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Abstracts of Remediation Case Studies

Volume 3

Federal Remediation Technologies Roundtable
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Prepared by the

Member Agencies of the Federal Remediation Technologies Roundtable

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Environmental Protection Agency
Department of Defense
- U.S. Air Force
- U.S. Army
- U.S. Navy

Department of Energy
Department of Interior
National Aeronautics and Space Administration
Tennessee Valley Authority
Coast Guard

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FOREWORD

This report is a collection of abstracts summarizing 86 case studies of site remediation prepared by federal agencies. The case studies, collected under the auspices of the Federal Remediation Technologies Roundtable, were undertaken to document the results and lessons learned from technology applications. They will help establish benchmark data on cost and performance which should lead to greater confidence in the selection and use of cleanup technologies.

The Roundtable was created to exchange information on site remediation technologies, and to consider cooperative efforts that could lead to a greater application of innovative technologies. Roundtable member agencies, including the U.S. Environmental Protection Agency, U.S. Department of Defense, and U.S. Department of Energy, expect to complete many site remediation projects in the near future. These agencies recognize the importance of documenting the results of these efforts, and the benefits to be realized from greater coordination.

The case study reports and abstracts are organized by technology in a multi-volume set listed below. Remediation Case Studies, Volumes 1-6, and Abstracts, Volumes 1 and 2, were published previously, and contain 54 projects. Remediation Case Studies, Volumes 7-13, and Abstracts, Volume 3, were published in September 1998. Abstracts, Volume 3, covers a wide variety of technologies, including full-scale remediations and large-scale field demonstrations of soil and groundwater treatment technologies. In the future, the set will grow as agencies prepare additional case studies.

1995 Series

Volume 1: Bioremediation, EPA-542-R-95-002; March 1995; PB95-182911

Volume 2: Groundwater Treatment, EPA-542-R-95-003; March 1995; PB95-182929

Volume 3: Soil Vapor Extraction, EPA-542-R-95-004; March 1995; PB95-182937

Volume 4: Thermal Desorption, Soil Washing, and In Situ Vitrification, EPA-542-R-95-005; March 1995; PB95-182945

1997 Series

Volume 5: Bioremediation and Vitrification, EPA-542-R-97-008; July 1997; PB97-177554

Volume 6: Soil Vapor Extraction and Other In Situ Technologies, EPA-542-R-97-009; July 1997; PB97-177562

1998 Series

Volume 7: Ex Situ Soil Treatment Technologies (Bioremediation, Solvent Extraction, Thermal Desorption), EPA-542-R-98-011; September 1998

Volume 8: In Situ Soil Treatment Technologies (Soil Vapor Extraction, Thermal Processes), EPA-542-R-98-012; September 1998

Volume 9: Groundwater Pump and Treat (Chlorinated Solvents), EPA-542-R-98-013; September 1998

1998 Series (continued)

Volume 10: Groundwater Pump and Treat (Nonchlorinated Contaminants), EPA-542-R-98-014; September 1998

Volume 11: Innovative Groundwater Treatment Technologies, EPA-542-R-98-015; September 1998

Volume 12: On-Site Incineration, EPA-542-R-98-016; September 1998

Volume 13: Debris and Surface Cleaning Technologies, and Other Miscellaneous Technologies, EPA-542-R-98-017; September 1998

Abstracts

Volume 1: EPA-542-R-95-001; March 1995; PB95-201711

Volume 2: EPA-542-R-97-010; July 1997; PB97-177570

Volume 3: EPA-542-R-98-010; September 1998

Accessing Case Studies

The case studies and case study abstracts are available on the Internet through the Federal Remediation Technologies Roundtable web site at: http://www.frtr.gov. The Roundtable web site provides links to individual agency web sites, and includes a search function. The search function allows users to complete a key word (pick list) search of all the case studies on the web site, and includes pick lists for media treated, contaminant types, and primary and supplemental technology types. The search function provides users with basic information about the case studies, and allows them to view or download abstracts and case studies that meet their requirements.

Users are encouraged to download abstracts and case studies from the Roundtable web site. Some of the case studies are also available on individual agency web sites, such as for the Department of Energy.

In addition, a limited number of hard copies are available free of charge by mail from NCEPI (allow 4-6 weeks for delivery), at the following address:

U.S. EPA/National Center for Environmental Publications and Information (NCEPI)
P.O. Box 42419
Cincinnati, OH 45242
Phone: (513) 489-8190 or
(800) 490-9198
Fax: (513) 489-8695

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INTRODUCTION

Increasing the cost effectiveness of site remediation is a national priority. The selection and use of more cost-effective remedies requires better access to data on the performance and cost of technologies used in the field. To make data more widely available, member agencies of the Federal Remediation Technologies Roundtable (Roundtable) are working jointly to publish case studies of full-scale remediation and demonstration projects. Previously, the Roundtable published six volumes of case study reports. At this time, the Roundtable is publishing seven additional volumes, primarily focused on soil and groundwater cleanup.

The case studies were developed by the U.S. Environmental Protection Agency (EPA), the U.S. Department of Defense (DoD), and the U.S. Department of Energy (DOE). They were prepared based on recommended terminology and procedures agreed to by the agencies. These procedures are summarized in the Guide to Documenting and Managing Cost and Performance Information for Remediation Projects (EPA 542-B-98-007; October 1998). (The October 1998 guide supersedes the original Guide to Documenting Cost and Performance for Remediation Projects, published in March 1995.)

The case studies and abstracts present available cost and performance information for full-scale remediation efforts and several large-scale demonstration projects. They are meant to serve as primary reference sources, and contain information on site background and setting, contaminants and media treated, technology, cost and performance, and points of contact for the technology application. The studies contain varying levels of detail, reflecting the differences in the availability of data and information. Because full-scale cleanup efforts are not conducted primarily for the purpose of technology evaluation, data on technology cost and performance may be limited.

The case study abstracts in this volume describe a wide variety of ex situ and in situ treatment technologies for both soil and groundwater. Contaminants treated include chlorinated solvents; petroleum hydrocarbons and benzene, toluene, ethylbenzene, and xylenes; polycyclic aromatic hydrocarbons; pesticides and herbicides; and metals; and radioactive materials. Many of the applications described in the case study reports are ongoing and interim reports are provided documenting their current status.

Tables 1-7 provides summary information about technology used, contaminants and media treated, and project duration for the 86 technology applications in this volume (these tables correspond with the case study reports provided in Remediation Case Studies, Volumes 7-13, respectively). These tables also provide highlights about each application. Table 8 summarizes cost data, including information on quantity of media treated and quantity of contaminant removed. In addition, Table 8 shows a calculated unit cost for some projects, and identifies key factors potentially affecting technology costs. (The column showing the calculated unit costs for treatment provides a dollar value per quantity of media treated and contaminant removed, if available.) Cost data are shown as reported in the case studies and have not been adjusted for inflation to a common year basis. The costs should be assumed to be dollars for the time period that the project was in progress (shown on Tables 1-7 as project duration).

While a summary of project costs is useful, it may be difficult to compare costs for different projects because of unique site-specific factors. However, by including a recommended reporting format, the Roundtable is working to standardize the reporting of costs to make data comparable across projects. In addition, the Roundtable is working to capture information in case study reports that identify and describe the primary factors that affect the cost and performance of a given technology. Factors that may affect project costs include economies of scale, concentration levels in contaminated media, required cleanup levels, completion schedules, and matrix characteristics and operating conditions for the technology.

Table 1. Summary of Remediation Case Studies: Ex Situ Soil Treatment Technologies (Bioremediation, Solvent Extraction, Thermal Desorption)

Site Name, State (Technology)	Principal Contaminants*						Media (Quantity Treated)	Project Duration	Highlights
	Chlorinated Solvents	BTEX and/or TPH	PAHs	Pesticides/Herbicides	Explosives	Metals			
Bioremediation									
Bonneville Power Administration Ross Complex, Operable Unit A, WA (Land Treatment)			●				Soil (2,300 yd^3)	11/94 - 1/96	Combination of bioremediation and enhancements used to land treat contaminated soil
Fort Greely, UST Soil Pile, AK (Land Treatment)		●					Soil (9,800 yd^3)	9/94 - 8/97	Application of land treatment to treat gasoline and diesel contaminated soil ex situ
Novartis Site, Ontario, Canada (Land Treatment)				●			Soil (200 tons)	3/96 - 9/97	Demonstrated the performance of the DARAMEND process for treating Metolachlor-contaminated soils
Solvent Extraction									
Sparrevohn Long Range Radar Station, AK (Solvent Extraction)							Soil (288 yd^3)	6/96 - 8/96	Application of an innovative technology to treat PCB-contaminated soil at a remote site in Alaska
Thermal Desorption									
FCX Washington Superfund Site, NC (Thermal Desorption)				●			Soil (13,591 yd^3)	3/95 - 3/96	Vacuum-enhanced low temperature thermal desorption used to treat pesticide-contaminated soil
Fort Lewis, Solvent Refined Coal Pilot Plant (SRCPP), WA (Thermal Desorption)			●				Soil (104,366 tons)	8/96 - 12/96	Thermal desorption of a relatively large amount of soil contaminated with PAHs

Table 1. Summary of Remediation Case Studies: Ex Situ Soil Treatment Technologies (Bioremediation, Solvent Extraction, Thermal Desorption) (continued)

Site Name, State (Technology)	Principal Contaminants*						Media (Quantity Treated)	Project Duration	Highlights
	Chlorinated Solvents	BTEX and/or TPH	PAHs	Pesticides/Herbicides	Explosives	Metals			
Naval Air Station Cecil Field, Site 17, OU 2, FL (Thermal Desorption)		●	●				Soil (11,768 tons)	6/95 - 9/25/95	Mobile thermal desorption unit used to treat soil contaminated with fuel and solvents
Port Moller Radio Relay Station, AK (Thermal Desorption)		●					Soil (9,500 yd^3)	6/95 - 8/95	Application of thermal desorption to treat sandy soil contaminated with diesel fuel at a remote site in Alaska
Re-Solve, Inc. Superfund Site, MA (Thermal Desorption)							Soil (36,200 yd^3)	6/93 - 12/94	Thermal desorption of PCB-contaminated soil
Waldick Aerospaces Devices Superfund Site, NJ (Thermal Desorption)	●	●				●	Soil (3,450 yd^3)	6/93 - 10/93	LTTD of soil contaminated with a wide range of organics

* Principal contaminants are one or more specific constituents within the groups shown that were identified during site investigations.

