



Treatment Experiences at RCRA Corrective Actions

Introduction

The RCRA Corrective Action program addresses cleanup of existing contamination at operating industrial facilities. Cleanup of these facilities is one of the U.S. Environmental Protection Agency's (EPA) highest priorities. The RCRA Cleanup Reforms¹, announced in 1999, are designed to achieve faster, more efficient cleanups at RCRA sites that treat, store, or dispose of hazardous waste and have potential environmental contamination. Information about treatment experiences at corrective action sites will help EPA, states, and the regulated community better understand the types of cleanup technologies available, and how the technologies are being used.

How Sites Were Selected

This fact sheet summarizes information about the use of treatment technologies at 30 RCRA corrective action sites. EPA identified these sites based on readily available sources of information. These sources were reviewed to identify RCRA sites that had ongoing or completed cleanups for contaminated soil or groundwater, and that identified key information about the cleanups, such as type of technology used and point of contact.

These sites illustrate the types of cleanups conducted at RCRA corrective actions; they are not intended to be representative of the whole universe of RCRA cleanups.

Summary of Information

Table 1 summarizes information about treatment experiences at the 30 RCRA corrective action sites. These projects, described in Table 2, include both *in situ* and *ex situ* treatment technologies, and both innovative and conventional processes.

As shown in Table 2, these corrective action sites include a wide range of industries, such as wood treaters, chemical plants, refineries, paper mills, manufacturing facilities, and waste treatment facilities. The sites vary in size, complexity, and types of contaminants. Contaminants include chlorinated solvents; polycyclic aromatic hydrocarbons (PAHs); benzene, toluene, ethylbenzene, and xylenes (BTEX); other volatile and semivolatile organic compounds (VOCs and SVOCs); and petroleum hydrocarbons.

¹ Additional information about the RCRA Cleanup Reforms is available at www.epa.gov/epaoswer/hazwaste/ca/reforms.htm

Table 1: Summary of Treatment Experiences

Treatment Technology	No. of Sites
<i>In Situ</i>	
Air Sparging	1
Bioventing	2
Bioremediation (<i>in situ</i> groundwater)	1
Bioremediation (<i>in situ</i> soil)	3
Chemical Oxidation (<i>in situ</i>)	2
Permeable Reactive Barriers	2
Soil Vapor Extraction	7
<i>Ex Situ</i>	
Bioremediation (<i>ex situ</i>)	6
Pump and Treat	5
Thermal Desorption	1

Of the 30 corrective actions, 12 are completed cleanups, and 18 are operational (at the time data were collected for this summary). For the completed projects, contaminant concentrations in soil after treatment included chlorobenzene - 0.002 mg/kg; PAHs - 100 mg/kg; phenol - 330 mg/kg; and trichloroethene (TCE) - below detection levels; treated groundwater concentrations included total petroleum hydrocarbon (TPH) - 300 ug/L.

Examples of projects listed in Table 2 are provided below.

Amoco Refinery, MO – Composting

At this site, composting—an *ex situ* bioremediation technology—was used to treat soil. The project was completed in eight years, and the concentration of PAHs was reduced from over 1,000 mg/kg to less than 300 mg/kg, meeting the cleanup goal at the site.

Safety Kleen Argonite Site, KS – Permeable Reactive Barrier

At this site, a permeable reactive barrier has been used for over four years to treat groundwater *in situ*. The PRB is a funnel and gate design, containing 225 tons of zero-valent iron, and is being used to treat chlorinated solvents.

Superior Tube Site, PA – Soil Vapor Extraction

At this site, a pilot study of soil vapor extraction has been operating since February 2000 to extract TCE from bedrock at depths of more than 60 feet below the surface. If this pilot project is successful, site managers will implement the technology at full scale.

