochloroethane (DCA)	0.00	0.00	24.7
Hexavalent Chromium	0.00	0.00	17.3
User added, also add stoichiometric demand	0.00	0.00	0.0
User added, also add stoichiometric demand	0.00	0.00	0.0

	Electron Acceptor Loading		Stoich. (wt/wt)
Competing Electron Acceptors:	Conc (mg/L)	Mass (lb)	contam/H_2
Oxygen	5.00	3.98	8.0
Nitrate	5.00	3.98	12.4
Est. Mn reduction demand (potential amt of Mn2+ formed)	5.00	3.98	27.5
Est. Fe reduction demand (potential amt of Fe2+ formed)	50.00	39.84	55.9
Estimated sulfate reduction demand	50.00	39.84	12.0

Microbial Demand Factor	3	Recommend 1-4x
Safety Factor	2	Recommend 1-4x
Lifespan for one application	3	Year(s)

Injection Spacing and Dose:

Number of rows in barrier	3	rows
Spacing within rows	10	ft on center spacing within rows
Effective spacing perpendicular to flow (ft)	3.3	
Total number of HRC injection locations	21	points
Minimum required HRC dose per foot (lb/ft)	6.9	

Project Summary			
Number of HRC delivery points (adjust as nec. for site)			21
HRC Dose in lb/foot (adjust as nec. for site)			6.9
Corresponding amount of HRC per point (lb)			69
Number of 30 lb HRC Buckets per injection point			2.3
Total Number of 30 lb Buckets			48
Total Amt of HRC (lb)			1,440
HRC Cost		$	19.00 List Price has been adjusted
Total Material Cost		**$**	**27,360**
Shipping and Tax Estimates in US Dollars			
Sales Tax	rate: 0%	$	-
Total Matl. Cost w/Tax		$	27,360
Shipping of HRC (call for amount)		$	-
Total Regenesis Material Cost		**$**	**27,360**

HRC-X®
HYDROGEN RELEASE COMPOUND

[eXtended release formula]

HYDROGEN RELEASE COMPOUND (HRC-X®)

[eXtended release formula]

HRC-X is specifically formulated to treat residual DNAPL in groundwater and to provide a long term solution for groundwater contaminant plume control

How it Works

HRC-X is a special formulation of the patented and widely accepted Hydrogen Release Compound (HRC®), which has been successfully applied on hundreds of project sites world-wide for the cost-effective, *in situ* treatment of groundwater contamination.

HRC-X is a viscous material, composed of glycerol polylactate, which is injected directly into the contaminated subsurface. Once in place, this compound slowly releases lactic acid for periods in excess of 3 years. This source of lactic acid is then metabolized by naturally occurring microbes producing consistent, low-level concentrations of hydrogen. This hydrogen, in turn, is used by microbes to degrade chlorinated solvent-type contaminants through a well understood process known as reductive dechlorination.

HRC-X can be used to degrade a range of contaminants including: degreasing agents (PCE, TCE, TCA and their breakdown products), carbon tetrachloride, chloroform, perchlorate, nitrate, and certain pesticides/herbicides.

Residual DNAPL Treatment

Residual Dense Non-Aqueous Phase Liquids (DNAPL's) are often difficult to find and very costly to treat. Residual DNAPL causes a lingering and unwanted source of groundwater contamination that can represent enormous and unexpected cleanup costs.

HRC-X is a proven solution to this challenging problem. Once injected into the general vicinity of the residual DNAPL, HRC-X goes to work releasing lactic acid and cost-effectively producing the desired hydrogen throughout the area. This, in turn, drives the rapid desorption, dissolution, and degradation of the bound residual DNAPL (Figure 1).

Since HRC-X facilitates a microbial driven process, it can be applied without the need to identify the exact location of the residual DNAPL, avoiding costs associated with detailed site analysis. Additionally, HRC-X does not require stationary equipment, any on-going power supply, piping, long-term operations and maintenance or labor costs. These characteristics alone can significantly reduce the costs of residual DNAPL remediation.

