

DEPARTMENT OF  
**ECOLOGY**  
State of Washington

## **Shelton Laundry and Cleaners Groundwater Monitoring Results**

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**November 2009 and June 2010**

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**Shelton Laundry and Cleaners  
Groundwater Monitoring Results**  

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**November 2009 and June 2010**

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 solvent spill outside the dry cleaner's commercial building. Monitoring of four shallow wells in 1998 detected PCE in the local aquifer at concentrations as high as 280 ug/L in the well located nearest to the reported spill location (4W). The Washington State Model Toxic Control Act (MTCA) Method A cleanup level for PCE is 5 ug/L.

In 2002, the Washington State Department of Ecology (Ecology) installed four additional deep wells and began monitoring the groundwater quality of all eight wells. From 2002 to 2005, PCE was consistently detected in well 4W over a concentration range of 10 to 25 ug/L. PCE was detected in one other shallow well, located near well 4W, but at concentrations below 1 ug/L. PCE was not detected in any of the other wells.

In June 2005, in an attempt to remediate the contamination, Ecology contractors injected a hydrogen release compound (HRC<sup>®</sup>) into the groundwater around well 4W. Following the HRC injection, groundwater monitoring results indicated that the HRC was temporarily effective in reducing the contaminant concentrations. However, since August 2006, concentrations have steadily returned to their pre-HRC injection concentrations, suggesting the HRC is no longer effective.

This report describes the water quality results for groundwater samples collected in November 2009 and June 2010 from three of the shallow wells and two of the deep wells. PCE was detected in well 4W at concentrations ranging from approximately 6 to 41 ug/L. Trichloroethylene (TCE) and cis-1,2-dichloroethylene (cis-DCE) were also detected in well 4W, at concentrations at or just above the reporting limit of 1 ug/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 remain above the MTCA Method A cleanup level of 5 ug/L in well 4W.

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# Introduction

## Background

Tetrachloroethylene (PCE) contamination of shallow groundwater was discovered in 1997 during an environmental site assessment of a commercial property in Shelton, Washington. The most likely source of the contamination was identified as a dry cleaning facility, located adjacent to the property where the site assessment was conducted (Building Analytics, 1997) (Figure 1).

Based on the environmental assessment report, which was submitted to the Washington State Department of Ecology (Ecology), Shelton Laundry and Cleaners was listed on Ecology's *Confirmed and Suspected Contaminated Site List* in December 1997.

A commercial laundry and dry cleaning facility has been in operation at the site since 1935. In 1993, an unknown quantity of dry cleaning solvent was reportedly spilled in the alley between the two properties during the removal of an old dry cleaning machine (GeoEngineers, 1998). 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 between 1997 and 2000. These investigations concluded that PCE contamination occurred in the shallow groundwater in the southeastern portion of the site beneath the alley (GeoEngineers, 2000). Groundwater samples collected from four shallow (approximately 15 feet deep) monitoring wells (1W, 4W, 7W, and 8W) showed that PCE contamination was primarily detected in the well located nearest to the reported spill location (4W) (Figure 2). PCE concentrations in this well decreased from 280 ug/L (July 1998) to 25 ug/L (September 2000) (GeoEngineers, 2000).

Ecology conducted a follow-up investigation in 2002 to determine the status of the PCE groundwater contamination. As part of the investigation, Ecology installed four additional monitoring wells (MW-5 through MW-8) 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.

Because PCE concentrations in well 4W were higher than the Washington State Model Toxic Control Act (MTCA) Method A cleanup level of 5 ug/L for groundwater, Ecology continued to monitor the water 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 ug/L.

In an effort to remediate the contamination, in June 2005, a Hydrogen Release Compound (HRC<sup>®</sup>) was injected into the shallow aquifer. HRC produces hydrogen that fuels the anaerobic biodegradation processes in soil and groundwater which is the mechanism by which chlorinated compounds are biodegraded into less harmful constituents. The HRC was injected below the water table at depths of 5 to 20 feet below ground surface (bgs) at 16 locations between wells 4W and 7W (Figure 2) (Balaraju, 2005).

