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Groundwater Monitoring Results

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Lakewood Plaza Cleaners, Groundwater Monitoring Results

June and November 2009

by
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Abstract

This progress report is one in a series describing results of long-term groundwater monitoring at the former Lakewood Plaza Cleaners site south of Tacoma. The Washington State Department of Ecology (Ecology) assumed collecting groundwater data at the site in 1991. The goal was to evaluate the effectiveness of municipal wells H1 and H2 to contain and remove the contaminated groundwater.

This report discusses volatile organic results of samples collected from project monitoring wells and Lakewood Water District municipal wells in June and November 2009.

Tetrachloroethene (PCE) concentrations continue to not meet (exceed) the MTCA cleanup level of 5 µg/L in monitoring wells MW-20B (160 and 250 µg/L) and MW-16A (67 and 28 µg/L). Since Ecology began sampling, PCE concentrations have varied, but overall trends indicate that concentrations in well MW-20B are decreasing while concentrations in well MW-16A are increasing. The average annual PCE concentration in well MW-20B in 1991 was 657 µg/L, decreasing to 205 µg/L in 2009. The average annual PCE concentration in well MW-16A in 1991 was 19 µg/L, increasing to 48 µg/L in 2009.

Samples collected from municipal wells H1 and H2 prior to treatment continue to have PCE concentrations near the MTCA cleanup level.

PCE was also detected in well LPMW-2 (4.1 and 11 µg/L). This well is located near the former septic system of Lakewood Plaza Cleaners which was identified as a source of the contamination.

The use of municipal wells H1 and H2 to treat contaminated groundwater associated with the Lakewood Plaza Cleaners site continues since the cleanup goals have not been achieved. Project data indicate that it will take much longer than the projected timeframe to meet the cleanup goals.

Further evaluation is needed to determine what additional actions are needed for this project to meet the final cleanup goals in a reasonable timeframe.

Introduction

In 1981, the U.S. Environmental Protection Agency (EPA) confirmed that the Lakewood Water District production wells H1 and H2 were contaminated with tetrachloroethene (PCE), trichloroethene (TCE), and cis-1,2-dichloroethene (cis-1,2-DCE). Lakewood is south of Tacoma in Pierce County. The source of the contamination was identified as the former Lakewood Plaza Cleaners (EPA, 1983). Contamination had resulted from the dumping of PCE into on-site septic tanks and the disposal of sludge on the ground surface.

Remedial activities at the site began in 1984 and ended in 1993. They included the operation of wells H1 and H2 to pump and treat contaminated groundwater, the removal of contaminated soils and sludges from the source area, and treatment of remaining septic field contaminated soils with vapor extraction. Early monitoring results projected that compliance with cleanup goals of 5 µg/L for PCE and TCE would be achieved throughout the contaminated plume by the mid-1990s.

In 1991, the Washington State Department of Ecology (Ecology) began semi-annual, long-term groundwater monitoring at the site. The objective of this sampling is to collect groundwater quality data for Ecology's Toxics Cleanup Program. The Toxics Cleanup Program will use this data to evaluate the effectiveness of Lakewood water supply wells H1 and H2 to contain, remove, and treat the groundwater contaminated by Plaza Cleaners.

In 1996, the monitoring program was evaluated. Based on data collected from 1986 to 1996, EPA and Ecology decided to decommission half of the remaining wells and reduce the monitoring program to wells in the immediate vicinity of Plaza Cleaners. The monitoring program is evaluated every five years. The most recent evaluation occurred in 2007.

Remediation of the groundwater is ongoing under a long-term response action as cleanup goals have not yet been achieved (EPA, 2007). The current monitoring program was determined to be sufficient to assess the progress of the cleanup action. Project data indicate that it will take much longer than the projected timeframe to meet the cleanup goals. Further evaluation is needed to determine what additional actions are needed for this project to meet the final cleanup goals.

Methods

Groundwater Sampling

In June 2009, Ecology collected groundwater samples from monitoring wells MW-16A, MW-19A, MW-20A, MW-20B, MW-27, MW-33, and LPMW-2 and municipal well H2 (Figure 1).

In November 2009, Ecology collected groundwater samples from wells MW-16A, MW-20A, MW-20B, MW-27 and LPMW-2.

Wells MW-16A, MW-19A, MW-20A, MW-27, MW-33 and municipal wells H1 and H2 are screened in the Advance Outwash deposits, the primary water-supply aquifer for the area.

Well MW-20B is screened in the Vashon Till, typically a very low permeable layer which forms an aquitard of unsaturated and saturated sediment separating the Steilacoom Gravel above and Advance Outwash below. Well MW-20B is the only well screened in the Vashon Till where contamination had been detected.

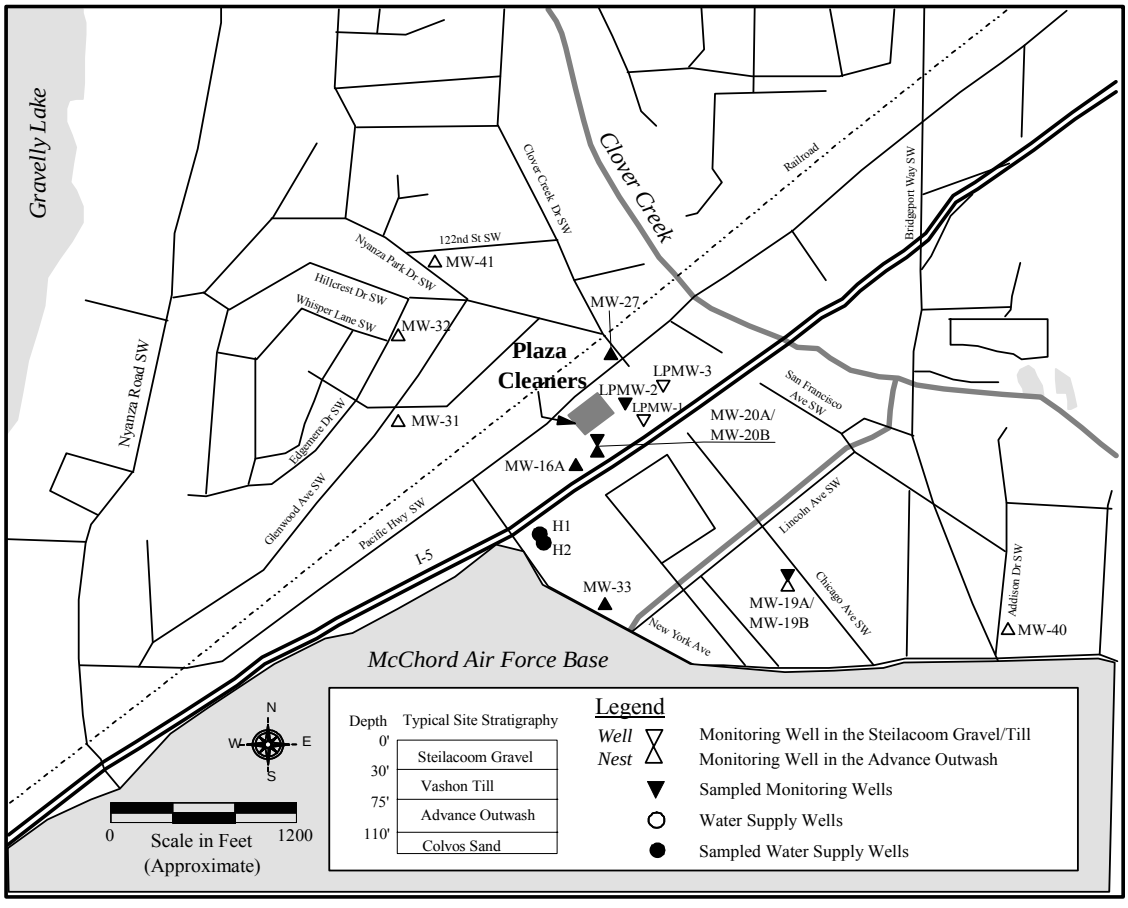

Figure 1. Lakewood Plaza Cleaners Sampling Locations.

