COST AND PERFORMANCE REPORT

Anaerobic In-situ Reactive Zone
at an Abandoned Manufacturing Facility,
Emeryville, California

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EPA
U.S. Environmental Protection Agency
Office of Solid Waste and Emergency Response
Technology Innovation Office

Anaerobic In-situ Reactive Zone at an Abandoned Manufacturing Facility, Emeryville, California

Summary Information

Site Name, Location	Abandoned Manufacturing Facility, Emeryville, California
EPA ID Number	Not Applicable
Mechanism(s)	Anaerobic Reductive Dechlorination and Metal Precipitation
Technology	Electron Donor Addition (Molasses)
Configuration	Direct Injection
Technology Scale	Pilot and Full scale
Media/Matrix Treated	Groundwater
Contaminants Targeted	TCE, hexavalent chromium
Period of Operation	Pilot study – August 1995 to February 1996 Full scale system-ongoing, data available from April 1997 to October 1998

Site History/Source of Contamination [1]

From 1952 until 1995, metal plating operations, including nickel plating, were performed at a manufacturing facility located in Emeryville, California (actual site name confidential). Solvents were used in degreasing operations until 1992, when they were replaced with a liquid-alkaline soak process. Plating operations were discontinued in 1995, and the associated plating equipment has subsequently been removed from the site. Operations at the site resulted in the groundwater becoming contaminated with chlorinated solvents and metals.

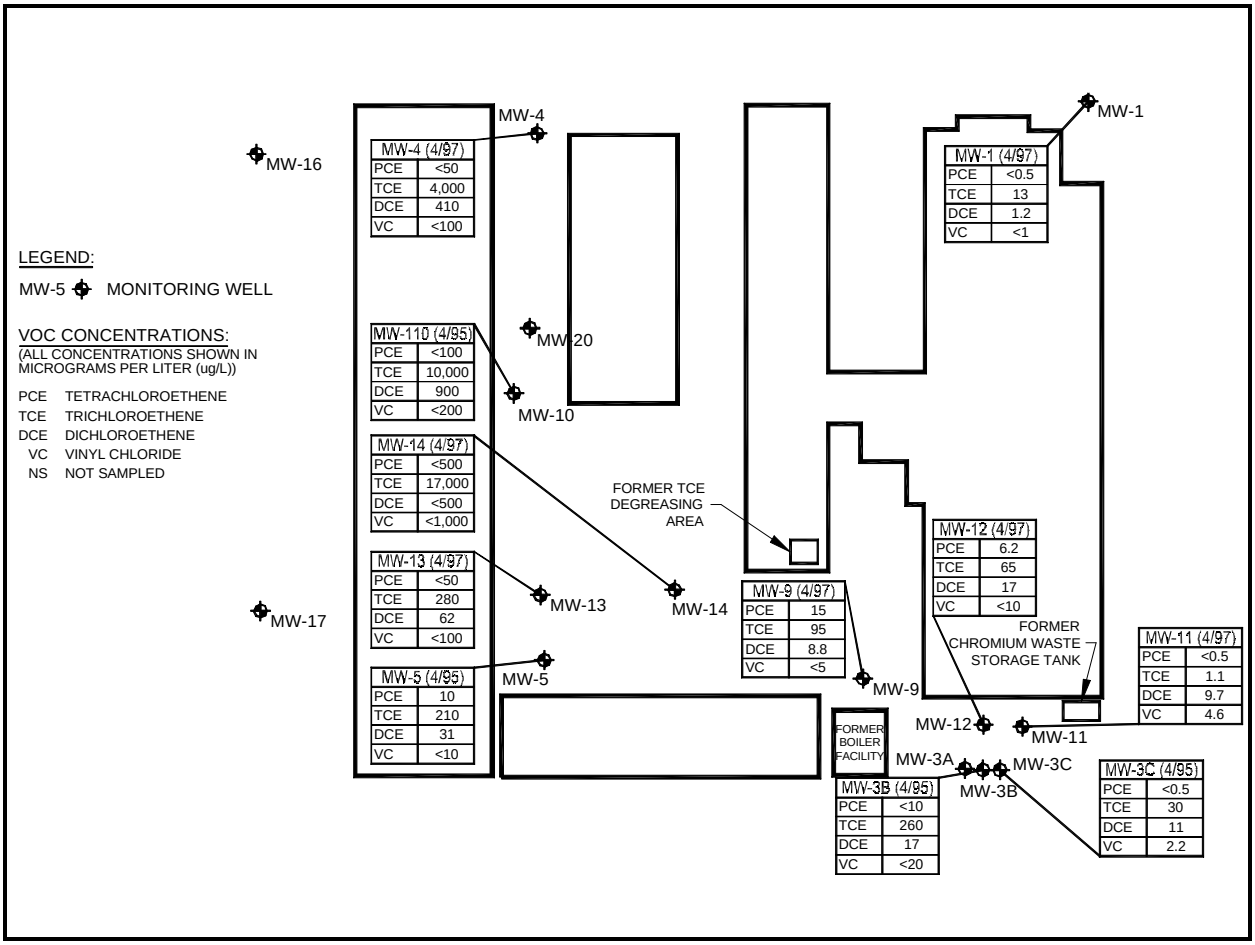
Between 1977 and 1985, 24 groundwater monitoring wells were installed at the site and on adjacent properties. Figure 1 shows the location of the 14 on-site monitoring wells. Elevated levels of chromium and trichloroethene (TCE) was detected in groundwater in the late 1970s and early 1980s. The cleanup of the site is being completed under a state voluntary cleanup program. In 1995, the site owner initiated a pilot study to evaluate anaerobic reductive dechlorination and metals precipitation via an in-situ reactive zone as a possible remedy for the site (as a potential alternative to a conventional pump and system). The following case study primarily focuses on the reductive dechlorination of TCE; limited data on the precipitation of hexavalent chromium was provided in the available references.