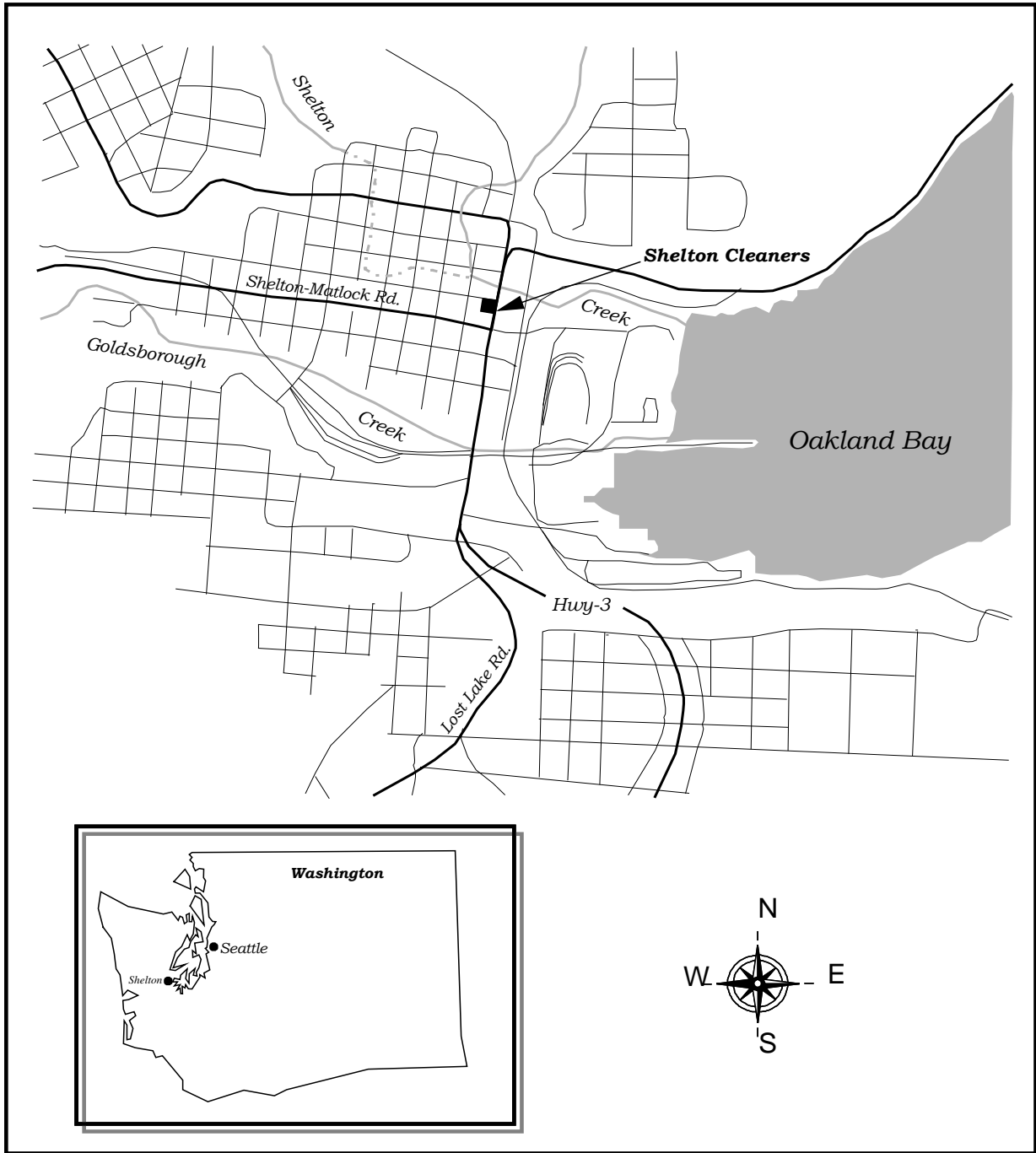


Figure 1. Shelton Laundry and Cleaners Site Location.