Table 2. Summary of Remediation Case Studies: In Situ Soil Treatment Technologies (Soil Vapor Extraction, Thermal Processes)

Site Name, State (Technology)	Principal Contaminants*						Media (Quantity Treated)	Project Duration	Highlights
	Chlorinated Solvents	BTEX and/or TPH	PAHs	Pesticides/Herbicides	Explosives	Metals			
Soil Vapor Extraction									
Camp LeJeune Military Reservation, Site 82, Area A, NC (Soil Vapor Extraction)	●						Soil (17,500 yd^3)	4/7/95 - 12/21/95	SVE application using a combination of vertical and horizontal wells
Davis-Monthan AFB, Site ST-35, AZ (Soil Vapor Extraction)		●					Soil (63,000 yd^3)	9/95 - 7/97	SVE application to remove TPH from soil; extracted vapors used as fuel for internal combustion engines
Defense Supply Center Richmond, OU 5, VA (Soil Vapor Extraction)	●						Soil (1,000 yd^3)	12/1/92 - 12/11/92	Pilot study of SVE for VOC contaminated soil
Fort Greely, Texas Tower Site, AK (Air Sparging, In Situ Bioremediation, and Soil Vapor Extraction)		●					Soil (6,300 yd^3) Groundwater	2/94 - 2/96	Combination of three technologies used to treat DRO-contaminated soil and groundwater in situ
Fort Lewis, Landfill 4, WA (Soil Vapor Extraction and Air Sparging)	●					●	Soil - saturated and unsaturated (volume not determined)	Status: Ongoing Report Covers: 12/5/94 - 10/31/97	Application of a combination of innovative technologies to treat halogenated organic contamination in soil and groundwater
Fort Richardson, Building 908 South, AK (Soil Vapor Extraction)		●					Soil (4,600 yd^3)	Status: Ongoing Report Covers: 2/95 - 3/96	Application of SVE to treat gravelly-soil contaminated with diesel fuel
Holloman AFB, Sites 2 and 5, NM (Soil Vapor Extraction)		●					Soil (9,500 yd^3)	4/94 - Ongoing	Treatment system has operated successfully with minimal downtime or maintenance requirements

Table 2. Summary of Remediation Case Studies: In Situ Soil Treatment Technologies (Soil Vapor Extraction, Thermal Processes) (continued)

Site Name, State (Technology)	Principal Contaminants*						Media (Quantity Treated)	Project Duration	Highlights
	Chlorinated Solvents	BTEX and/or TPH	PAHs	Pesticides/Herbicides	Explosives	Metals			
Intersil/Siemens Superfund Site, CA (Soil Vapor Extraction)	●						Soil (280,000 yd^3)	5/88 - 8/23/93	SVE application using paired wells - one shallow and one deep - to improve contaminant extraction
NAS North Island, Site 9, CA (Photolytic Destruction)	●						Soil Vapor (estimated 1,151 lbs of VOCs)	10/12/97 - 2/6/98	Demonstrate the effectiveness of PTI's photolytic destruction units in treating VOC-contaminated vapor from an SVE system
Seymour Recycling Corporation Superfund Site, IN (Soil Vapor Extraction)	●						Soil (200,000 yd^3)	Status: Ongoing Report Covers: 6/92 - 1996	SVE system using horizontal wells under a multimedia cap
Shaw AFB, OU 1, SC (Soil Vapor Extraction and Groundwater Containment)		●					Soil (30,000 ft^2, confining clay layer at 70 to 80 ft bgs) Groundwater	SVE system - 12/95 - ongoing Groundwater - 2/92 - 9/97	SVE system to remediate soil and two interim response action systems to contain groundwater
Tyson's Dump Superfund Site, PA (Soil Vapor Extraction)	●						Soil (30,000 yd^3)	11/88 - 9/96	SVE application involving more than 14 enhancements

Table 2. Summary of Remediation Case Studies: In Situ Soil Treatment Technologies (Soil Vapor Extraction, Thermal Processes) (continued)

Site Name, State (Technology)	Principal Contaminants*						Media (Quantity Treated)	Project Duration	Highlights
	Chlorinated Solvents	BTEX and/or TPH	PAHs	Pesticides/Herbicides	Explosives	Metals			
Thermal Processes									
Brodhead Creek Superfund Site, PA (Contained Recovery of Oily Waste)			●			●	Free Product - coal tar (1,500 gallons)	7/95 - 6/96	Recover free and residual coal tar using the CROW™ process
Missouri Electric Works Superfund Site, MO (In Situ Thermal Desorption)							Soil (52 yd^3)	4/21/97 - 6/1/97	Demonstrate the performance of in situ thermal desorption to treat PCB-contaminated soil

* Principal contaminants are one or more specific constituents within the groups shown that were identified during site investigations.

Table 3. Summary of Remediation Case Studies: Groundwater Pump and Treat (Chlorinated Solvents)

Site Name, State (Technology)	Principal Contaminants*						Media (Quantity Treated**)	Project Duration	Highlights
	Chlorinated Solvents	BTEX and/or TPH	PAHs	Pesticides/Herbicides	Explosives	Metals			
Des Moines TCE Superfund Site, OU 1, IA (Pump and Treat with Air Stripping)	●						Groundwater (4,900 million gallons)	Status: Ongoing Report Covers: 12/87 - 10/96	Met goals for off-site plume within two years of operation; nearly five billion gallons treated
Former Firestone Facility Superfund Site, CA (Pump and Treat with Air Stripping, Carbon Adsorption, and Oil/Water Separation)	●						Groundwater (1,800 million gallons)	2/86 - 11/92	Met goals within seven years of operation; site had relatively high hydraulic conductivity and was located near high-volume agricultural wells
JMT Facility RCRA Site (formerly Black & Decker RCRA Site), NY (Pump and Treat with Air Stripping)	●						Groundwater (50.1 million gallons)	Status: Ongoing Report Covers: 5/88 - 12/97	RCRA corrective action site with relatively low groundwater flow; greater than 90% reduction in average concentrations of contaminants
Keefe Environmental Services Superfund Site, NH (Pump and Treat with Air Stripping and Coagulation/Flocculation)	●						Groundwater (46 million gallons)	Status: Ongoing Report Covers: 4/93 - 5/97	Performed optimization study after two years of operation; relatively low groundwater flow
Lawrence Livermore National Laboratory (LLNL) Site 300 - General Services Area (GSA) Operable Unit, CA (Pump and Treat with Air Stripping and Carbon Adsorption; Soil Vapor Extraction)	●						Groundwater (93.8 million gallons)	Status: Ongoing Report Covers: 6/91 - 7/97	Combined use of groundwater pump and treat and SVE to remediate TCE and DNAPLs
Mystery Bridge at Hwy 20 Superfund Site, Dow/DSI Facility - Volatile Halogenated Organic (VHO) Plume, WY (Pump and Treat with Air Stripping; Soil Vapor Extraction)	●						Groundwater (192.8 million gallons)	Status: Ongoing Report Covers: 3/94 - 10/97	Remedial strategy includes use of pump and treat for the on-site plume and natural attenuation for the off-site plume
Offutt AFB, Site LF-12, NE (Pump and Treat with Air Stripping)	●						Groundwater (quantity not provided)	Not Available; System was operating in 1/97	Containment of groundwater using active pumping

Table 3. Summary of Remediation Case Studies: Groundwater Pump and Treat (Chlorinated Solvents) (continued)

