

Union Chemical Company

Pump and Treat—Hot Air Injection—Soil Vapor Extraction—In Situ Chemical Oxidation— Biostimulation

Site Name: Union Chemical Company

Site Location: South Hope, Maine

Technology Used:

- Pump and Treat (P&T)
- Hot Air Injection (HAI) with Soil Vapor Extraction (SVE)
- In Situ Chemical Oxidation (ISCO) Potassium and Sodium Permanganate and Hydrogen Peroxide)
- Biostimulation (Molasses and Sodium Lactate)

Regulatory Program: U.S. EPA Superfund NPL Site

Remediation Scale: Full

Project Duration: 1994 to present

Site Information: Union Chemical began operations as a paint stripping and solvent manufacturer in 1967 on about 2.5 acres of a 12.5-acre parcel. Later, the company expanded operations to include the recycling of used stripping compounds and solvents from other businesses. Operations were further expanded in 1982 to include a full-scale, fluidized-bed incinerator to treat waste solvents and other compounds. The hazardous waste operations were stopped in 1984. Groundwater and surface water contamination was discovered in November 1979.

Contaminants: The remedial investigation found 23 contaminants of concern. The primary contaminants in the soil, groundwater and debris were tetrachloroethene (PCE), trichloroethene (TCE), 1,1,1-trichloroethane (TCA), toluene, xylenes, dioxin, arsenic, lead, and asbestos. Many of the contaminants have penetrated the overburden soil and entered the weathered bedrock. Before remediation began, a contaminant plume existed in the overburden and weathered bedrock groundwater that discharged to a surface water body bordering the site. Table 1 displays representative maximum contaminant con-

centrations in the groundwater and associated remedial goals for selected chemicals.

Table 1. Representative Maximum Groundwater Contaminant Concentrations (1995) and Cleanup Goals (µg/L)			
Contaminant	Overburden	Bedrock	Cleanup Goal
1,1-Dichloroethene	3,200	630	7
<i>trans</i> -1,2-Dichloroethene	16,000 (total)	1,700 (total)	100
1,1-Dichloroethane	13,000	11,000	5
2-Butanone	12,000	ND	170
<i>cis</i> -1,2-Dichloroethene	16,000 (total)	1,700 (total)	70
Tetrahydrofuran	NA	NA	70
1,1,1-Trichloroethane	24,000	NA	200
Trichloroethene	8,200	1,100	5
Vinyl Chloride	NA	NA	2
4-Methyl-2-pentanone	3,100	39	NA
Toluene	12,000	1,600	70
Tetrachloroethene	1,200	ND	5
Ethylbenzene	7,700	2,100	700
Total Xylenes	48,000	7,200	10,000
Dimethylformamide	26,000	710	390
NA=Not available or established; ND=Not detected			
Source: Rizzo Associates 2004			

Hydrogeology: The surficial geology at the site is a heterogeneous mixture of sand, silt, clay, and stones. Stratification is rare. The dense till varies in thickness from 80 ft in proximity to Quiggle Brook, to less than 25 ft in the western portion of the site, and it is directly underlain by bedrock. The bedrock is characterized by about a 5-ft thick area of high weathering underlain by a 15 to 25 ft moderately fractured zone. The fractures become less abundant with depth. Competent bedrock is generally found below 110 ft below ground surface (bgs).

Depth to groundwater varies from 15 to 20 ft bgs, and artesian conditions exist in some wells adjacent to Quiggle Brook. The overburden soil has a low permeability, and the primary flow and yield of groundwater occurs through the weathered bedrock, which was characterized in some drilling logs as a fine to medium grain sand.

Project Goals: The primary goals were to prevent further leaching and migration of contaminants from the soil into the groundwater; restore groundwater quality throughout the site to concentrations that will protect current and future users as well as natural resources, such as wildlife; and prevent offsite migration of contaminated groundwater.

Cleanup Approach: With the exception of the weathered bedrock, the overburden soil has a relatively low permeability. A dual-phase system or combination of groundwater pumping wells to dewater the overburden and SVE wells to recover contaminant vapors was chosen to address source zone contaminated soil. This system was augmented with HAI.