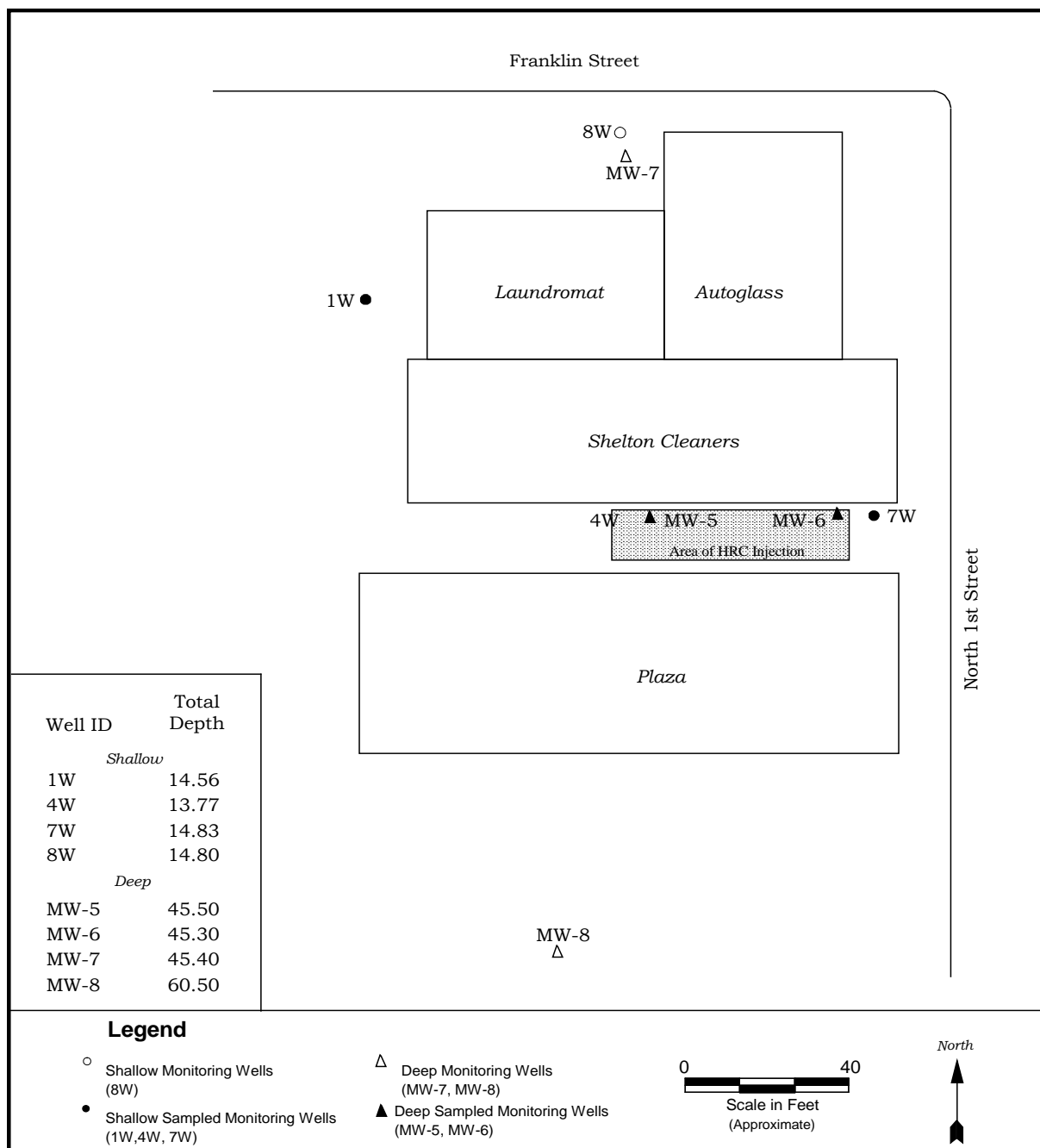


Figure 2. Shelton Laundry and Cleaners Sample Locations, November 2009 and June 2010.

Prior to the HRC injection, Ecology collected groundwater and soil samples from some of the temporary remediation borings. Groundwater samples were collected at a depth of 10–13 feet bgs. In the four borings where PCE was detected, concentrations ranged from approximately 0.25 to 27 ug/L. PCE was also detected in two shallow soil samples collected from 4-8 feet bgs at concentrations of 88 and 269 ug/Kg. PCE concentrations in soil samples collected from 12-16 feet bgs in the same borings decreased to an estimated 0.65 and 1.2 ug/Kg, respectively. The two borings in which these soil samples were collected were located near well 4W.

Results from the first year of monitoring following the HRC injection suggest that enhanced degradation was occurring. PCE and trichloroethylene (TCE) concentrations decreased while cis-1,2-dichloroethylene (cis-DCE), a breakdown product, concentrations increased. The contaminant concentrations in well 4W were at their lowest in August 2006, 15 months following the HRC injection, but have steadily increased to pre-injection concentrations. HRC typically has an effective longevity of about 12 to 18 months (Willett, 2004).

Ecology continues to monitor the site groundwater because PCE concentrations in well 4W continue to exceed the MTCA cleanup level of 5 ug/L.

## Hydrogeology

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. These surficial deposits are underlain by an undetermined thickness of gravely sands with minor sand interbeds. The well log for 4W, the location where PCE is primarily detected, shows the upper silty-sand layer grading to silty, fine gravel with some fine to coarse sand from 6 to 14 feet bgs (GeoEngineers, 1998). Soils from split spoon samples collected in June 2005 near well 4W indicate the presence of a silt layer at approximately four feet below the ground surface. Ecology detected elevated concentrations of PCE in soil samples collected at this depth.

The gravely sands in which all eight monitoring wells are screened are interpreted as Vashon recessional outwash deposits, which underlay the western outwash plain between Shelton and the Skokomish Valley to the north. The site wells do not reach the base of this unit, but well logs for deeper production wells 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 beneath the project site ranged from approximately three to six feet during the 1997 – 2009 study period. Groundwater flow patterns determined from site water levels are southward. It is likely that the direction of groundwater flow is influenced by Shelton Creek, located about 300 feet north of the site. The local flow direction in the area of well 4W, the primary location of the PCE contamination, is toward the southeast and Oakland Bay (approximately 2000 feet away).

# Methods

## Groundwater Monitoring

Ecology collected groundwater samples in November 2009 and June 2010 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) are 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) are constructed of 2-inch diameter PVC to a depth of about 45 feet, with the screened interval from 35-45 feet bgs.

Ecology measured static water levels in all wells, prior to well purging and sampling, using a water level meter with a 1/4-inch diameter probe. Measurements were collected according to procedures in standard operating procedure (SOP) EAP052 (Marti, 2009).