Well LPMW-2, along with wells LPMW-1 and LPMW-3, are screened in the Steilacoom Gravel, which generally contains areas of perched water above the Vashon Till and regional water table. These wells, installed in 2004, are located on property adjoining the former Plaza Cleaners property. Ecology added the wells to the monitoring program in 2006. Wells LPMW-1 and LPMW-3 were removed from the monitoring program in 2008 because access to the wells had been restricted and PCE had not been detected.

Ecology continues to sample well LPMW-2 because PCE is detected in samples from this well. This well is located near the former septic system of Plaza Cleaners which was identified as a source of the contamination.

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

Monitoring wells MW-16A, MW-19A, MW-20A, and MW-33 were purged and sampled using dedicated bladder pumps.

Wells MW-20B, MW-27, and LPMW-2 were purged and sampled with a stainless-steel submersible pump with dedicated tubing using low-flow sampling techniques. The submersible pump was decontaminated between wells by circulating laboratory-grade detergent/water through the pump followed by a clean water rinse, with each cycle lasting five minutes.

The monitoring wells were purged until pH, temperature, and specific conductance readings stabilized or three well volumes of water had been removed. Purge water from the monitoring wells was collected and stored in 55-gallon drums. The purge water waste was transported and disposed of in accordance with Washington State regulations (Chapter 173-340-400 WAC). At the completion of purging, samples were collected from the monitoring wells directly from the dedicated pump discharge tubing into laboratory-supplied containers. Municipal well H2, which pumps continuously, was sampled from the tap nearest the well.

Volatile organics 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 Operations Center in Lacey. Samples were kept in the walk-in cooler until taken by the courier to the Ecology/EPA Manchester Environmental Laboratory in Manchester, Washington. Chain-of-custody procedures were followed according to Manchester Laboratory protocol (Ecology, 2008).

Laboratory

Table 1 lists analytes, analytical methods, and detection limits for both field and laboratory parameters. All groundwater samples were analyzed for volatile organics.

Table 1. Field and Laboratory Methods, May and October 2008.

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

SOP = Standard Operating Procedure.
EAP = Environmental Assessment Program, Ecology.
EPA = U.S. Environmental Protection Agency.
[1] Probe used with a WTW multiline P4 meter.

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Data Quality

Quality control samples collected in the field consisted of blind field duplicates obtained from well MW-16A. 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 also by the natural variability of the concentrations in the media (e.g., groundwater) being sampled.

The numeric comparison of duplicate results is expressed as the relative percent difference (RPD). The RPD is calculated as: the difference between sample results, divided by the mean, and expressed as a percent.

Table 2 shows the results of the duplicate samples and their RPD. The RPD for the June data ranged from 4% to 6%. In November the RPD for PCE was 7%. The quality of the data for this progress report is acceptable.

Table 2. Relative Percent Difference (RPD) of Duplicate Sample Results (µg/L), June and November 2009.

Well Sample ID	Tetrachloroethylene (PCE)		Trichloroethylene (TCE)		Cis-1,2-Dichloroethylene (cis-DCE)	
	6/09	11/09	6/09	11/09	6/09	11/09
MW-16A	67	28	0.94 J	0.52 J	2.2	0.83 J
MW-16B	71	26	1.1	1 U	2.3	0.77 J
RPD[1] (%)	6%	7%	--	--	4%	--

[1] : RPD target ±30%.
J : Analyte was positively identified. The associated numerical result is an estimate.
U: Analyte was not detected at or above the reported value.

A review of the data quality control and quality assurance from laboratory case narratives indicates that analytical performance was good. The reviews include descriptions of analytical methods, holding times, instrument calibration checks, blank results, 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.

Results

Field Observations

Depth-to-water measurements and purge volume, as well as pH, specific conductance, and temperature readings, at the time of sampling are listed in Table 3.

Table 3. Summary of Field Parameter Results, June 4 and November 19, 2009.

Well	Total Depth (feet)[1]	Depth to Water (feet)[1]	pH (standard units)	Specific Conductance (µmhos/cm)	Temperature (°C)	Purge Volume (gallons)
June						
MW-16A	109	34.43	7.2	233	13.0	54
MW-19A	97.5	34.59	6.8	195	12.0	18
MW-20A	97.3	29.07	7.8	206	12.7	24
MW-20B	50.4	28.24	6.9	419	14.5	5
MW-27	93	28.35	6.8	181	14.6	17
MW-33	99.3	++	7.1	203	12.0	24
LPMW-2	29	22.48	6.8	174	14.1	4
H2	110	++	6.5	179	13.1	>1000
November						
MW-16A	109	36.75	7.3	234	12.6	46
MW-20A	97.3	31.10	7.9	230	12.5	16
MW-20B	50.4	32.04	6.7	469	15.0	9
MW-27	93	29.05	7.0	191	13.8	18
LPMW-2	29	22.81	6.8	170	14.3	4

[1] Measured from top of PVC casing.
++ Dedicated pump obstructed water-level measurement.

Most of the sampled wells are screened in the Advance Outwash deposits (MW-16A, MW-19A, MW-20A, MW-27, MW-33, and H1/H2). Depth to water in the advanced outwash ranged from 28.35- 34.59 ft. in June and 29.05-36.75 ft. in November. A pump test conducted in 1981 in which municipal wells H1/H2 were shut down determined that the natural groundwater flow direction in the Advance Outwash is west-northwest toward Gravelly Lake. When in use, these wells create a large cone of depression which influences groundwater flow directions. Previous studies showed that drawdowns occur in shallow monitoring wells drilled in the Steilacoom gravel when H1 and H2 are pumping (EPA, 1985). This indicates possible hydraulic interconnection between the Steilacoom gravel and the Advance Outwash.

Well MW-20B is screened in the Vashon Till. Depth to water was 28.24 ft. in June and 32.04 ft. in November. The Vashon Till forms an aquitard when composed of silt and clay-rich gravels. The Vashon Till also contains thin layers of sandy gravel, one of which appears to be large in lateral extent, covering the area including Plaza Cleaners. This lens is saturated and appears to be hydraulically interconnected with the Steilacoom gravel (EPA, 1985). Well LPMW-2 is screened in the Steilacoom Gravel. Depth to water in this well ranged from 22.48-22.81 ft. over the monitoring period.

