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September 2007 through May 2008
Groundwater Monitoring Results

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Shelton Laundry and Cleaners
September 2007 through May 2008
Groundwater Monitoring Results

by
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Abstract

Tetrachloroethylene (PCE) contamination of shallow groundwater underlying Shelton Laundry and Cleaners was discovered in 1997. The source of contamination was assumed to be a 1993 spill outside the dry cleaners. Monitoring of four shallow wells in 1998 detected PCE at a concentration of 280 µg/L (well 4W). The Model Toxic Control Act (MTCA) Method A cleanup level for PCE is 5 µg/L.

In 2002 Ecology installed four deep wells and began monitoring the groundwater quality of all eight wells. From 2002 to 2005, PCE concentrations in well 4W ranged from 10 to 25 µg/L. PCE was not detected in the four deep wells.

To remediate the remaining contaminants, in June 2005 Ecology contractors injected a hydrogen release compound (HRC®) into the groundwater around well 4W. Five months following the HRC injection, groundwater monitoring results indicated that the HRC may have been effective in reducing the contaminant concentrations.

However, since August 2006, 15 months following the HRC injection, contaminant concentrations have steadily increased, suggesting the HRC is no longer effective. HRC typically has an effective longevity of 12 to 18 months.

Between September 2007 and May 2008, groundwater samples were collected quarterly from three shallow wells and two deep wells. PCE was detected in well 4W with concentrations ranging from 14 to 43 µg/L, exceeding the MTCA cleanup level. TCE and cis-DCE were also detected in well 4W, mostly at concentrations near or below the practical quantitation limit of 2 µg/L. TCE exceeded the cleanup level of 5 µg/L in September 2007 with a concentration of 9.5 µg/L. PCE, TCE, and cis-DCE were not detected in the two deep wells.

Groundwater monitoring should continue in the five wells on a semi-annual basis since PCE concentrations in monitoring well 4W continue to exceed the cleanup level.

This site may benefit from a second injection of a hydrogen release compound.

Background

Site History

Tetrachloroethylene (PCE) contamination of shallow groundwater was discovered in 1997 during an environmental site assessment of a property in Shelton, Washington (Building Analytics, 1997) (Figure 1). PCE was detected at a concentration of 130 µg/L in groundwater collected from a shallow boring approximately 11 feet deep. The Model Toxic Control Act (MTCA) Method A cleanup level for PCE in groundwater is 5 µg/L.

The Washington State Department of Ecology (Ecology) was notified of the contamination when it received copies of the Environmental Site Assessment Reports in June 1997 (Building Analytics, 1997). Based on these reports, Shelton Laundry and Cleaners was listed on Ecology's *Confirmed and Suspected Contaminated Sites List* in December 1997 and ranked under the Washington Ranking System.

The most likely source of the contamination was identified as the dry cleaning facility, Shelton Laundry and Cleaners, which is located adjacent to the property where the site assessment was conducted. A commercial laundry and dry cleaning facility has been in operation at this site since 1935. In 1993, a small quantity of dry cleaning solvent was reportedly spilled in the alley between the two properties during the removal of an old dry cleaning machine. This spill event is assumed to be the source of the groundwater contamination.

Several environmental investigations were conducted at the Shelton Laundry and Cleaners site in 1997 and 1998. During these investigations, several shallow borings were drilled to collect both soil and groundwater samples. In July 1998, four shallow (approximately 15 feet deep) monitoring wells were installed (1W, 4W, 7W, and 8W) (Figure 2). Groundwater was sampled from these wells four times between July 1998 and September 2000. PCE contamination was primarily detected in the well (4W) located nearest to the reported spill location. Concentrations ranged from 280 µg/L (July 1998) to 25 µg/L (September 2000).

Ecology conducted a follow-up investigation in 2002 to determine the status of the PCE groundwater contamination. As part of the investigation, four additional monitoring wells (MW-5 through MW-8) were installed to gain a better understanding of contaminant concentrations at greater depths. Three of the wells were installed adjacent to existing shallow wells to a depth of 45 feet. The fourth well was installed south of the site to a depth of 60 feet. PCE was not detected in any of the four deeper wells during the 2002 monitoring (Marti, 2003).

Because PCE concentrations were higher than the MTCA cleanup standard in well 4W, Ecology continued to monitor the groundwater quality in both the shallow and deep wells. From July 2002 to April 2005, PCE concentrations in well 4W ranged from approximately 10 to 25 µg/L.