Geology/Hydrogeology/Contaminant Characteristics [1]

The geology of the site geology consists of interbedded sand and clay units. Groundwater is found at depths of 3.5 to 8 feet below ground surface (bgs). Groundwater velocity is estimated to be 60 feet per year.

TCE and chromium are the primary contaminants in the groundwater at the site. TCE concentrations from April 1995 (prior to initiation of the pilot study) were as high as 17,000 ug/L (Well MW-14). Historical groundwater data from on-site wells indicated that, over the past 10 years, TCE concentrations have been slowly decreasing. For example, TCE concentrations in Well MW-10 were 12,000 µg/L during a June 1985 sampling event and 10,000 µg/L during an April 1995 sampling event.

Figure 1: Pre-Injection CAH Concentrations, Abandoned Manufacturing Facility, Emeryville, California (April 1995) [1]



Matrix Characteristics at Abandoned Manufacturing Building [1]

Parameter	Value
Soil Type	Interbedded sand and clay units
Depth to Groundwater	Approximately 3.5 to 8 feet
Thickness of Aquifer	Not available
Fraction of Organic Carbon	Not available
DNAPL Presence	Not Indicated
Hydraulic Conductivity	Not available
Groundwater Velocity	60 feet per year

Technology Description [1,3]

Pilot Study

The pilot study was conducted between August 1995 and February 1996. The pilot study was performed to determine if the rate of TCE degradation and metals precipitation could be enhanced by an anaerobic in-situ reactive zone. Groundwater monitoring data, collected prior to the start of the pilot study, indicated that limited reductive dechlorination of TCE to cis-1,2-dichloroethene (DCE) was occurring, but that the rate of dechlorination was limited due to the biogeochemical conditions at the site (the organic carbon source was depleted or the environment was not sufficiently reducing). Vinyl chloride (VC), the degradation product of cis-1,2-DCE, was either not detected or was sporadically detected in many of the wells. According to the site contractor, DCE and VC may have been present in some wells prior to start of the pilot study, but were not detected because of high method detection limits (e.g., 1,000 µg/L for DCE and 2,000 µg/L for VC).

To establish the anaerobic reactive zone, a mixture of molasses, biologically inoculated solution (supernatent), and tap water was injected into the subsurface. Injection of the supernatent was needed because of low plate counts observed in one well during a baseline sampling event. The supernatent used for the pilot study was from the anaerobic treatment system of a local municipal authority.