Table 2. Treatment Experiences at RCRA Corrective Action Sites

Site Name, Location (RCRA Facility ID No.)	Contaminants	Media	Technology (Scale/Description)	Period of Performance (POP) / Status	Performance (Cleanup Goal/Target; Initial and Final or Current Concentration)	Contact	Sources ¹
AIR SPARGING							
Burlington Northern, MN (MND000686204)	Creosote, Phenol	Groundwater	Scale: Full; Additional information not provided in source.	POP not provided / Operational	Information not provided in source.	Linda Kern, USEPA, 312-886-7341, <i>kern.linda@epa.gov</i>	ASR
BIOREMEDIATION (BIOVENTING)							
Atlantic Research Corporation, VA (VAD023741705)	Chlorobenzene	Soil	Scale: Pilot (as interim measure); Ammonia phosphate nutrients added to above-ground cells; Air Flow Rate: 100 std. cubic feet per minute; Treatment of Vapors: None (vented to atmosphere without treatment).	9/89-5/90 / Complete	Initial: 2,200 mg/kg Target: 50 mg/kg Final: 0.002 mg/kg	Linda Holden, USEPA, 215-814-3428, <i>holden.linda@epa.gov</i>	BFSS
Hill Air Force Base, UT (UT0571724350)	Benzene, Toluene, Ethylbenzene, Xylene (BTEX), Total Recoverable Petroleum Hydrocarbons (TRPH)	Soil	Scale: Pilot; No. of Bioventing Wells: 1; Additional information not provided in source.	6/92-Present / Operational	TRPH: Initial: 13,200 mg/kg Target: 1,000 mg/kg Current: Not provided	Robert Stites, USEPA, 303-312-6756, <i>stites.rob@epa.gov</i>	BFSS
IN SITU BIOREMEDIATION (GROUNDWATER)							
Savannah River Site, SC (SC1890008989)	Trichloroethene (TCE), Vinyl chloride (VC)	Groundwater	Scale: Full (Interim Action); No. of Extraction/Injection Wells: 2 horizontally oriented (0.25 miles long); Depth of Wells: 60 ft; Types of Amendments Added: air/methane/triethylphosphate/nitrous oxide mixture.	8/99-Present / Operational	TCE: Initial: 60 ug/L Target: 5 ug/L Current: 10 ug/L VC: Initial: 100 ug/L Target: 2 ug/L Current: 80 ug/L	James Kuper, WSRC, 803-952-6525, <i>james.kuper@SRS.gov</i>	ASR
IN SITU BIOREMEDIATION (SOIL)							
A.B. Dick, IL (ILR000060103)	Dichloroethene, Polycyclic Aromatic Hydrocarbons (PAH), Trichloroethane (TCA), TCE	Soil	Scale: Full; Depth of Treatment: 15 ft; Types of Amendments Added: De-halogenation components; Additional Comment: No turning or air injection was used.	1995 / Complete	PAH: Initial: 1,500 mg/kg Target: 160 mg/kg Final: <0.1 mg/kg	David Frycek, Inland Environmental, Inc., 847-677-7500, <i>dfrycek@inlandenv.com</i>	BFSS
Aristech Chemical, OH (OHD005108477)	Phenol	Soil	Scale: Full; Depth of Treatment: 16 ft; Types of Amendments Added: Ammonia nitrate and Munox 10x SeriesV bacteria.	1994 / Complete	Phenol: Initial: 32,000 mg/kg Target: 2,740 mg/kg Final: 330 mg/kg	Jim Fain, Environmental Manager, Aristech Chemical Company, 740-533-5412, <i>fainje@aristechchem.com</i>	BFSS

Table 2. Treatment Experiences at RCRA Corrective Action Sites (continued)