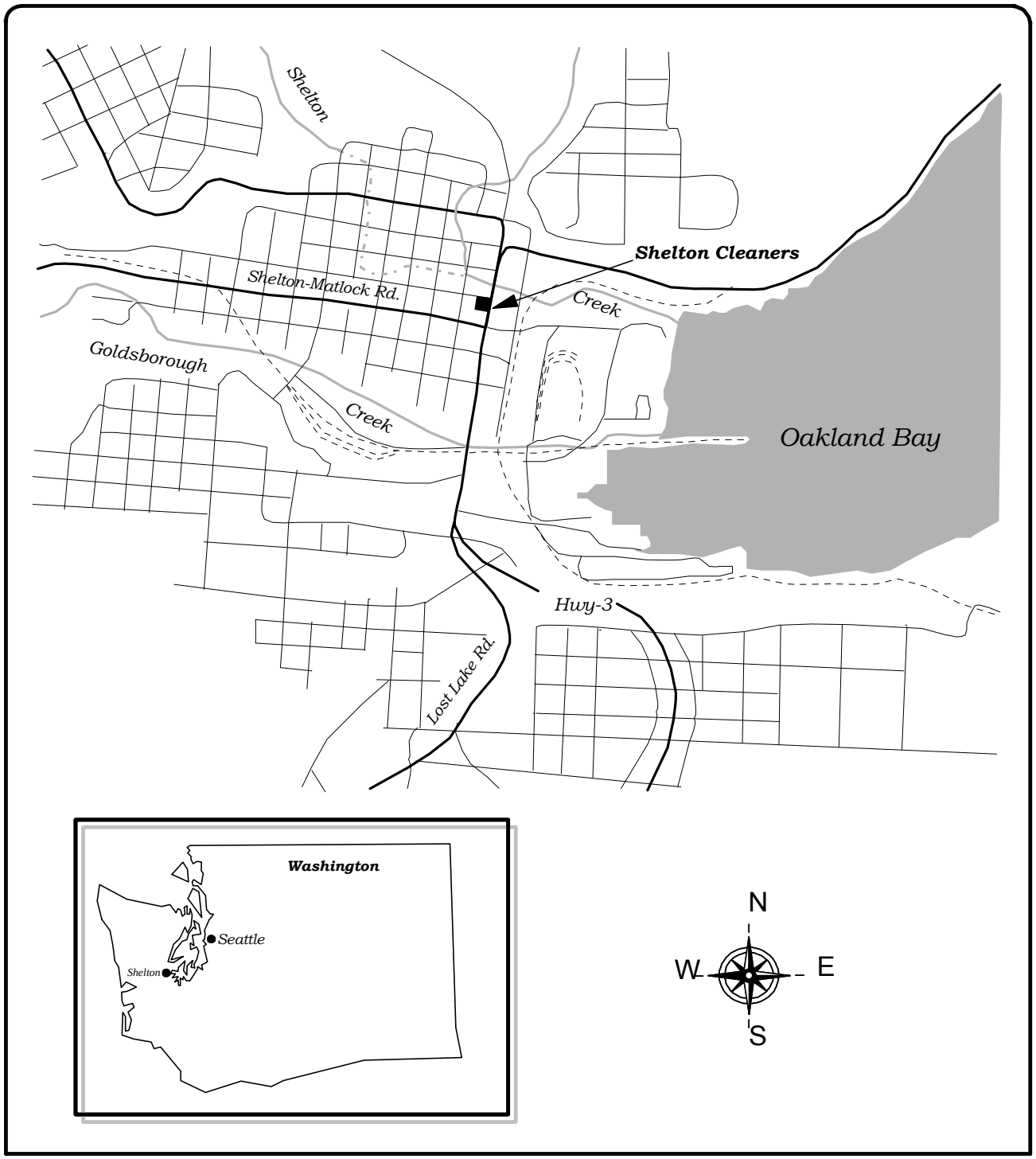

Figure 1: Shelton Laundry & Cleaners Site Location

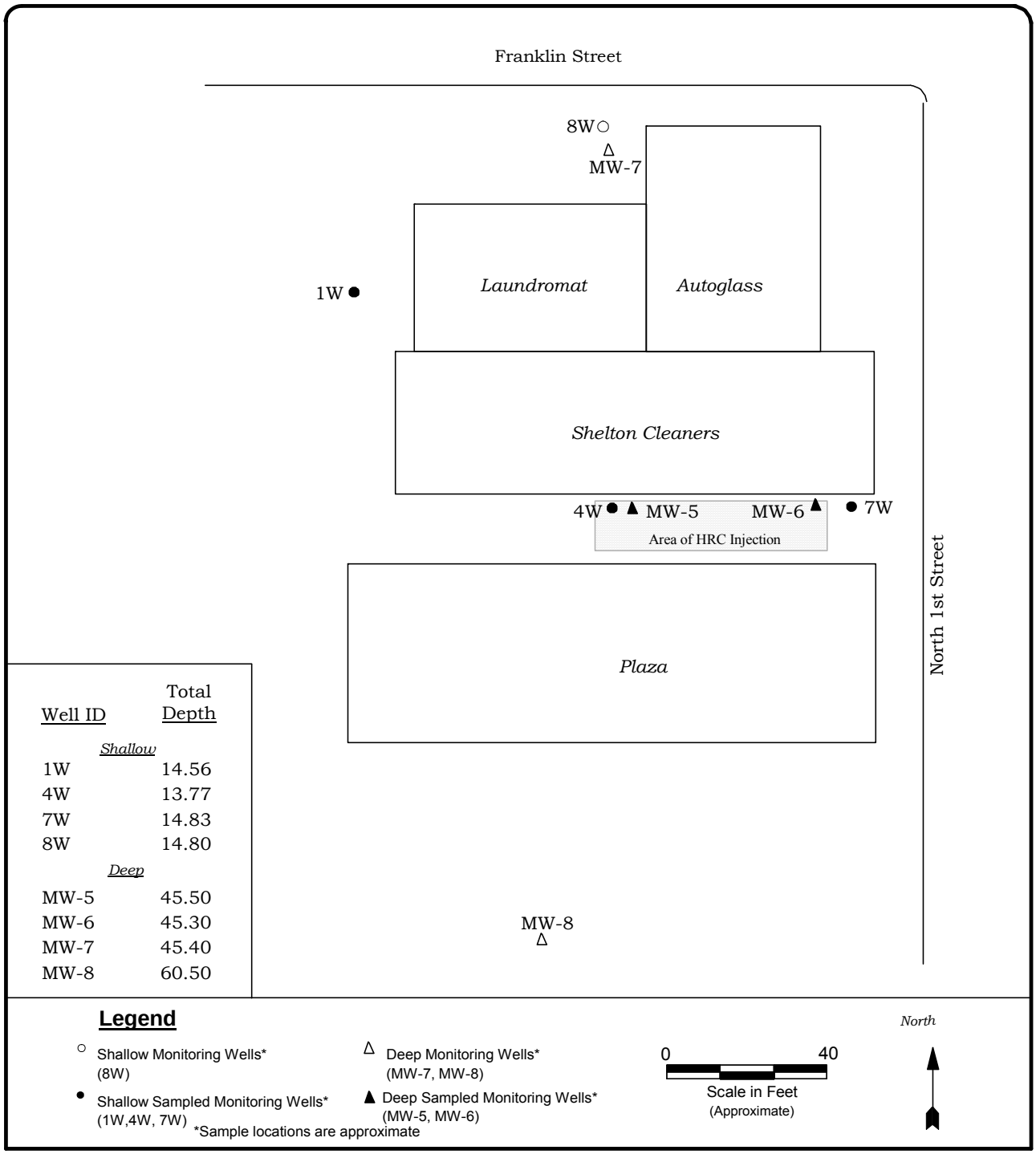

Figure 2: Shelton Laundry & Cleaners Sample Locations

In an effort to remediate the remaining contaminants, in June 2005, 1,050 pounds of a hydrogen release compound (HRC®) was injected into the shallow groundwater between wells 4W and 7W (Figure 2). The HRC was injected 5 to 20 feet below the ground surface at 16 locations spaced 8 feet apart over an area of 60 feet by 15 feet (Balaraju, 2005).