Field parameters (pH, specific conductance, and temperature) were within expected ranges. The specific conductance in well MW-20B (419-469 µmhos/cm) was greater than the other wells. Well MW-20B is screened in the fine-grained till unit. Specific conductance readings are typically higher for water from fine-grained units.

Analytical Results

June and November 2009 analytical results for volatile organics of interest are summarized in Table 4 and presented in Figure 2.

All field measurements and analytical results data are available in electronic format from Ecology's EIM data management system: www.ecy.wa.gov/eim/index.htm. Search study ID LAKEWOOD.

Table 4. Results (µg/L) of Volatile Organics of Interest, June 4 and November 19, 2009.

Well	Tetrachloroethene (PCE)	Trichloroethene (TCE)	Cis-1,2-Dichloroethene (cis-1,2-DCE)
June			
MW-16A	**67**	**0.94 J**	**2.2**
MW-19A	1 U	1 U	1 U
MW-20A	1 U	1 U	1 U
MW-20B	**160**	**4.1**	**7.4**
MW-27	1 U	1 U	1 U
MW-33	1 U	1 U	1 U
LPMW-2	**4.1**	1 U	1 U
H2	**6.8**	1 U	1 U
November			
MW-16A	**28**	**0.52 J**	**0.83 J**
MW-20A	**0.64 J**	1 U	1 U
MW-20B	**250**	**4.7**	**9.6**
MW-27	1 U	1 U	1 U
LPMW-2	**11**	1 U	1 U

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

Chlorinated solvents continue to be detected in monitoring wells MW-20B, MW-16A, and LPMW-2 as well as municipal wells H1 and H2.

Well LPMW-2 is typically dry during the fall sample round. Because of the late fall sample date during this monitoring period and heavy precipitation, water was available to sample in November. PCE was detected at a concentration of 11 µg/L. Well LPMW-2 is located near the former septic system of Plaza Cleaners which was identified as a source of the contamination.

Monitoring wells MW-20B and MW-16A, and municipal wells H1 and H2, continue to have PCE concentrations not meeting (exceeding) the MTCA cleanup level of 5 µg/L.

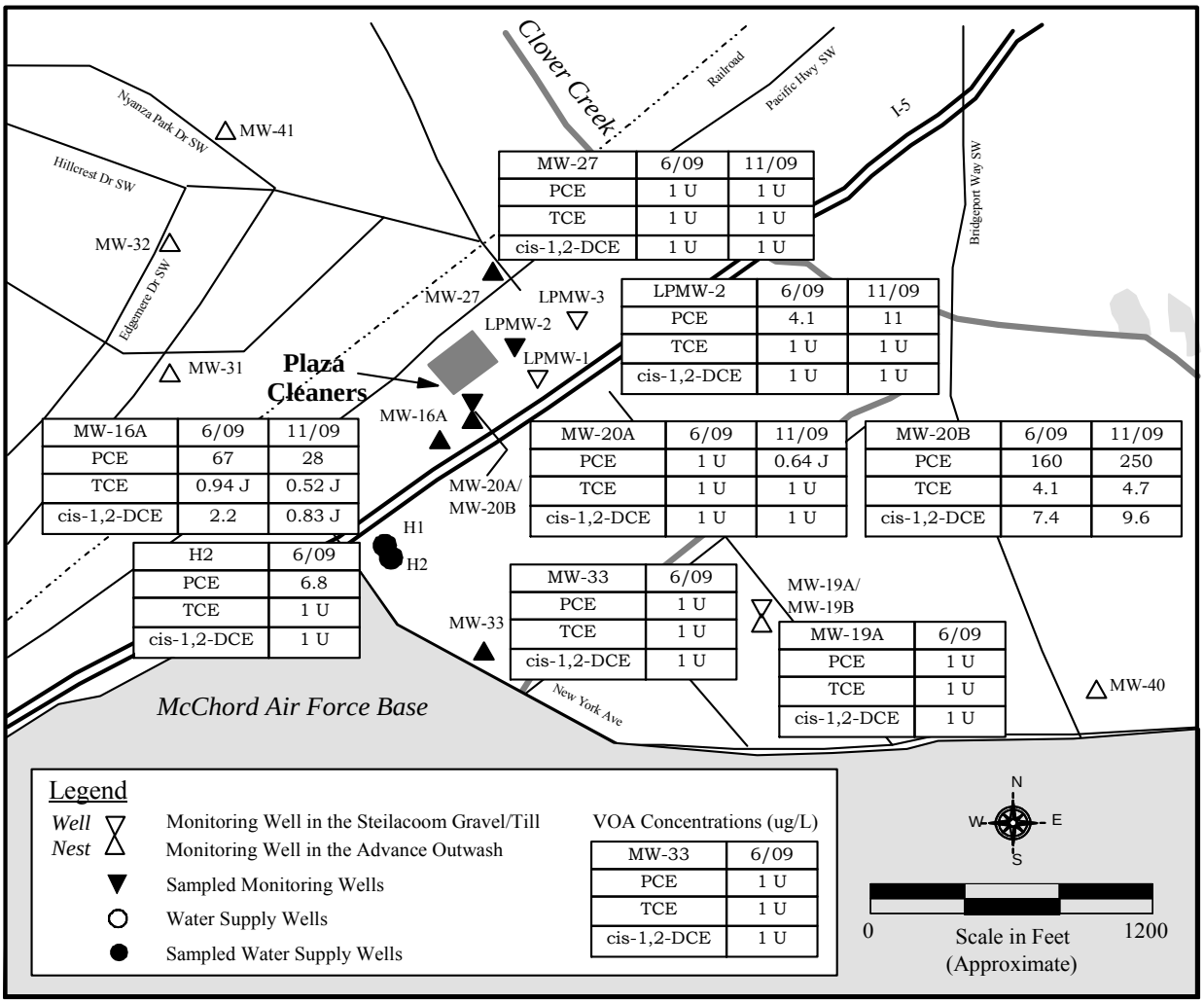

Figure 2. Lakewood Plaza Cleaners PCE, TCE, and Cis-1,2-DCE Concentrations (µg/L), June and November 2009.

Discussion

In 1991, Ecology assumed long-term groundwater monitoring of the former Lakewood Plaza Cleaners site with the goal of collecting data to evaluate the effectiveness of municipal wells H1 and H2 to contain and remove the contaminated groundwater.

Table 5 shows average PCE and TCE concentrations that have exceeded the MTCA cleanup level of 5 µg/L during Ecology's sample period of 1991 to 2009. All PCE, TCE, and cis-1,2-DCE concentrations from January 1991 through November 2009 are presented in Appendix A. PCE concentrations for wells MW-20B and MW-16A for the same time period are also presented as graphs in Appendix A.

Table 5. Average Annual PCE and TCE Concentrations (µg/L) for Wells that Exceed the MTCA Method A Cleanup Level for Groundwater of 5 µg/L.