Site Name, Location (RCRA Facility ID No.)	Contaminants	Media	Technology (Scale/Description)	Period of Performance (POP) / Status	Performance (Cleanup Goal/Target; Initial and Final or Current Concentration)	Contact	Sources ¹
Federated Paint Manufacturing Company, Inc., IL (ILD021293717)	Tetrachloroethene (PCE), TCE, Dichloroethene (DCE), Dichloroethane (DCA)	Soil	Scale: Full; Depth of Treatment: 18 ft; Types of Amendments Added: Formulation of electron acceptors and donors designed to promote accelerated biodegradation.	1992 / Complete	Initial PCE: 810 mg/kg TCE: 170 mg/kg DCE: 125 mg/kg DCA: 65 mg/kg Target: 1 mg/kg Final: <0.1 mg/kg (for all contaminants)	David Frycek, Inland Environmental, Inc., 847-677-7500, dfrycek@inlandenv.com	E-mail
IN SITU CHEMICAL OXIDATION							
NAS Pensacola, FL (HF-292641) ²	cis-Dichloroethene (cis-DCE), TCE, VC	Groundwater	Scale: Full; Number of Injection Wells: 15; Depth of Treatment: 7 to 40 ft; Type of Amendments Added: 50% hydrogen peroxide and 50% ferrous iron catalyst solution; Additional Comments: In situ chemical oxidation treatment was used to reduce the source area concentrations and to facilitate the use of MNA as the final remedy.	1998 / Complete	Initial cis-DCE: 500 ug/L TCE: 3,600 ug/L VC: 63 ug/L Target: Not Provided Final cis-DCE: 18 ug/L TCE: 180 ug/L VC: <5 ug/L	Maxie Keisler, Southern Division NAVFAC, 843-820-7322, keislermr@efdsouth.navy.mil , Mike Maughon, Southern Division NAVFAC, 843-820-7422, maughonmj@efdsouth.navy.mil	Report, FRTR
Site 11, NSB Kings Bay, GA (GA4170090001)	cis-DCE, PCE, TCE	Groundwater	Scale: Full; Number of Injection Wells: 23; Depth of Treatment: 32 to 42 ft; Type of Amendments Added: 50% hydrogen peroxide and 50% ferrous iron catalyst solution; Additional Comments: In situ chemical oxidation treatment was used to reduce the source area concentrations and to facilitate the use of MNA as the final remedy.	1998 / Complete	Initial cis-DCE: 60 ug/L PCE: 8,500 ug/L TCE: 550 ug/L Target in Source Area: 100 ug/L (total CVOCs) Final cis-DCE: <1 ug/L PCE: 69 ug/L TCE: 2 ug/L	Anthony Robinson, Southern Division NAVFAC, 843-820-7339, robinsonab@efdsouth.navy.mil , Cliff Casey, Southern Division NAVFAC, 843-820-5561, caseycc@efdsouth.navy.mil	Report, FRTR
PERMEABLE REACTIVE BARRIER							
Safety Kleen Argonite, Inc., KS (KSD981506025)	PCE, TCE	Groundwater	Scale: Full; Type of Barrier: Funnel and Gate, Length: 4,000 ft, Width: 3 ft (funnel) and 10 ft (gate); Depth: 30 ft (funnel and gate); Type and Quantity of Reactive Media: 225-tons of zero-valent iron.	1/96-Present / Operational	Information not provided in source.	Gregg Somermyer, Thermo Retec, 970-493-3700, gsomermyer@thermoretec.com	GWRTAC

Table 2. Treatment Experiences at RCRA Corrective Action Sites (continued)