Site Name, State (Technology)	Principal Contaminants*						Media (Quantity Treated**)	Project Duration	Highlights
	Chlorinated Solvents	BTEX and/or TPH	PAHs	Pesticides/Herbicides	Explosives	Metals			
Old Mill Superfund Site, OH (Pump and Treat with Air Stripping and Carbon Adsorption)	●						Groundwater (13 million gallons)	Status: Ongoing Report Covers: 9/89 - 7/97	Remediation at site with low groundwater flow; relatively small quantity of groundwater extracted
SCRDI Dixiana Superfund Site, SC (Pump and Treat with Air Stripping)	●						Groundwater (20.6 million gallons)	Status: Ongoing Report Covers: 8/92 - 3/97	Remediation at a site with complex hydrogeology, consisting of eight distinct hydrogeological units
Shaw AFB, Site OT-16B, SC (Hydraulic Containment Through Active Pumping)	●						Groundwater and Free Product	2/95 - 12/96	Groundwater containment of chlorinated solvents using active pumping
Shaw AFB, Sites SD-29 and ST-30, SC (Free Product Recovery with Air Stripping)	●	●					Groundwater and Free Product	3/95 - 2/96	Interim action to recover free product from groundwater
Solid State Circuits Superfund Site, MO (Pump and Treat with Air Stripping)	●						Groundwater (257 million gallons)	Status: Ongoing Report Covers: 1993 - 3/97	Groundwater characterized as a leaky artesian system occurring in a karst formation

Table 3. Summary of Remediation Case Studies: Groundwater Pump and Treat (Chlorinated Solvents) (continued)

Site Name, State (Technology)	Principal Contaminants*						Media (Quantity Treated**)	Project Duration	Highlights
	Chlorinated Solvents	BTEX and/or TPH	PAHs	Pesticides/Herbicides	Explosives	Metals			
Sol Lynn/Industrial Transformers Superfund Site, TX (Pump and Treat with Air Stripping, Carbon Adsorption, and Filtration)	●						Groundwater (13 million gallons)	Status: Ongoing Report Covers: 10/93 - 10/96	Contamination located in three zones at the site
Solvent Recovery Services of New England, Inc. Superfund Site, CT (Pump and Treat with Carbon Adsorption, Chemical Treatment, Filtration, and UV/Oxidation; Vertical Barrier Wall)	●					●	Groundwater (32.5 million gallons)	Status: Ongoing Report Covers: 7/95 - 6/98	UV/oxidation has been effective at treating water contaminated with pure phase contaminants, including a mix of VOCs, PCBs, and metals

* Principal contaminants are one or more specific constituents within the groups shown that were identified during site investigations.
** Quantity treated is the amount of groundwater extracted and treated above ground.

Table 4. Summary of Remediation Case Studies: Groundwater Pump and Treat (Nonchlorinated Contaminants)

Site Name, State (Technology)	Principal Contaminants*						Media (Quantity Treated**)	Project Duration	Highlights
	Chlorinated Solvents	BTEX and/or TPH	PAHs	Pesticides/Herbicides	Explosives	Metals			
Baird and McGuire Superfund Site, MA (Pump and Treat with Aeration, Air Stripping, Chemical Treatment, Clarification, and Filtration)		●	●	●		●	Groundwater (80 million gallons)	Status: Ongoing Report Covers: 4/93 - 2/97	Groundwater contaminated with a wide variety of contaminants; relatively expensive remediation, with high capital costs for treatment system
Bofors Nobel Superfund Site - OU 1, MI (Pump and-Treat with Air Stripping, Carbon Adsorption, Chemical Treatment, Filtration, and UV/Oxidation)	●						Groundwater (700 million gallons)	Status: Ongoing Report Covers: 9/94 - 10/97	The extraction system has contained the contaminant plume; the treatment system has consistently met discharge requirements since system startup in 1994
City Industries Superfund Site, FL (Pump and Treat with Air Stripping)	●	●					Groundwater (151.7 million gallons)	Status: Ongoing Report Covers: 5/94 - 5/97	The hydrogeology at this site is relatively simple and hydraulic conductivity relatively high
King of Prussia Technical Corporation Superfund Site, NJ (Pump and Treat with Air Stripping, Carbon Adsorption, and Electrochemical Treatment)	●	●				●	Groundwater (151.5 million gallons)	Status: Ongoing Report Covers: 4/95 - 12/97	Treatment system consists of a treatment train designed for removal of metals and organics
LaSalle Electrical Superfund Site, IL (Pump and Treat with Air Stripping, Carbon Adsorption, and Oil/Water Separation)	●						Groundwater (23 million gallons)	Status: Ongoing Report Covers: 12/92 - 5/97	System consists of collection trenches instead of extraction wells; relatively low groundwater flow; contaminants include PCBs and chlorinated solvents
Mid-South Wood Products Superfund Site, AR (Pump and Treat with Carbon Adsorption, Filtration, and Oil/Water Separation)			●			●	Groundwater (100.6 million gallons)	Status: Ongoing Report Covers: 9/89 - 12/97	Groundwater contaminated with wood treating chemicals; system optimization performed after eight years of operation; groundwater contamination had been reduced to one localized area of concern

Table 4. Summary of Remediation Case Studies: Groundwater Pump and Treat (Nonchlorinated Contaminants) (continued)

Site Name, State (Technology)	Principal Contaminants*						Media (Quantity Treated**)	Project Duration	Highlights
	Chlorinated Solvents	BTEX and/or TPH	PAHs	Pesticides/Herbicides	Explosives	Metals			
Odessa Chromium I Superfund Site, OU 2, TX (Pump and Treat with Chemical Treatment, Flocculation, Multimedia Filtration, pH Adjustment, and Precipitation)						●	Groundwater (125 million gallons)	Status: Ongoing Report Covers: 11/93 - 1/98	Includes on-site treatment for chromium; relatively low groundwater flow; contamination in one aquifer
Odessa Chromium IIS Superfund Site, OU 2, TX (Pump and Treat with Chemical Treatment, Flocculation, Multimedia and Cartridge Filtration, pH Adjustment, and Precipitation)						●	Groundwater (121 million gallons)	Status: Ongoing Report Covers: 11/93 - 12/97	Includes on-site treatment for chromium; relatively low groundwater flow; contamination in two aquifers
Pope AFB, Site FT-01, NC (Free Product Recovery)		●					Groundwater and Free Product	Status: Ongoing Report Covers: 11/93 - 11/96	Recovery of free product from groundwater
Pope AFB, Site SS-07, Blue Ramp Spill Site, NC (Free Product Recovery)		●					Groundwater	Status: Ongoing Report Covers: 11/93 - 11/96	Recovery of free product using active pumping
Sylvester/Gilson Road Superfund Site, NH (Pump and Treat with Air Stripping, Biological Treatment, Chemical Treatment, Clarification, Flocculation, and Mixed-media Pressure Filtration; Cap; Soil Vapor Extraction; Vertical Barrier Wall)	●					●	Groundwater (1,200 million gallons)	Status: Ongoing Report Covers: 1982 - 12/95	A combination of technologies was used to remediate the site; cleanup goals were met for all contaminants with one exception (1,1-DCA) which was reported as below the detection limit
United Chrome Superfund Site, OR (Pump and Treat with Reduction and Precipitation)						●	Groundwater (62 million gallons)	Status: Ongoing Report Covers: 8/88 - 3/97	Extracted groundwater was treated on-site at the beginning of this application; however, because concentrations dropped over time, on-site treatment was discontinued

Table 4. Summary of Remediation Case Studies: Groundwater Pump and Treat (Nonchlorinated Contaminants) (continued)

Site Name, State (Technology)	Principal Contaminants*						Media (Quantity Treated**)	Project Duration	Highlights
	Chlorinated Solvents	BTEX and/or TPH	PAHs	Pesticides/Herbicides	Explosives	Metals			
U.S. Aviex Superfund Site, MI (Pump and Treat with Air Stripping)	●						Groundwater (329 million gallons)	Status: Ongoing Report Covers: 7/93 - 12/96	Performed modeling for system optimization (MODFLOW and Randomwalk); contaminants included diethyl ether and chlorinated solvents
Western Processing Superfund Site, WA (Pump and Treat with Air Stripping and Filtration; Vertical Barrier Wall)	●		●			●	Groundwater (974 million gallons)	Status: Ongoing Report Covers: 10/88 - 12/96	Met goals for off-site plume within eight years of operation; shallow well points recently replaced with deeper wells to provide containment

* Principal contaminants are one or more specific constituents within the groups shown that were identified during site investigations.
** Quantity treated is the amount of groundwater extracted and treated above ground.

