Cost and Performance Summary Report
In Situ Bioremediation at the Cleaners #1 Site in Kent, Washington
July 2006

Summary Information [1]

The Cleaners #1 site is an operational dry cleaning facility in a retail strip mall in Kent, Washington. The site occupies approximately 1,600 square feet and is surrounded by mixed retail, commercial, and residential properties. Contamination was first discovered at the site in August 1998 during a Phase II environmental site assessment (ESA). Interior soil samples were collected from below the facility floor near the dry cleaning machine, and exterior soil samples were collected outside the facility near the rear door. Groundwater samples were collected from outside the facility. Tetrachloroethene (PCE) and trichloroethene (TCE) were detected in groundwater at concentrations above state cleanup levels, and PCE concentrations slightly exceeded the cleanup level in exterior soil samples. Interior soil samples contained only trace concentrations of PCE.

Subsequent soil sampling conducted in September 1998 at six exterior borings and three interior borings indicated that PCE and TCE concentrations did not exceed state cleanup levels. However, groundwater samples collected from three of the six exterior locations contained PCE at concentrations exceeding the state cleanup levels, with the highest concentration being near the rear door of the facility. Figure 1 shows the site sampling locations.

Enhanced bioremediation was conducted at the site using hydrogen release compound® (HRC®) primarily to address groundwater contamination, while also treating some of the soil contamination. Mechanical soil aeration and thermal desorption were also conducted to address residual soil contamination. After the first round of HRC® injection at the site, PCE concentrations increased. To determine potential sources of the contamination, sewer effluent discharging from the site to the sanitary sewer system was sampled. Results showed that PCE was being discharged in the effluent from the site at levels above the state cleanup level.

This report focuses on the bioremediation of PCE-contaminated groundwater at the Cleaners #1 site using HRC®, including a technology description, operating parameters, performance data, and cost information.

Voluntary Cleanup Program ID #: NW0470
Federal Site ID #: 29843481
Type of Action: State Corrective Action
Lead: State (Washington Department of Ecology)

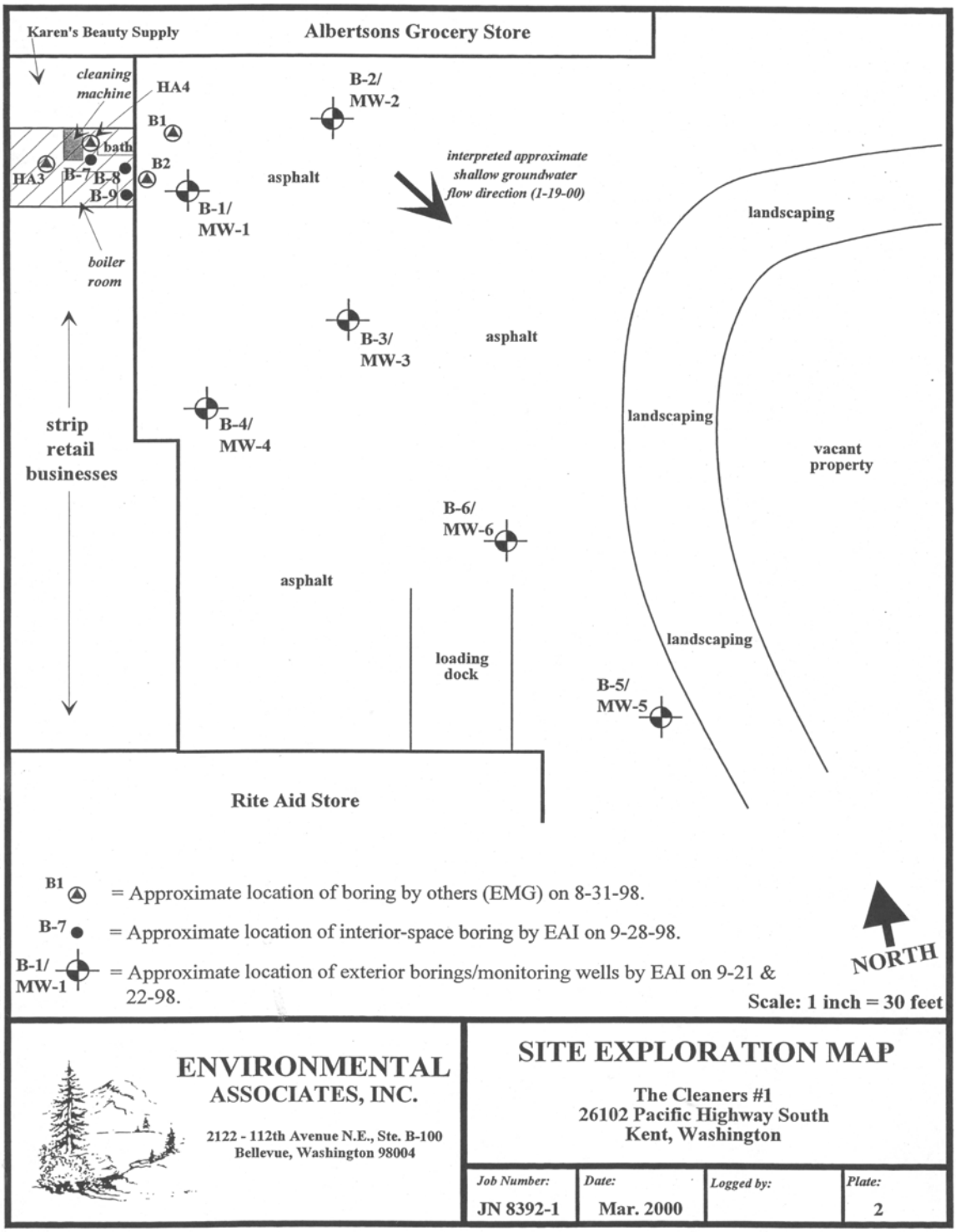
Timeline [1, 2, 4]