Year	MW-20B		MW-16A	H1/H2	LPMW-2
	PCE	TCE	PCE	PCE	PCE
1991	657	12	19	---	---
1992	640	14	8	---	---
1993	443	12	28	---	---
1994	279	8.6	21	---	---
1995	340[a]	8.4[a]	27[a]	9[a]	---
1996	370	7	45	4	---
1997	297	4	50	13	---
1998	515	8	33	10	---
1999	715	7	22[a]	3	---
2000	416	6	31	9	---
2001	489	7	28	9	---
2002	309	8.5	34	9	---
2003	234	5.4	42	6.4	---
2004	293	6.6	39	5.3	---
2005	484	6.5	62	10.2	---
2006	367	4.9	77	6.1	9.9[a]
2007	348	6	54	4.5	4.8[a]
2008	201	5	43	7.4	2.5[a]
2009	205	4.4	48	6.8 [a]	7.6

--: Not tested.
a: Single annual result.

Figures 3 and 4 show the average annual PCE concentrations for MW-20B and MW-16A from 1985 through 2009. PCE concentrations in both wells have varied substantially.

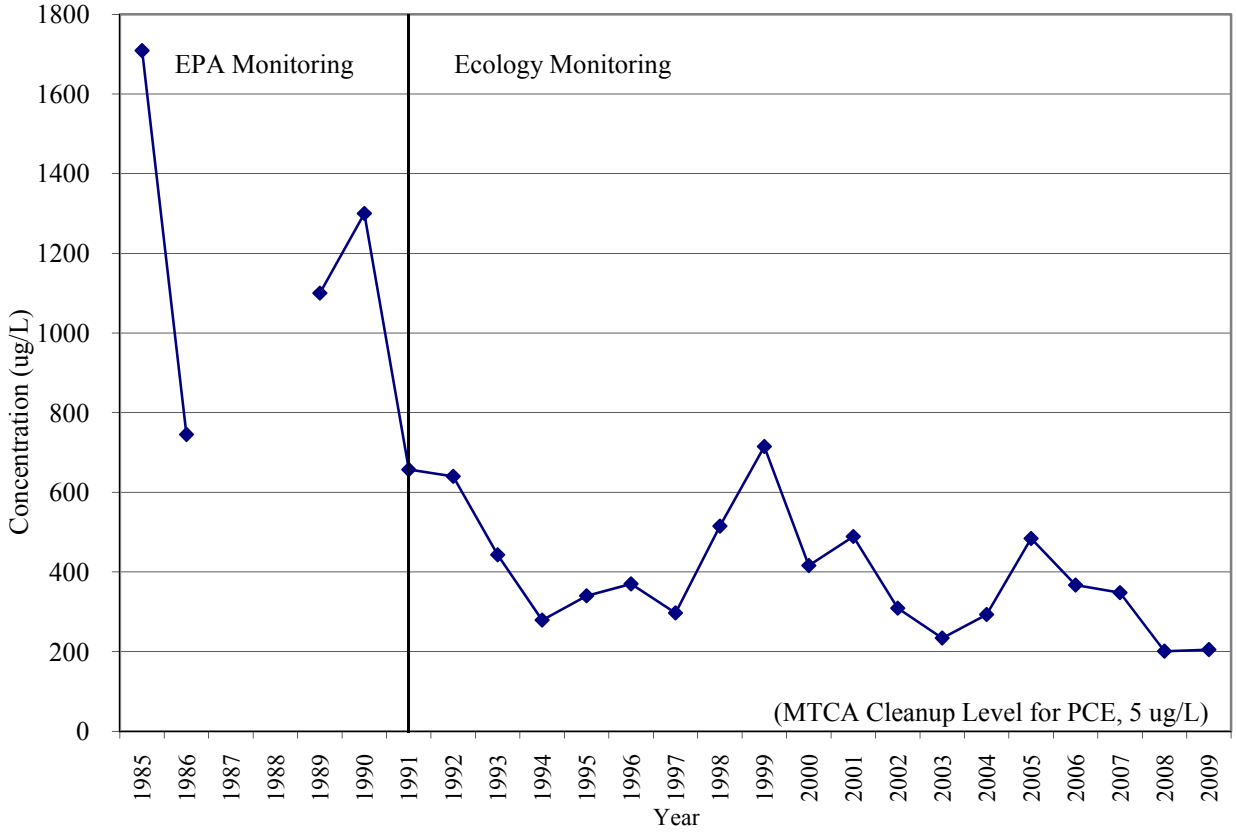

Figure 3. Average Annual PCE Concentrations for Well MW-20B, 1985 through 2009.

PCE concentrations decreased in well MW-20B during the 1980s with the implementation of remedial activities. In 1991, Ecology began semi-annual, long-term groundwater monitoring at the site. Although PCE concentrations have varied, primarily due to seasonal fluctuations, the overall trend indicates that concentrations in well MW-20B are decreasing (Figure A1). The average annual PCE concentration in 1991 was 657 µg/L, and in 2009 it was 205 µg/L.

PCE concentrations also initially decreased in well MW-16A. As with well MW-20B, concentrations have varied over the monitoring period. However, the overall trend indicates that PCE concentrations in well MW-16A are increasing (Figure A2). The average annual PCE concentration in 1991 was 19 µg/L, and in 2009 it was 48 µg/L.

