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For more information contact:

Publications Coordinator
Environmental Assessment Program
P.O. Box 47600, Olympia, WA 98504-7600
Phone: (360) 407-6677

Washington State Department of Ecology - www.ecy.wa.gov/

o	Headquarters, Olympia	(360) 407-6000
o	Northwest Regional Office, Bellevue	(425) 649-7000
o	Southwest Regional Office, Olympia	(360) 407-6300
o	Central Regional Office, Yakima	(509) 575-2490
o	Eastern Regional Office, Spokane	(509) 329-3400

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Shelton Laundry and Cleaners
Groundwater Monitoring Results

October 2008 and June 2009

by
Pamela B. Marti

Environmental Assessment Program
Washington State Department of Ecology
Olympia, Washington 98504-7710

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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 was primarily detected in well 4W with a concentration range of 10 to 25 µg/L. PCE was detected at concentrations near the reporting limit of 1 µg/L in shallow well 7W and was not detected in any of the other wells.

In June 2005, to remediate the contamination, 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, contaminant concentrations have been steadily increasing to their pre-injection concentrations. HRC typically has an effective longevity of 12 to 18 months.

This report describes the results of groundwater samples collected in October 2008 and June 2009 from three shallow wells and two deep wells. PCE was detected in well 4W with concentrations ranging from 8 to 11 µg/L, not meeting the MTCA cleanup level. Trichloroethylene (TCE) and cis-1,2-dichloroethylene (cis-DCE) were also detected in well 4W, at concentrations near or below the reporting limit of 1 µg/L. PCE, TCE, and cis-DCE were not detected in any of the other sampled wells.

Groundwater monitoring should continue for the next year because PCE concentrations continue to not meet the MTCA Method A cleanup level of 5 µg/L in well 4W. However, reducing the number of wells in the monitoring program should be considered to lower the financial expenditure of this project.

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 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, 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 located nearest to the reported spill location (4W). 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 to a depth of 45 feet, adjacent to existing shallow wells. The fourth well was installed south of the site to a depth of 60 feet. PCE was not detected in any of the four deep 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.