Site Name, Location (RCRA Facility ID No.)	Contaminants	Media	Technology (Scale/Description)	Period of Performance (POP) / Status	Performance (Cleanup Goal/Target; Initial and Final or Current Concentration)	Contact	Sources ¹
U.S. Coast Guard Support Center, NC (NC2690308232)	Chromium ⁺⁶ (Cr ⁺⁶), TCE	Groundwater	Scale: Full; Type of Barrier: Continuous Wall; Length: 152 ft, Width: 2 ft, Depth of Barrier: Began 4-8 ft bgs and extended to 24 ft bgs; Type and Quantity of Reactive Media: 450-tons of zero-valent iron.	6/96-Present / Operational	Cr ⁺⁶ : Initial: >3,430 ug/L Target: 100 ug/L Current: 0.1 ug/L TCE: Initial: 74,320 ug/L Target: 5 ug/L Current: 548 ug/L	Robert Puls, USEPA, 580-436-8543, puls.robert@epa.gov , Jim Vardy, US Coast Guard, 919-335-6847	FRTR
SOIL VAPOR EXTRACTION							
Evanite Fiber Corporation, OR (ORD009023466)	TCE	Soil	Scale: Full; No. of Extraction Wells: 8; Depth of Wells: 40 ft; Above-Ground Treatment Technologies: None; Additional Comments: SVE system used pulse pumping to reduce intake of GW.	90-Present / Operational	22% of the 56 tons of TCE has been extracted by SVE (57% by P&T and 21% through DNAPL recovery)	Jim Billings, Oregon Department of Environmental Quality, 503-378-8240, billings.jim@deq.state.or.us	ASR
General Motors Corporation, WV (WVD044145209)	Ethylbenzene, Naphthalene, PCE	Soil	Scale: Full; No. of Extraction Wells: 15 (6 inches in dia.); Depth of Wells: 30 ft (20 ft long screens); Vapor Extraction Flow Rate: 257 cfm; Above-Ground Treatment Technologies: Vapors treated by a thermal destruction unit and water is treated by carbon canisters; Additional Comments: Only 8 extraction wells are currently active.	9/96-Present / Operational	Information not provided in source.	Mike Jacobi, USEPA, 215-814-3435, jacobi.mike@epa.gov	ASR
IBM, VA (VAD064872575)	DCE, PCE, TCE	Soil	Scale: Full; No. of Extraction Wells: 6; Depth of Wells: 60-150 ft; Vapor Extraction Flow Rate: 25-30 scfm; Above-Ground Treatment Technologies: Air flushing; Additional Comments: P&T also used on site.	89-Present / Operational	Initial: 1,800 mg/kg Target: Not provided Current: 23 mg/kg	Diane Schott, USEPA, 215-814-3430, schott.diane@epa.gov	ASR
IBM, VT (VTD002084705)	Acetone, DCE, PCE, Toluene, TCE, Xylenes	Soil	Scale: Full; No. of Extraction Wells: 50, Depth of Wells: Most less than 20 ft.	93-Present / Operational	Information not provided in source.	Micheal Smith, Vermont Ag. Natural Res. (VTANR), 802-241-3879, MikeS@DEC.ANR.State.VT.US	ASR
Merck & Company, Inc., PA (PAD002387926)	Chloroform	Soil	Scale: Full; No. of Extraction Wells: 6; Depth of Wells: 28-98 ft; Above-Ground Treatment Technologies: GAC system; Additional Comment: P&T also used on site.	90-9/98 (P&T continues) / Complete	Initial: 5,000 mg/L Target: Not Provided Final: 1,600 mg/L	Renee Gelblat, USEPA, 215-814-3421, gelblat.renee@epa.gov	ASR

Table 2. Treatment Experiences at RCRA Corrective Action Sites (continued)