Table 5. Summary of Remediation Case Studies: Innovative Groundwater Treatment Technologies

Site Name, State (Technology)	Principal Contaminants*						Media (Quantity Treated)	Project Duration	Highlights
	Chlorinated Solvents	BTEX and/or TPH	PAHs	Pesticides/Herbicides	Explosives	Metals			
Balfour Road Site, CA; Fourth Plain Service Station Site, WA; Steve's Standard and Golden Belt 66 Site, KS (Enhanced Bioremediation of Groundwater)		●					Groundwater (estimated 20,400 ft^2 for Fourth Plain)	Balfour Road: Status: Ongoing Report Covers: 12/95 - 10/97 Fourth Plain and Steve's Standard: Status: Ongoing Report Covers: 7/96 - 10/97	Evaluate the cost and performance of ORC^R to remediate groundwater at three sites
Coastal Systems Station, AOC 1, FL (Chemical Reaction and Flocculation, and Dissolved Air Flotation)		●				●	Wastewater (126,400 gallons)	8/97 (Demonstration conducted for a total of 448 hours)	Demonstrate the effectiveness of CRF/DAF and Oleofiltration^{TM} in treating TPH and metals in wastewater from a full-scale bioslurper system
Former Intersil, Inc. Site, CA (Pump and Treat with Air Stripping; Permeable Reactive Barrier)	●						Groundwater: P&T (38 million gallons) PRB (2 million gallons)	Status: PRB Ongoing Report Covers: P&T (11/87 - 2/95) PRB (2/95 - 11/97)	Used P&T for eight years; replaced this technology with PRB; PRB used for three years
French Ltd. Superfund Site, TX (Pump and Treat with Activated Sludge for Extracted Groundwater; In Situ Bioremediation)	●						Groundwater (306 million gallons, ex situ)	Status: Ongoing Report Covers: 1/92 - 12/95	Regulatory requirements for this site based on use of modeling results to show effects of natural attenuation at a site boundary 10 years after pump and treat completed

Table 5. Summary of Remediation Case Studies: Innovative Groundwater Treatment Technologies (continued)

Site Name, State (Technology)	Principal Contaminants*						Media (Quantity Treated)	Project Duration	Highlights
	Chlorinated Solvents	BTEX and/or TPH	PAHs	Pesticides/Herbicides	Explosives	Metals			
Gold Coast Superfund Site, FL (Pump and Treat with Air Sparging)	●						Groundwater (80 million gallons)	7/90 - 3/94: pump and treat 11/94 - 2/95: air sparging	Met goals within four years of operation; included pump and treat and air sparging
Libby Groundwater Superfund Site, MT (Pump and Treat; In Situ Bioremediation)			●				Groundwater (15.1 million gallons)	Status: Ongoing Report Covers: 9/91 - 12/96	Combination of pump and treat and in situ bioremediation at site with LNAPL, DNAPL, and dissolved-phase contaminants
Moffett Federal Airfield, CA (Permeable Reactive Barrier)	●						Groundwater (0.284 million gallons)	Status: Ongoing Report Covers: 4/96 - 7/97	Use of PRB technology in a pilot study for treatment of chlorinated solvents; included extensive sampling conducted at locations within the wall
Pinellas Northeast Site, FL (In Situ Air and Steam Stripping -Dual Auger Rotary Steam Stripping)	●						Soil (2,000 yd^3) Groundwater	12/96 - 4/97	Demonstration of in situ air and steam stripping technology used to supplement an ongoing system of pump and treat with air stripping
Pinellas Northeast Site, FL (In Situ Anaerobic Bioremediation)	●						Groundwater (250,000 gallons)	2/7/97 - 6/30/97	Demonstration of in situ anaerobic bioremediation technology used to supplement an ongoing system of pump and treat with air stripping
Pinellas Northeast Site, FL (Membrane Filtration - PerVap)	●						Groundwater (6,200 gallons)	6/14/95 - 3/2/96	Demonstration of the PerVap™ technology for treating VOC-contaminated groundwater

Table 5. Summary of Remediation Case Studies: Innovative Groundwater Treatment Technologies (continued)

Site Name, State (Technology)	Principal Contaminants*						Media (Quantity Treated)	Project Duration	Highlights
	Chlorinated Solvents	BTEX and/or TPH	PAHs	Pesticides/Herbicides	Explosives	Metals			
Site A (actual name confidential), NY (Pump and Treat with Air Stripping; In Situ Bioremediation; Air Sparging; Soil Vapor Extraction)		●					Groundwater (8.4 million gallons)	Status: Ongoing Report Covers: 7/95 - 10/96	System included groundwater extraction, air sparging, and SVE wells
U.S. Coast Guard Support Center, NC (Permeable Reactive Barrier)	●					●	Groundwater (2.6 million gallons)	Status: Ongoing Report Covers: 7/96 - 7/97	Use of PRB to treat groundwater contaminated with TCE and hexavalent chromium; extensive sampling conducted to evaluate PRB

* Principal contaminants are one or more specific constituents within the groups shown that were identified during site investigations.

Table 6. Summary of Remediation Case Studies: On-Site Incineration

Site Name, State (Technology)	Principal Contaminants*						Media (Quantity Treated)	Project Duration	Highlights
	Chlorinated Solvents	BTEX and/or TPH	PAHs	Pesticides/Herbicides	Metals	Dioxin and/or PCBs			
Baird and McGuire, MA (rotary kiln incinerator)			●	●	●	●	Soil (210,000 tons) Sediment (1,500 cubic yards)	3/95 - 3/97	Successfully treated a wide variety of contaminants in soil and sediment, including dioxins, VOCs, PAHs, and pesticides.
Bayou Bonfouca, LA (rotary kiln incinerator)			●				Sediment (250,000 tons)	11/93 - 7/95	Project completed 18 months ahead of schedule for this relatively large quantity of waste.
Bridgeport Refinery and Oil Services, NJ (rotary kiln incinerator)		●			●	●	Lagoon sediment and sludge (138,350 tons) Debris (13,000 tons) Levee material (12,550 tons) Lagoon oil (3,850 tons) Soil (4,250 tons)	12/91 - 1/96	Inadequate design caused numerous mechanical problems during the treatment of a variety of matrices, including sludge, sediment, debris, oil, and soil, contaminated with VOCs and PCBs. However, all performance standards and emissions requirements were met during the 50 months of operation.
Celanese Corporation Shelby Fiber Operations, NC (rotary kiln incinerator)	●		●		●		Soil and sludge (4,660 tons)	4/91 - 12/91	The project was completed within nine months.
Coal Creek, WA (rotary kiln incinerator)					●	●	Soil (9,715 tons)	1/94 - 5/94	Incineration operated under a TSCA permit; therefore, compliance with DRE requirements was allowed to be demonstrated without spiking.

Table 6. Summary of Remediation Case Studies: On-Site Incineration (continued)

Site Name, State (Technology)	Principal Contaminants*						Media (Quantity Treated)	Project Duration	Highlights
	Chlorinated Solvents	BTEX and/or TPH	PAHs	Pesticides/Herbicides	Metals	Dioxin and/or PCBs			
FMC Corporation - Yakima, WA (rotary kiln incinerator)				●	●		Soil (5,600 cubic yards or 7,840 tons)	1/93 - 5/93	Frigid ambient air temperatures caused delays in setting up the incinerator, as shakedown activities occurred during the winter months (shakedown and testing originally had been scheduled for spring and summer).
Former Nebraska Ordnance Plant - OU 1, NE (rotary kiln incinerator)							Soil and debris (16,449 tons)	9/97 - 12/97	Primary contaminants were explosives and propellants (TNT, RDX, TNB, DNT, DNB, HMX, Tetryl, o-NT, and m-NT); project was completed in extremely short time period, including all permitting requirements
MOTCO, TX (rotary kiln incinerator)	●				●	●	Soil (4,699 tons) Sludge (283 tons) Organic liquids (7,568 tons) Aqueous waste (10,471 tons)	5/90 - 12/91	Mechanical problems, caused in part by the lack of accurate waste characterization, were encountered. On-site incineration was stopped in December 1991 because of a dispute between the contractor and the responsible party (RP); the remedy was changed to off-site incineration, in part because of the dispute and mechanical problems.
Old Midland Products, AR (rotary kiln incinerator)			●				Soils, sludges, and sediments (102,000 tons)	6/92 - 5/93	According to project managers, this incineration project encountered few problems because of good waste characterization.

Table 6. Summary of Remediation Case Studies: On-Site Incineration (continued)

Site Name, State (Technology)	Principal Contaminants*						Media (Quantity Treated)	Project Duration	Highlights
	Chlorinated Solvents	BTEX and/or TPH	PAHs	Pesticides/Herbicides	Metals	Dioxin and/or PCBs			
Petro Processors, LA (horizontal liquid injection incinerator)	●	●	●		●		Organic liquids and fumes (213,376 gallons, as of June 1997)	(Ongoing report covers 11/94 through 5/97)	Incineration was used to treat free product and emissions from a groundwater pump and treat system.
Rocky Mountain Arsenal, CO (submerged quench incinerator)				●	●		Liquids (10.9 million gallons)	7/93 - 7/95	Submerged quench incinerator used to treat liquid pesticide wastes. Innovative design was used to capture metal particulates.
Rose Disposal Pit, MA (rotary kiln incinerator)	●					●	Soil (51,000 tons)	2/94 - 7/94	Incinerator used to treat more than 50,000 tons of soil contaminated with high levels of PCBs (400,000 mg/kg).
Rose Township Dump, MI (infrared incinerator)		●				●	Soils and debris (34,000 tons)	9/92 - 10/93	Infrared incinerator used to treat contaminated soil and debris. Weather-related operational problems led to delays in the project schedule.
Sikes Disposal Pits, TX (rotary kiln incinerator)	●		●				Soil and debris (496,000 tons) Contaminated water (350 million gallons)	2/92 - 6/94	Two SCCs in parallel were required to maximize throughput of incinerator. Steam generated by quenching of slag caused overpressurization in the kiln.
Times Beach, MO (rotary kiln incinerator)						●	Soil and debris (265,000 tons)	3/96 - 6/97	The incinerator was used as a central treatment facility for 27 sites in the state of Missouri that were contaminated with dioxin.

Table 6. Summary of Remediation Case Studies: On-Site Incineration (continued)

Site Name, State (Technology)	Principal Contaminants*						Media (Quantity Treated)	Project Duration	Highlights
	Chlorinated Solvents	BTEX and/or TPH	PAHs	Pesticides/Herbicides	Metals	Dioxin and/or PCBs			
Vertac Chemical Corporation, AR (rotary kiln incinerator)				●		●	Still bottom waste and soil in drums (9,804 tons)	1/92 - 9/94	Two temporary restraining orders were filed to stop the incineration project in light of public concern about the incineration of dioxin-listed waste; on-site incineration proceeded with non-dioxin wastes.