Results from the first year of monitoring following the HRC injection seem to indicate that enhanced degradation was occurring. PCE and TCE (trichloroethylene) concentrations decreased while cis-DCE (cis-1,2-dichloroethylene) concentrations increased. The contaminant concentrations were at their lowest in August 2006, 15 months following the HRC injection, but have since then been steadily increasing. HRC typically has an effective longevity of about 12 to 18 months.

Site Geology

Site well logs indicate the site is covered with a thin layer of fill and two to six feet of silty sand, which is underlain by an undetermined thickness of gravely sands with some sand interbeds. The well log for 4W shows the upper silty sand layer which grades to silty, fine gravel with some fine to coarse sand from 6 to 14 feet below ground surface. Soils from split spoon samples collected in June 2005 indicate the presence of a thin silt layer at approximately four feet below the ground surface in the area of well 4W.

The gravely sands in which all eight monitoring wells are screened is part of the Vashon recessional outwash deposits which underlay the western outwash plain between Shelton and the Skokomish Valley to the north. Deeper production well logs near the site indicate that the recessional deposits can attain a thickness of more than 100 feet in the area of Oakland Bay.

Depth to the water table on the project site ranged from about three to six feet over the 1997 – 2008 study period. Regionally, groundwater flow is described as being southward in the loose sand and gravel toward the Shelton Valley and Oakland Bay (Molenaar and Noble, 1970). Groundwater flow patterns determined from site water levels are toward the southwest and southeast across the site, consistent with regional flow patterns.

Methods

Groundwater Sampling

Groundwater samples were collected in September and November 2007 and in February and May 2008 from three shallow and two deep monitoring wells (Figure 2). Samples were submitted for analysis of volatile organic compounds (VOCs) to determine PCE concentrations in the vicinity of well 4W.

The three shallow wells installed in 1998 (1W, 4W, and 7W) were constructed of 1-inch diameter PVC to a depth of about 15 feet with 10-foot screens. The two deep wells installed in 2002 (MW-5 and MW-6) were constructed of 2-inch diameter PVC to a depth of about 45 feet, with the screened interval from 35-45 feet below ground surface (bgs).

Static water levels were measured in all wells, prior to well purging and sampling, using a Solinst water level meter with a ¼-inch diameter probe. Measurements were recorded to 0.01-foot and are accurate to ±0.03 foot. The probe was rinsed with deionized water between measurements.

Because of their small diameter (1 inch), wells 1W, 4W, and 7W were purged and sampled with a stainless steel mechanical bladder pump at a rate of 0.1 to 0.5-liter/minute. The wells were purged until field parameters (temperature, pH, and specific conductivity) readings from grab samples stabilized. At the completion of purging, samples were collected directly from the monitoring well's dedicated pump discharge tubing into laboratory-supplied containers.

Monitoring wells MW-5 and MW-6 were purged and sampled using a stainless steel submersible pump, at a rate of 1-liter/minute. These wells were purged through a continuous flow cell until the field parameter readings stabilized. At the completion of purging, the flow cell was disconnected and the samples were collected directly from the well's dedicated pump discharge tubing into the sample containers.

VOC samples were collected free of headspace in three 40-mL glass vials with Teflon-lined septa lids and preserved with 1:1 hydrochloric acid. Upon sample collection and labeling, all samples were stored in an ice-filled cooler. Samples were transported to Ecology's Operation Center in Lacey. Samples were kept in the walk-in cooler until picked up by the courier and transported to the Ecology/EPA Manchester Environmental Laboratory in Manchester, Washington. Chain-of-custody procedures were followed according to Manchester Environmental Laboratory protocol (Ecology, 2005).

Both pumps were decontaminated after each well was sampled by circulating a solution of laboratory-grade detergent and water through the pump, followed by a clean water rinse. Purge water from all the wells was collected and stored on-site in a 55-gallon drum. The purge water was transported and disposed of in accordance with Washington State Dangerous Waste Regulations (Chapter 173-303 WAC).

Laboratory

Analytes, analytical methods, and detection limits for both field and laboratory parameters are listed in Table 1. All groundwater samples were analyzed for volatile organics (VOCs) by the Ecology/EPA Manchester Environmental Laboratory.

Table 1. Field and Laboratory Methods.

Field Measurements	Instrument Type	Method	Accuracy
Water Level	Solinst Water Level Meter	EPA SOP 2043	±0.03 feet
Temperature	Orion 25A Field Meter	EPA Method 150.1	±0.1 ºC
pH	Orion 25A Field Meter	EPA Method 150.1	±0.1 std. units
Specific Conductance	YSI 3520 Conductivity Cell	EPA Method 120.1	±10 µmhos/cm
Laboratory Analytes	**Method**	**Reference**	**Reporting Limit**
VOCs	EPA SW-846 Method 8260B	EPA 1996	1-5 µg/L

EPA – Environmental Protection Agency.
SOP - Standard operating procedure.
VOCs - Volatile organics.

Data Quality

Quality control samples collected in the field consisted of blind field duplicates. Field duplicates were collected by splitting the pump discharge between two sets of sample bottles, which provides a measure of the overall sampling and analytical precision. Precision estimates are influenced not only by the random error introduced by collection and measurement procedures, but are also influenced by the natural variability of the concentrations in the media being sampled. Field duplicates were collected from well 4W during all sample rounds.

Table 2 shows the results of the duplicate samples and the relative percent difference (RPD). RPD is calculated as the difference between sample results, divided by the mean and expressed as a percent.

Table 2. Relative Percent Difference (RPD) of Duplicate Sample Results (µg/L) from September 2007 through May 2008.

Well Sample ID	Tetrachloroethylene (PCE)				Trichloroethylene (TCE)				Cis-1,2-Dichloroethylene (cis-DCE)			
	9/07	11/07	2/08	5/08	9/07	11/07	2/08	5/08	9/07	11/07	2/08	5/08
4W	43	14	11	15 J	9.5	2	3.4	3.6	2.5	0.67 J	1.4 J	1
4W-A	41	13	18	13 J	8.7	2.2	5.1	2.9	2.1	0.63 J	1.7 J	0.73 J
RPD (%)	5%	7%	**48%**	--	9%	9%	**40%**	22%	17%	--	--	--

J - Analyte was positively identified. The associated numerical result is an estimate.
Bold - Does not meet data quality objectives.