Long Term, Low-Cost Plume Control

When long-term plume control is required to halt the migration of groundwater contaminants, HRC-X may be one of the most cost-effective alternatives available. In the past, the only alternative in these situations was to cut-off the plume by intercepting the groundwater with very inefficient and costly pump and treat systems, or by disruptive construction of expensive sheet pile barriers and "iron filing walls."

Groundwater remediation professionals now have an effective alternative to offer their clients and to reduce their cost burden, HRC-X. When applied perpendicular to the migrating plume, HRC-X passively releases the hydrogen required to degrade the mobile contaminant flux. The HRC-X material, once installed, continues to release hydrogen, effectively "cutting off" the migrating plume for a period in excess of 3 years, while avoiding the capital costs associated with engineering, construction and O&M intensive systems.

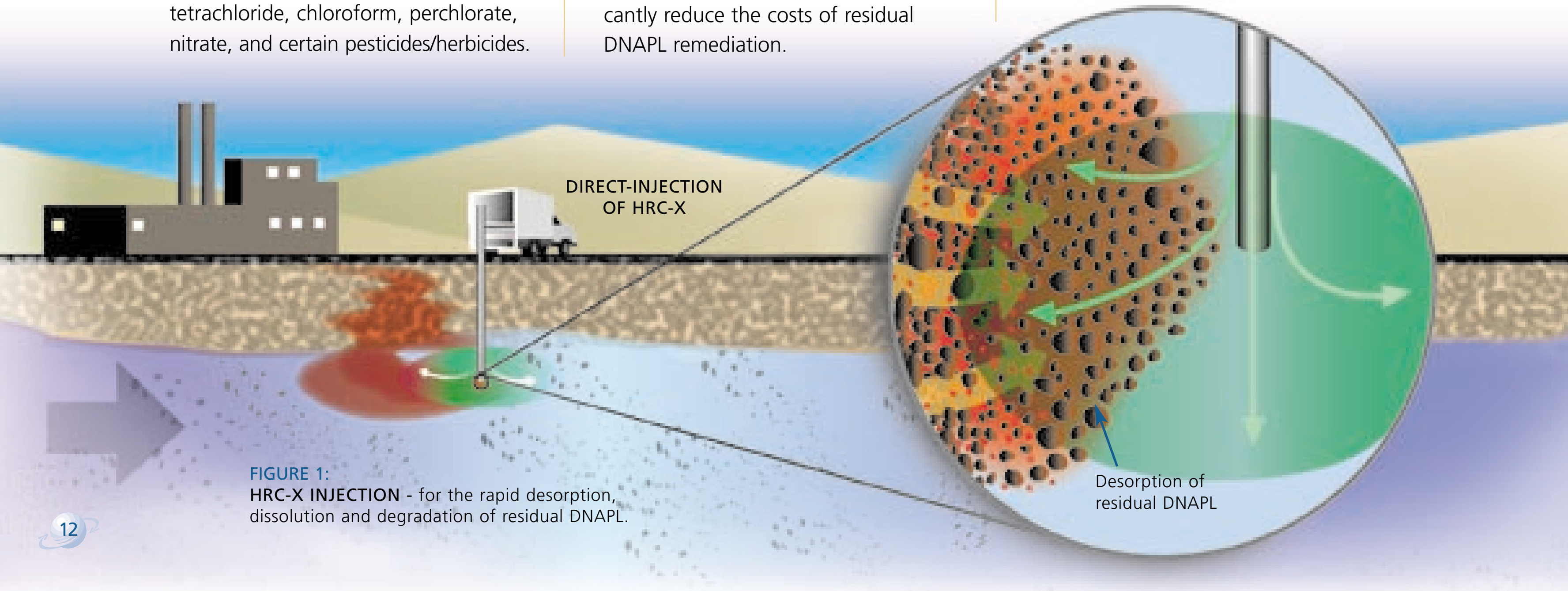
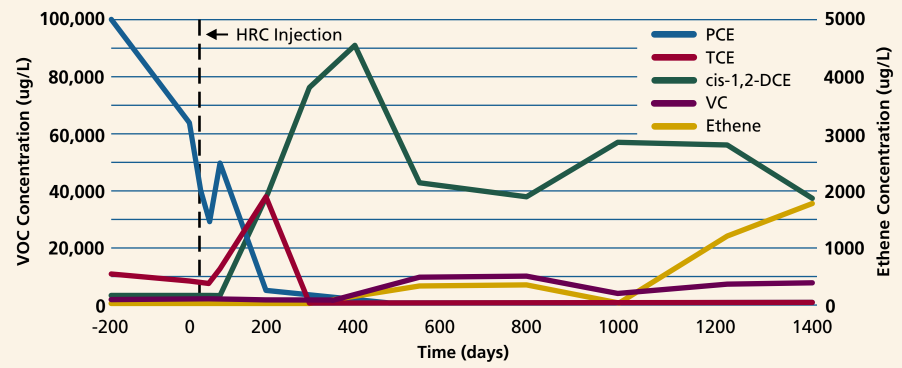