* Principal contaminants are one or more specific constituents within the groups shown that were identified during site investigations.

Table 7. Summary of Remediation Case Studies: Debris and Surface Cleaning Technologies, and Other Miscellaneous Technologies

Site Name, State (Technology)	Principal Contaminants*						Media (Quantity Treated)	Project Duration	Highlights
	Chlorinated Solvents	BTEX and/or TPH	PAHs	Pesticides/Herbicides	Explosives	Radioactivity			
Alabama Army Ammunition Plant, AL (Transportable Hot-Gas Decontamination)					●		Explosives: contaminated piping and debris	12/4/95 - 3/15/96	Demonstration and validation testing to determine effectiveness of treating explosives-contaminated materials using the Hot-Gas Decontamination System
Chicago Pile 5 (CP-5) Research Reactor, Argonne National Laboratory, IL (Centrifugal Shot Blast)						●	Concrete floor covered with radioactive - contaminated paint (800 ft^2)	1/28/97 - 2/4/97	Demonstrate a modified centrifugal shot blast unit compared to mechanical scabbing
Chicago Pile 5 (CP-5) Research Reactor, Argonne National Laboratory, IL (Rotary Peening with Captive Shot)						●	Concrete floor covered with radioactive - contaminated paint (425 ft^2)	1/28/97 - 2/4/97	Demonstrate Roto Peening with captive shot compared to mechanical scabbing
Chicago Pile 5 (CP-5) Research Reactor, Argonne National Laboratory, IL (Roto Peen Scaler with VAC-PAC^R System)						●	Concrete floor covered with radioactive - contaminated paint (650 ft^2)	12/9/96 - 12/12/96	Demonstrate Roto Peen Scaler with VAC-PAC^R System compared to mechanical scabbing; hand held unit
Envirocare of Utah, UT (Polyethylene Macroencapsulation)						●	lead bricks: radioactive - contaminated (500,000 lb)	Fiscal Year 1996	Determine production-scale feasibility of this technology for mixed lead waste

Table 7. Summary of Remediation Case Studies: Debris and Surface Cleaning Technologies, and Other Miscellaneous Technologies (continued)

Site Name, State (Technology)	Principal Contaminants*						Media (Quantity Treated)	Project Duration	Highlights
	Chlorinated Solvents	BTEX and/or TPH	PAHs	Pesticides/Herbicides	Explosives	Radioactivity			
Lawrence Livermore National Laboratory (LLNL) Site 300 - Pit 6 Landfill OU, CA (Cap)	●					●	2.4 acre multilayer cap over a landfill	Installed Summer 1997	Multilayer capping of a landfill

* Principal contaminants are one or more specific constituents within the groups shown that were identified during site investigations.

Table 8. Remediation Case Studies: Summary of Cost Data

Site Name, State (Technology)	Technology Cost ($)*	Quantity of Media Treated	Quantity of Contaminant Removed	Calculated Unit Cost for Treatment**	Key Factors Potentially Affecting Technology Costs***
Ex Situ Soil Treatment Technologies (Bioremediation, Solvent Extraction, Thermal Desorption)					
Bioremediation					
Bonneville Power Administration Ross Complex, Operable Unit A, WA (Land Treatment)	Total: 1,082,859	2,300 yd^3	Not applicable	$470/$yd^3$	Costs were relatively high because this project involved researching rates of degradation under various enhancement techniques
Fort Greely, UST Soil Pile, AK (Land Treatment)	Total: $290,288	9,800 yd^3	Not applicable	$29.62/$yd^3$	Costs were higher than anticipated because treatment took twice as long as anticipated
Novartis Site, Ontario, Canada (Land Treatment)	Not provided	200 tons	Not applicable	Projected as $186/ton (Canadian dollars) for a full-scale application at this site	Factors for full-scale include site location (distance from material and climate), quantity of soil treated, initial concentrations of target compounds, applicable remediation criteria, and soil pretreatment requirements
Solvent Extraction					
Sparrevohn Long Range Radar Station, AK (Solvent Extraction)	Total: $828,179	288 yd^3	Not applicable	$780/$yd^3$	High transportation costs were incurred because this site was at a remote location and was accessible only by air
Thermal Desorption					
FCX Washington Superfund Site, NC (Thermal Desorption)	Total: $1,696,800	13,591 yd^3	Not applicable	$125/$yd^3$	One of the first applications of this vendor's technology at a full-scale; required several modifications during operation at this site
Fort Lewis, Solvent Refined Coal Pilot Plant (SRCPP), WA (Thermal Desorption)	Total (for entire RA): $7,100,000 Total (for treatment only): $tbd	104,366 tons	Not provided	$68/ton (for entire RA) $34/ton (for treatment only)	Unit costs were relatively low because of economies-of-scale

Table 8. Remediation Case Studies: Summary of Cost Data (continued)

Site Name, State (Technology)	Technology Cost ($)*	Quantity of Media Treated	Quantity of Contaminant Removed	Calculated Unit Cost for Treatment**	Key Factors Potentially Affecting Technology Costs***
Naval Air Station Cecil Field, Site 17, OU 2, FL (Thermal Desorption)	Total: $1,946,122	11,768 tons	Not applicable	$165/ton	Site work and preparation including extensive storm water management lead to increased costs for this application
Port Moller Radio Relay Station, AK (Thermal Desorption)	Total: $3,325,000	9,500 yd^3	Not applicable	$350/$yd^3$	Mobilization and demobilization costs for this application were relatively high because of the remote site location
ReSolve, Inc. Superfund Site, MA (Thermal Desorption)	Total: $6,800,000	44,000 tons	Not applicable	$155/ton	Treatment of condensate from thermal desorber to meet strict water discharge limits required use of a multi-stage, on-site wastewater treatment system
Waldick Aerospaces Devices Superfund Site, NJ (Thermal Desorption)	Total (for entire RA): $4,995,159 Total (for treatment only): $2,017,361	3,450 yd^3	Not provided	$585/$yd^3$	Costs were higher because system was temporarily shut down because of non-compliance with air emission standard
In Situ Soil Treatment Technologies (Soil Vapor Extraction, Thermal Processes)					
Soil Vapor Extraction					
Camp LeJeune Military Reservation, Site 82, Area A, NC (Soil Vapor Extraction)	Total: $469,949 C: $222,455 O: $247,485	17,500 yd^3	Not provided	$27/$yd^3$	Costs were reduced for this application because some overhead and operation costs were shared with other activities ongoing at the site, such as operation of a pump and treat system use of an on-site laboratory
Davis-Monthan AFB, Site ST-35, AZ (Soil Vapor Extraction)	Total: $207,000 C: $162,000 O: $45,000 (total) $1,818-2,602 (monthly)	63,000 yd^3	585,700 lbs (14,700-67,800 lbs/month)	$3.30/$yd^3$ $0.35/lb O: $0.06/lb	Costs were reduced because extracted vapors were used as fuel for operating internal combustion engines that ran extraction system

Table 8. Remediation Case Studies: Summary of Cost Data (continued)

Site Name, State (Technology)	Technology Cost ($)*	Quantity of Media Treated	Quantity of Contaminant Removed	Calculated Unit Cost for Treatment**	Key Factors Potentially Affecting Technology Costs***
Defense Supply Center Richmond, OU 5, VA (Soil Vapor Extraction)	Total: $76,099 C: $18,225 O: $57,874	1,000 yd^3	Not provided	$76/$yd^3$	Costs were low because the cleanup goals for this site were achieved during a 10-day pilot test involving one extraction well
Fort Greely, Texas Tower Site, AK (Air Sparging, In Situ Bioremediation, and Soil Vapor Extraction)	Total: $295,760 C: $178,530 O: $117,230	6,300 yd^3	Not provided	$47/$yd^3$	Because the site is isolated, the USACE reported that the cost of transportation of equipment to the site and setup at the site was a significant portion of the total cost; operating costs were kept low by monitoring the system remotely
Fort Lewis, Landfill 4, WA (Soil Vapor Extraction and Air Sparging)	Total: $1,710,303 (negotiated cost to date)	Not provided	60 lbs	Not calculated	Unit costs could not be calculated; only preliminary results available at this time; technology used to treat soil and groundwater contaminated with relatively low concentrations of contaminants; system operation included extensive variations in operating conditions
Fort Richardson, Building 908 South, AK (Soil Vapor Extraction)	Total (for entire RA): $305,053 Total (for technology): $252,200	4,600 yd^3	Not provided	$55/$yd^3$	No supplemental technology was needed for air emissions
Holloman AFB, Sites 2 and 5, NM (Soil Vapor Extraction)	Total: $610,000	9,500 yd^3	44,000 lbs	$64/$yd^3$ $14/lb	Use of fiberglass piping caused increase in technology cost
Intersil/Siemens Superfund Site, CA (Soil Vapor Extraction)	Total: $770,000 C: $550,000 O: $220,000	280,000 yd^3	3,000 lbs	$3/$yd^3$ $260/lb	Unit cost per volume of soil treated was kept low because economies-of-scale in treating a relatively large site; also cleanup was achieved within the time frame predicted for treatment