Between September 2007 and May 2008, the RPD for most duplicate sample results from monitoring well 4W ranged from 5% to 22%. The February 2008 PCE and TCE RPDs were high. However, because the concentrations are within the range of other results detected in this well, an average concentration of the duplicate samples will be used in the remainder of this report and will be "J" qualified as estimated. PCE results for May 2008 have also been qualified because PCE concentrations were slightly above the laboratory's criteria for the initial calibration. Cis-DCE results have been qualified because the reported concentrations are below the practical quantitation limit. Overall, the data met the measurement quality objectives established in the Quality Assurance Project Plan (Marti, 2002).

A review of the laboratory data quality control and quality assurance results indicates analytical performance was good. The reviews include descriptions of analytical methods, holding times, instrument calibration checks, blank results, matrix spikes, surrogate recoveries, and laboratory control samples. With the exception of the May 2008 initial calibration, no other problems were reported that compromised the usefulness or validity of the sample results. No data were rejected, and all results were usable as qualified. Quality assurance case narratives and laboratory reporting sheets are available upon request.

All field measurements and analytical result data are available in electronic format from Ecology's Environmental Information Management (EIM) database: www.ecy.wa.gov/eim/index.htm at study ID, PMART001.

Results – Field Observations

Total depth of each monitoring well and the range of depth-to-water, as well as temperature, pH, and specific conductance readings, at the time of sampling are listed in Table 3. All field data are presented in Appendix A.

Table 3. Summary of Field Parameter Results for September 2007 through May 2008.

Well	Total Depth (feet)[1]	Depth to Water (feet)[1]		Temperature (°C)		pH (standard units)		Specific Conductance (µmhos/cm)	
		Range	Difference	Range	Difference	Range	Mean	Range	Mean
Shallow									
1W	14.56	4.22 - 6.72	2.50	9.1 - 13.5	4.4	5.3 - 7.3	6.7	154 – 225	199
4W	13.77	4.20 - 6.76	2.56	9.6 - 16.0	6.4	6.7 - 7.2	7.0	111 – 153	123
7W	14.83	3.83 - 6.48	2.65	10.0 - 11.4	4.4	7.1 - 7.4	7.2	107 – 210	143
Deep									
MW-5	45.5	4.19 - 6.74	2.55	10.8 - 13.7	2.9	6.4 - 7.2	6.9	173 – 206	198
MW-6	45.3	3.81 - 6.44	2.63	10.8 - 12.6	1.8	7.1 - 7.2	7.2	185 - 210	202

[1] Measured from top of PVC casing.

Completion depths for the five monitoring wells ranged from 13.77 to 45.5 feet. Depth-to-water ranged from 3.81 to 6.76 feet below the measuring point and fluctuated approximately 2.5 feet during the monitoring period. Hydrographs showing water-level elevations for each well from May 2002 to May 2008 are shown in Figure 3. Hydrograph data are presented in Appendix B. The hydrographs indicate that, overall, the seasonal fluctuation is small throughout the year (about 1-2 feet), and the groundwater gradient is fairly flat. Peak water levels were not measured in 2004 and 2005 because monitoring occurred semi-annually. Water level elevations in September and November 2007 were much lower; this may be attributed to sewer and other construction work conducted in the area during this time period.

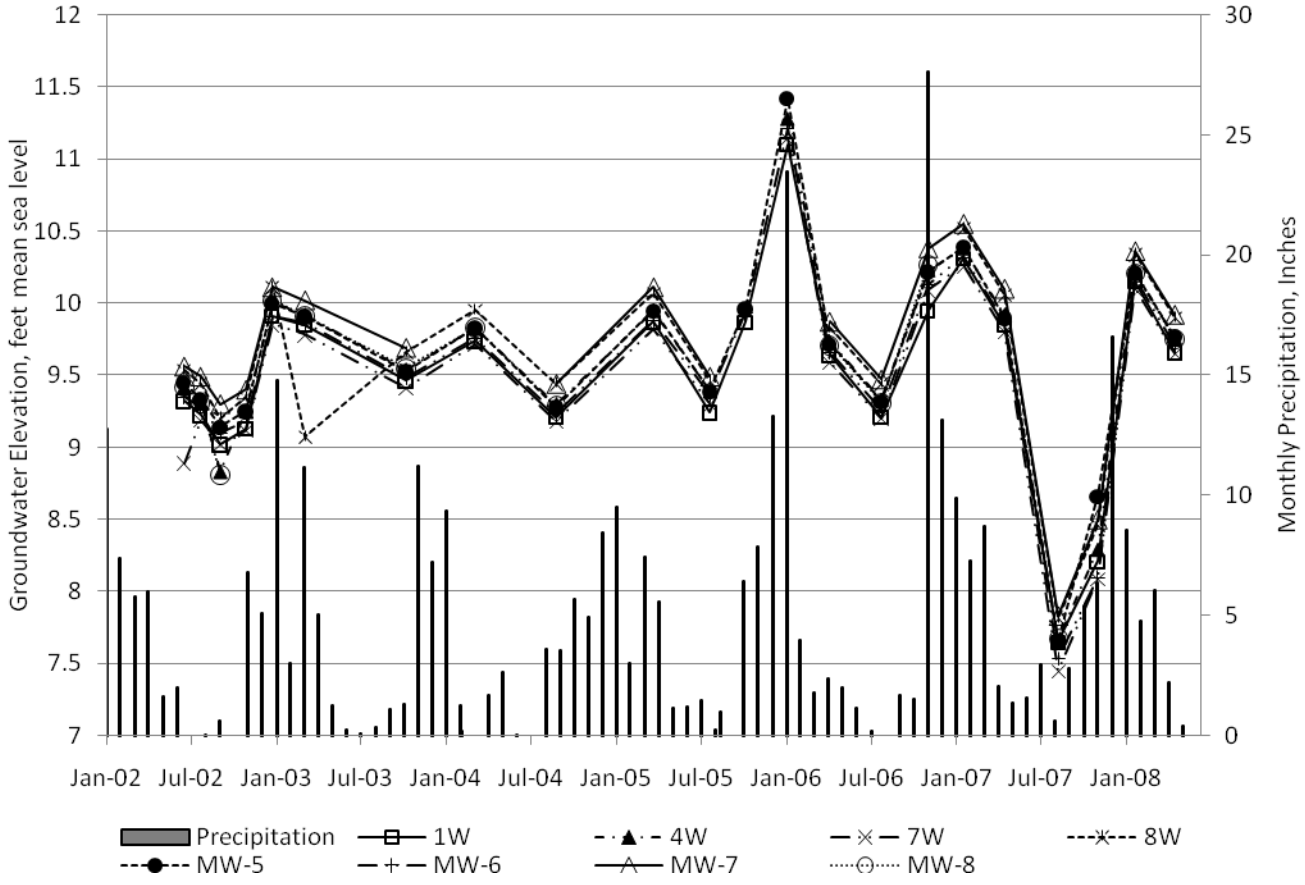

Figure 3. Shelton Laundry and Cleaners – Hydrographs, May 2002 to May 2008.