August - September 1998	Phase II ESA (initial discovery of PCE contamination)
September 1998	Follow-up sampling
December 15 - 18, 1998	Initial injection of HRC®
December 28, 1998 - January 16, 1999	Laboratory treatability study to evaluate suitability of HRC® to treat site soils
March 1999	Sewer pipe survey to determine areas of potential leakage
April 21 - 22, 1999	Soil excavation and second application of HRC®
April 1999	Mechanical soil aeration and thermal desorption
July 21, 2000	Third HRC® application (second injection)

Factors That Affected Technology Cost or Performance [1, 2]

Listed below are the key matrix characteristics for this technology and the values measured for each characteristic during site characterization.

FIGURE 1
SITE EXPLORATION MAP



Matrix Characteristics [1, 2]

Matrix Characteristic	Value
Soil classification	Gravelly sand
Groundwater velocity	0.75 ft/day
Groundwater flow direction	Southeast
Depth to groundwater	6 ft bgs
Average gradient	2.4%
Aquifer depth	6 - 18 ft bgs

Notes:
bgs = Below ground surface
ft = Foot
ft/day = Foot per day

Treatment Technology Description [1, 2]

In Situ Bioremediation

HRC® is a proprietary mixture produced by Regenesis that consists of ammonium chloride, potassium tripolyphosphate, lactic acid, yeast extract, and sodium hydroxide. HRC® has the ability to enhance biodegradation of PCE and its daughter compounds by stimulating the growth of anaerobic bacteria.

Baseline groundwater samples were collected from the Cleaners #1 site in December 1998 before the first HRC® injection. At MW-1, these samples contained 551 micrograms per liter (µg/L) PCE, 139 µg/L TCE, 522 µg/L dichloroethene (DCE), and less than 1 µg/L vinyl chloride. Prior to injection of HRC®, trial pumping runs were conducted to determine the correct volume of HRC® to be injected. From December 15 through 18, 1998, HRC® was injected into groundwater through 55 Geoprobe boreholes over a 2,000-square-foot area. Figure 2 shows the injection points across the site. HRC® was injected using a double-stroke piston pump to a depth of 6 to 18 feet below ground surface (bgs). The injection rate of 1.25 pounds per vertical foot (lb/ft) resulted in a total of 2 gallons per borehole. A total of 1,140 pounds (114 gallons) of HRC® was injected.

A video survey of a sewer pipe was conducted on March 24, 1999, to determine areas of potential leakage. Two areas of potential leakage were discovered: (1) a section of cast iron pipe extending approximately 14 feet east from the east wall of the facility and (2) another section of pipe approximately 45 feet east-southeast of the east wall.

On April 21 and 22, 1999, a total of 86 cubic yards of soil was excavated from the two areas and the pipes were repaired. Figure 2 shows pipe and excavation locations. HRC® was applied to the soil at the bottom of both excavations before they were backfilled to address any remaining residual contamination. Approximately 15 gallons of HRC® was applied directly to the bottom of the large excavation located adjacent to the dry cleaning facility, and 3 gallons were applied to the smaller excavation to the east-southeast. This was the second application of HRC® at the site.