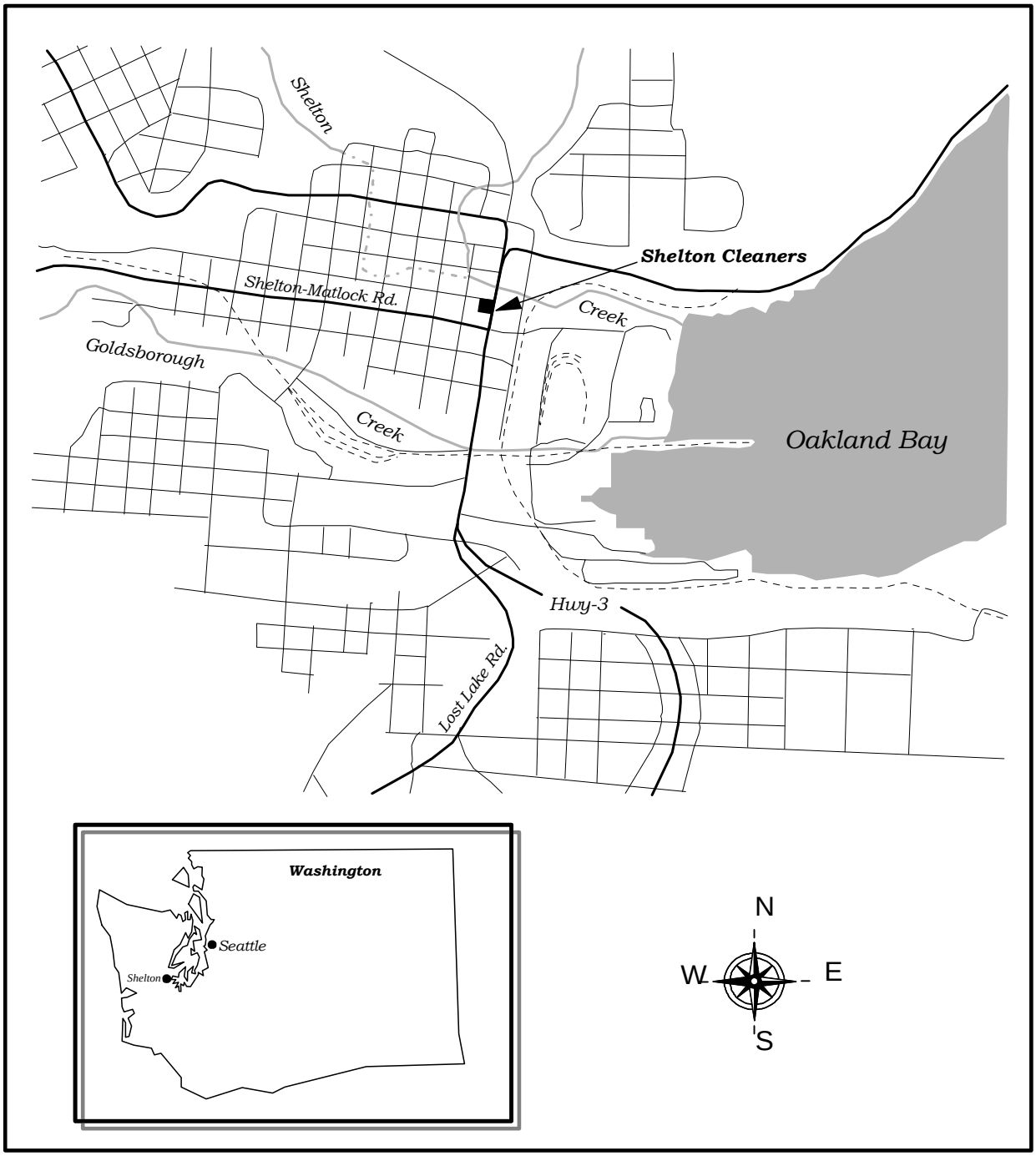

Figure 1. Shelton Laundry and Cleaners Site Location.