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  $\leq 1$ -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).

## Analysis

Analytes, analytical methods, and reporting limits for both field and laboratory parameters are listed in Table 1. Manchester Laboratory analyzed all groundwater samples for VOCs.

Table 1. Field and Laboratory Methods.

Field Measurements	Instrument Type	Method	Accuracy
Water Level	Solinst Water Level Meter	SOP EAP052	±0.03 feet
pH	YSI ProPlus with Quatro Cable	EPA 150.1 (EPA, 2001a)	±0.2 standard units
Specific Conductance	YSI ProPlus with Quatro Cable	EPA 120.1 (EPA, 2001b)	±10 umhos/cm
Temperature	YSI ProPlus with Quatro Cable	EPA Method 150.1	±0.2 °C
Laboratory Analytes	Method	Reference	Reporting Limit
VOCs	EPA SW-846 Method 8260B	EPA 1996	1-5 ug/L

EAP: Ecology's Environmental Assessment Program.

# Results

## Data Quality Assessment

Quality control samples collected in the field consisted of blind field duplicates from well 4W. Ecology collected field duplicates 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 (ug/L), November 2009 and June 2010.

Well Sample ID	Tetrachloroethylene (PCE)		Trichloroethylene (TCE)		Cis-1,2-Dichloroethylene (cis-DCE)	
	11/09	6/10	11/09	6/10	11/09	6/10
4W	6.9	32	1.2	3.3	1 U	1.0
4W-A	5.3	49	0.97 J	4.6	1 U	1.2
RPD (%)	26%	42%	--	33%	--	18%

MW-4A is the duplicate sample identification.

U: Analyte was not detected at or above the reported value.

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

In November 2009 and June 2010, the RPD for duplicate results from monitoring well 4W ranged from 18% to 42%. The data from well 4W did not meet the data quality objectives established in the Quality Assurance Project Plan (Marti, 2002). The goal for total precision (analytical and sampling) for duplicate volatile organic samples is 15% RPD. The RPDs for the PCE and TCE data failed to meet this goal. However, because the concentrations are within the range of previous results detected in this well, an average concentration of the duplicate samples will be used in the remainder of this report. All data have been “J” qualified as estimated.

A review of the laboratory data quality control and quality assurance results indicates that the overall 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](http://www.ecy.wa.gov/eim/index.htm) at study ID: PMART001.

## Field Results

Ecology measured depth-to-water in each monitoring well 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, November 2009 and June 2010.

Well Sample ID	Total Depth (feet) <sup>1</sup>	Depth-to-Water Below Ground Surface (feet)		Water Table Elevation (feet) <sup>2</sup>		pH (standard units)		Temperature (°C)		Specific Conductance (umhos/cm)		Purge Volume (gallons)	
		11/09	6/10	11/09	6/10	11/09	6/10	11/09	6/10	11/09	6/10	11/09	6/10
Shallow Wells													
1W	14.56	4.05	--	11.05	--	7.2	7.3	11.0	12.1	201	196	2	2
4W	13.77	3.55	--	11.12	--	7.1	7.2	11.9	12.2	196	194	2	2
7W	14.83	3.13	4.30	10.97	9.80	7.2	7.3	11.2	11.3	196	196	2	1.75
Deep Wells													
MW-5	45.5	3.55	4.64	11.11	10.02	7.1	7.2	12.5	11.9	193	193	8	8
MW-6	45.3	3.20	4.30	11.05	9.95	7.1	7.2	11.8	11.5	201	199	7	8

<sup>1</sup> Measured from top of PVC casing.

<sup>2</sup> Vertical Datum NGVD29.