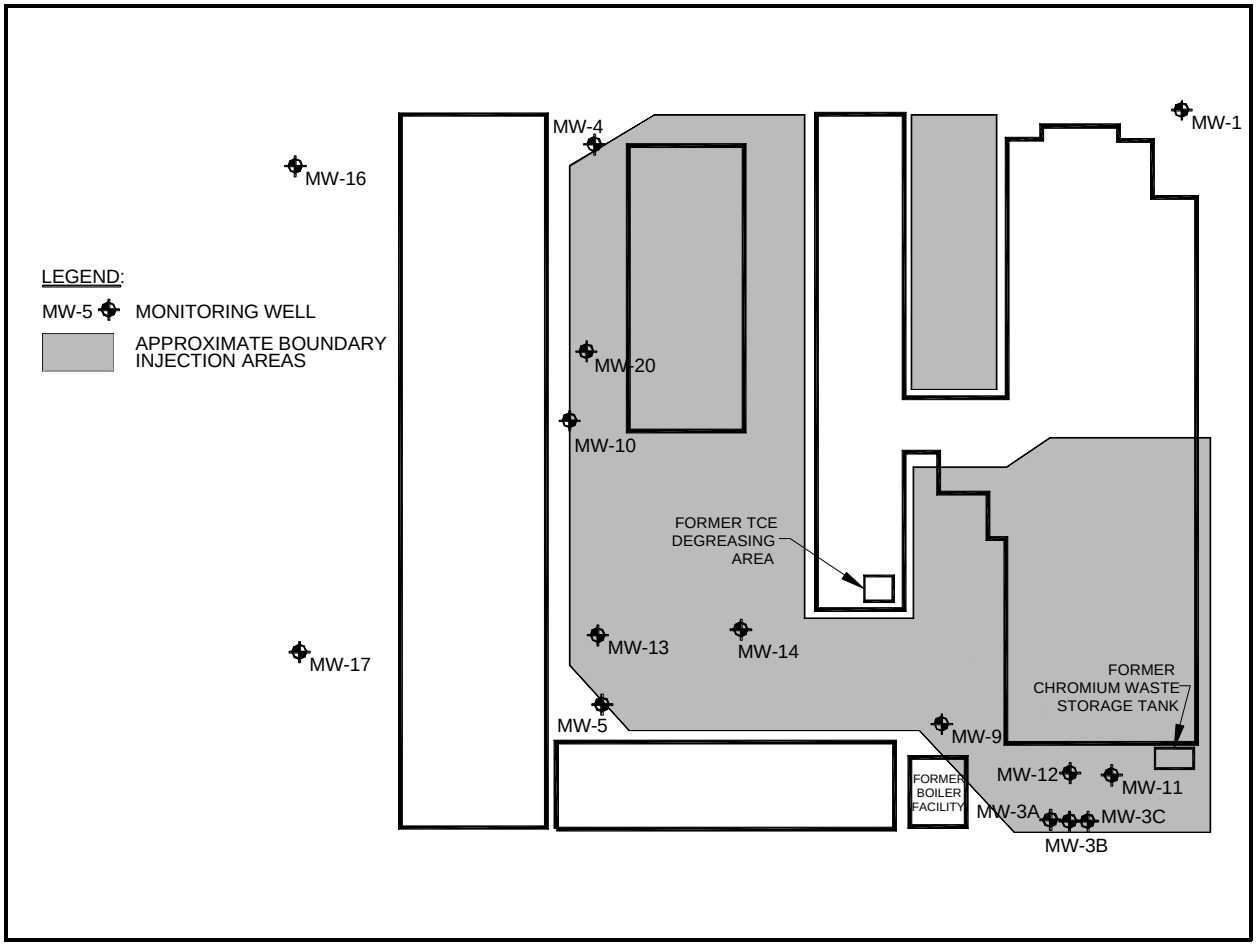
The results of the pilot study indicated that the historical reductive dechlorination rate at the site could be enhanced via the injection of the molasses solution. For example, TCE concentrations in Well MW-10 were reduced from 10,000 µg/L in April 1995 to 4,200 µg/L in February 1996.