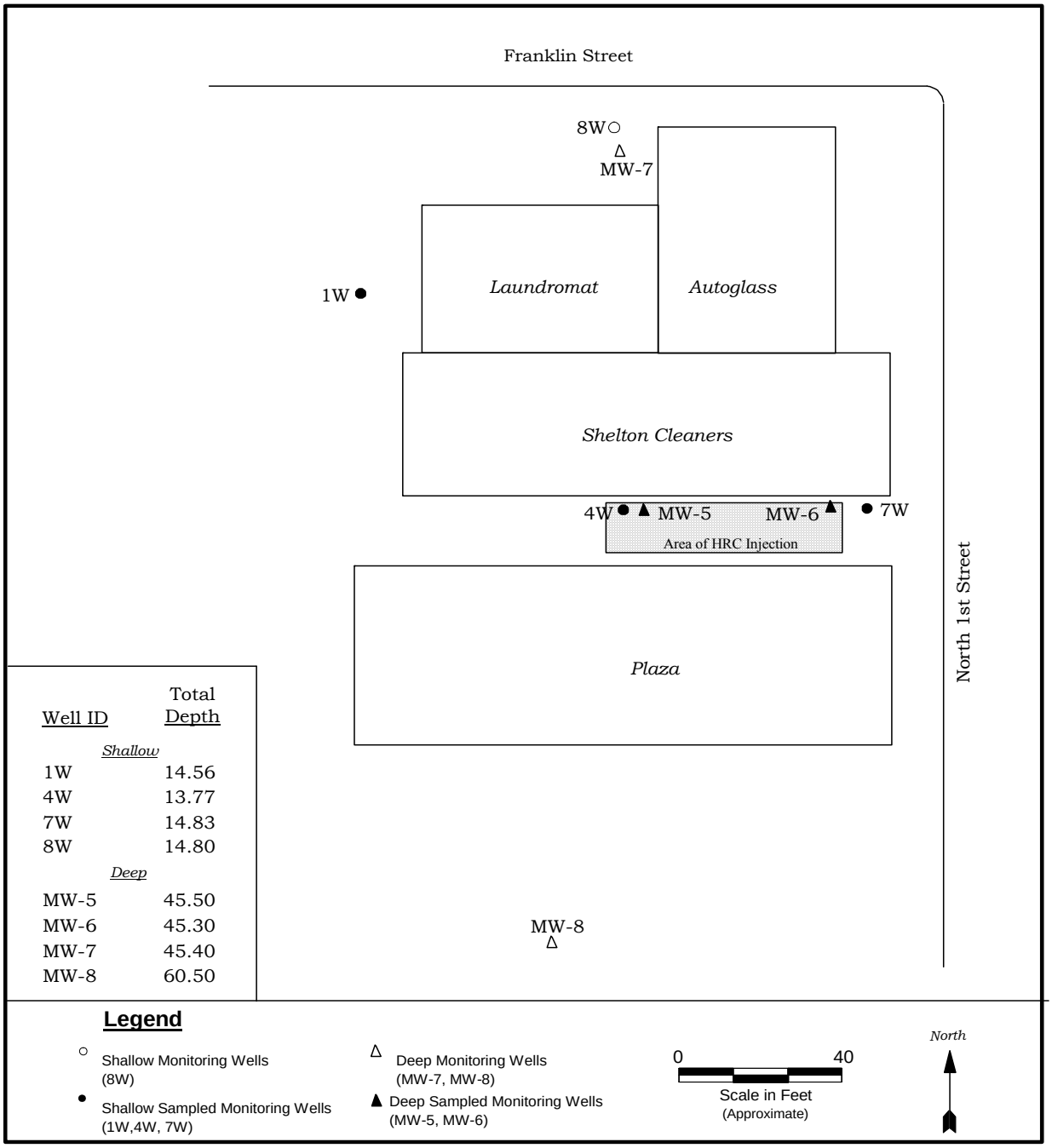

Figure 2. Shelton Laundry and Cleaners Sample Locations, October 2008 and June 2009.

In an effort to remediate the 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 trichloroethylene (TCE) concentrations decreased while cis-1,2-dichloroethylene (cis-DCE) 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 to the pre-injection concentrations. HRC typically has an effective longevity of about 12 to 18 months.

Site Geology

Site well logs indicate the Shelton Laundry and Cleaners 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 grades to silty, fine gravel with some fine to coarse sand from 6 to 14 feet below the 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 – 2009 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 October 2008 and June 2009 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. After labeling, all samples were stored in an ice-filled cooler. Samples were transported to Ecology's Operation Center in Lacey, Washington. 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 Laboratory protocol (Ecology, 2008).

Both sampling 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 VOCs by Manchester Laboratory.

Table 1. Field and Laboratory Methods.

Field Measurements	Instrument Type	Method	Accuracy
Water Level	Solinst Water Level Meter	SOP EAP052	±0.03 feet
pH	Sentix® 41-3 probe[1]	EPA Method 150.1	±0.1 std. units
Specific Conductance	Tetracon® 325 probe[1]	EPA Method 120.1	±10 µmhos/cm
Temperature	Sentix® 41-3 probe[1]	EPA Method 150.1	±0.1 ºC
Laboratory Analytes	**Method**	**Reference**	**Reporting Limit**
VOCs	EPA SW-846 Method 8260B	EPA 1996	1-5 µg/L

SOP = standard operating procedure.
EAP = Ecology's Environmental Assessment Program.
EPA = U.S. Environmental Protection Agency.
[1] Probe used with a WTW multiline P4 meter.

Data Quality

Quality control samples collected in the field consisted of blind field duplicates from well 4W. 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.

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), October 2008 and June 2009.

Well Sample ID	Tetrachloroethylene (PCE)		Trichloroethylene (TCE)		Cis-1,2-Dichloroethylene (cis-DCE)	
	10/08	6/09	10/08	6/09	10/08	6/09
4W	8	11	1.5	1.9	0.5 J	0.62 J
4W-A	7.4	14	1.3	2.3	0.43 J	0.72 J
RPD (%)	8%	24%	14%	19%	--	--

J - Analyte was positively identified. The associated numerical result is an estimate.

In October 2008 and June 2009, the RPD for duplicate results from monitoring well 4W ranged from 8% to 24%. Cis-DCE results have been qualified as estimates 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. No problems were reported that compromised the usefulness or validity of the sample results; therefore, all results are 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

Depth-to-water of each monitoring well was measured prior to purging. End-of-purge pH, temperature, and specific conductivity readings, as well as the total purge volume, are listed in Table 3.

Table 3. Summary of Field Parameter Results, October 2008 and June 2009.