FIGURE 1:
HRC-X INJECTION - for the rapid desorption, dissolution and degradation of residual DNAPL.

Effective DNAPL Source Zone Treatment

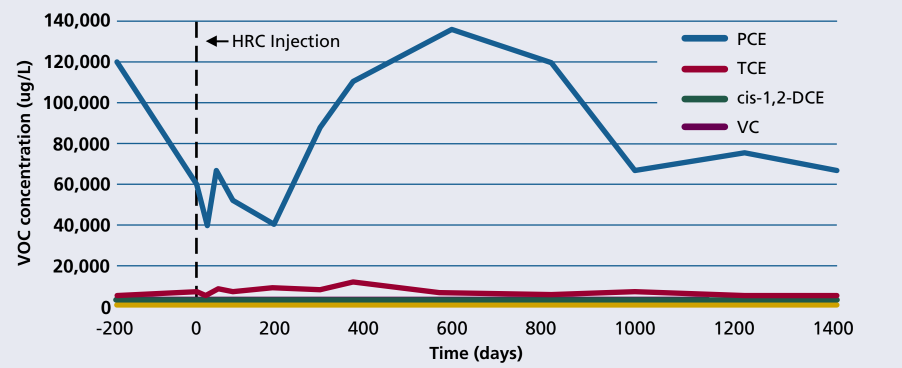
At a dry cleaner site managed by the Oregon Department of Environmental Quality, PCE concentrations in groundwater reached 100,000 ug/L – indicating the presence of residual DNAPL in the area. At the site, approximately 700 lbs of HRC-X material was injected through 5 direct-injection points. The application was situated in the general residual DNAPL area monitored by well JEMW-4. The results clearly indicate that HRC-X stimulated the rapid, *in situ,* desorption and degradation of PCE and its resulting intermediate compounds (Figure 2).

Figure 2: Monitoring Well (JEMW-4) within HRC-X Treated DNAPL Area



In the control well, JEMW-5, located within the residual DNAPL area but not affected by HRC-X, PCE concentrations in groundwater remained high over the treatment period, (from 60,000 ug/L to 120,000 ug/L). The results from JEMW-4 indicate that HRC-X continued to degrade an influx of PCE starting at day 200 and peaking at day 600, while maintaining its longevity out to 1400 days (Figure 3).