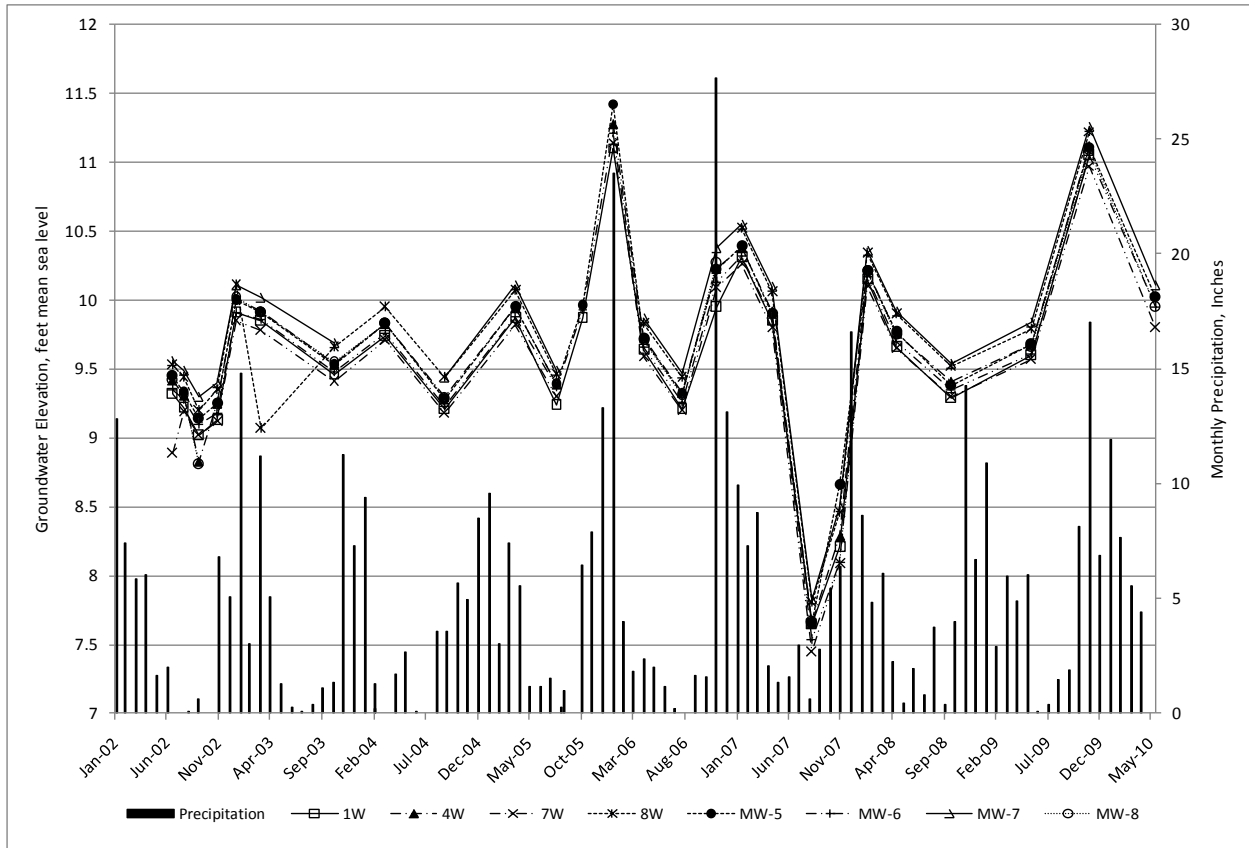
-- Not measured.

Completion depths for the five monitoring wells ranged from 13.77 to 14.83 feet for the shallow wells and 45.3 to 45.5 feet for the deep wells. Depth-to-groundwater below the ground surface was measured in all eight wells and ranged from 2.82 to 4.23 feet in November 2009 and 4.06 to 5.37 feet in June 2010.

Hydrographs showing water-level elevations for each well, along with monthly precipitation values from May 2002 to June 2010, 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 horizontal 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 than normal; this may be attributed to dewatering during sewer and other construction work conducted in the area during this period.

A typical groundwater flow pattern based on water levels measured in November 2009 is shown in Figure 4. The groundwater flow direction is approximately perpendicular to the contours. The local flow direction downgradient of the PCE source area is toward the southeast.





Precipitation data provided by the Office of Washington State Climatologist, Station #457585, Sanderson Field Airport, Shelton, Washington.

Figure 3. Shelton Laundry and Cleaners – Hydrographs, May 2002 through June 2010.