In July 2000, a third application of HRC® (second injection) was conducted to address any potential for contaminant rebound or vinyl chloride buildup.

Mechanical Soil Aeration and Off-Site Thermal Desorption

During excavation, soils with concentrations of PCE greater than the state cleanup level of 0.5 milligram per kilogram (mg/kg) were separated from soils containing less than 0.5 mg/kg. Approximately 6 cubic yards of soil removed from the excavation east-southeast of the Cleaners #1 facility exceeded the state cleanup level for PCE, with a maximum concentration of 3 mg/kg. Prior to treatment through thermal desorption, these soils were treated using mechanical soil aeration at an on-site treatment cell that consisted of a plastic liner with straw bale berms. To volatilize the PCE, the soils were stirred at 2-hour intervals for several hours. This process was conducted until a photoionization detector (PID) measured no detectable volatile organic compound (VOC) concentrations in the soil. After mechanical soil aeration, these soils were transported off site to TPS Technologies in Tacoma, Washington, for thermal desorption treatment followed by disposal.

Approximately 80 cubic yards (120 tons) of soil excavated from the area close to the facility contained less than 0.5 mg/kg PCE. The soils had been excavated from a maximum depth of 12 feet bgs. These soils were transported off site to TPS Technologies in Tacoma, Washington, for thermal desorption treatment prior to disposal.

Operating Parameters [1, 2]

Listed below are the key site operating parameters for in situ bioremediation.

Parameter	Value
Injection rate	1.25 lb/ft
Injection spacing	5 and 10 feet on-center

Performance Information [1, 2]

Cleanup levels for groundwater at the site are based on Washington State's Model Toxic Control Act (MTCA).