Four hotspots consisting of approximately 2,260 yd³ of contaminated soil were excavated and consolidated over the source area that was to be treated by hot air assisted SVE. The contaminated soil was capped with 18 inches of clay overlain by six inches of gravel.

The groundwater treatment system, which included an ion exchange unit to address metals, was unable to meet state levels for discharge to surface water for copper and manganese and thus delayed startup. The ion exchange system was replaced with a pH adjustment and flocculation system that achieved the discharge levels though not consistently. The pumping rate was lowered while maintaining hydraulic control to allow the treated groundwater to be re-injected into the subsurface (U.S. EPA 2002 [p 4-8]).

Following completion of startup activities in October 1996, the hot air-assisted SVE system operated continuously until March 1998.

Groundwater was pumped from the extraction wells to lower the water table and extend the depth to which the soil could be treated by the SVE system. Air was heated to approximately 775 °F and injected into the 91 HAI wells to enhance the volatilization of volatile organic compounds (VOCs) (U.S. EPA 2002 [p 4-8]). Vapors were collected from SVE wells placed within the hexagonal grid of HAI wells.

The SVE treatment system consisted of a propane-fired thermal oxidizer and a heat exchange unit that heated clean air for the hot air injection system. The groundwater treatment system consisted of sand filters, equalization tank, tray-type air stripper, an advanced oxidation unit, two granulated activated carbon (GAC) filters, an ion exchange unit (later replaced by pH adjustment and flocculation), and a 500-gallon effluent tank.

The rate of mass removal of VOCs decreased dramatically between 1996 and 1999; however concentrations of VOCs in the groundwater did not show a similar decline.

A potassium permanganate pilot study was completed in October 1997. Based on the results of this study, potassium permanganate was used on an expanded basis in the summers of 1998, 1999, and 2000 in an attempt to achieve further reductions in VOC concentrations.

Sodium permanganate was also used on site in 2000 near the pumping wells and Quiggle Brook. Sodium permanganate was used in this sensitive area since it could be added in a greater concentration per unit volume than potassium permanganate, which has a much lower solubility, thereby requiring less fluid to be injected to achieve the same oxidation potential. A lesser volume of oxidant solution would decrease the risk of the extraction wells allowing it to enter the brook.

Following groundwater sampling in the spring of 2001, EPA approved the in situ addition of carbon sources in the form of molasses and sodium lactate. EPA approved the change from an oxidizer to a reducing agent because the per-

manganate applications had significantly reduced the concentrations of the predominant contaminants, TCE, dichloroethene, and PCE. However, permanganate was not very effective in treating chlorinated ethanes and the concentrations of dichloroethane (DCA) and TCA had not decreased. As a result, DCA became the most widespread VOC above the performance standards and was found at the highest concentrations, whereas prior to groundwater remediation. Food-grade molasses and sodium lactate were added to the subsurface in separate locations. Sodium lactate was found to be preferable, and a second treatment took place in 2002.

While the groundwater conditions were made anaerobic by these injections there appeared to be little change in the concentrations of DCA and TCA. A microcosm study dated July 2003 indicated that the presence of microorganisms capable of degrading VOCs, and specifically 1,1-DCA, was well-specific. The growth of the microorganism populations, when present, was very slow and the carbon addition program was suspended.

In 2005 a total of 1,100 gallons of a 35% hydrogen peroxide solution was injected in two phases into selected wells at the site. The results were uneven with concentrations of contaminants falling in the injections wells but not in wells where peroxide was not injected.

Project Results: The initial response actions implemented at the site included the removal of 2,000-2,500 55-gallon drums and 28 liquid storage tanks. Site-related buildings and structures containing asbestos were demolished and removed from the site (Rizzo 2004).

Remedial activities, including the operation of the SVE and groundwater P&T systems, have reportedly removed about 10,000 lbs of VOCs from the subsurface (9,500 lbs from soil and 600 lbs from groundwater). Due to the SVE treatment, the unsaturated soil at the site is no longer considered an ongoing source of the dissolved-phase VOC contamination.