Well Sample ID	Total Depth (feet)[1]	Depth-to-Water Below Ground Surface (feet)		Water Table Elevation (feet msl)		pH (standard units)		Temperature (°C)		Specific Conductivity (µmhos/cm)		Purge Volume (gallons)	
		10/08	6/09	10/08	6/09	10/08	6/09	10/08	6/09	10/08	6/09	10/08	6/09
Shallow													
1W	14.56	5.81	5.50	9.29	9.60	--	7.4	11.5	13.0	201	198	1.5	2
4W	13.77	5.26	4.99	9.41	9.68	--	7.2	12.7	12.9	198	194	2	2
7W	14.83	4.80	4.53	9.3	9.57	--	7.3	11.8	11.8	200	195	2	2
Deep													
MW-5	45.5	5.28	4.98	9.38	9.68	--	7.3	12.7	11.9	199	193	7	8
MW-6	45.3	4.90	4.64	9.35	9.61	--	7.2	12.0	11.3	206	200	8	8

[1] Measured from top of PVC casing.
-- Not measured.

Completion depths for the five monitoring wells ranged from 13.77 to 45.5 feet. Depth-to-groundwater below the land surface ranged from 4.80 to 5.81 feet in October 2008 and 4.53 to 5.50 feet in June 2009.

Hydrographs showing water-level elevations for each well, along with monthly precipitation values from May 2002 to June 2009, are shown in Figure 3. Hydrograph data are presented in Appendix A. 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, 2005, and 2009 because semi-annual monitoring did not occur during peak months. Water level elevations in September and November 2007 were lower; this may be attributed to sewer and other construction work conducted in the area during this period.

A typical groundwater flow pattern based on water levels measured in June 2009 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.