FIGURE 2
INJECTION/EXCAVATION MAP

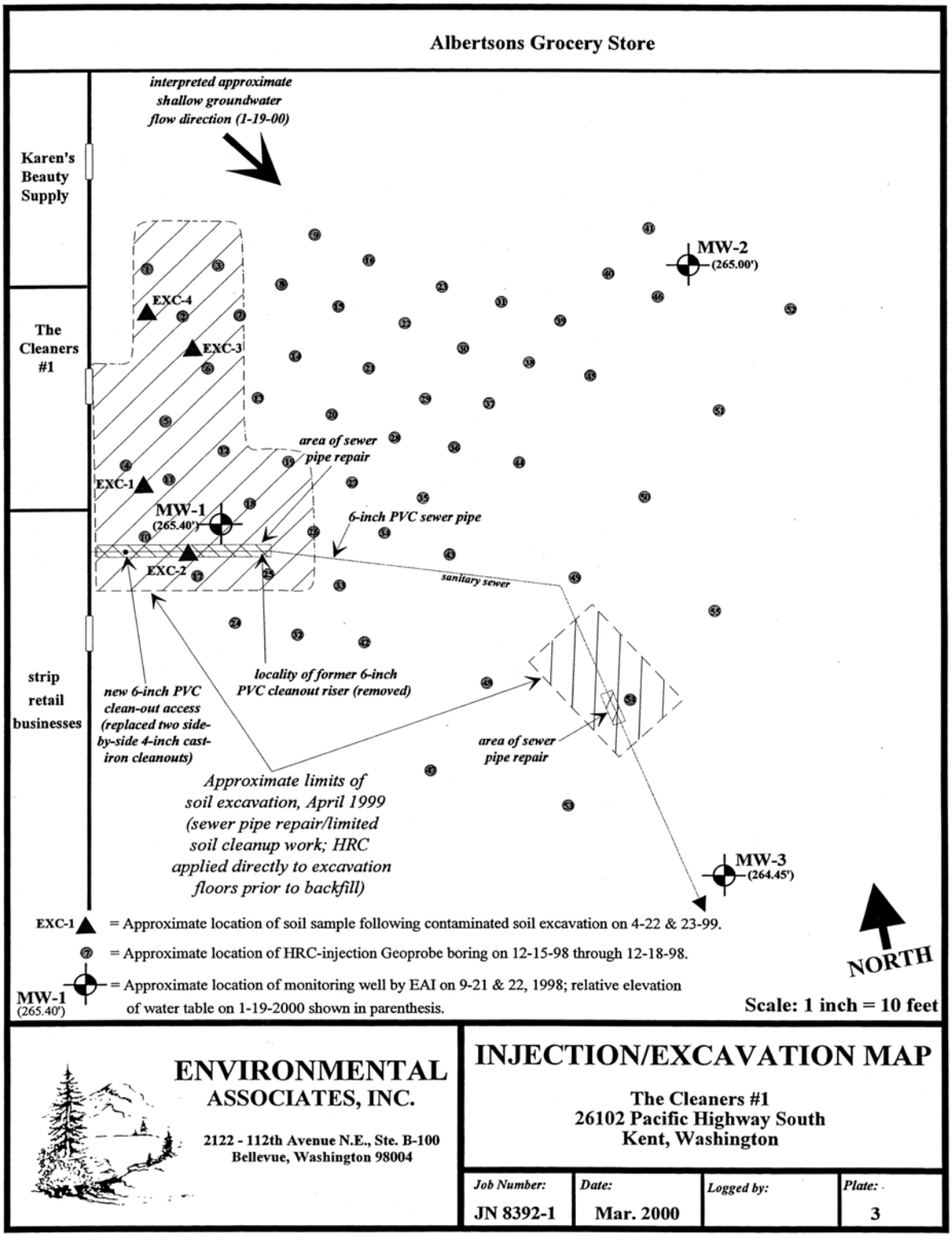


Table 1. Cleanup Goals for Contaminants of Concern [2, 3]

Compound	Cleanup Level (µg/L)
PCE	5 (A)
TCE	5 (A)
cis-1,2-DCE	80 (B)
trans-1,2-DCE	160 (B)
Vinyl chloride	0.2 (A)

(A) denotes MTCA Method A cleanup level for residential use
(B) denotes MTCA Method B cleanup level for universal use at all sites

In Situ Bioremediation

A treatability study was performed in a laboratory while HRC® injection was being conducted to evaluate the suitability of HRC® treatment at the site. During the study, HRC® and TCE were added to site soils, and concentrations of TCE, DCE, and vinyl chloride were measured at several time intervals (6, 13, and 25 days). Study results indicate that HRC® degraded TCE in site soils.

After HRC® injection into groundwater in December 1998, PCE concentrations increased significantly at MW-1 from 551 to 67,000 µg/L in January, February, and March 1999. This increase was attributed to a leaking sewer pipe that allowed PCE-contaminated sewer effluent to seep into the subsurface. Table 2 summarizes data collected in the source area (MW-1) and upgradient (MW-2) and downgradient (MW-3) of the treatment areas. Figures 3, 4, and 5 show the VOC concentrations over time in MW-1, -2, and -3, respectively.

After excavation activities, samples of remaining soils were collected and results indicated concentrations below cleanup levels (0.5 mg/kg for both PCE and TCE). After soil removal, repair of sewer pipes, and treatment of soil with HRC® in the bottom of excavations (second HRC® application), PCE and TCE concentrations in groundwater at MW-1 decreased approximately 99 and 86 percent, respectively, but goals were not met. Concentrations of vinyl chloride in MW-1 increased as a by-product of the increased degradation of cis-1,2-DCE. Sample results for soil remaining in the excavations were below cleanup levels.

After the third HRC® application (second injection), PCE, TCE, and DCE concentrations met the cleanup goals. These concentrations decreased by 99.9 percent, to less than 2 µg/L for PCE and TCE and to 0.24 µg/L for DCE. Vinyl chloride concentrations also decreased by 99.9 percent but slightly exceeded the cleanup level of 0.2 µg/L at a concentration of 0.29 µg/L in June 2004. According to the project manager and vendor, subsequent sampling has shown vinyl chloride at non-detect concentrations.

Groundwater samples collected from MW-4, MW-5, and MW-6, which are located further downgradient of MW-3, have not contained detectable concentrations of PCE or PCE-degradation by-products.

Mechanical Soil Aeration and Off-Site Thermal Desorption

Laboratory analysis of mechanically aerated soils revealed PCE concentrations from 0.12 to 0.28 mg/kg prior to thermal desorption.

Performance Data Quality [1]

Groundwater samples were collected using low-flow sampling techniques. No exceptions to established quality assurance/quality control (QA/QC) procedures were noted in the references reviewed.

Cost Information [2]

The cost of HRC® for the two injections (December 1998 and July 2000) was $13,860.

Observations and Lessons Learned [1, 2]

HRC® was effective at reducing PCE, TCE, DCE, and vinyl chloride concentrations to below cleanup levels.