Full-Scale System

In April 1997, ninety-one temporary injection points were installed at the site, as shown in Figure 2. The injection points are located in two areas due to the location of existing buildings. Each injection points was installed to a depth of 24 feet bgs.

The full-scale system has been operating since April 1997 and data are available through October 1998. Two molasses injection events have been performed at the site, in April 1997 and in February 1998. Each molasses injection event included a mixture of water, molasses, and a small amount of supernatent (to provide additional bacteria capable of degrading TCE). During the first injection event, each injection point received 25 gallons of molasses, 1 gallon of supernatent, and 125 gallons of water. Information about the volume and composition of the solution used in the second injection event was not available. The reagent was mixed on-site and manually injected into the subsurface using a centrifugal pump.

Figure 2: Full-Scale Injection Area, Abandoned Manufacturing Facility, Emeryville, California [2]



Technology Performance [1,2]

Performance data are available through October 1998. Figure 3 presents the data on concentrations of PCE, TCE, DCE, and VC in on-site wells as of October 1998. Figures 4 and 5 show the change in concentrations of TCE, DCE, and VC from December 1996 through October 1998 for Wells MW-4 and MW-14, respectively. Well MW-14 is located in the source area and MW-4 is in the mid-plume area. Figure 6 shows the average TCE, DCE and VC concentrations in the on-site monitoring wells within the remediation area (MW-4, MW-10, W-13, and MW-14).

As shown in Figure 3, the maximum contaminant concentrations measured in groundwater at the site as of October 1998 were PCE (0.75 ug/L), TCE (17 ug/L), DCE (1,400 ug/L), and VC (180 ug/L). Figures 4 and 5 show that TCE, DCE, and VC concentrations in wells MW-14 and MW-4 were reduced to below the detectable levels by October 1998. Initial DCE and VC concentrations increased following the first reagent injection, but then declined by October 1998. According to the site contractor, the trends for TCE degradation products (DCE and VC) indicate that TCE is being reductively dechlorinated to ethene. As shown in Figure 6, concentrations of TCE in wells located within the remediation area have decreased by 99% (3,040 µg/L in April 1995 to 4 µg/L in October 1998).

Figure 3: CAH Concentrations - October 1998, Abandoned Manufacturing Facility, Emeryville, California [2]