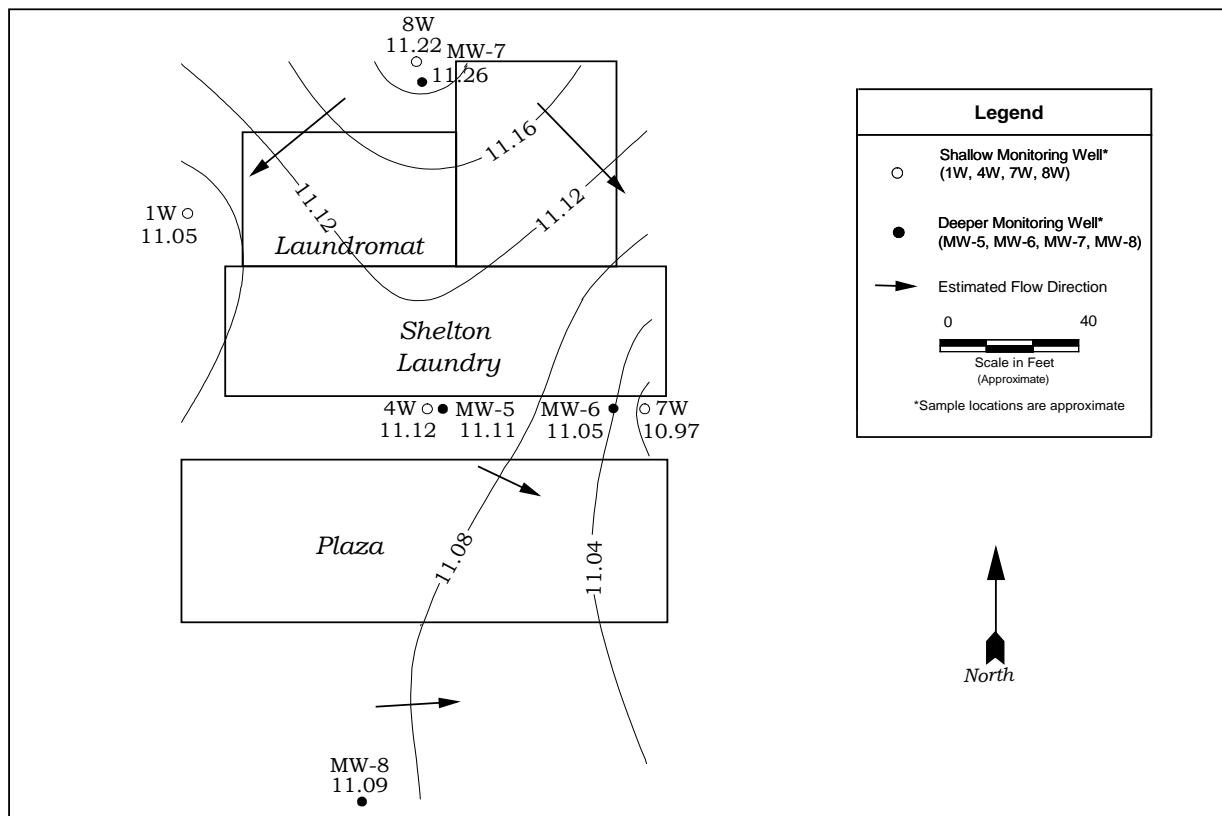


Figure 4. Shelton Laundry and Cleaners – Water Table Elevation (ft, NGVD29), November 2009.

Field parameter results for November 2009 and June 2010 were within expected ranges. During the monitoring period, pH of the groundwater had an average of 7.2. Groundwater temperatures from grab samples ranged from 11.0° to 12.5 °C with an average of 11.7°C. 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 conductance measurements had an average of 197  $\mu\text{mhos/cm}$ .

## 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 (ug/L), November 2009 and June 2010.

Well ID	Tetrachloroethylene (PCE)		Trichloroethylene (TCE)		Cis-1,2-Dichloroethylene (cis-DCE)	
	11/09	6/10	11/09	6/10	11/09	6/10
Shallow						
1W	1 U	1 U	1 U	1 U	1 U	1 U
4W	<b>6.1 J<sup>a</sup></b>	<b>41 J<sup>a</sup></b>	<b>1.2</b>	<b>3.9 J<sup>a</sup></b>	1 U	<b>1</b>
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

<sup>a</sup> Average concentration of duplicate samples. Result is J qualified as an 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 and TCE were detected in well 4W during both the November 2009 and June 2010 sampling. PCE concentrations in this well ranged from approximately 6 to 41 ug/L. TCE and cis-DCE concentrations in well 4W were at or just above the practical quantitation limit of 1 ug/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 ug/L.

Volatile organics 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 injection, the average PCE and TCE concentrations in this well were 15 ug/L and 1.6 ug/L, respectively. Five months following the HRC injection (November 2005), PCE and TCE concentrations decreased to 6.8 ug/L and 0.52 ug/L respectively, while cis-DCE concentrations increased from a pre-HRC average of 0.62 ug/L to 1.8 ug/L. The decrease in PCE and TCE concentrations, combined with the increase in cis-DCE concentrations, a breakdown product, suggest a period of enhanced degradation due to the HRC injection.

PCE concentrations increased to 17.5 ug/L in February 2006 and to a high of 324 ug/L in May 2006. Concentrations of TCE and cis-DCE also increased to a high of 13 ug/L and 16 ug/L, respectively, in May 2006. Hansen et al. (2000) noted that there can be temporary increases in aqueous contaminant concentrations in a 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 ug/L in August 2005 to a low of 2 ug/L in May 2006. MEK was detected in well 7W in August and November 2005 at concentrations of 9.8 ug/L and 3.8 ug/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 ug/L), TCE (0.6 ug/L), and cis-DCE (0.19 ug/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 ug/L since monitoring began in 2002. However, since August 2006, PCE, TCE, and cis-DCE concentrations have steadily increased, returning to their pre-HRC injection concentrations (Figure 5). The average PCE concentration in well 4W for data collected from 2007 through 2010 is 17 ug/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. Data from the Shelton site corresponds to the predicted HRC effective longevity.