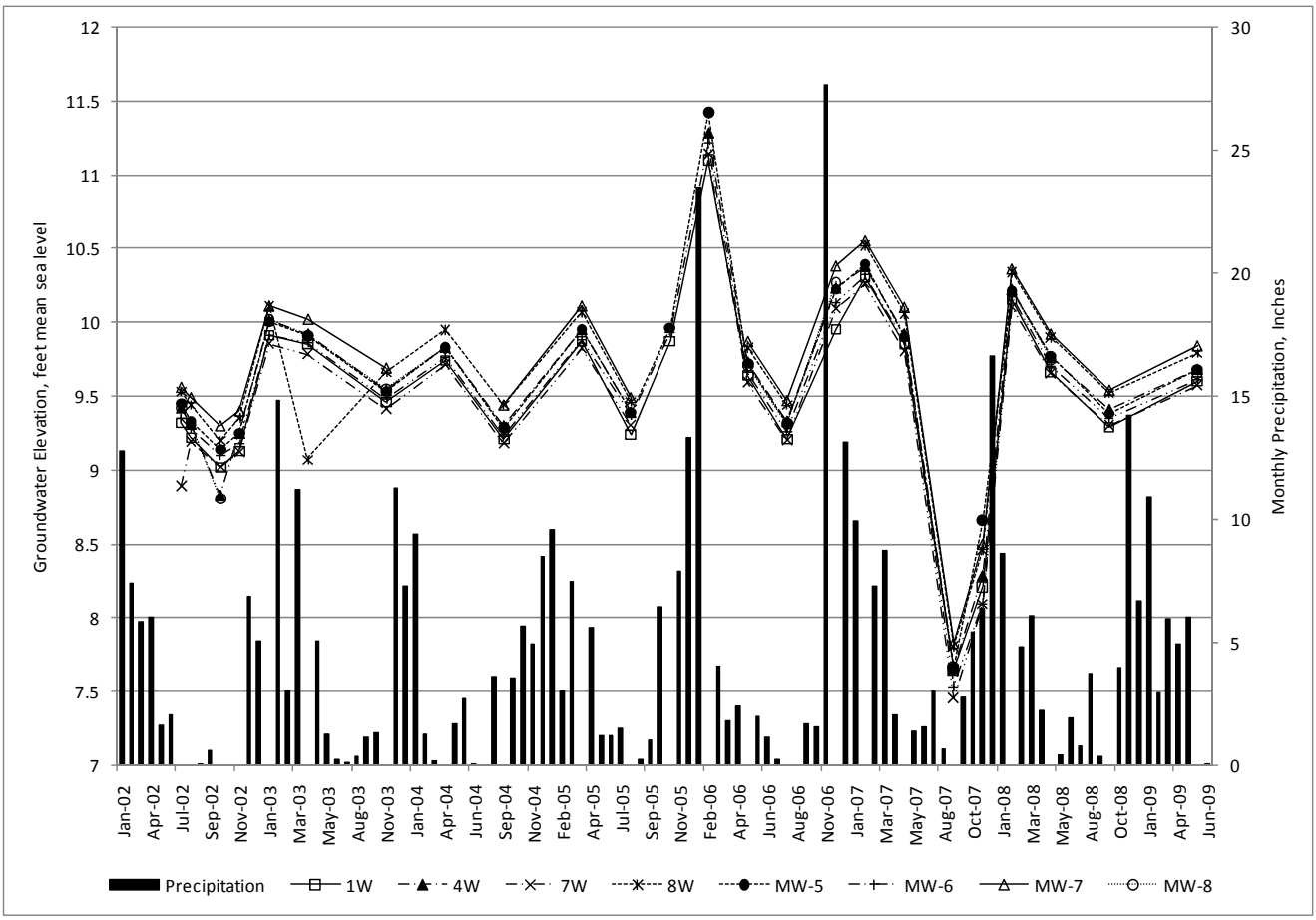

Figure 3. Shelton Laundry and Cleaners – Hydrographs, May 2002 through June 2009.

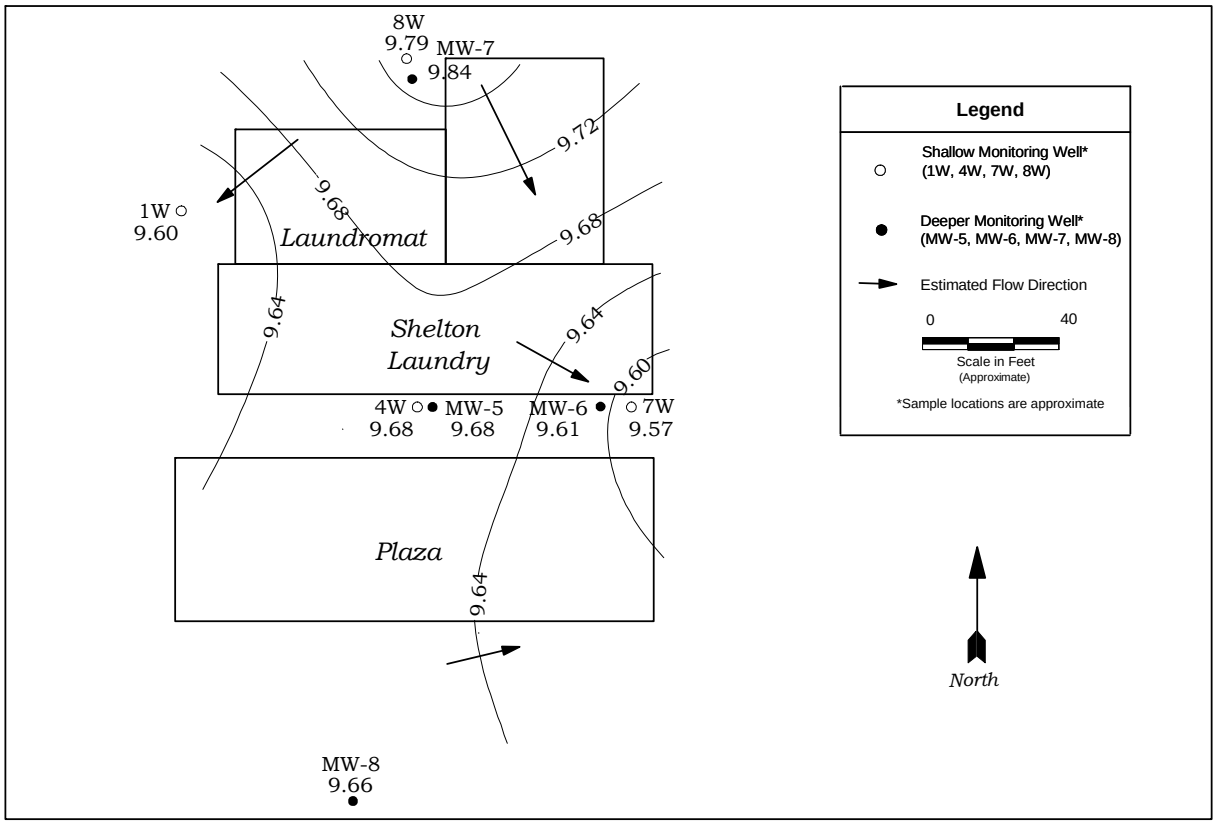

Figure 4. Shelton Laundry and Cleaners – Water Table Elevation, June 2009.