Site Name, Location (RCRA Facility ID No.)	Contaminants	Media	Technology (Scale/Description)	Period of Performance (POP) / Status	Performance (Cleanup Goal/Target; Initial and Final or Current Concentration)	Contact	Sources ¹
Savannah River Site, SC (SC1890008989)	PCE, TCE	Soil	Scale: Full; No. of Extraction Wells: 9; Vapor Extraction Flow Rate: 30 to 600 scfm; Above-Ground Treatment Technologies: None.	95-Present / Operational	PCE: Initial: Not Provided Target: Not Provided Current: 18.1 mg/kg	Joseph Amari, Westinghouse (WSRC), 803-952-2981, joseph.amari@SRS.gov	ASR
Superior Tube Company, PA (PAD002353407)	DCE, TCE, VC	Soil (Bedrock)	Scale: Pilot; No. of Extraction Wells: 5; Depth of Wells: 60-65 ft; Vapor Extraction Flow Rate: 35-50 cfm (combined influent flow for all wells); Above-Ground Treatment Technologies: Two activated carbon beds extract pure TCE which is recycled and reused by the facility; Additional Comment: Since 2/00, approximately 2,750 lbs of TCE has been extracted.	2/00-Present / Operational	TCE: Initial: 9,000 ug/L Target: 5 ug/L Current: 900 ug/L (TCE is sample from air) DCE & VC: Secondary contaminants of concern. Cleanup performance for both is based on TCE cleanup performance.	Khai Dao, USEPA, 215-814-5467, dao.khai@epa.gov	ASR
EX SITU BIOREMEDIATION							
Amoco Refinery, MO (MOD007161425)	Naphthalene, Phenanthrene, Pyrene	Soil	Scale: Full; Type of Process: Composting; Size of Unit: 180,000 yd ³ ; Types of Amendments Added: Fertilizer and mulch; Additional Comments: Land tilled to aerate and control moisture.	1/91-5/99 / Complete	PAHs: Initial: >1,000 mg/kg Target: 300 mg/kg Final: <300 mg/kg	Brian McCurren, Missouri Department of Natural Resources Division of Environmental Quality, 573-751-3176, nrmccub@mail.dnr.state.mo.us	BFSS
Hudson Refining Company, OK (OKD082471988)	Benzo(a)pyrene, Benzo(a)anthracene, Chrysene, Oil & Grease	Soil	Scale: Full; Type of Process: Land Treatment; Size of Unit: 11 acres; Types of Amendments Added: Fertilizer: 300-500 lbs/acre/yr; soil conditioners, and water; Additional Comments: Soil conditioners maintained 6<pH<7.5.	1/86-Present / Operational	Total PAHs: Initial: Not provided Target: 15 mg/kg Current: Not provided	David Abshire, USEPA, 214-665-7188, abshire.charles@epa.gov	BFSS
International Paper, MO (MOD007129935)	Naphthalene, Pentachlorophenol, Phenanthrene, Pyrene, Toluene, Xylenes	Soil	Scale: Full; Type of Process: Land Treatment; Size of Unit: 80,000 yd ³ ; Types of Amendments Added: None (only indigenous microorganisms).	6/95-7/00 / Complete	Initial Not provided (all contaminants) Target: Naphthalene: 1.5 mg/kg Pentachlorophenol: 7.4 mg/kg Phenanthrene: 1.5 mg/kg Pyrene: 1.5 mg/kg Toluene: 28 mg/kg Xylenes: Not Provided Final: Not provided (all contaminants)	Brian McCurren, Missouri Department of Natural Resources Division of Environmental Quality, 573-751-3176, nrmccub@mail.dnr.state.mo.us	BFSS

Table 2. Treatment Experiences at RCRA Corrective Action Sites (continued)

Site Name, Location (RCRA Facility ID No.)	Contaminants	Media	Technology (Scale/Description)	Period of Performance (POP) / Status	Performance (Cleanup Goal/Target; Initial and Final or Current Concentration)	Contact	Sources ¹
Marvin Windows, MN (MND006164511)	Pentachlorophenol (PCP), Total Petroleum Hydrocarbons (TPH)	Soil	Scale: Full; Type of Process: Biopile; Additional Comments: Amendments enhanced indigenous contaminant degrading microbes.	1996 / Complete	Initial: Not provided Target: PCP: 5 mg/kg TPH: 10 mg/kg Final: Not provided	Elizabeth Gawrys, Minnesota Pollution Control Agency, 612-297-8376, elizabeth.gawrys@pca.state.mn.us	BFSS
Owens-Corning, KS (KSD000610725)	Formaldehyde	Soil	Scale: Full; Type of Process: Land Treatment; Size of Unit: Soil stockpiled in volume 130 ft by 50 ft by 15 inches deep; Types of Amendments Added: Ammonium phosphate; Additional Comment: Soil BOD and COD checked weekly.	POP: Not provided / Complete	Information not provided in source.	Dave Growcock, Owens-Corning, 913-281-9545	BFSS
Savannah River Site, SC (SC1890008989)	TPH	Soil	Scale: Full; Type of Process: Land Treatment; Types of Amendments Added: Fertilizer (added as needed); Additional Comments: Excavated soil placed in cement trough bed, leachate collection system redistributed collected water via sprinkler, facility rototilled weekly.	3/94-Present / Operational	Initial: 17,000 mg/kg Target: 100 mg/kg Current: 1 mg/kg	Michelle Ewart, Savannah River Operations, 803-725-1115, michelle.ewart@srs.gov	BFSS
PUMP AND TREAT							
Baldwin Pole and Piling Company Inc., AL (ALD982114704)	PAH	Groundwater	Scale: Full; Above-Ground Treatment Technologies: Biological treatment occurred in three reaction chambers connected in series; Additional Comments: Treatment lowered constituent concentrations prior to discharge to POTW for further treatment.	4/91-Present / Operational	Information not provided in source.	Steven Cobb, Alabama Department of Environmental Management Land Division, 334-271-7739, landmail@adem.state.al.us	BFSS
BKK Landfill, CA (CAD067786749)	1,2-dichloropropane, Benzene, Carbon Tetrachloride, Chloroform, Dichloromethane, Phenols, Toluene, TCE, VC	Groundwater	Scale: Full; Bioreactor was a leachate treatment plant using complexation with EDTA and flocculation; Additional information not provided in source.	1/87-Present / Operational	Information not provided in source.	Carmen Santos, USEPA, 415-744-2037, carmen.santos@epa.gov	BFSS
Cavenham Forest Industries Inc., AL (ALD057226904)	Benzene, PCP, PAH, Toluene	Groundwater	Scale: Full; Above-Ground Treatment Technologies: Water treated in a fixed film biological system consisting of 2 parallel units with 4 reaction chambers each after conditioning consisting of aeration/blending/nutrient addition/pH adjustment.	7/93-Present / Operational	Information not provided in source.	Jeffery Kitchens, Alabama Department of Environmental Management Land Division, 334-271-7754, landmail@adem.state.al.us	BFSS