Table 2. Groundwater Monitoring Results for MW-1, MW-2, and MW-3 (µg/L)

Well	Sampling Date	PCE	TCE	(cis)1,2-DCE	(trans)1,2-DCE	Vinyl chloride
MW-1 (source area)	12-14-98	551	139	522	5.4	<1
	First HRC® injection	--	--	--	--	--
	01-99	40,800	235	914	5.2	<1
	02-99	67,400	796	965	2.9	<1
	03-99	60,900	1,630	1,360	3.4	<1
	4-22-99 (sewer repair and HRC® application)	--	--	--	--	--
	05-99	34,800	11,700	1,140	<10	<10
	06-99	2,790	3,990	987	<25	<25
	07-99	1,150	2,620	4,770	<25	<25
	09-99	559	1,020	9,310	<25	<25
	11-99	259	404	9,940	<50	<50
	01-00	368	224	951	<5	29
	05-00	611	360	973	3.8	424
	Second HRC® injection	--	--	--	--	--
	08-00	110	95	1,200	<20	980
	09-00	63	30	910	<20	960
	10-00	32	<20	430	<20	500
	12-00	34	17	530	5.4	690
	02-01	22	17	460	5.3	930
	04-01	3.9	3.5	290	3.0	930
	06-01	<2	<2	90	<2	420
	09-01	0.71	0.66	26	1.1	360
	12-01	1.6	2.2	37	1.2	48
	03-02	1.5	3.2	44	0.85	13
	06-02	0.29	0.30	2.3	0.48	31
	09-02	0.64	1.2	14	<0.2	0.27
	01-03	0.83	1.4	16	0.25	1.6
	07-03	<0.2	<0.2	0.9	<0.2	0.89
	11-03	<0.2	<0.2	2.7	0.40	6.1
	02-04	<0.2	<0.2	0.41	<0.2	0.4
	06-04	<0.2	<0.2	0.24	<0.2	0.29
MW-2 (upgradient)	12-14-98	10.8	<1	<1	<1	<1
	First HRC® injection	--	--	--	--	--
	01-99	1.4	<1	<1	<1	<1
	02-99	1.3	<1	<1	<1	<1
	03-99	7.2	<1	<1	<1	<1
	4-22-99 (sewer repair and HRC® application)	--	--	--	--	--
	05-99	2.3	<1	<1	<1	<1
	06-99	2.8	<1	<1	<1	<1
	07-99	<1	<1	<1	<1	<1
	09-99	<1	<1	5.1	<1	<1
	11-99	<1	<1	1.8	<1	<1
	01-00	<1	<1	7.6	<1	<1
	05-00	<1	<1	3.5	<1	<1
	Second HRC® injection	--	--	--	--	--
	08-00	<0.2	<0.2	<0.2	<0.2	<0.2
	09-00	<0.2	<0.2	<0.2	<0.2	<0.2
	10-00	<0.2	<0.2	<0.2	<0.2	<0.2
	12-00	<0.2	<0.2	0.22	<0.2	<0.2
	02-01	<0.2	<0.2	0.36	<0.2	<0.2
MW-2	04-01	<0.2	<0.2	<0.2	<0.2	<0.2