A typical groundwater flow pattern based on water levels measured in May 2008 is shown in Figure 4. The location of the water-table contours was determined using a kriging algorithm in the Surfer software program. The groundwater flow direction is approximately perpendicular to the contours. The flow direction is toward the southwest and southeast which corresponds to the regional flow direction.

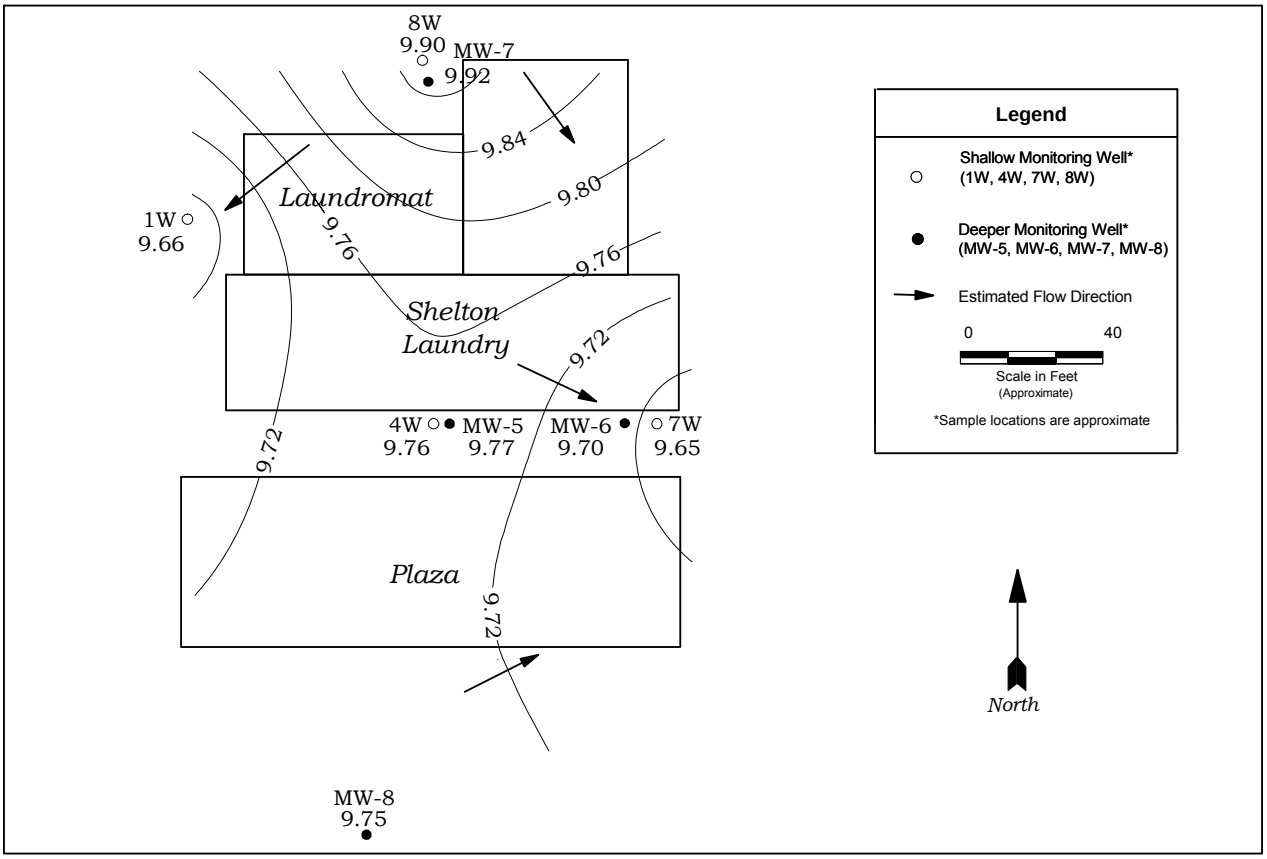

Figure 4. Shelton Laundry and Cleaners – Water Table Elevation, May 2008.

Field parameter results for September 2007 to May 2008 were within expected ranges. Groundwater temperatures from grab samples from the 1-inch wells, and the flow cell from the 2-inch wells, are subject to change due to ambient air temperatures. Temperatures from the grab samples ranged from 9.1º to 16.0ºC, while temperatures from the flow cell ranged from 10.8º to 13.7ºC. The lowest groundwater temperatures were measured in February 2008 and the highest in September 2007. The average pH was 7.0. Specific conductivity had a mean range of 123 to 202 µmhos/cm.

Analytical Results

Analytical results for the primary contaminants of concern are summarized in Table 4. A summary of historical data is presented in Appendix C. PCE, TCE, and cis-DCE were the only volatile organics detected.

Table 4. Summary of Analytical Results (µg/L) for September 2007 through May 2008.

Well ID	Tetrachloroethylene (PCE)				Trichloroethylene (TCE)				Cis-1,2-Dichloroethylene (cis-DCE)			
	9/07	11/07	2/08	5/08	9/07	11/07	2/08	5/08	9/07	11/07	2/08	5/08
Shallow												
1W	2 U	2 U	1 U	2 U	2 U	1 U	1 U	1 U	1 U	1 U	2 U	1 U
4W	**43**	**14**	**15J**[a]	**15 J**	**9.5**	**2**	**4.3J**[a]	**3.6**	**2.5**	**0.67 J**	**1.4 J**	**1**
7W	2 U	2 U	1 U	2 U	2 U	1 U	1 U	1 U	1 U	1 U	2 U	1 U
Deep												
MW-5	2 U	2 U	1 U	2 U	2 U	1 U	1 U	1 U	1 U	1 U	2 U	1 U
MW-6	2 U	2 U	1 U	2 U	2 U	1 U	1 U	1 U	1 U	1 U	2 U	1 U

a - Average concentration of duplicate samples. Results are J qualified as estimate.
U - Analyte was not detected at or above the reported value.
J - Analyte was positively identified. The associated numerical result is an estimate.
Bold - Analyte was detected.