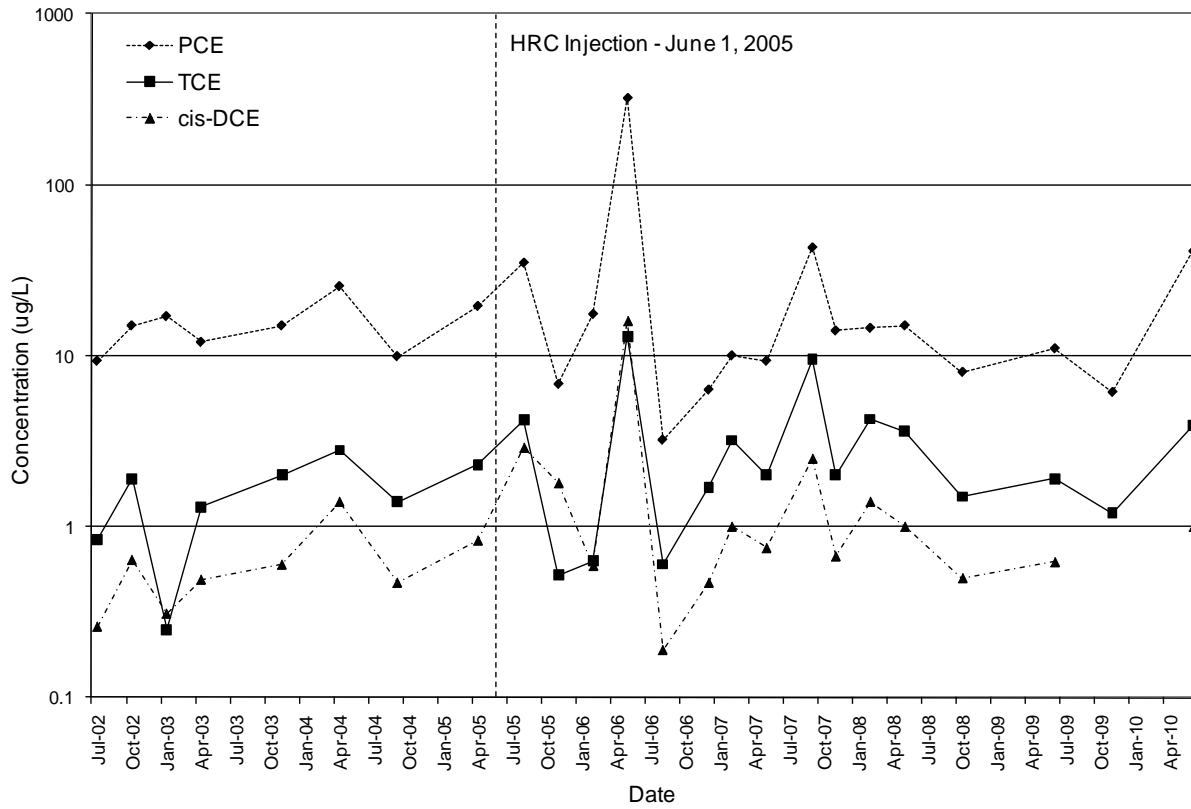


Figure 5. PCE, TCE, and cis-DCE Concentrations (ug/L – log scale) in Well 4W, July 2002 through June 2010.

# Conclusions and Recommendations

## Conclusions

During the monitoring periods of November 2009 and June 2010, PCE concentrations in well 4W continue to not meet (exceed) the MTCA Method A cleanup level of 5 ug/L. PCE concentrations ranged from approximately 6.1 to 41 ug/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 ug/L and 70 ug/L. TCE concentrations ranged from approximately 1.2 to 3.9 ug/L, and cis-DCE concentrations ranged from non-detect to 1.0 ug/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<sup>®</sup>) in June 2005.

PCE, TCE, and cis-DCE results following the HRC injection suggest 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 steadily increased the past four 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.

## Recommendations

Groundwater monitoring should continue in the three shallow wells (1W, 4W, and 7W) 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 ug/L.

Because contaminants have never been detected in deep wells MW-5 and MW-6, it is recommended that these wells be considered for removal from the monitoring program.

However, the Shelton Laundry and Cleaners site is in need of a better placed downgradient well. Groundwater flow direction from the source area consistently appears to be to the southeast. It is recommended that a more appropriate downgradient well be installed or an existing well be located that may be used in the monitoring program.

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# Appendices

## Appendix A. Hydrograph Data

Table A-1. Groundwater Elevations (feet, NGVD29), May 2002 through June 2010.

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
11/20/09	11.05	11.12	10.97	11.22	11.11	11.05	11.26	11.09
6/10/2010	--	--	9.8	--	10.02	9.95	10.11	9.95

-- Not measured.

## Appendix B. Historical Data

Table B-1. PCE, TCE, and DCE Groundwater Results (ug/L), May 1997 through June 2010.