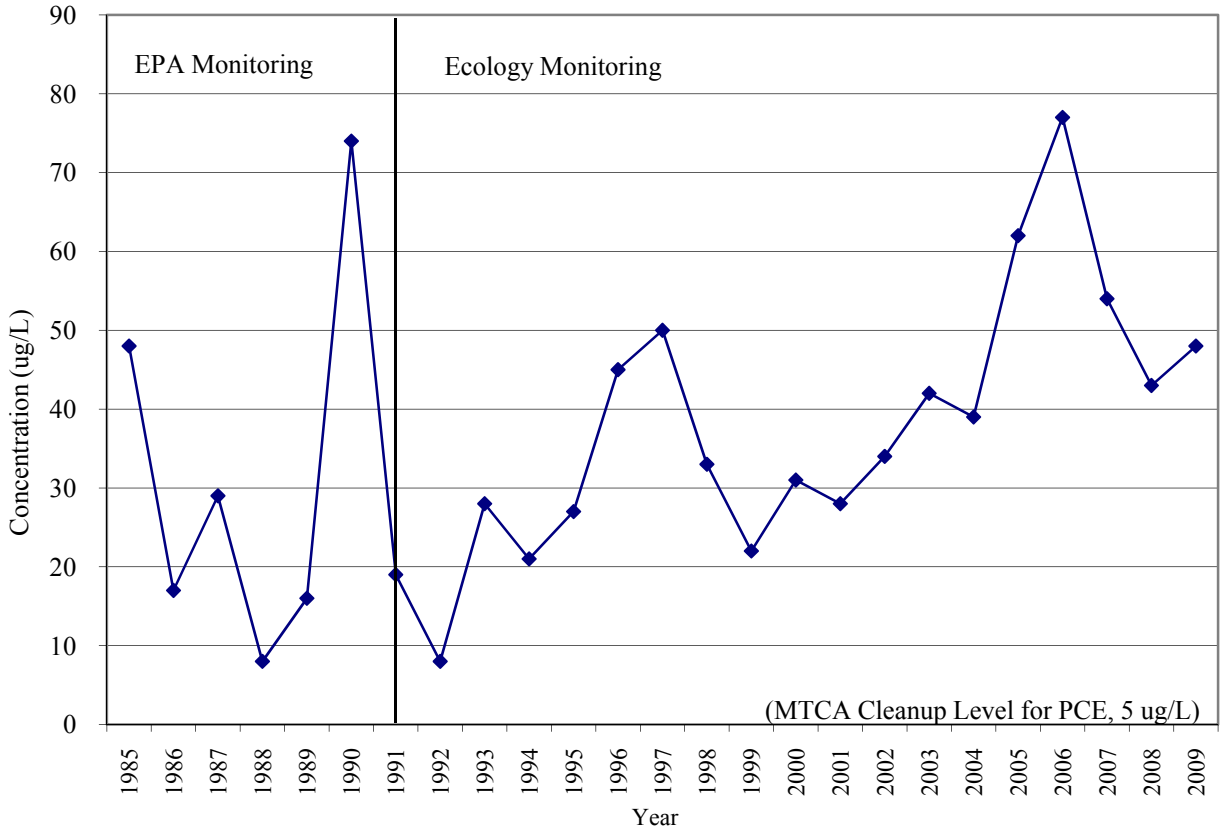

Figure 4. Average Annual PCE Concentrations for Well MW-16A, 1985 through 2009.

As shown in Figures 3 and 4, PCE concentrations continue to exceed the MTCA cleanup level of 5 µg/L in monitoring wells MW-20B and MW-16A. In addition, contaminant concentrations in well MW-16A appear to be gradually increasing over time.

Samples collected from municipal wells H1 and H2 prior to treatment also have PCE concentrations above the MTCA cleanup level (Table 5).

Compliance with the groundwater cleanup goals have not been met for this project. Project data indicate that it will take much longer than the projected timeframe to meet the cleanup goals.

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Conclusions and Recommendations

Ecology conducted groundwater monitoring in June 2009 at seven monitoring wells and one municipal well, and in November 2009 at five monitoring wells, to evaluate volatile organics in groundwater at the former Lakewood Plaza Cleaners site.

- Monitoring wells MW-20B and MW-16A, as well as municipal wells H1 and H2, continue to have PCE concentrations not meeting (higher than) the MTCA cleanup level of 5 µg/L.
- PCE concentrations in well LPMW-2 are typically near the cleanup level of 5 µg/L.

Concentrations of PCE have decreased from their 1980s levels, but continue to not meet the project cleanup goals of 5 µg/L. Since Ecology began sampling in 1991, PCE concentrations have varied, but overall trends indicate that concentrations in well MW-20B are decreasing while concentrations in well MW-16A are increasing. The average annual PCE concentration in well MW-20B in 1991 was 657 µg/L, decreasing to 205 µg/L in 2009. The average annual PCE concentration in well MW-16A in 1991 was 19 µg/L, increasing to 48 µg/L in 2009.

The use of municipal wells H1 and H2 to contain, remove, and treat contaminated groundwater associated with the Lakewood Plaza Cleaners site continues since the cleanup goals have not yet been achieved. Project data indicates that it will take much longer than the projected timeframe to meet the cleanup goals.

Further evaluation is needed to determine what additional actions are needed for this project to meet the final cleanup goals in a reasonable timeframe.

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Appendices

Appendix A. Summary of Results

Table A-1. Summary of Sample Results (ug/L), January 1991 to November 2009.

Well Number	January 1991			May 1991			November 1991			May 1992			December 1992		
	PCE	TCE	cis-1,2-DCE	PCE	TCE	cis-1,2-DCE	PCE	TCE	cis-1,2-DCE	PCE	TCE	cis-1,2-DCE	PCE	TCE	cis-1,2-DCE
MW-16A	**28**	**1 J**	**2.4 J**	**26**	**0.6 J**	**2**	**2.7 J**	1 U	**0.6 J**	**7**	1 U	**1**	**9 J**	**0.3 J**	**0.8 J**
MW-20A	1 U	1 U	1 U	**0.4 J**	1 U	1 U	**0.4 J**	1 U	1 U	**0.5 J**	1 U	1 U	**0.8 J**	1 UJ	1 UJ
MW-20B	**1100 D**	**18**	**33**	**752**	**16**	**30**	**120**	**2.6 J**	**6.7**	**940**	**13**	**32**	**340 J**	**14 J**	**20 J**
MW-21	**2.1 J**	1 U	**1 J**	**2**	1 U	**0.7 J**	**2.2 J**	1 U	**1.0 J**	**2**	1 U	**0.6 J**	**2**	**0.2 J**	**0.3 J**
MW-27	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 UJ	1 UJ	1 UJ
MW-28A	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-31	**1 J**	1 U	**1.9 J**	**0.6 J**	1 U	**2**	**0.9 J**	1 U	**2.2 J**	**0.8 J**	1 U	**1**	**0.5 J**	1 UJ	**0.9 J**
MW-32	**1 J**	1 U	**1.1 J**	**1**	1 U	**2**	**0.6 J**	1 U	**0.6 J**	**0.7 J**	1 U	**1**	**0.7 J**	1 UJ	**0.5 J**
MW-41	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 UJ	1 UJ	1 UJ
MW-19A	--	--	--	--	--	--	1 U	**0.5 J**	1 U	--	--	--	1 UJ	1 UJ	1 UJ
MW-33	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-40	1 U	1 U	1 U	--	--	--	1 U	1 U	1 U	--	--	--	1 UJ	1 UJ	1 UJ
H1/H2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Well Number	May 1993			December 1993			April 1994			November 1994			July 1995		
	PCE	TCE	cis-1,2-DCE	PCE	TCE	cis-1,2-DCE	PCE	TCE	cis-1,2-DCE	PCE	TCE	cis-1,2-DCE	PCE	TCE	cis-1,2-DCE
MW-16A	**44**	10 U	**2 J**	**13**	**0.3 J**	**0.7 J**	**33**	**0.6**	**1.4**	**9.7**	**0.3 J**	**0.5 J**	**27**	**0.5 J**	**0.8 J**
MW-20A	10 U	10 U	10 U	**0.3 J**	1 U	1 U	**0.4**	0.2 U	0.2 U	**0.3 J**	1 U	1 U	**0.4 J**	1 U	1 U
MW-20B	**700 D**	**12**	**21**	**187**	50 U	**8.2 J**	**472**	**8.6 J**	**12.6**	**86**	50 U	**3 J**	**340 D**	**8.4**	**17**
MW-21	**1 J**	10 U	10 U	**1.6**	1 U	**0.4 J**	**1.5**	**0.2 J**	**0.3**	**1.8**	**0.2 J**	**0.3 J**	--	--	--
MW-27	10 U	10 U	10 U	1 U	1 U	1 U	0.2 U	0.2 U	0.2 U	1 U	1 U	1 U	1 U	1 U	1 U
MW-28A	--	--	--	--	--	--	--	--	--	--	--	--	1 U	1 U	1 U
MW-31	10 U	10 U	10 U	**0.8 J**	1 U	**1.2 J**	**0.7**	0.2 U	**1.0**	**0.8 J**	1 U	**1**	**0.6 J**	1 U	**0.5 J**
MW-32	10 U	10 U	10 U	**0.7 J**	1 U	**0.6 J**	**0.7**	0.2 U	**0.6**	**0.6 J**	1 U	**0.5 J**	**0.7 J**	1 U	**0.5 J**
MW-41	10 U	10 U	10 U	1 U	1 U	1 U	0.2 U	0.2 U	0.2 U	1 U	1 U	1 U	1 U	1 U	1 U
MW-19A	--	--	--	1 U	**0.4**	1 U	0.2 U	**0.5**	0.2 U	--	--	--	1 U	**0.4 J**	1 U
MW-33	--	--	--	--	--	--	--	--	--	--	--	--	1 U	1 U	1 U
MW-40	--	--	--	1 U	1 U	1 U	0.2 U	0.2 U	0.2 U	--	--	--	1 U	1 U	1 U
H1/H2	--	--	--	--	--	--	--	--	--	--	--	--	**9**	**0.3 J**	1 U

Table A-1 (cont.). Summary of Sample Results (ug/L) from January 1991 to November 2009.