Table 8. Remediation Case Studies: Summary of Cost Data (continued)

Site Name, State (Technology)	Technology Cost ($)*	Quantity of Media Treated	Quantity of Contaminant Removed	Calculated Unit Cost for Treatment**	Key Factors Potentially Affecting Technology Costs***
NAS North Island, Site 9, CA (Photolytic Destruction)	Total: $93,726 (for demonstration)	1,151 lbs of VOCs	Not provided	Full-scale projected as $3.77/lb (only for treatment of extracted vapors)	Projected costs reflect the first demonstration of this technology
Seymour Recycling Corporation Superfund Site, IN (Soil Vapor Extraction)	Total: Not provided C: $1,200,000	200,000 yd^3	30,000 lbs	Not calculated	Unit costs could not be calculated; separate costs not provided for the complex activities at this site (a combination of soil, groundwater, and other remedial activities)
Shaw AFB, OU 1, SC (Soil Vapor Extraction and Groundwater Containment)	O: $568,500 (total) $18,000-57,500 (monthly)	30,000 ft^2	518,000 lbs (2,560-94,800 lbs/month)	O: $1.09/lb	Use of pulsed system reduced operating costs; report provides data only for operating costs
Tyson's Dump Superfund Site, PA (Soil Vapor Extraction)	Total: $43,400,000	30,000 yd^3	200,000 lbs	$1,400/$yd^3$ $220/lb	Several conditions at the site limited the diffusion rate for VOCs (e.g., geology), and the technology vendor implemented 14 enhancements to improve system performance
Thermal Processes					
Brodhead Creek Superfund Site, PA (Contained Recovery of Oily Waste)	Total: $1,200,000	Not provided	1,500 gals	$800/gal	Elevated costs due to complexity of contaminants (coal tar); problems with methodology used to estimate amount of coal tar removed resulted in system being required to operate longer
Missouri Electric Works Superfund Site, MO (In Situ Thermal Desorption)	Not provided	52 yd^3	Not provided	Full-scale projected as $120-200/$yd^3$ for "most standard sites"	Factors affecting full-scale costs include the moisture content of the soil, and the extent and depth of contamination, which affects the number and depth of wells required for treatment

Table 8. Remediation Case Studies: Summary of Cost Data (continued)

Site Name, State (Technology)	Technology Cost ($)*	Quantity of Media Treated	Quantity of Contaminant Removed	Calculated Unit Cost for Treatment**	Key Factors Potentially Affecting Technology Costs***
Groundwater Pump and Treat (Chlorinated Solvents)					
Des Moines TCE Superfund Site, OU 1, IA (Pump and Treat with Air Stripping)	Total: $2,596,000 C: $1,587,000 O: $1,009,000	4,900 million gallons	30,000 lbs	$0.53/1,000 gals GW $80/lb of cont.	Unit cost reflects economies-of-scale for treatment of large volume of extracted groundwater
Former Firestone Facility Superfund Site, CA (Pump and Treat with Air Stripping, Carbon Adsorption, and Oil/Water Separation)	Total: $12,884,813 C: $4,133,543 O: $8,751,270	1,800 million gallons	496 lbs	$7/1,000 gals GW $26,000/lb of cont.	Site operators frequently adjusted operation of extraction system to maximize contaminant removal; site had complex hydrogeology
JMT Facility RCRA Site (formerly Black & Decker RCRA Site), NY (Pump and Treat with Air Stripping)	Total: $2,163,000 C: $879,000 O: $1,284,000	50.1 million gallons	842 lbs	$47/1,000 gals GW $2,569/lb of cont.	Two modifications to treatment system (including enclosure for treatment system) increased capital costs by 35% over original estimate
Keefe Environmental Services Superfund Site, NH (Pump and Treat with Air Stripping and Coagulation/Flocculation)	Total: $2,408,000 C: $1,582,539 O: $826,000	46 million gallons	68 lbs	$52/1,000 gals GW $35,000/lb of cont.	As a result of an optimization study, replaced two extraction wells to increase removal of contaminant mass
Lawrence Livermore National Laboratory (LLNL) Site 300 - General Services Area (GSA) Operable Unit, CA (Pump and Treat with Air Stripping and Carbon Adsorption; Soil Vapor Extraction)	Total: $36,600,000 (costs not provided separately for P&T and SVE)	93.8 million gallons GW 399,000 ft^3 soil vapor	22 lbs (P&T) 67 lbs (SVE)	Not calculated	Costs relatively high because site uses three systems (two groundwater and one soil) to treat contaminated media
Mystery Bridge at Hwy 20 Superfund Site, Dow/DSI Facility - Volatile Halogenated Organic (VHO) Plume, WY (Pump and Treat with Air Stripping; Soil Vapor Extraction)	Total: $918,000 C: $305,000 O: $613,000	192.8 million gallons	21 lbs	$5.65/1,000 gals GW $44,000/lb of cont.	Relatively low concentrations in groundwater (20-70 ug/L) lead to relatively high unit costs per pound of contaminant removed

Table 8. Remediation Case Studies: Summary of Cost Data (continued)

Site Name, State (Technology)	Technology Cost ($)*	Quantity of Media Treated	Quantity of Contaminant Removed	Calculated Unit Cost for Treatment**	Key Factors Potentially Affecting Technology Costs***
Offutt AFB, Site LF-12, NE (Pump and Treat with Air Stripping)	Total (not provided) C: $540,000 O: $20,000/year (average)	Not provided	12.81 gals	Not calculated	Information not provided
Old Mill Superfund Site, OH (Pump and Treat with Air Stripping and Carbon Adsorption)	Total: $3,236,000 C: $1,596,000 O: $1,640,000	13 million gallons	124 lbs	$250/1,000 gals GW $26,100/lb of cont.	Modifications to improve plume containment increased capital costs by 22%
SCRDI Dixiana Superfund Site, SC (Pump and Treat with Air Stripping)	Total: $1,439,700 (EPA-lead portion) C: $1,189,700 O: $250,000	20.6 million gallons	7 lbs	$464/1,000 gals GW $200,000/lb of cont.	Complex hydrogeology; major modifications were made by PRP to modify system used during EPA-lead portion of application
Shaw AFB, Site OT-16B, SC (Hydraulic Containment Through Active Pumping)	Total: $2,010,000 C: $1,960,000 O: $50,000	Not provided	40.5 gals	Total: $50,000/gal of cont. O&M (average): $15.12/gal of cont.	Containment system was operating efficiently and was meeting its operational objectives
Shaw AFB, Sites SD-29 and ST-30, SC (Free Product Recovery with Air Stripping)	Total (not provided) C: $394,000 (for SD-29) O: $17,000 (cum. for SD-29 and ST-30)	Not provided	102 gals	O&M (average): $166/gal of cont.	To reduce operating costs, passive skimmer bailers were installed in recovery wells
Solid State Circuits Superfund Site, MO (Pump and Treat with Air Stripping)	Total: $2,510,400 C: $893,700 O: $1,616,700	257 million gallons	2,754 lbs	$10/1,000 gals GW $913/lb of cont.	Capital costs do not include costs for installation of four deeper wells, which were installed as part of the RI/FS and not available as a separate cost element

Table 8. Remediation Case Studies: Summary of Cost Data (continued)

Site Name, State (Technology)	Technology Cost ($)*	Quantity of Media Treated	Quantity of Contaminant Removed	Calculated Unit Cost for Treatment**	Key Factors Potentially Affecting Technology Costs***
Sol Lynn/Industrial Transformers Superfund Site, TX (Pump and Treat with Air Stripping, Carbon Adsorption, and Filtration)	Total: $2,547,387 C: $2,104,910 O: $442,477	13 million gallons	4,960 lbs	$196/1,000 gals GW $514/lb of cont.	Site characterization performed during RI did not identify extent of contamination and system had to be modified after the remedial design was completed
Solvent Recovery Services of New England, Inc. Superfund Site, CT (Pump and Treat with Carbon Adsorption, Chemical Treatment, Filtration, and UV/Oxidation; Vertical Barrier Wall)	Total: $5,556,900 C: $4,339,600 O: $1,217,300	32.5 million gallons	4,344 lbs	$265/1,000 gals GW $1,280/lb of cont.	Presence of DNAPLs contributed to elevated costs
Groundwater Pump and Treat (Nonchlorinated Contaminants)					
Baird and McGuire Superfund Site, MA (Pump and Treat with Aeration, Air Stripping, Chemical Treatment, Clarification, and Filtration)	Total: $22,726,000 C: $14,958,000 O: $7,768,000	80 million gallons	2,100 lbs	$284/1,000 gals GW $10,822/lb of cont.	Operating costs are high because of relatively high analytical costs for large number of contaminants
Bofors Nobel Superfund Site - OU 1, MI (Pump and Treat with Air Stripping, Carbon Adsorption, Chemical Treatment, Filtration, and UV/Oxidation)	Total: $13,726,000 C: $12,200,000 O: $763,000	700 million gallons	7,500 lbs	$19.61/1,000 gals GW $1,830/lb of cont.	There is a continuing source of contamination at this site; remediation focused on containing the plume
City Industries Superfund Site, FL (Pump and Treat with Air Stripping)	Total: $1,674,800 C: $1,094,800 O: $580,000	151.7 million gallons	2,700 lbs	$10.60/1,000 gals GW $590/lb of cont.	Biological growth in wells, equalization, and air stripping tower degraded system performance; in addition, optimization was performed to optimize pumping rates
King of Prussia Technical Corporation Superfund Site, NJ (Pump and Treat with Air Stripping, Carbon Adsorption, and Electrochemical Treatment)	Total: $2,816,000 C: $2,031,000 O: $785,000	151.5 million gallons	5,420 lbs	$19/1,000 gals GW $520/lb of cont.	Use of an on-site electrochemical treatment system to remove metals from groundwater increased cost