Table 2. Treatment Experiences at RCRA Corrective Action Sites (continued)

Site Name, Location (RCRA Facility ID No.)	Contaminants	Media	Technology (Scale/Description)	Period of Performance (POP) / Status	Performance (Cleanup Goal/Target; Initial and Final or Current Concentration)	Contact	Sources ¹
Langdale Facility, TN (TND003493103)	PAH	Groundwater	Scale: Full; No. of Extraction Wells: 3, Depth of Wells: 90-100 ft; Above-Ground Treatment Technologies: Air stripping followed by biological treatment.	1998-Present / Operational	Information not provided in source.	Charles Burroughs, Tennessee Department of Environmental Conservation, Division of Solid Waste, 615-532-0863, cburroughs@mail.state.tn.us	Call
US DOE Kansas City, MO (MO9890010524)	1,2-DCE, PCE, TCE	Groundwater	Scale: Full; No. of Extraction Wells: 14 and one interceptor trench (trench dimensions: 250 ft long, 22-31 ft deep); Groundwater Extraction Flow Rate: 0.9-5 gpm.; Above-Ground Treatment Technologies: UV/Peroxide system.	5/88-Present / Operational	Chlorinated Solvents: Influent: 10,600 ug/L Effluent: 10 ug/L Target: Not provided	G. Phil Keary, Keary Environmental Restoration, 816-997-7288, pkeary@kcp.com	FRTR
THERMAL DESORPTION							
Lockheed Martin, CO (COD981552979)	TCE	Soil	Scale: Full; Type of System: Rotary Kiln; Type of Process: Continuous; Temperature: 540 F; Throughput: 10-20 tons/hr, Type of Emission Controls/Technologies: GAC system and HEPA filters.	9/98-1/99 / Complete	Initial: 2,091 mg/kg Target: Non-Detect Final: Non-Detect	Charles Johnson, Colorado Public Health Envir. (CDPHE), 303-692-3348, johnson.charles@state.co.us	ASR

Notes:

1 - Key to Sources:

ASR	Treatment Technologies for Site Cleanup: Annual Status Report (9 th Edition), EPA 542-R-99-001, April 1999, < www.clu-in.org >	FRTR	Federal Remediation Technologies Roundtable, EPA 542-C-00-001, June 2000, < www.frtr.gov/cost >
BFSS	Bioremediation in the Field Search System, Version 2.1. Not Dated. < www.clu-in.org >	GWRTAC	Groundwater Remediation Technologies Analysis Center, Technology Evaluation Report, Treatment Walls, TE-96-01, October 1996, < www.gwrtac.org >
Call	Telephone communication with site contact.	Report	Maughon, Michael J., Clifton C. Casey, J. Daniel Bryant, James T. Wilson, <i>Chemical Oxidation Source Reduction and Natural Attenuation For Remediation of Chlorinated Hydrocarbons in Groundwater</i> , The Second International Conference on Remediation of Chlorinated and Recalcitrant Compounds, May 22-25, 2000, Battelle Press.
E-mail	E-mail communication with site contact.		

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