Well Number	January 1996			July 1996			January 1997			July 1997			February 1998		
	PCE	TCE	cis-1,2-DCE	PCE	TCE	cis-1,2-DCE	PCE	TCE	cis-1,2-DCE	PCE	TCE	cis-1,2-DCE	PCE	TCE	cis-1,2-DCE
MW-16A	**47 E**	**0.8 J**	**1.5**	**43**	**0.7 J**	**1.9**	**54**	**1.1**	**3.1**	**47**	**0.7 J**	**2.5**	**36**	**0.7 J**	**2 J**
MW-20A	**0.2 J**	1 U	1 U	**0.4 J**	1 U	1 U	**0.4 J**	1 U	1 U	**0.3 J**	1 U	2 U	**0.4 J**	1 U	1 U
MW-20B	**353**	**7.2**	**15**	**387**	**7.6**	**15**	**373**	100 U	**6.4 J**	**222**	**4**	**6.4**	**456**	**7 J**	**12**
MW-21	--	--	--	Well Decommissioned											
MW-27	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	2 U	1 U	1 U	1 U
MW-28A	1 U	1 U	1 U	Well Decommissioned											
MW-31	**0.6 J**	1 U	**0.7 J**	--	--	--	--	--	--	**0.9 J**	1 U	**0.9 J**	--	--	--
MW-32	**0.8 J**	1 U	**0.6 J**	--	--	--	--	--	--	--	--	--	--	--	--
MW-41	1 U	1 U	1 U	--	--	--	--	--	--	--	--	--	--	--	--
MW-19A	--	--	--	--	--	--	--	--	--	1 U	**0.3 J**	2 U	--	--	--
MW-33	--	--	--	1 U	1 U	1 U	--	--	--	1 U	1 U	2 U	--	--	--
MW-40	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
H1/H2	**8.4**	**0.2 J**	**0.2 J**	**0.1 J**	1 U	1 U	**18**	**0.4 J**	**0.4 J**	**8.8**	**0.3 J**	**0.6 J**	**11**	**0.4 J**	**0.3 J**

Well Number	July 1998			January 1999			August 1999			January 2000			August 2000		
	PCE	TCE	cis-1,2-DCE	PCE	TCE	cis-1,2-DCE	PCE	TCE	cis-1,2-DCE	PCE	TCE	cis-1,2-DCE	PCE	TCE	cis-1,2-DCE
MW-16A	**30**	1 U	**1.5 J**	--	--	--	**22**	**0.4 J**	**1.1**	**40**	**0.7 J**	**1.9**	**22**	**0.3 J**	**0.7**
MW-20A	**0.6 J**	1 U	1 U	1 U	2 U	1 U	**0.8 J**	2 U	1 U	**0.2 J**	2 U	1 U	**0.1 J**	2 U	1 U
MW-20B	**575 D**	**10**	**23**	**708**	**5.2**	**12**	**722**	**8.4 J**	**16 J**	**184**	**6**	**13**	**648**	200 U	100 U
MW-27	**0.05 J**	1 U	1 U	1 U	2 U	1 U	1 U	2 U	1 U	1 U	2 U	1 U	1 U	2 U	1 U
MW-31	--	--	--	--	--	--	**0.9 J**	2 U	**0.4 J**	--	--	--	--	--	--
MW-32	--	--	--	--	--	--	--	--	--	--	--	--	**0.8 J**	2 U	1 U
MW-41	--	--	--	--	--	--	--	--	--	--	--	--	1 U	2 U	1 U
MW-19A	--	--	--	--	--	--	1 U	**0.4 J**	1 U	--	--	--	--	--	--
MW-33	1 U	1 U	1 U	--	--	--	1 U	2 U	1 U	--	--	--	1 U	2 U	1 U
MW-40	--	--	--	--	--	--	--	--	--	--	--	--	1 U	2 U	1 U
H1/H2	**10**	1 U	**0.1 J**	**1.5**	1 U	1 U	**5.2**	**0.2 J**	1 U	**10**	1 U	1 U	**8.7**	**0.03 J**	1 U

Table A-1 (cont.). Summary of Sample Results (ug/L) from January 1991 to November 2009.

Well Number	January 2001			August 2001			February 2002			August 2002			February 2003		
	PCE	TCE	cis-1,2-DCE	PCE	TCE	cis-1,2-DCE	PCE	TCE	cis-1,2-DCE	PCE	TCE	cis-1,2-DCE	PCE	TCE	cis-1,2-DCE
MW-16A	**31**	**0.4 J**	**1**	**25**	**0.3 J**	**0.7 J**	**47**	**0.8 J**	**2.3**	**22**	**0.3 J**	**0.8 J**	**59 J**	**0.2 J**	**2.4**
MW-20A	**0.2 J**	1 U	1 U	1 U	2 U	1 U	--	--	--	--	--	--	1 U	1 U	1 U
MW-20B	**493**	**6.6 J**	**12**	**486**	**8.2**	**18**	**248**	200 U	100 U	**371**	**8.5**	**16**	**230**	100 U	100 U
MW-27	1 U	1 U	1 U	1 U	2 U	1 U	1 U	2 U	1 U	1 U	2 U	1 U	1 U	1 U	1 U
MW-31	--	--	--	**0.4 J**	2 U	**0.3 J**	--	--	--	--	--	--	--	--	--
MW-32	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-41	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-19A	--	--	--	1 U	**0.3 J**	1 U	--	--	--	--	--	--	--	--	--
MW-33	--	--	--	1 U	2 U	1 U	--	--	--	1 U	1 U	1 U	--	--	--
MW-40	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
H1/H2	**11**	**0.2 J**	1 U	**6.8**	**0.2 J**	1 U	**12**	**0.2 J**	**0.2 J**	**6.1**	1 U	1 U	**1.3**	1 U	1 U