Table 8. Remediation Case Studies: Summary of Cost Data (continued)

Site Name, State (Technology)	Technology Cost ($)*	Quantity of Media Treated	Quantity of Contaminant Removed	Calculated Unit Cost for Treatment**	Key Factors Potentially Affecting Technology Costs***
LaSalle Electrical Superfund Site, IL (Pump and Treat with Air Stripping, Carbon Adsorption, and Oil/Water Separation)	Total: $6,138,576 C: $5,314,576 O: $824,000	23 million gallons	127 lbs	$266/1,000 gals GW $48,000/lb of cont.	Contamination initially thought to be PCBs, later found to include chlorinated solvents; DNAPLs present at site
Mid-South Wood Products Superfund Site, AR (Pump and Treat with Carbon Adsorption, Filtration, and Oil/Water Separation)	Total: $1,212,600 C: $465,300 O: $747,300	100.6 million gallons	800 lbs	$13/1,000 gals GW $1,500/lb of cont.	Initial use of french drains to improve groundwater yield from fractured bedrock proved to be less effective than use of drilled extraction wells
Odessa Chromium I Superfund Site, OU 2, TX (Pump and Treat with Chemical Treatment, Flocculation, Multimedia Filtration, pH Adjustment, and Precipitation)	Total: $2,742,000 C: $1,954,000 O: $728,000	125 million gallons	1,143 lbs	$30/1,000 gals GW $2,400/lb of cont.	The ROD requirement that ferrous iron be produced on-site electrochemically limited the number of system vendors to two, increasing the cost of treatment
Odessa Chromium IIS Superfund Site, OU 2, TX (Pump and Treat with Chemical Treatment, Flocculation, Multimedia and Cartridge Filtration, pH Adjustment, and Precipitation)	Total: $2,487,700 C: $1,927,500 O: $560,200	121 million gallons	131 lbs	$26/1,000 gals GW $19,000/lb of cont.	There were several startup problems including clogging of injection wells and encrusting of polishing filters; requirement to produce ferrous iron on site increased the cost of treatment
Pope AFB, Site FT-01, NC (Free Product Recovery)	Total: $355,600 C: $289,000 O: $66,600	Not provided	5,163 gals	O (average): $12.90/gal of free product	Containment system was operating efficiently and was meeting its operational objectives
Pope AFB, Site SS-07, Blue Ramp Spill Site, NC (Free Product Recovery)	Total: $490,200 C: $394,000 O: $96,200	Not provided	3,516 gals	O (average): $27.36/gal of free product	Containment system was operating efficiently and was meeting its operational objectives
Sylvester/Gilson Road Superfund Site, NH (Pump and Treat with Air Stripping, Biological Treatment, Chemical Treatment, Clarification, Flocculation, and Mixed-media Pressure Filtration; Cap; Soil Vapor Extraction; Vertical Barrier Wall)	Total: $27,600,000 C: $9,100,000 O: $18,500,000	1,200 million gallons	427,000 lbs	$23/1,000 gals GW $64/lb of cont.	An ESD required modifications to the system (adding extraction wells and SVE for toluene source control) resulted in a 15% increase in capital costs

Table 8. Remediation Case Studies: Summary of Cost Data (continued)

Site Name, State (Technology)	Technology Cost ($)*	Quantity of Media Treated	Quantity of Contaminant Removed	Calculated Unit Cost for Treatment**	Key Factors Potentially Affecting Technology Costs***
United Chrome Superfund Site, OR (Pump and Treat with Reduction & Precipitation)	Total: $4,637,160 C: $3,329,840 O: $1,307,320	62 million gallons	31,459 lbs	$75/1,000 gals GW $140/lb of cont.	Initially used a modular treatment system rather than a more expensive permanent system; later able to discontinue use of treatment, reduced operational costs by an order of magnitude
U.S. Aviex Superfund Site, MI (Pump and Treat with Air Stripping)	Total: $1,942,000 C: $1,332,000 O: $610,000	329 million gallons	664 lbs	$5/1,000 gals GW $2,925/lb of cont.	Operation of an interim pump and treat system prior to final remediation system reduced total costs
Western Processing Superfund Site, WA (Pump and Treat with Air Stripping, and Filtration; Vertical Barrier Wall)	Total: $48,730,112 C: $16,032,629 O: $32,697,483	974 million gallons	102,000 lbs	$50/1,000 gals GW $478/lb of cont.	Initial goal required use of costly pump and treat system; revised goal of containment is being achieved through use of a slurry wall
Innovative Groundwater Treatment Technologies					
Balfour Road Site, CA; Fourth Plain Service Station Site, WA; Steve's Standard and Golden Belt 66 Site, KS (Enhanced Bioremediation of Groundwater)	Balfour Road: $33,500; Fourth Plain Service Station: $35,700 Steve's Standard and Golden Belt 66: $93,400	Not provided	Not provided	Not provided	Amount of ORC^{R} applied, number of ORC^{R} source points, and method used to apply ORC^{R}
Coastal Systems Station, AOC 1, FL (Chemical Reaction and Flocculation, and Dissolved Air Flotation)	Monthly lease and operation costs: CRF/DAF: $7,580 Oleofiltration: $3,650	126,400 gallons	Not provided	Not provided	Operating costs for CRF/DAF are twice as high as for Oleofiltration primarily due to higher leasing costs; however, the CRF/DAF had a much higher removal percentage of contaminants
Former Intersil, Inc. Site, CA (Pump and Treat with Air Stripping; Permeable Reactive Barrier)	Total (P&T): $1,343,800 Total (PRB) $762,000	Total: 38 million gallons P&T: 36 million gallons PRB: 2 million gallons	Total: 140 lbs P&T: 124 lbs PRB: 16 lbs	P&T: $38/1,000 gals GW $10,900/lb of cont. PRB: $38/1,000 gals GW $49,400/lb of cont.	P&T replaced with PRB to minimize operating cost for treatment while increasing treatment effectiveness

Table 8. Remediation Case Studies: Summary of Cost Data (continued)

Site Name, State (Technology)	Technology Cost ($)*	Quantity of Media Treated	Quantity of Contaminant Removed	Calculated Unit Cost for Treatment**	Key Factors Potentially Affecting Technology Costs***
French Ltd. Superfund Site, TX (Pump and Treat with Activated Sludge for Extracted Groundwater; In Situ Bioremediation)	Total: $33,689,000 C: $15,487,000 O: $18,202,000	306 million gallons	517,000 lbs	$110/1,000 gals GW $15/lb of cont.	Use of three technologies (P&T, in situ bioremediation, and sheet pile walls to contain DNAPL source)
Gold Coast Superfund Site, FL (Pump and Treat with Air Sparging)	Total: $694,325 C: $249,005 O: $445,320	80 million gallons	1,961 lbs	$9/1,000 gals GW $354/lb of cont.	Optimization of extractions wells to focus on problem areas; cleanup goals achieved within four years
Libby Groundwater Superfund Site, MT (Pump and Treat; In Situ Bioremediation)	Total: $5,628,600 C: $3,101,000 O: $2,618,600	15.1 million gallons	37,570 lbs	$374/1,000 gals GW $150/lb of cont.	Use of Protec pump for source area increased both capital and operating costs (pumps malfunctioned if run for extended periods of time)
Moffett Federal Airfield, CA (Permeable Reactive Barrier)	Total: $405,000 C: $373,000 O: $32,000	0.284 million gallons	Not provided	$1,400/1,000 gals GW	Increased performance monitoring conducted for technology certification and validation
Pinellas Northeast Site, FL (In Situ Air and Steam Stripping - Dual Auger Rotary Steam Stripping)	Total: $981,251 (for demonstration)	2,000 yd^3 of soil	1,200 lbs	Projected for full-scale O: $50-400/$yd^3$ $300-500/lb of cont.	Factors for full-scale include accurate design and operation of key sub-systems (drill tower, catox unit, acid gas scrubber) is crucial for cost effective operation of this technology
Pinellas Northeast Site, FL (In Situ Anaerobic Bioremediation)	Total: $397,074 (for demonstration)	0.25 million gallons	Not provided	Projected for full-scale O: $0.12/gal GW	Limiting factors for full-scale are the ability to deliver appropriate nutrients to all contaminated areas and the hydrogeologic characteristics of the site which affect nutrient transport
Pinellas Northeast Site, FL (Membrane Filtration - PerVap)	Total: $88,728 (for demonstration)	6,200 gallons	Not provided	Projected for full-scale $0.01-0.015/gal GW	Costs for full-scale will vary based on desired treatment volume and level; unit costs for pilot system should be comparable to those for full-scale operation

Table 8. Remediation Case Studies: Summary of Cost Data (continued)