Figure 3: Residual DNAPL Area JEMW-5 (Untreated)

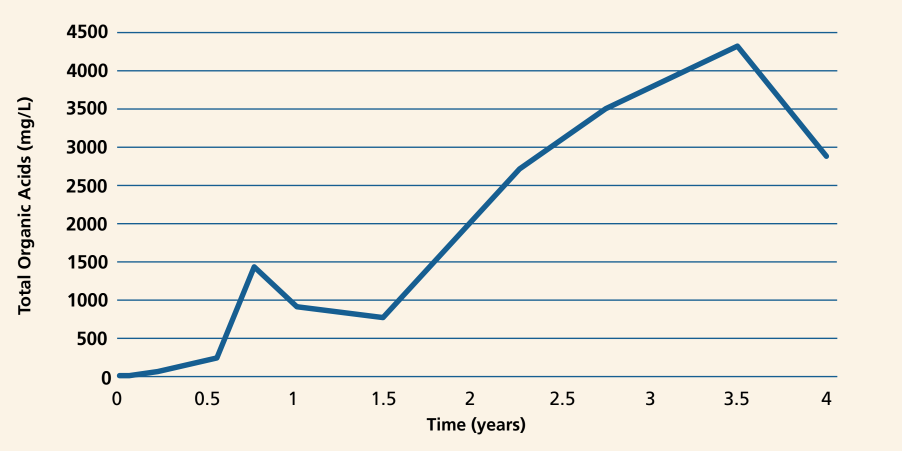


Organic acids, a strong indicator of the conditions produced by HRC-X, peaked at 3.5 years and remained elevated out to 4 years (Figure 4).

The total cost of HRC-X used to treat the residual DNAPL area was $20,000. The product was applied by simply injecting the material into the aquifer using direct-push technology. No expensive on-site equipment, operations, maintenance, or wells were required.

HRC-X is a proven technology used to rapidly and cost-effectively treat residual DNAPL source areas. For a site design and cost estimate please contact Regenesis directly. Regenesis technical support services are provided free of charge.

Figure 4: Organic Acids from HRC-X in JEMW-4 (Treated)



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REGENESIS

INSTALLATION INSTRUCTIONS

Hydrogen Release Compound (HRC-X™)
[eXtended release formula]

(Direct-Push Injection)

General Information

HRC-X™ is a special formulation of the patented and widely accepted Hydrogen Release Compound (HRC®) which has been successfully installed on hundreds of project sites world-wide. It is specifically formulated to treat residual dense non-aqueous phase liquids (DNAPL) in the groundwater and provide a long-term solution to groundwater plume control. HRC-X™ is manufactured as a viscous gel that can be injected into the saturated zone in a grid- or barrier-based configuration for either localized area or cutoff-based treatment approaches. The use of HRC-X™ for groundwater remediation offers a comparatively simple and cost effective remediation alternative for sites that would otherwise require unacceptably long periods of time for natural attenuation or the high levels of capital investment and operating expense associated with active remediation technologies.

Regenesis believes that the best method to install HRC-X™ into the subsurface is using direct-push drilling techniques. This method allows for the product to be pushed into the formation instantly and provides greater coverage/treatment over the life of the product. As a minimum the following equipment will be needed to perform this type of installation:

- Direct-push drilling unit
- Grout pump
- Appropriate hose assembly including a fitting that links a hose from the grout pump to the direct-push rods
- A method to heat the HRC-X™ (see below)
- 100+ gallon Water tank (or equivalent)
- Pressure washer (or equivalent) for cleaning

When is HRC-X™ Appropriate?

HRC-X™ should not be considered appropriate for all potential HRC® projects because of its physical and chemical characteristics. The viscosity of the product is approximately 10x greater than that of HRC® and its release period is about twice as long. Based on their cumulative project experience Regenesis's Technical Service Group

(TSG) has determined that there are specific conditions that justify the use of HRC-X™ for a specific project. The conditions are:

- The total concentration of tetrachloroethene (PCE) and trichloroethene (TCE) exceeds 100 mg/L
- The groundwater velocity at the site is greater than one-foot per day
- The application location is currently not accessible or will not be in the future and re-application(s) of the product are not feasible

Material Overview, Handling, and Safety

At this time, HRC-X™ is sold and distributed in plastic buckets only. Each bucket has a volume of 4.25-gallons and has a gross weight of approximately 32-pounds (net weight of HRC-X™ = 30-pounds). At an ambient temperature of approximately 70 °F (21 °C) the viscosity of HRC-X™ is approximately 200,000 centipoise which is similar in consistency to very cold honey. However the viscosity of HRC-X™ is temperature sensitive and Regenesis's TSG has observed significant changes in the viscosity of the material after it is heated to temperatures greater than 110 °F (43°C).