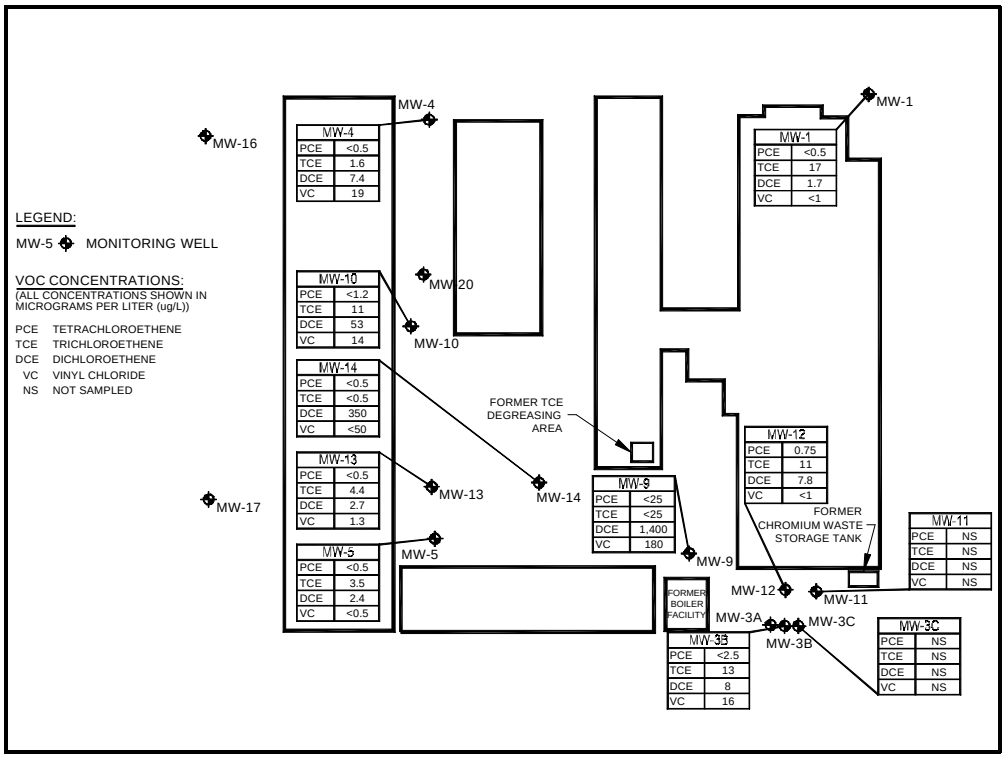


Figure 4: Analytical Results for Well MW-4, Abandoned Manufacturing Facility, Emeryville, California [2]

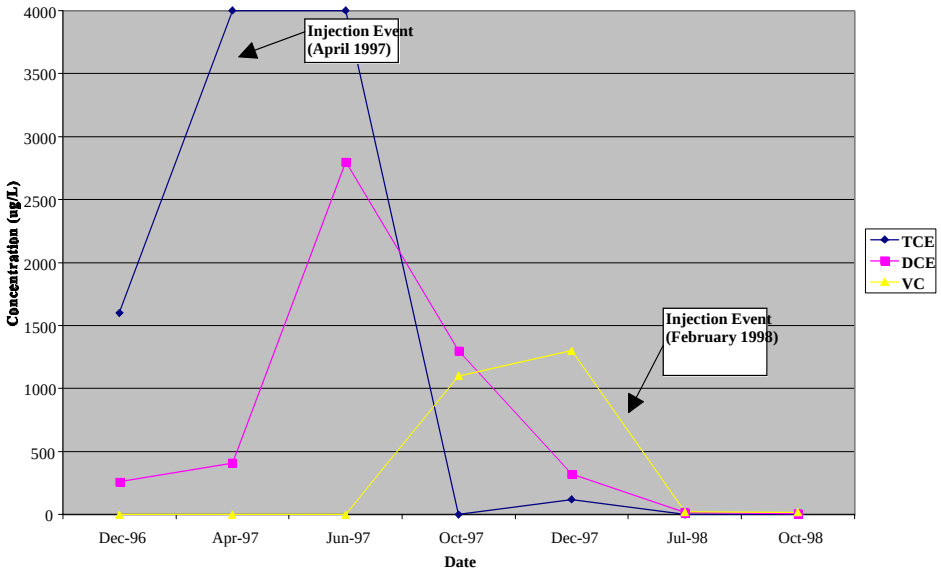


Figure 5: Analytical Results for Well MW-14, Abandoned Manufacturing Facility, Emeryville, California [2]