PCE, TCE, and cis-DCE were detected in well 4W during all four rounds of sampling from September 2007 to May 2008. PCE concentrations increased to 43 µg/L in September 2007, returning to approximately 15 µg/L for the remainder of the monitoring period. TCE and cis-DCE also increased in September 2007 to 9.5 µg/L and 2.5 µg/L, respectively, decreasing to concentrations near or below the practical quantitation limit of 2 µg/L for the rest of the monitoring period.

PCE, TCE, and cis-DCE have not been detected in the deep wells since the wells were installed in July 2002.

Discussion

PCE, TCE, and cis-DCE concentrations in well 4W have fluctuated since the injection of the HRC in June 2005 (Figure 5). Prior to its injection, the average PCE and TCE concentrations in this well were 15 µg/L and 1.6 µg/L, respectively. Five months following the HRC injection (November 2005), PCE and TCE concentrations decreased to 6.8 µg/L and 0.52 µg/L, while cis-DCE concentrations increased from a pre-HRC average of 0.62 µg/L to 1.8 µg/L. The decrease in PCE and TCE concentrations, combined with the increase in cis-DCE concentrations, which is a breakdown product, could be an indication of enhanced degradation due to the HRC injection.

PCE concentrations increased during the next two sampling periods to 17.5 µg/L (February 2006) and a high of 324 µg/L (May 2006). Concentrations of TCE and cis-DCE also increased to a high of 13 µg/L and 16 µg/L, respectively. Hansen et al. (2000) have noted that there can be temporary increases in aqueous contaminant concentrations in the treatment area as biosurfactants (microbial surface active agents), produced by stimulating microbial growth in the subsurface, solubilize volatile organics that are adsorbed to the aquifer media.

Between August 2005 and May 2006, 2-butanone, also known as methyl ethyl ketone (MEK), was detected for the first time in wells 4W and 7W. MEK concentrations in well 4W ranged from a high of 222 µg/L in August 2005 to a low of 2 µg/L in May 2006. MEK was detected in well 7W in August and November 2005 at concentrations of 9.8 µg/L and 3.8 µg/L, respectively. Based on information provided by the HRC® manufacturer, MEK can be produced by soil bacteria through fermentation of a wide range of organic carbon compounds, either native to the site or introduced during engineered bioremediation. The production of MEK at other HRC sites has not appeared to be significant or long-lasting (Biondolillo, 2006). MEK has not been detected in any of the site wells since May 2006.

In August 2006, PCE (3.2 µg/L), TCE (0.6 µg/L), and cis-DCE (0.19 µg/L) had decreased to some of the lowest concentrations observed. This was the first occurrence of PCE concentrations below the MTCA Method A cleanup level of 5 µg/L since monitoring began in 2002. However, since August 2006, PCE, TCE, and cis-DCE concentrations have been steadily increasing. The average PCE concentration is now 14 µg/L.

The parallel increases of PCE, TCE, and cis-DCE concentrations suggest that the HRC is past its effectiveness. In a review of HCR® case histories, Willett et al. (2004) found that the effective longevity of HRC is about 12 to 18 months. As seen in Figure 5, the parallel concentrations begin to occur in August 2006, 15 months following the HRC injection. This corresponds to the predicted HRC effective longevity.

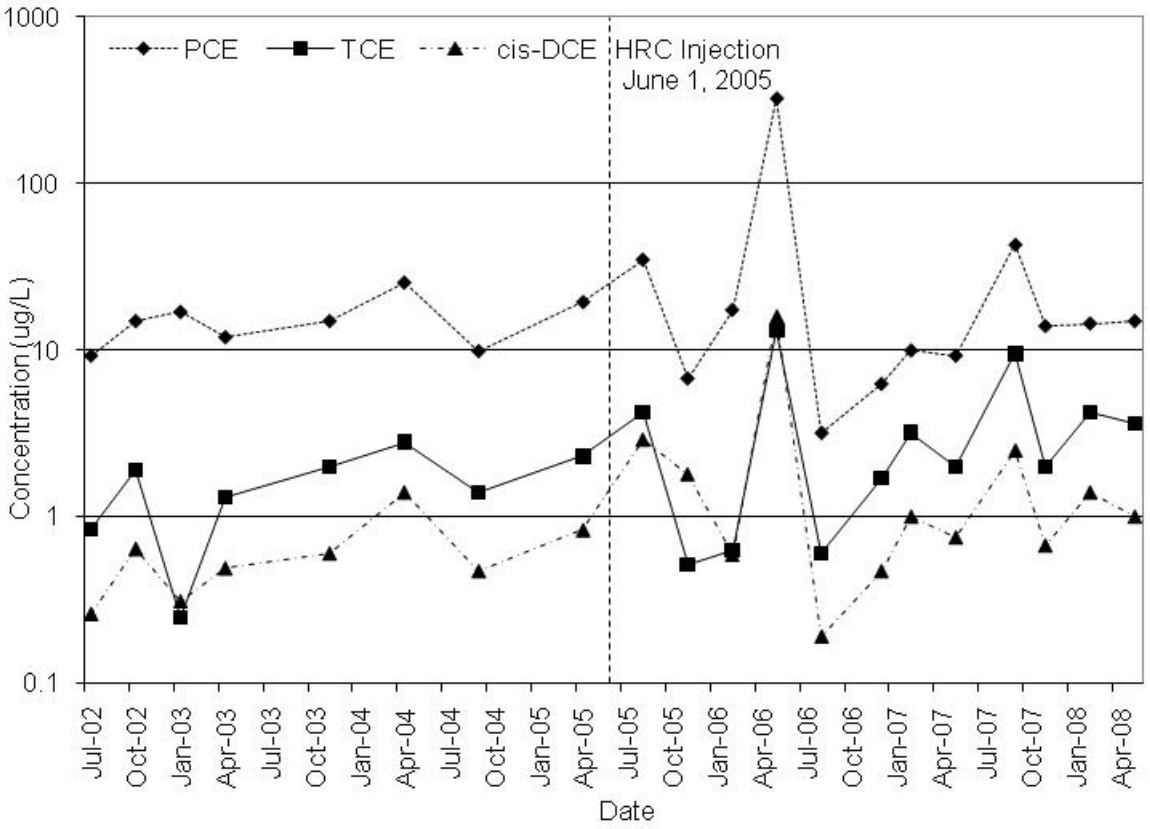

Figure 5: PCE, TCE, and cis-DCE Concentrations (µg/L – log scale) in well 4W, July 2002 through May 2008.