Well Number	September 2003			June 2004			November 2004			June 2005			November 2005		
	PCE	TCE	cis-1,2-DCE	PCE	TCE	cis-1,2-DCE	PCE	TCE	cis-1,2-DCE	PCE	TCE	cis-1,2-DCE	PCE	TCE	cis-1,2-DCE
MW-16A	**26**	**0.3 J**	**0.5 J**	**30**	**0.4 J**	**0.8 J**	**48**	1 U	**1.4**	**80**	**1.3**	**2.8**	**43**	**0.7 J**	**1.0 J**
MW-20A	**0.1 J**	1 U	1 U	**0.2 J**	1 U	1 U	**0.3 J**	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
MW-20B	**239**	**5.4 J**	**12**	**344**	**6.5 J**	**15**	**241**	**6.7**	**13**	**413**	**6.6**	**12**	**555**	**6.4**	**11**
MW-27	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
MW-31	**0.5 J**	1 U	**0.1 NJ**	--	--	--	--	--	--	**0.5 J**	1 U	1 U	--	--	--
MW-32	--	--	--	--	--	--	--	--	--	**1.4**	1 U	1 U	--	--	--
MW-41	--	--	--	--	--	--	--	--	--	1 U	1 U	1 U	--	--	--
MW-19A	1 U	**0.4 NJ**	1 U	--	--	--	--	--	--	1 U	**0.6 J**	1 U	--	--	--
MW-33	1 U	1 U	1 U	--	--	--	--	--	--	1 U	1 U	1 U	--	--	--
MW-40	--	--	--	--	--	--	--	--	--	1 U	1 U	1 U	--	--	--
H1/H2	**6.4**	**0.2 NJ**	1 U	**7.9**	**0.2 J**	**0.1 J**	**2.6**	1 U	1 U	**14**	**0.3 J**	1 U	**6.4**	1 U	1 U

Table A-1 (cont.). Summary of Sample Results (ug/L) from January 1991 to November 2009.

Well	May 2006			September 2006			June 2007			October 2007			May 2008		
Number	PCE	TCE	cis-1,2-DCE	PCE	TCE	cis-1,2-DCE	PCE	TCE	cis-1,2-DCE	PCE	TCE	cis-1,2-DCE	PCE	TCE	cis-1,2-DCE
MW-16A	**124**	**1.8**	**4.6**	**29**	**0.3 J**	**0.48 J**	**83**	**1.2**	**2.5**	**24**	1 U	**0.64 J**	**55**	**1.2**	**2.8**
MW-20A	1 U	1 U	1 U	1 U	1 U	1 U	2 U	2 U	2 U	2 U	1 U	1 U	1 U	1 U	1 U
MW-20B	**216**	**4.2**	**6.6**	**518**	**5.6**	**11**	**204**	**4.4**	**7.8**	**491**	**7.5**	**15**	**143**	**5.5**	**12**
MW-27	1 U	1 U	1 U	1 U	1 U	1 U	2 U	2 U	2 U	2 U	1 U	1 U	1 U	1 U	1 U
MW-31	--	--	--	--	--	--	**1.6 J**	2 U	2 U	--	--	--	--	--	--
MW-32	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-41	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-19A	--	--	--	--	--	--	2 U	**1.2 J**	2 U	--	--	--	--	--	--
MW-33	1 U	1 U	1 U	--	--	--	2 U	2 U	2 U	--	--	--	1 U	1 U	1 U
MW-40	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
LPMW-2	**9.9**	1 U	1 U	--	--	--	**4.8**	1 U	1 U	--	--	--	**2.5**	1 U	1 U
LPMW-3	1 U	1 U	1 U	--	--	--	2 U	1 U	1 U	--	--	--	--	--	--
H1/H2	**7.3**	**0.2 J**	1 U	**4.8**	1 U	1 U	**5.2**	2 U	2 U	**3.8**	1 U	1 U	**9.6**	1 U	1 U

Well	October 2008			June 2009			November 2009		
Number	PCE	TCE	cis-1,2-DCE	PCE	TCE	cis-1,2-DCE	PCE	TCE	cis-1,2-DCE
MW-16A	**31**	**0.45 J**	**0.6 J**	**67**	**0.94 J**	**2.2**	**28**	**0.52 J**	**0.83 J**
MW-20A	1 U	1 U	1 U	1 U	1 U	1 U	**0.64 J**	1 U	1 U
MW-20B	**258**	**4.5**	**9**	**160**	**4.1**	**7.4**	**250**	**4.7**	**9.6**
MW-27	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
MW-31	--	--	--	--	--	--	--	--	--
MW-32	--	--	--	--	--	--	--	--	--
MW-41	--	--	--	--	--	--	--	--	--
MW-19A	--	--	--	1 U	1 U	1 U	--	--	--
MW-33	--	--	--	1 U	1 U	1 U	--	--	--
MW-40	--	--	--	--	--	--	--	--	--
LPMW-2	--	--	--	**4.1**	1 U	1 U	**11**	1 U	1 U
H1/H2	**5.1**	1 U	1 U	**6.8**	1 U	1 U	--	--	--

U = The analyte was not detected at or above the reported result.
J = The analyte was positively identified. The associated numerical result is an estimate.
UJ = The analyte was not detected at or above the reported estimated result.
D = Analysis performed at secondary dilution.
E = The concentration of the associated value exceeds the known calibration range.
-- = Not tested
Bold = The analyte was positively identified.