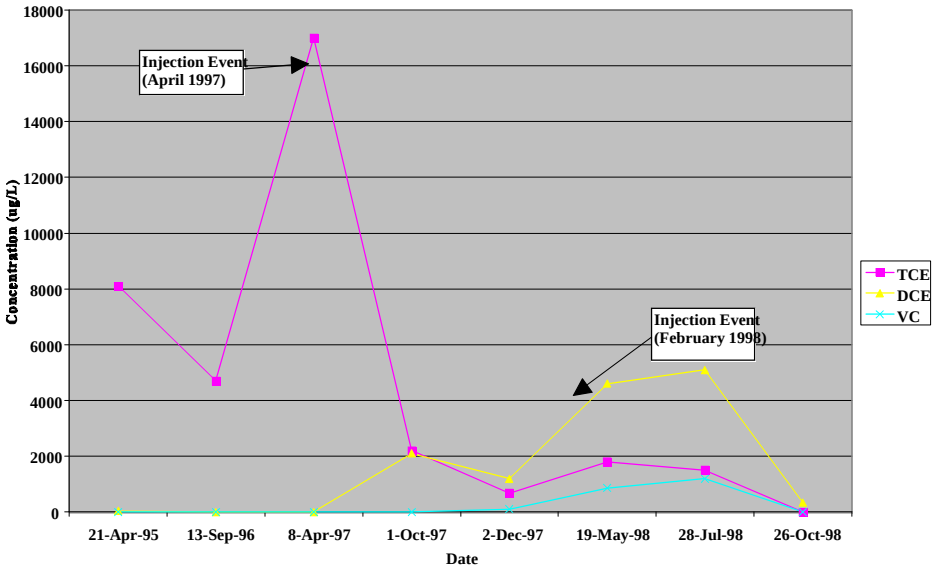
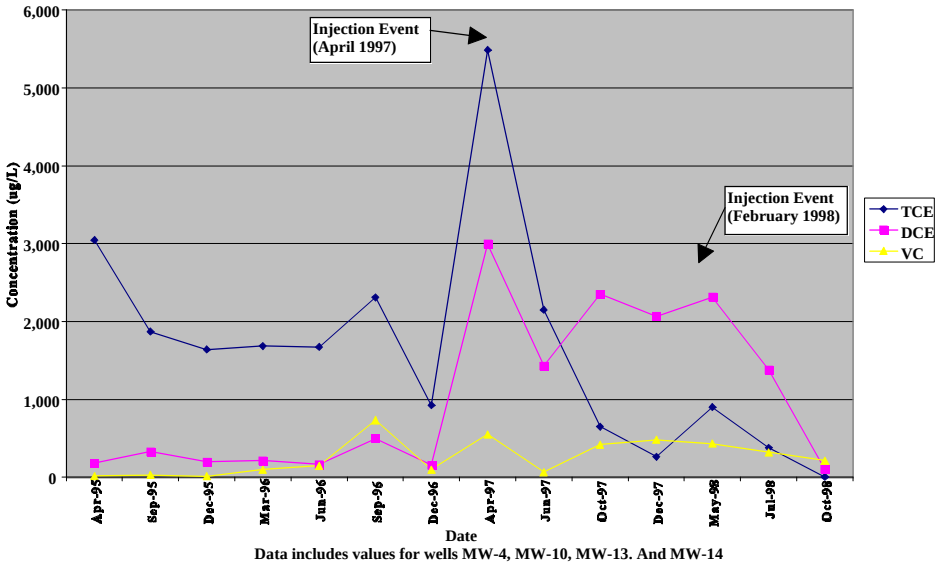


Figure 6: Average Concentrations, On-Site Wells in Remediation Area, Abandoned Manufacturing Facility, Emeryville, California [2]



In addition, the average concentrations of total chromium and hexavalent chromium in the injection area have been reduced by approximately 98% and 99%, respectively, and some of the wells where historic hexavalent chromium concentrations were in excess of 100,000 µg/L are now less than the detection limit (5 µg/L).

Technology Costs [1]

The overall project cost is approximately $400,000. No further information was provided about the components of this cost, such as a breakdown of capital or operations and maintenance (O&M) costs.

Summary Observation and Lessons Learned [1,2,3]

The injection of molasses reagent solution created conditions favorable for the reduction in TCE, DCE, VC, and chromium concentrations in the subsurface. During an 18-month period of full-scale operation, average concentrations of TCE were reduced by 99%, from more than 3,000 ug/L to 4 ug/L. Average concentrations of hexavalent chromiumwere were reduced by 99% to below detection levels.

The solution of molasses, supernatent, and water was injected through 91 temporary injection points installed using a Geoprobe™. According to the remediation contractor, the use of a Geoprobe™ allowed the injection points to be installed relatively quickly and at low cost.

A pilot study was conducted prior to the full-scale operation. The pilot study showed that the rate of reductive dechlorination could be enhanced with the use of an injected molasses solution.

Contact Information

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References:

1. E-mail Transmittal from Dan Jacobs, ARCADIS Geraghty & Miller, to Richard Weisman, Tetra Tech EM Inc. 1999. California Text - ECI EPA.doc. March 24.

2. E-mail Transmittal from Dan Jacobs, ARCADIS Geraghty & Miller, to Richard Weisman, Tetra Tech EM Inc. 1999. California Text - ECI Figures.xls. March 24.

3. Fax Transmittal from Dan Jacobs, ARCADIS Geraghty & Miller, to Kathy Yager, EPA. 1998. Site 3 - Abandoned Manuafacturing Facility, Emeryville, California. May 18.