Conclusions

PCE concentrations in well 4W during the past year (September 2007 to May 2008) continue to increase and exceed the Model Toxic Control Act (MTCA) Method A cleanup level of 5 µg/L. PCE concentrations ranged from 14 to 43 µg/L.

TCE and cis-DCE concentrations also increased in well 4W but overall were below their respective cleanup levels of 5 µg/L and 70 µg/L. TCE exceeded the cleanup level in September 2007 with a concentration of 9.5 µg/L. TCE concentrations ranged from 2 to 9.5 µg/L, and cis-DCE concentrations ranged from 0.67 J to 2 µg/L. TCE and cis-DCE are typically associated with the breakdown of PCE.

Results indicate that groundwater underlying the Shelton Laundry and Cleaners site continues to be contaminated in the area of well 4W, even after injection of the hydrogen release compound (HRC®) in June 2005.

PCE, TCE, and cis-DCE results from the first year following the HRC injection seem to indicate that enhanced degradation was occurring. Despite a spike in contaminant concentrations in May 2006, PCE and TCE concentrations decreased while cis-DCE concentrations increased.

The lowest contaminant concentrations were observed in August 2006, 15 months following the HRC injection. However, contaminant concentrations have been steadily increasing during the past two years. The parallel increase in PCE, TCE, and cis-DCE concentrations suggests the HRC is no longer effective in reducing contaminant concentrations. HRC typically has an effective longevity of about 12 to 18 months.

Recommendations

Groundwater monitoring should continue in the three shallow wells (1W, 4W, and 7W) and two deep wells (MW-5 and MW-6) on a semi-annual basis for the next year since PCE concentrations in monitoring well 4W continue to exceed the MTCA Method A cleanup level of 5 µg/L.

This site may benefit from a second injection of a hydrogen release compound (HRC®). However, a longer lasting formula such as HRC-X® should be considered. HRC-X is an extended release formula designed to treat source areas with residual dense nonaqueous phase liquid (DNAPL) and has an anticipated lifetime of three to five years (Regenesis.com).

If a second HRC injection occurs, the five site monitoring wells should be sampled quarterly to determine the effectiveness of the remediation. Samples should also be collected and analyzed for total organic carbon (TOC), dissolved iron, sulfate, and chloride from any wells within the treatment area. These additional parameters will help indicate if reductive dechlorination is occurring. It has been observed at other sites where HRC has been successful at creating reducing conditions that TOC, chloride, and dissolved iron concentrations increase, and sulfate concentrations decrease.

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Appendices

Appendix A. Field Parameters

Table A-1. Field Parameter Results for September and November 2007 and February and May 2008.

Well ID	Date	Total Depth (feet)[1]	Depth to Water (feet)[1]	Temperature (°C)	pH (standard units)	Specific Conductance (umhos/cm)	Purge Volume (gallons)
1W	9/7/07	14.56	6.72	13.5	7.3	225	1.75
1W	11/30/07		6.16	9.8	5.3	210	2
1W	2/19/08		4.22	9.1	7.1	208	3
1W	5/14/08		4.71	12.1	7.2	154	1.75
4W	9/7/07	13.77	6.76	16.0	7.1	115	1.5
4W	11/30/07		6.13	10.5	6.7	114	2
4W	2/19/08		4.20	9.6	7.2	111	3
4W	5/14/08		4.66	11.9	7.1	153	2
7W	9/7/07	14.83	6.48	14.4	7.2	107	1.5
7W	11/30/07		5.84	10.6	7.4	210	2
7W	2/19/08		3.83	10.0	7.1	111	2
7W	5/14/08		4.28	11.4	7.1	143	2
MW-5	9/7/07	45.50	6.74	13.7	7.2	206	10
MW-5	11/30/07		6.08	11.8	6.4	206	7
MW-5	2/19/08		4.19	10.8	7.0	205	8
MW-5	5/14/08		4.63	11.1	7.1	173	7
MW-6	9/7/07	45.30	6.44	12.6	7.2	207	9
MW-6	11/30/07		5.88	11.5	7.2	210	8
MW-6	2/19/08		3.81	10.8	7.1	207	9
MW-6	5/14/08		4.28	11.0	7.1	185	9

[1] Measured from top of PVC casing.

Appendix B. Hydrograph Data

Table B-1. Groundwater Elevations (feet above mean sea level), May 2002 through May 2008.

Well ID:	1W	4W	7W	8W	MW-5	MW-6	MW-7	MW-8
5/13/02	9.51	9.61	9.49	9.74	9.64	9.57	9.77	--
7/16/02	9.32	9.42	8.89	9.53	9.45	9.35	9.56	9.42
8/20/02	9.22	9.31	9.19	9.44	9.33	9.28	9.49	9.31
10/2/02	9.02	8.83	9.02	9.2	9.14	9.1	9.3	8.81
11/26/02	9.13	9.25	9.12	9.35	9.25	9.18	9.5	--
1/21/03	9.91	10.01	9.85	10.11	10	9.91	10.11	10.02
4/2/03	9.85	9.92	9.78	9.07	9.91	9.86	10.02	9.91
11/5/03	9.46	9.54	9.41	9.66	9.53	9.48	9.69	9.55
4/1/04	9.74	9.83	9.71	9.95	9.83	9.76	--	9.83
9/23/04	9.21	9.3	9.18	9.44	9.28	9.23	9.44	9.29
4/20/05	9.87	9.95	9.82	10.07	9.95	9.88	10.11	--
8/19/05	9.24	9.39	9.30	9.46	9.39	9.37	9.49	--
11/3/05	9.87	--	--	--	9.96	9.93	--	--
2/1/06	11.1	11.28	11.14	--	11.42	11.21	--	--
5/3/06	9.64	9.73	9.59	9.83	9.72	9.66	9.87	9.71
8/22/06	9.21	9.33	9.2	9.44	9.32	9.26	9.47	9.31
12/1/06	9.95	10.23	10.09	--	10.22	10.13	10.38	10.27
2/15/07	10.31	10.38	10.26	10.52	10.39	10.32	10.55	--
5/14/07	9.85	9.92	9.8	10.06	9.9	9.87	10.1	--
9/7/07	7.65	7.66	7.45	7.81	7.66	7.54	7.83	7.67
11/30/07	8.21	8.29	8.09	8.46	8.66	8.1	8.5	--
2/19/08	10.15	10.22	10.10	10.34	10.21	10.17	10.36	10.21
5/14/08	9.66	9.76	9.65	9.9	9.77	9.7	9.92	9.75

-- Not measured.