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	
<b>1W</b>																	
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	
<b>4W</b>																	
PCE	<b>130<sup>1</sup></b>	<b>1510<sup>2</sup></b>	<b>280</b>	<b>130</b>	<b>39</b>	<b>25</b>	<b>9.3</b>	<b>15</b>	<b>17</b>	<b>12</b>	<b>15</b>	<b>26<sup>a</sup></b>	<b>9.9</b>	<b>20<sup>a</sup></b>	<b>35<sup>a</sup></b>	<b>6.8</b>	
TCE	NR	NR	<b>4.7</b>	<1.0	<1.0	<1.0	<b>0.84 J</b>	<b>1.9 J</b>	<b>0.25 J</b>	<b>1.3</b>	<b>2</b>	<b>2.8<sup>a</sup></b>	<b>1.4</b>	<b>2.3</b>	<b>4.2<sup>a</sup></b>	<b>0.52 J</b>	
DCE	NR	NR	<b>33</b>	<1.0	<1.0	<1.0	<b>0.26 J</b>	<b>0.64 J</b>	<b>0.31 J</b>	<b>0.49 J</b>	<b>0.60 J</b>	<b>1.4</b>	<b>0.47 J</b>	<b>0.83 J</b>	<b>2.9<sup>a</sup></b>	<b>1.8</b>	
<b>7W</b>																	
PCE	--	--	<b>4.3</b>	<b>3</b>	<1.0	<b>1.2</b>	1 U	<b>0.19 J</b>	1 U	1 U	1 U	<b>1.7</b>	<b>0.47 J</b>	<b>0.15 J</b>	<b>0.38 J</b>	1 U	
TCE	--	--	<1.0	<1.0	<1.0	<1.0	1 U	2 U	1 U	1 U	1 U	1 U	<b>0.26 J</b>	1 U	1 U	1 U	
DCE	--	--	<b>6.4</b>	<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	
<b>8W</b>																	
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	--	--	--	--	--	--	
<b>MW-5</b>	This deep monitoring well was installed in 2002.																
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	1 U
TCE	This deep monitoring well was installed in 2002.						1 U	2 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
<b>MW-6</b>	This deep monitoring well was installed in 2002.																
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	1 U
TCE	This deep monitoring well was installed in 2002.						1 U	2 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
<b>MW-7</b>	This deep monitoring well was installed in 2002.																
PCE	This deep monitoring well was installed in 2002.						1 U	1 U	1 U	1 U	--	--	--	--	--	--	--
TCE	This deep monitoring well was installed in 2002.						1 U	2 U	1 U	1 U	--	--	--	--	--	--	--
<b>MW-8</b>	This deep monitoring well was installed in 2002.																
PCE	This deep monitoring well was installed in 2002.						1 U	1 U	1 U	1 U	--	--	--	--	--	--	--
TCE	This deep monitoring well was installed in 2002.						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.

<sup>1</sup> Concentration reported by Building Analytics from a temporary boring located in vicinity of well 4W.

<sup>2</sup> 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.

<sup>a</sup> Average concentration of duplicate samples.

Table B-1 (continued). PCE, TCE, and DCE Groundwater Results (ug/L), May 1997 through June 2010.

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	11/20/09	6/10/10
<b>1W</b>														
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	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	1 U	1 U
<b>4W</b>														
PCE	<b>18<sup>a</sup></b>	<b>324</b>	<b>3.2 J</b>	<b>6.3</b>	<b>10</b>	<b>9.3</b>	<b>43</b>	<b>14</b>	<b>15 J<sup>a</sup></b>	<b>15 J</b>	<b>8</b>	<b>11</b>	<b>6.1 J<sup>a</sup></b>	<b>41 J<sup>a</sup></b>
TCE	<b>0.63 J</b>	<b>13</b>	<b>0.60 J</b>	<b>1.7</b>	<b>3.2</b>	<b>2</b>	<b>9.5</b>	<b>2</b>	<b>4.3 J<sup>a</sup></b>	<b>3.6</b>	<b>1.5</b>	<b>1.9</b>	<b>1.2</b>	<b>3.9 J<sup>a</sup></b>
DCE	<b>0.59 J</b>	<b>16</b>	<b>0.19 J</b>	<b>0.47 J</b>	<b>1</b>	<b>0.75 J</b>	<b>2.5</b>	<b>0.67 J</b>	<b>1.4 J</b>	<b>1</b>	<b>0.5 J</b>	<b>0.62 J</b>	1 U	<b>1</b>
<b>7W</b>														
PCE	<b>0.53 J</b>	1 U	1 U	1 U	1 U	1 U	2 U	2 U	1 U	2 U	1 U	1 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	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	1 U	1 U
<b>8W</b>														
PCE	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TCE	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<b>MW-5</b>														
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	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	1 U	1 U
<b>MW-6</b>														
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	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	1 U	1 U
<b>MW-7</b>														
PCE	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TCE	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<b>MW-8</b>														
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.

<sup>a</sup> 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

Bgs	Below ground surface
Cis-DCE	Cis-1,2-dichloroethylene
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
HRC <sup>®</sup>	Hydrogen release compound
MTCA	Model Toxic Control Act
PCE	Tetrachloroethylene
PVC	Polyvinyl chloride
RPD	Relative percent difference
SOP	Standard operating procedure
TCE	Trichloroethylene
VOC	Volatile organic compound
WAC	Washington Administrative Code

#### *Units of Measurement*

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