The permanganate addition programs significantly contributed to the groundwater VOC concentration reductions observed in the monitoring wells. The permanganate addition program removed an estimated 35 lbs of VOCs from the groundwater and 310 lbs from saturated soil. Table 2 provides a series of maximum concentrations detected over 23 quarters of time. Quarter 12 is considered typical of pre-cleanup levels.

The results of the carbon source addition program indicated that although conditions were amenable to have reductive dechlorination occur in the site groundwater, the achieved reduction in VOC concentration was minimal and localized to various wells and sections of the Site. The conclusion was made that biodegradation was not a viable option for the site.

The hydrogen peroxide injections resulted in lower contaminant concentrations where contact was made, but the aerial extent of the active peroxide was limited.

The pump and treat system was deactivated in 2006 (EPA 2012).

As of August 2011, the plume has stabilized and the site is in a long term monitoring mode. A request for a finding of Technical Impracticability is under review by EPA

The soil and groundwater cleanup costs for the SVE and P&T remedial activities were approximately \$9.5 million with an additional \$2 million expended on site assessment and system design costs (Rizzo 2004).

The permanganate injection program is estimated to have cost about \$600,000. The approximate cost of the carbon addition program was \$125,000 (Rizzo 2004).

Sources:

EMS, Inc. Personal contact with Terry Connelly August 25, 2011.

Rizzo Associates. 2004. Conceptual Site Model Report Union Chemical Company Site 214 Main Street South Hope, Maine, 132 pp.

<http://www.epa.gov/region1/superfund/sites/union/260700.pdf>

U.S. EPA. 1990. Record of Decision for Union Chemical Co., Inc., South Hope, Maine, 48 pp.

<http://www.epa.gov/region01/superfund/sites/union/35238.pdf>

U.S. EPA. 2001. Explanation of Significant Differences: Union Chemical Co., Inc., EPA ID: MED042143883, OU 01, South Hope, ME 09/28/2001, 39 pp.

<http://www.epa.gov/superfund/sites/rods/fulltext/e0101018.pdf>

U.S. EPA. 2002. Five-Year Review: Union Chemical Company Site, South Hope, Maine, 92 pp.

<http://www.epa.gov/region01/superfund/sites/union/35789.pdf>

U.S. EPA. 2012. Five-Year Review: Union Chemical Company Site, South Hope, Maine, 67 pp.

<http://www.epa.gov/region1/superfund/sites/union/522178.pdf>

Project Contacts

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Contaminant	Overburden Q12	Overburden Q31	Overburden Q37	Bedrock Q12	Bedrock Q31	Bedrock Q37
1,1-Dichloroethene	3,200	320	250	630	220	310
<i>trans</i> -1,2-Dichloroethene	16,000 (total)	42	250	1,700 (total)	NA	45
1,1-Dichloroethane	13,000	3,800	2,800	11,000	2,000	3,000
2-Butanone	12,000	1,700	1,000	ND	NA	100U
<i>cis</i> -1,2-Dichloroethene	16,000 (total)	1,800	1,500	1,700 (total)	1,000	2,100
Tetrahydrofuran	NA	40	ND	NA	130	NA
1,1,1-Trichloroethane	24,000	33	10U	NA	NA	NA
Trichloroethene	8,200	460	570	1,100	40	66
Vinyl Chloride	NA	240	110	NA	20	220
4-Methyl-2-Pentanone	3,100	320	NA	39	2,100	NA
Toluene	12,000	30	NA	1,600	20	NA
Tetrachloroethene	1,200	30	10U	ND	NA	20U
Ethylbenzene	7,700	720	460	2,100	140	1,900
Total Xylenes	48,000	920	NA	7,200	60	NA
Dimethylformamide	26,000	1,900	1,500	710	2,600	1,200

¹ Data for each quarter are not necessarily from the same well. NA=Not available; ND=Not detected; U=ND at concentration