HRC-X™ should be stored in a place that is dry and warm and should not be left directly in the sunlight. After HRC-X™ has been stored for an extended period of time it is not uncommon for a thin layer of material to form at the bottom of the bucket. Therefore, the material should be mixed into a uniform fluid before installation.

During installation activities Regenesis recommends that field personnel use at least level D personal protection equipment (PPE). It is highly recommended that eye protection and gloves be used throughout the installation process because of the product's low pH and high viscosity. In addition, even though the product is made using only food grade raw materials, Regenesis does not recommend its consumption. A Materials Safety Data Sheet (MSDS) is sent with each shipment and should be reviewed before proceeding with installation activities.

Specific Installation Procedures

1. Prior to the installation of HRC-X™, all surface and overhead impediments should be identified as well as the location(s) of any underground structures. Underground structures include but are not limited to: utility lines (gas, electrical, sewer, etc), drain piping, and landscape irrigation systems.
2. The planned injection locations should be adjusted in the field to account for impediments and obstacles.

3. The actual injection locations should be marked prior to the start of installation activities to facilitate the application process.
4. To expedite the installation process, Regenesis strongly recommends heating the HRC-X™ material in a hot water bath prior to application. Once the HRC-X™ reaches a temperature of approximately 110 °F (43 °C) it becomes less viscous and can be pumped much more easily. This is accomplished by adding hot water, 160 °F+ (71 °C), to a large trough (plastic or metal) and then placing the buckets of HRC-X™ product inside. Regenesis has used the following methods to heat up water:
    - Heated pressure washer
    - Steam cleaner
    - Camping stoves
    - Propane tanks

    **Please note that the buckets used to package the HRC-X™ product should not be heated directly, another medium such as water must be used so that the physical structure of the buckets is not jeopardized.
5. The period of time needed to heat the HRC-X™ product up to the desired temperature of 110 °F (43 °C) is highly dependent on ambient conditions (i.e. cold weather conditions will require more time) and can take up to 1.5 hours.
6. After the HRC-X™ product reaches the target temperature the installation activities can begin
7. Using an appropriate pump to install the HRC-X™ product is very critical to the success of the application as well as the overall success of the project. Based on our experience in the field, Regenesis strongly recommends using a pump that has a pressure rating of at least 1,500 pounds per square inch (psi) and a delivery rate of three gallons per minute.
8. After the HRC-X™ product has been heated the direct-push unit can be moved over one of the targeted injection points and prepared for installation. The drive rod assembly should be fitted with a disposable tip on the first drive rod and pushed down to the desired depth. This process should be done in accordance with the manufacturer's standard operating procedure (SOP). Due to the viscous nature of the product, Regenesis recommends using drive rods with an inner-diameter of at least 0.625-inches.
9. The quantity of HRC-X™ product needed for each injection point should be poured into the pump's hopper after it has been heated to the appropriate temperature and before the drive rods are pushed down to the desired depth.
10. A sub-assembly connecting the delivery hose to the drive rods and pump should be used. The sub-assembly should be constructed in a manner that allows for the drive rods to be withdrawn while the material is being pumped.

11. Prior to connecting the hose to the sub-assembly a volume check should be completed to determine the volume and weight of product displaced with each pump stroke (see Table 1).