Field parameter results for October 2008 and June 2009 were within expected ranges. During the monitoring period, pH of the groundwater had an average of 7.3. Groundwater temperatures from grab samples ranged from 11.3º to 13 ºC with an average of 12.2ºC. Temperatures measured from grab samples are subject to change due to ambient air conditions and therefore are not considered to be representative of in-situ groundwater conditions. Specific conductivity measurements had an average range of 196 to 201 µmhos/cm.

Analytical Results

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

Table 4. Summary of Analytical Results (µg/L), October 2008 and June 2009.

Well ID	Tetrachloroethylene (PCE)		Trichloroethylene (TCE)		Cis-1,2-Dichloroethylene (cis-DCE)	
	10/08	6/09	10/08	6/09	10/08	6/09
Shallow						
1W	1 U	1 U	1 U	1 U	1 U	1 U
4W	**8**	**11**	**1.5**	**1.9**	**0.5 J**	**0.62 J**
7W	1 U	1 U	1 U	1 U	1 U	1 U
Deep						
MW-5	1 U	1 U	1 U	1 U	1 U	1 U
MW-6	1 U	1 U	1 U	1 U	1 U	1 U

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 both the October 2008 and June 2009 sampling. PCE concentrations in this well ranged from 8 to 11 µg/L. TCE and cis-DCE concentrations in well 4W were near or below the practical quantitation limit of 1 µg/L.

PCE, TCE, and cis-DCE were not detected in shallow wells 1W and 7W. These contaminants have not been detected in well 1W since monitoring began in 1998. PCE was last detected in well 7W in February 2006 at a concentration of 0.53 µg/L.

Volatile organics have not been detected in the four 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 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 respectively, 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, a breakdown product, could be an indication of enhanced degradation due to the HRC injection.

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

Between August 2005 and May 2006, 2-butanone, also known as methyl ethyl ketone (MEK), was detected 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. 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 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, returning to their pre-HRC injection concentrations. The average PCE concentration in well 4W for data collected from 2007 through 2009 is 15 µg/L.

The increase of PCE, TCE, and cis-DCE concentrations suggest that the HRC is past its effectiveness. In a review of HRC 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.