Appendix C. Historical Data

Table C-1. PCE, TCE, and DCE Groundwater Results (µg/L), May 1997 through May 2008.

Well ID	Building Analytics	AA Enviro Assessment	GeoEngineers				Ecology									
	5/21/97	3/3/98					7/17/02	10/3/02	1/22/03	4/3/03	11/5/03	4/1/04	9/23/04	4/20/05	8/19/05	11/3/05
1W																
PCE	--	--	<1.0	<1.0	<1.0	<1.0	1 U	1 U	1 U	1 U	--	--	--	--	1 U	1 U
TCE	--	--	<1.0	<1.0	<1.0	<1.0	1 U	2 U	1 U	1 U	--	--	--	--	1 U	1 U
4W																
PCE	**130**[1]	**1510**[2]	**280**	**130**	**39**	**25**	**9.3**	**15**	**17**	**12**	**15**	**26**[a]	**9.9**	**20**[a]	**35**[a]	**6.8**
TCE	NR	NR	**4.7**	<1.0	<1.0	<1.0	**0.84 J**	**1.9 J**	**0.25 J**	**1.3**	**2**	**2.8**[a]	**1.4**	**2.3**	**4.2**[a]	**0.52 J**
DCE	NR	NR	**33**	<1.0	<1.0	<1.0	**0.26 J**	**0.64 J**	**0.31 J**	**0.49 J**	**0.60 J**	**1.4**	**0.47 J**	**0.83 J**	**2.9**[a]	**1.8**
7W																
PCE	--	--	**4.3**	**3**	<1.0	**1.2**	1 U	**0.19 J**	1 U	1 U	1 U	**1.7**	**0.47 J**	**0.15 J**	**0.38 J**	1 U
TCE	--	--	<1.0	<1.0	<1.0	<1.0	1 U	2 U	1 U	1 U	1 U	1 U	**0.26 J**	1 U	1 U	1 U
DCE	--	--	**6.4**	<1.0	<1.0	<1.0	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
8W																
PCE	--	--	<1.0	<1.0	<1.0	NS	1 U	1 U	1 U	1 U	--	--	--	--	--	--
TCE	--	--	<1.0	<1.0	<1.0	NS	1 U	2 U	1 U	1 U	--	--	--	--	--	--
MW-5																
PCE	Monitoring well installed in 2002.						1 U	1 U	1 U	1 U	1 U	1 UJ	1 U	1 U	1 U	1 U
TCE							1 U	2 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
MW-6																
PCE	Monitoring well installed in 2002.						1 U	1 U	1 U	1 U	1 U	1 UJ	1 U	1 U	1 U	1 U
TCE							1 U	2 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
MW-7																
PCE	Monitoring well installed in 2002.						1 U	1 U	1 U	1 U	--	--	--	--	--	--
TCE							1 U	2 U	1 U	1 U	--	--	--	--	--	--
MW-8																
PCE	Monitoring well installed in 2002.						1 U	1 U	1 U	1 U	--	--	--	--	--	--
TCE							1 U	2 U	1 U	1 U	--	--	--	--	--	--

PCE - tetrachloroethylene. TCE - trichloroethylene. DCE - cis-1,2-dichloroethylene. **Bold** = Analyte was detected.

NS – Not Sampled NR – Not Reported <1.0 – Analyte was not detected at a concentration above the value shown.

[1] – Concentration reported by Building Analytics from a temporary boring located in vicinity of well 4W.

[2] – Concentration reported by AA Enviro Assessment from a temporary boring located in vicinity of well 4W.

U - Analyte was not detected at or above the reported value. J - Analyte was positively identified. The associated numerical result is an estimate.

UJ - Analyte was not detected at or above the reported estimated result. [a] - Average concentration of duplicate samples.

Table C-1 (continued). PCE, TCE, and DCE Groundwater Results (µg/L), May 1997 through May 2008.

Well ID	Ecology									
	2/1/06	5/3/06	8/22/06	12/1/06	2/15/07	5/14/07	9/7/07	11/30/07	2/19/08	5/14/08
1W										
PCE	1 U	1 U	1 U	1 U	1 U	1 U	2 U	2 U	1 U	2 U
TCE	1 U	1 U	1 U	1 U	1 U	1 U	2 U	1 U	1 U	1 U
4W										
PCE	**18** [a]	**324**	**3.2 J**	**6.3**	**10**	**9.3**	**43**	**14**	**15J** [a]	**15 J**
TCE	**0.63 J**	**13**	**0.60 J**	**1.7**	**3.2**	**2**	**9.5**	**2**	**4.3J** [a]	**3.6**
DCE	**0.59 J**	**16**	**0.19 J**	**0.47 J**	**1**	**0.75 J**	**2.5**	**0.67 J**	**1.4 J**	**1**
7W										
PCE	**0.53 J**	1 U	1 U	1 U	1 U	1 U	2 U	2 U	1 U	2 U
TCE	1 U	1 U	1 U	1 U	1 U	1 U	2 U	1 U	1 U	1 U
DCE	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	2 U	1 U
8W										
PCE	--	--	--	--	--	--	--	--	--	--
TCE	--	--	--	--	--	--	--	--	--	--
MW-5										
PCE	1 U	1 U	1 UJ	1 U	1 U	1 U	2 U	2 U	1 U	2 U
TCE	1 U	1 U	1 U	1 U	1 U	1 U	2 U	1 U	1 U	1 U
MW-6										
PCE	1 U	1 U	1 UJ	1 U	1 U	1 U	2 U	2 U	1 U	2 U
TCE	1 U	1 U	1 U	1 U	1 U	1 U	2 U	1 U	1 U	1 U
MW-7										
PCE	--	--	--	--	--	--	--	--	--	--
TCE	--	--	--	--	--	--	--	--	--	--
MW-8										
PCE	--	--	--	--	--	--	--	--	--	--
TCE	--	--	--	--	--	--	--	--	--	--

PCE - tetrachloroethylene. TCE - trichloroethylene. DCE - cis-1,2-dichloroethylene.

U - Analyte was not detected at or above the reported value.
J - Analyte was positively identified. The associated numerical result is an estimate.
UJ - Analyte was not detected at or above the reported estimated result.

[a] - Average concentration of duplicate samples.

Bold = Analyte was detected.