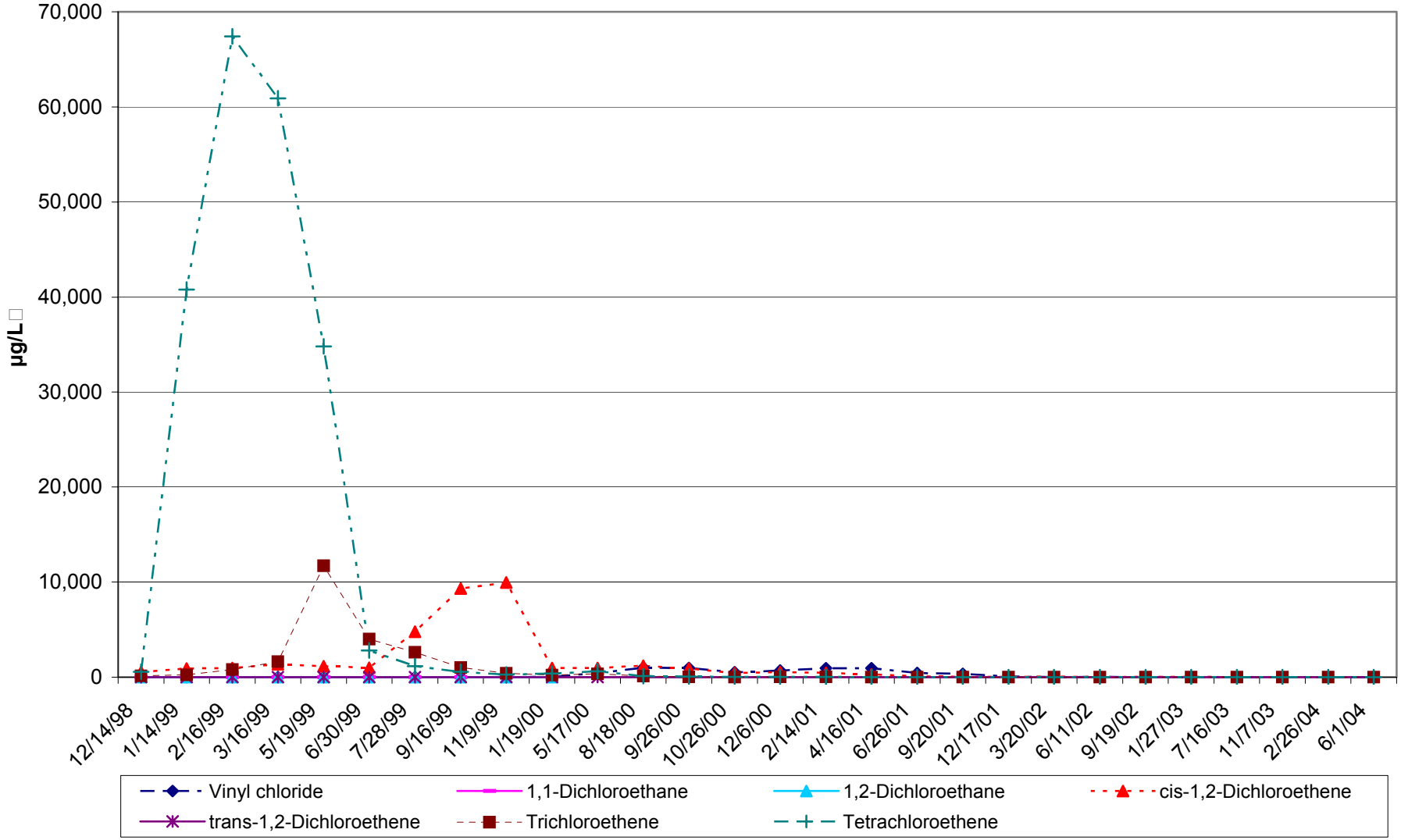
Well	Sampling Date	PCE	TCE	(cis)1,2-DCE	(trans)1,2-DCE	Vinyl chloride
(upgradient) (cont'd)	06-01	<0.2	<0.2	<0.2	<0.2	<0.2
	09-01	<0.2	<0.2	0.3	<0.2	<0.2
	12-01	<0.2	<0.2	<0.2	<0.2	<0.2
	03-02	<0.2	<0.2	<0.2	<0.2	<0.2
	06-02	<0.2	<0.2	<0.2	<0.2	<0.2
	09-02	NS	NS	NS	NS	NS
	01-03	<0.2	<0.2	<0.2	<0.2	<0.2
	07-03	NS	NS	NS	NS	NS
	11-03	<0.2	<0.2	<0.2	<0.2	<0.2
	02-04	<0.2	<0.2	<0.2	<0.2	<0.2
	06-04	<0.2	<0.2	<0.2	<0.2	<0.2
MW-3 (downgradient)	12-14-98	60.6	35.1	360	<1	57.4
	First HRC® injection	--	--	--	--	--
	01-99	58.9	31.0	295	1.8	27.0
	02-99	57.7	23.2	188	<1	13.5
	03-99	44.2	16.6	115	<1	10.6
	4-22-99 (sewer repair and HRC® application)	--	--	--	--	--
	05-99	3.4	11.5	89.4	<1	7.5
	06-99	<1	<1	138	<1	53.4
	07-99	<1	<1	91.3	<1	137
	09-99	<1	<1	43.8	2.3	220
	11-99	<1	<1	13	1.5	174
	01-00	<1	<1	9.2	<1	58.8
	05-00	<1	<1	1.2	<1	45
	Second HRC® injection	--	--	--	--	--
	08-00	<2	<2	19	<2	48
	09-00	<0.2	<0.2	36	1.6	82
	10-00	<0.2	3.5	24	1.2	66
	12-00	<0.2	0.41	15	1.4	67
	02-01	<0.2	0.51	11	0.87	38
	04-01	<0.2	0.42	4.9	0.59	20
	06-01	<0.2	0.45	11	1.1	42
	09-01	<0.2	3.7	47	1.7	110
	12-01	<0.2	0.26	2.2	<0.2	0.77
	03-02	<0.2	0.33	1.3	<0.2	0.53
	06-02	<0.2	0.26	2.2	0.26	2.4
	09-02	0.62	1.2	15	0.27	0.32
	01-03	0.28	0.50	6.4	<0.2	0.42
	07-03	<0.2	<0.2	0.46	<0.2	0.46
	11-03	<0.2	<0.2	1.5	0.36	3.2
	02-04	<0.2	<0.2	<0.2	<0.2	0.26
	06-04	<0.2	<0.2	<0.2	<0.2	<0.2
Washington State MTCA Cleanup Level		5 (A)	5 (A)	80 (B)	160 (B)	0.2 (A)