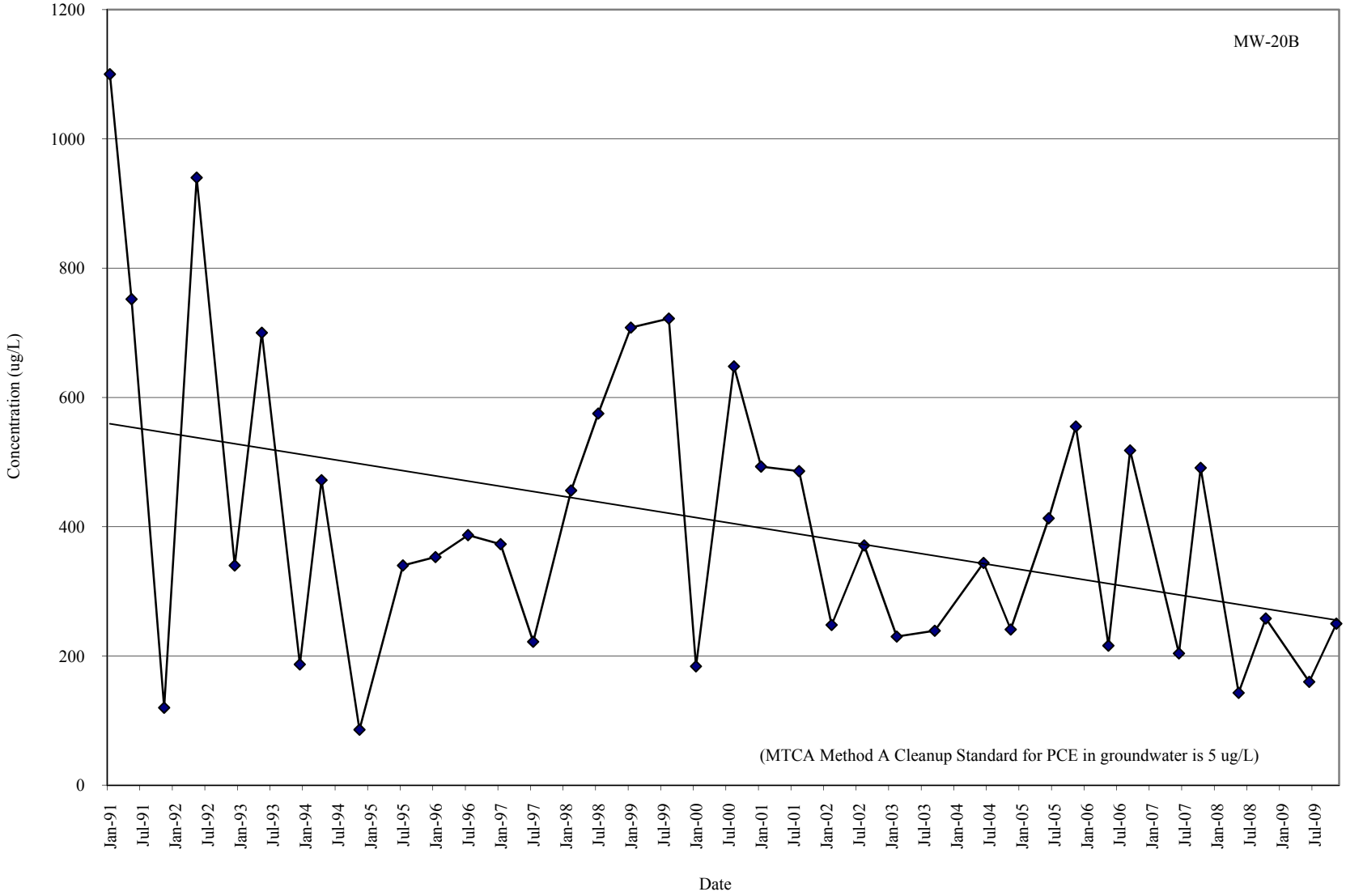

Figure A-1. PCE Concentrations for Well MW-20B, January 1991 to November 2009.

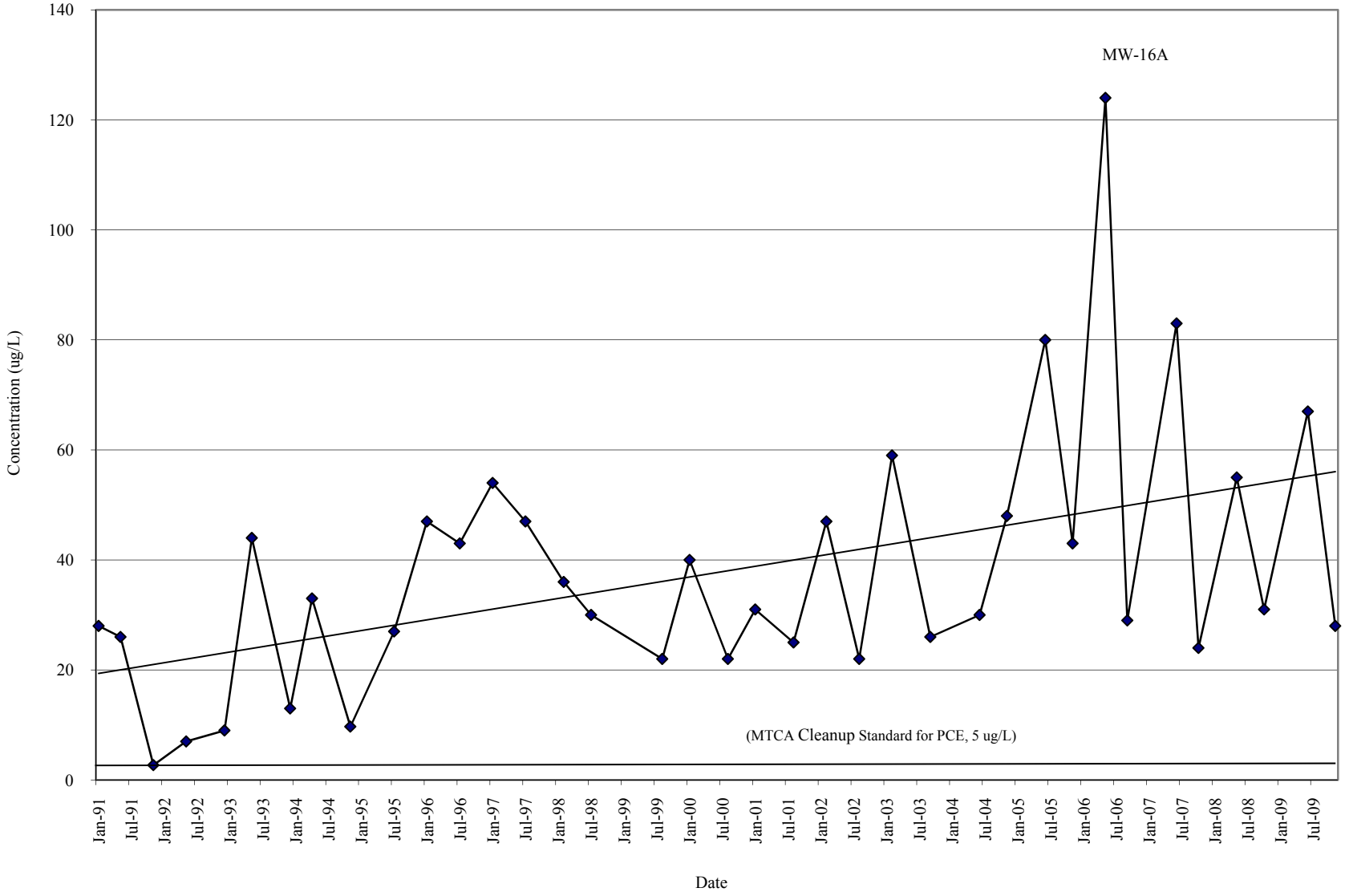

Figure A-2. PCE Concentrations for Well MW-16A, January 1991 to November 2009.

Appendix B. Glossary, Acronyms, and Abbreviations

Glossary

Aquifer: An underground geological formation, or group of formations, containing water.

Aquitard: Geologic formation that may contain groundwater but is not capable of transmitting significant quantities of it under normal hydraulic gradients. May function as a confining bed.

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

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.

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

pH: A measure of the acidity or alkalinity of water. A low pH value (0 to 7) indicates that an acidic condition is present, while a high pH (7 to 14) indicates a basic or alkaline condition. A pH of 7 is considered to be neutral. Since the pH scale is logarithmic, a water sample with a pH of 8 is ten times more basic than one with a pH of 7.

Purge water: Water removed from the sampling zone in a well prior to sample collection.

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.

Volatile organics: Organic chemical compounds that have high enough vapor pressures under normal conditions to significantly vaporize and enter the earth's atmosphere.

Acronyms and Abbreviations

Cis-1,2-DCE	Cis-1,2-dichloroethene
EAP	Environmental Assessment Program
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management
EPA	Environmental Protection Agency
MTCA	Model Toxic Control Act
PCE	Tetrachloroethene
PVC	Polyvinyl chloride
RPD	Relative Percent Difference
TCE	Trichloroethene
VOA	Volatile Organics Analysis
WAC	Washington Administrative Code

Units of Measurement

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