Table 1 – Volume Check Information			
Volume of HRC-X™ pumped	**Number of pump strokes required**	**Density of HRC-X™**	**Mass of HRC-X™ per pump stroke**
3.0 gal	14	10.8 lbs/gal	2.3 lbs
3.0 gal	10	10.8 lbs/gal	3.2 lbs

12. After the drive rods have been pushed to the correct depth the assembly should be withdrawn three- to six-inches so that the disposable tip has room to be dropped.
13. Fill the annular space of the drive rods with water. This will minimize the amount of air introduced to the system.
14. Connect the hose from the grout pump to the drive rod assembly
15. Start pumping the HRC-X™ product
16. The initial volume of HRC-X™ pumped should only be enough to displace the water within the drive rods. Once this is done the actual injection can start.
17. Begin withdrawing the drive rods, in accordance with the manufacturer's SOP, and start pumping the HRC-X™ simultaneously. The withdrawal rate should be such that it allows the appropriate quantity of material to be injected into each vertical foot of aquifer being treated. The withdrawal rate should be slow. If the drive rods are withdrawn too quickly a vacuum can be created and pull the product to the surface.
18. Depending on site-specific conditions, a different approach may need to be used. Less permeable soils such as clays and silts may have difficulty accepting the volume of material being installed. In this case Regenesis recommends using a "step-wise" application approach. For this approach we suggest withdrawing the drive rods in one-foot increments and then injecting the quantity of material required per foot.
19. Look for any indications of aquifer refusal such as:
    - Excessive pump noise such as squealing
    - Surfacing of material through the injection point (typically called "blow-by")

    If acceptance appears to be an issue it is critical that the aquifer is given enough time to equilibrate before breaking down the drive rods and/or removing the hose.

The failure to do this can lead to excessive splashing of the product on personnel, equipment, and the ground surface.

20. If HRC-X™ continues to “surface” after the drive rods have been completely removed from the borehole a plug may need to be used. Large diameter disposable tips or wood stakes have been used successfully for this purpose.
21. Drive rods should be disconnected after one rod (typically four–feet) has been withdrawn. The drive rods should be placed in a bucket (or equivalent) after they have been disconnected. More often than not some residual HRC-X™ will remain in the drive rods and the bucket can be used to collect this residual material. The collected material should be poured back into the pump hopper periodically.
22. Install HRC-X™ at the designated application rate across the entire targeted vertical interval.
23. After the injection is complete, an appropriate seal should be installed above the vertical interval where the HRC-X™ has been placed to prevent contaminant migration. Typically bentonite powder or chips are used to create this seal. However, consultants should review local regulations before beginning field installation activities to confirm that this approach can be used.
24. Complete the borehole at the surface as appropriate using concrete or asphalt.
25. Repeat steps 12 through 24 until the entire application has been completed.

HELPFUL HINTS

A. Applications in Cold Weather Settings

As discussed previously the viscosity of HRC-X™ is directly related to ambient temperature conditions. To maintain the temperature of HRC-X™ you can:

- Keep the temperature of the product at or above 110 °F (43 °C) before pouring it into the pump hopper
- Insulate the hose(s) used to deliver the material from the pump to the drive rods
- Place the pump and hot water bath used to heat the product inside a building or equivalent structure (e.g. cargo van)
- Periodically check the temperature of the product in the pump hopper
- Occasionally re-circulate the product through the pump and hose to maintain temperature and viscosity
- The volume of product re-circulated should not exceed the quantity of material in the pump hopper

- Do not constantly recirculate the product through the pump and hose(s) because it could potentially affect the longevity of the product

B. HRC-X™ Physical Characteristics

- Density: 1.3 g/cc or 10.8 lbs/gal
- Viscosity: 200,000 centipoise

C. Grout Pump Cleaning

The physical characteristics of the product make it a challenge to work with during installation and an even bigger challenge to clean after the installation has been completed. The internal workings of the grout pump can be cleaned easily by recirculating a solution of hot water and a biodegradable cleaner (e.g. Simple Green) through the pump and delivery hose(s). If additional cleaning and decontamination is required it should be conducted in accordance with the manufacturer's SOP and local regulatory requirements.

For more information contact Regenesis at 949-366-8000.