Notes:

µg/L = Microgram per liter
DCE = Dichloroethene
MTCA = Model Toxic Control Act
PCE = Tetrachloroethene
TCE = Trichloroethene

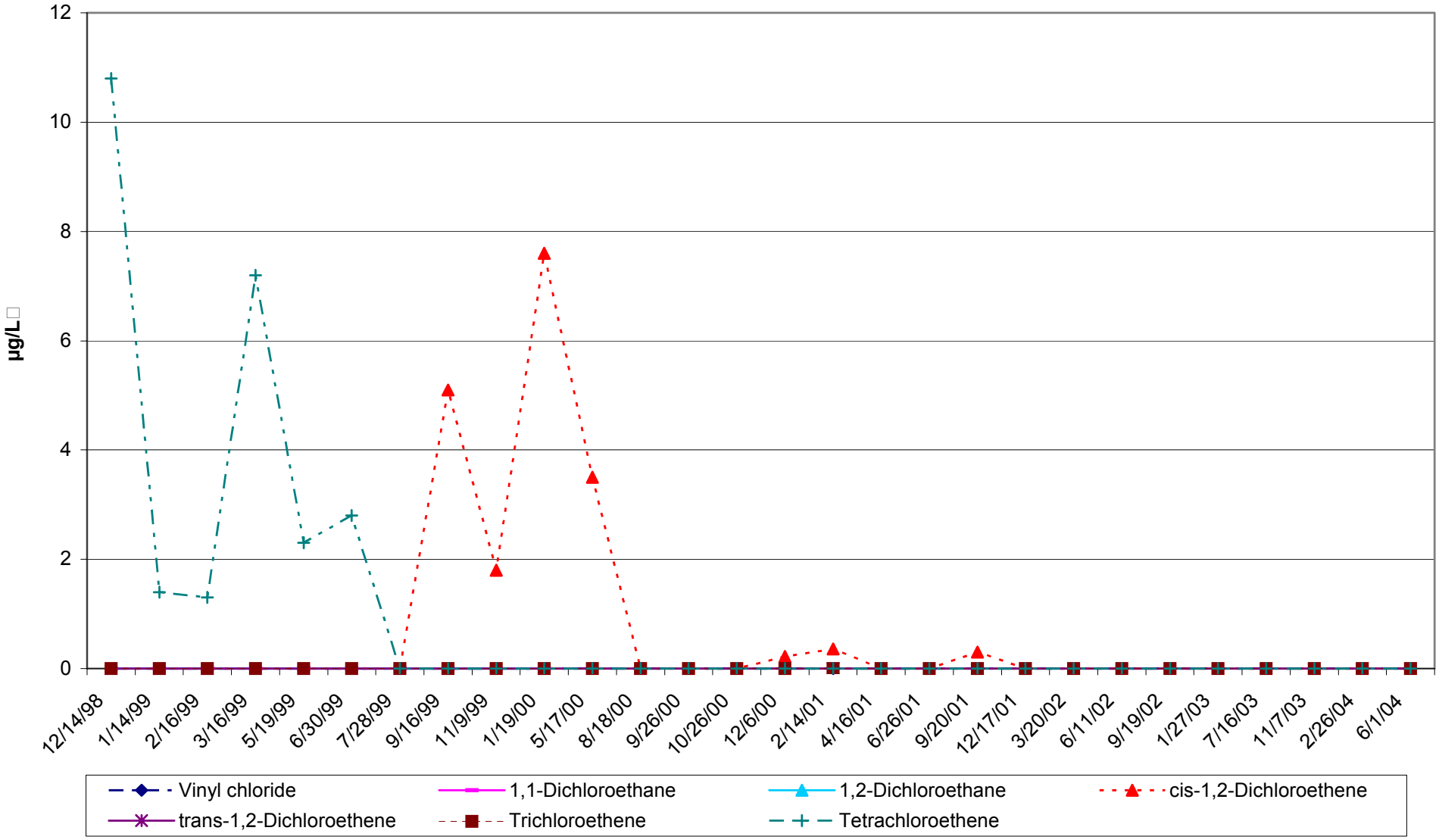
(A) denotes MTCA Method A cleanup levels for residential uses
(B) denotes MTCA Method B cleanup levels for universal use at all sites