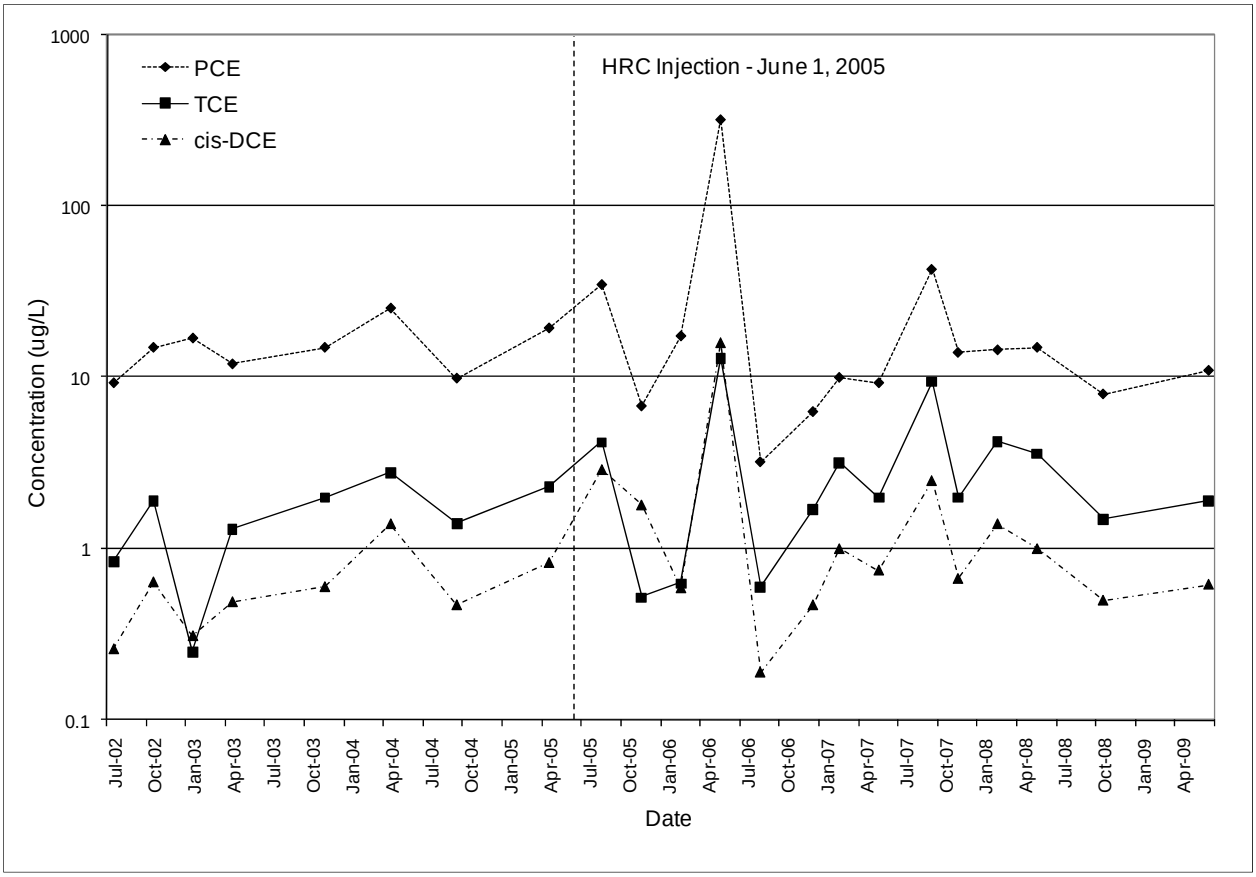

Figure 5: PCE, TCE, and cis-DCE Concentrations (µg/L – log scale) in well 4W, July 2002 through June 2009.

Conclusions and Recommendations

Conclusions

During the monitoring periods of October 2008 and June 2009, PCE concentrations in well 4W continue to exceed the MTCA Method A cleanup level of 5 µg/L. PCE concentrations ranged from 8 to 11 µg/L.

TCE and cis-DCE, associated with the breakdown of PCE, were also detected in well 4W but below their respective cleanup levels of 5 µg/L and 70 µg/L. TCE concentrations ranged from 1.5 to 1.9 µg/L, and cis-DCE concentrations ranged from an estimated 0.5 to 0.62 µg/L.

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 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 following the injection.

The lowest contaminant concentrations were observed in August 2006, 15 months following the HRC injection. However, concentrations have been steadily increasing during the past three years, returning to their pre-HRC injection concentrations. The 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 for the next year because PCE concentrations in well 4W continue to exceed the MTCA Method A cleanup level of 5 µg/L. However, reducing the number of wells in the monitoring program should be considered to lower the financial expenditures of this project.

Well 4W should continue to be sampled on a semi-annual basis because of the continued PCE contamination in groundwater samples from this well.

PCE has been detected in groundwater samples from shallow well 7W (0.15 µg/L to 1.7 µg/L), Although it has not been detected since February 2006 (0.53 J µg/L), this well should remain in the monitoring program for the time being.

Because contaminants have never been detected in shallow well 1W and deep wells MW-5 and MW-6, it is recommended that these wells be removed from the monitoring program.

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Appendices

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Appendix A. Hydrograph Data

Table A-1. Groundwater Elevations (feet above mean sea level), May 2002 through June 2009.

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	9.20	9.14	9.10	9.30	8.81
11/26/02	9.13	9.25	9.12	9.35	9.25	9.18	9.50	--
1/21/03	9.91	10.01	9.85	10.11	10.00	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	9.30	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	11.10	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	9.20	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	9.80	10.06	9.90	9.87	10.10	--
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	8.10	8.50	--
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	9.90	9.77	9.70	9.92	9.75
10/20/08	9.29	9.41	9.30	9.52	9.38	9.35	9.54	--
6/12/09	9.60	9.68	9.57	9.79	9.68	9.61	9.84	9.66

-- Not measured.

Appendix B. Historical Data

Table B-1. PCE, TCE, and DCE Groundwater Results (µg/L), May 1997 through June 2009.

Well ID	Building Analytics	AA Enviro Assessment	GeoEngineers				Ecology									
	5/21/97	3/3/98	7/24/98	11/18/98	7/12/99	9/6/00	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	NS	1 U	1 U	1 U	1 U	--	--	--	--	1 U	1 U
TCE	--	--	<1.0	<1.0	<1.0	NS	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	This deep monitoring well was 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	This deep monitoring well was 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	This deep monitoring well was installed in 2002.						1 U	1 U	1 U	1 U	--	--	--	--	--	--
TCE							1 U	2 U	1 U	1 U	--	--	--	--	--	--
MW-8																
PCE	This deep monitoring well was installed in 2002.						1 U	1 U	1 U	1 U	--	--	--	--	--	--
TCE							1 U	2 U	1 U	1 U	--	--	--	--	--	--

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.

UJ - Analyte was not detected at or above the reported estimated result.

J - Analyte was positively identified. The associated numerical result is an estimate.

[a] - Average concentration of duplicate samples.

Table B-1 (continued). PCE, TCE, and DCE Groundwater Results (µg/L), May 1997 through June 2009.

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	10/20/09	6/12/09
1W												
PCE	1 U	1 U	1 U	1 U	1 U	1 U	2 U	2 U	1 U	2 U	1 U	1 U
TCE	1 U	1 U	1 U	1 U	1 U	1 U	2 U	1 U	1 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**	**8**	**11**
TCE	**0.63 J**	**13**	**0.60 J**	**1.7**	**3.2**	**2**	**9.5**	**2**	**4.3J**[a]	**3.6**	**1.5**	**1.9**
DCE	**0.59 J**	**16**	**0.19 J**	**0.47 J**	**1**	**0.75 J**	**2.5**	**0.67 J**	**1.4 J**	**1**	**0.5 J**	**0.62 J**
7W												
PCE	**0.53 J**	1 U	1 U	1 U	1 U	1 U	2 U	2 U	1 U	2 U	1 U	1 U
TCE	1 U	1 U	1 U	1 U	1 U	1 U	2 U	1 U	1 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	1 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	1 U	1 U
TCE	1 U	1 U	1 U	1 U	1 U	1 U	2 U	1 U	1 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	1 U	1 U
TCE	1 U	1 U	1 U	1 U	1 U	1 U	2 U	1 U	1 U	1 U	1 U	1 U
MW-7												
PCE	--	--	--	--	--	--	--	--	--	--	--	--
TCE	--	--	--	--	--	--	--	--	--	--	--	--
MW-8												
PCE	--	--	--	--	--	--	--	--	--	--	--	--
TCE	--	--	--	--	--	--	--	--	--	--	--	--

Bold = Analyte was detected.

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.

Appendix C. Glossary, Acronyms, and Abbreviations

Glossary

Depth-to-water: A measure of depth to the water (i.e., water level) in a well.

Depth-to groundwater: A measure of depth to the water (i.e., water level) in a well.

Grab sample: A discrete sample from a single point in the water column or sediment surface.

Groundwater: Water in the subsurface that saturates the rocks and sediment in which it occurs. The upper surface of groundwater saturation is commonly termed the water table.

Hydrograph: A graph showing a record of water levels observed in wells over time showing the seasonal change.

Parameter: Water quality constituent being measured (analyte). A physical, chemical, or biological property whose values determine environmental characteristics or behavior.

Specific conductance: A measure of water's ability to conduct an electrical current. Specific conductance is related to the concentration and charge of dissolved ions in water.

Acronyms and Abbreviations

Cis-DCE	Cis-1,2-dichloroethylene
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
HRC	Hydrogen release compound
MTCA	Model Toxic Control Act
PCE	Tetrachloroethylene
PVC	Polyvinyl chloride
RPD	Relative percent difference
TCE	Trichloroethylene
VOC	Volatile organic compound
WAC	Washington Administrative Code

Units of Measurement

°C	degrees centigrade
µg/L	micrograms per liter (parts per billion)
umhos/cm	micromhos per centimeter