FIGURE 3
MONITORING WELL MW-1 VOC CONCENTRATIONS OVER TIME



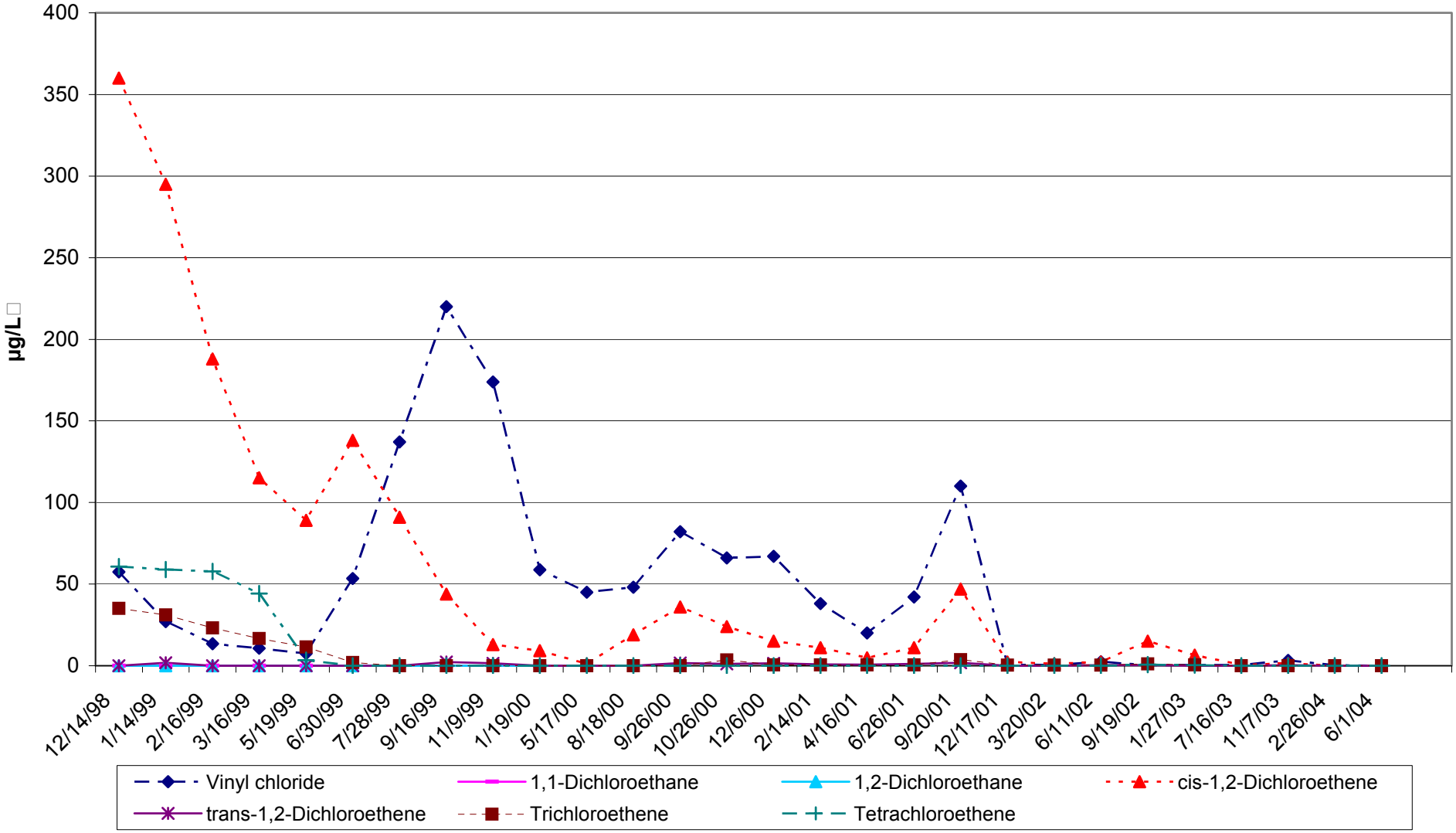
*Adapted from Environmental Associates, Inc., 2000 [1, 4]

FIGURE 4
MONITORING WELL MW-2 VOC CONCENTRATIONS OVER TIME



*Adapted from Environmental Associates, Inc., 2000 [1, 4]

FIGURE 5
MONITORING WELL MW-3 VOC CONCENTRATIONS OVER TIME



*Adapted from Environmental Associates, Inc., 2000 [1, 4]

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