Site Name, State (Technology)	Technology Cost ($)*	Quantity of Media Treated	Quantity of Contaminant Removed	Calculated Unit Cost for Treatment**	Key Factors Potentially Affecting Technology Costs***
Site A (actual name confidential), NY (Pump and Treat with Air Stripping; In Situ Bioremediation; Air Sparging; Soil Vapor Extraction)	Total: $1,941,560 C: $1,503,133 O: $358,427	8.4 million gallons	5,315 lbs	$200/1,000 gals GW $365/lb of cont.	Use of skid-mounted modular equipment reduced construction costs
U.S. Coast Guard Support Center, NC (Permeable Reactive Barrier)	Total: $585,000 C: $500,000 O: $85,000	2.6 million gallons	Not provided	$225/1,000 gals GW	Use of a PRB was estimated to save nearly $4,000,000 in construction and long-term maintenance costs when compared with a typical pump and treat system
On-Site Incineration					
Baird & McGuire, MA	Total: $133,000,000 Treatment: NA	248,000 tons of soil and sediment	NA	$540/ton	No comments.
Bayou Bonfouca, LA	Total: $110,000,000 Treatment: $72,000,000	250,000 tons of sediment	$288/ton	$440/ton	EPA paid for the incineration on the basis of dry weight of the ash instead of the weight of the feed material. It therefore was more desirable to the contractor to optimize the process train and guard against the unnecessary incineration of moisture.
Bridgeport Refinery and Oil Services, NJ	Total: NA Treatment: NA	172,000 tons of sediment, sludge, debris, oil, and soil	NA	NA	SCC supports required rebuilding to repair loss of structural integrity. Slag falling into ash quench caused damage to ash and feed augers requiring numerous repairs.
Celanese Corporation, NC	Total: $5,300,000 Treatment: $1,900,000	4,660 tons of soil and sludge	$410/ton	$1,000/ton	The site operator believes on-site incineration was uneconomical, compared with off-site incineration because a relatively small amount of waste was treated.
Coal Creek, WA	$8,100,000 Treatment: NA	9,715 tons of soil	NA	$830/ton	No comments.

Table 8. Remediation Case Studies: Summary of Cost Data (continued)

Site Name, State (Technology)	Technology Cost ($)*	Quantity of Media Treated	Quantity of Contaminant Removed	Calculated Unit Cost for Treatment**	Key Factors Potentially Affecting Technology Costs***
FMC Corporation-Yakima, WA	Total: $6,000,000 Treatment: NA	7,840 tons of soil* (5,600 cubic yards)	NA	$770/ton	Statistical methodology used to minimize the amount of soil excavated.
Former Nebraska Ordnance Plant - OU 1, NE	Total: $10,700,000 Treatment: $6,479,245	16,449 tons of soil and debris	$394/ton	$650/ton	Project costs were higher than expected due to the increased volume of contaminated soil than was encountered during excavation. Additional costs were also incurred due to shutdown of the system during a period of inclement winter weather.
MOTCO, TX	Total: $76,000,000 Treatment: $31,000,000	23,021 tons of soil, sludge, organic liquid, and aqueous waste	$1,346/ton	$3,300/ton	Inaccurate initial characterization of the waste stream resulted in many mechanical problems during incineration operation.
Old Midland, AR	Total: $27,100,000 Treatment: $22,500,000 (excavate, incinerate, backfill)	102,000 tons of soil, sludge, and sediment	$220/ton (excavate, incinerate, backfill)	$264/ton	The criterion for dioxin and furans in ash was raised from 0.1 to 1.0 ppb, reducing residence time and increasing throughput. Amount of contaminated soil underestimated.
Petro Processors, LA	Total: $59,220,000 through 5/97 Treatment: $4,800,000 through 5/97	213,376 gallons of organic liquid and fumes (as of June 1997)	$21/gal	$280/gal	No comments.
Rocky Mountain Arsenal, CO	Total: $93,000,000 Treatment: $58,000,000	10.9 million gallons of liquid	$5/gal	$9/gal	Heavy rainfall increased volume of liquid requiring treatment. The construction of a special holding pond was required, increasing “before treatment” capital costs. Before treatment costs were $14,800,000; after treatment costs were $18,900,000.

Table 8. Remediation Case Studies: Summary of Cost Data (continued)

Site Name, State (Technology)	Technology Cost ($)*	Quantity of Media Treated	Quantity of Contaminant Removed	Calculated Unit Cost for Treatment**	Key Factors Potentially Affecting Technology Costs***
Rose Disposal Pit, MA	Total: NA Treatment: NA	51,000 tons of soil	NA	NA	Operating in the winter caused weather-related difficulties, resulting in suspension of the operation until spring.
Rose Township Dump, MI	Total: $12,000,000 Treatment: NA	34,000 tons of soil and debris	NA	$350/ton	An estimated 600 tons of incinerator ash required reincineration because it did not meet criteria for on-site disposal.
Sikes Disposal Pits, TX	Total: $115,000,000 (total includes $11,000,000 in miscellaneous O&M costs) Treatment: $81,000,000	496,000 tons of soil and debris	$160/ton	$230/ton	Completed 18 months ahead of schedule because the contractor supplied a larger incinerator. Before treatment costs were $20,000,000; after treatment costs were $3,000,000.
Times Beach, MO	Total: $110,000,000 Treatment: Confidential	265,000 tons of soil and debris	Confidential	$800/ton	An estimated 1,900 tons of incinerator ash required reincineration because it did not meet criteria for backfilling.
Vertac Chemical Corporation, AR	Total: $31,700,000 Treatment: NA	9,804 tons waste and soil	NA	$3,200/ton	The mixed solid and liquid waste stream had a variable Btu content, creating difficulties in maintaining optimal temperature in the kiln. Because of low pH of waste stream issues related to worker health and safety arose. Residual ash was disposed of in a facility permitted under RCRA Subtitle C, thereby increasing disposal costs.
Debris and Surface Cleaning Technologies, and Other Miscellaneous Technologies					
Alabama Army Ammunition Plant, AL (Transportable Hot-Gas Decontamination)	C: $689,500 O: $3,337	Not provided	Not provided	Not calculated	Cost for full-scale application at other sites will vary based on labor costs, equipment transportation costs, and selected operating conditions

Table 8. Remediation Case Studies: Summary of Cost Data (continued)

Site Name, State (Technology)	Technology Cost ($)*	Quantity of Media Treated	Quantity of Contaminant Removed	Calculated Unit Cost for Treatment**	Key Factors Potentially Affecting Technology Costs***
Chicago Pile 5 (CP-5) Research Reactor, Argonne National Laboratory, IL (Centrifugal Shot Blast)	Total: $23,000	800 ft^2	Not provided	Not calculated	The centrifugal shot blast has a lower incremental operating cost than mechanical scabbing resulting in savings for areas greater than 1,900 ft^2
Chicago Pile 5 (CP-5) Research Reactor, Argonne National Laboratory, IL (Rotary Peening with Captive Shot)	Total: $4,500	425 ft^2	Not provided	Not calculated	Cost for this technology was lower than mechanical scabbing; no temporary structure needed to contain airborne contaminants
Chicago Pile 5 (CP-5) Research Reactor, Argonne National Laboratory, IL (Roto Peen Scaler with VAC-PAC^R System)	Total: $6,500	650 ft^2	Not provided	Not calculated	Cost for this technology was lower than mechanical scabbing; no temporary structure needed to contain airborne contaminants
Envirocare of Utah, UT (Polyethylene Macroencapsulation)	Not provided	Not provided	Not provided	Total: $90-100/$ft^3$ O: $800/55-gal drum (average)	Costs for full-scale application depends on ability to use virgin or recycled polymer; affects the melt index needed to provide adequate flow characteristics
Lawrence Livermore National Laboratory (LLNL) Site 300 - Pit 6 Landfill OU, CA (Cap)	Construction: $1,500,000	2.4 acres	Not applicable	Not applicable	Substituting geosynthetic materials for natural materials in portions of the cap saved over $500,000

Technology Cost*
C = Capital costs
O = Operation and maintenance (O&M) costs

Calculated Cost for Treatment**
Calculated based on sum of capital and O&M costs, divided by quantity treated or removed. Calculated costs shown as "Not Calculated" if an estimate of costs or quantity treated or removed was not available. Unit costs calculated based on both quantity of media treated and quantity of contaminant removed, as appropriate.

******* For full-scale remediation projects, this identifies factors affecting actual technology costs. For demonstration-scale projects, this identifies generic factors which would affect costs for a future application using this technology.

EX SITU SOIL TREATMENT TECHNOLOGIES
(BIOREMEDIATION, SOLVENT EXTRACTION, THERMAL DESORPTION)

ABSTRACTS

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BIOREMEDIATION ABSTRACTS

Land Treatment at the Bonneville Power Administration
Ross Complex, Operable Unit A, Wood Pole Storage Area
Vancouver, Washington

<table>
<tr><td>Site Name:
Bonneville Power Administration
Ross Complex, Operable Unit A,
Wood Pole Storage Area</td><td rowspan="2">Contaminants:
High molecular weight polycyclic aromatic hydrocarbons (HPAHs) and pentachlorophenol (PCP)
- HPAHs in soils during RI at levels up to 150 mg/kg (1,500 mg/kg in hot spots)
- PCP in soils during RI at levels up to 62 mg/kg (5,00 mg/kg in hot spots)</td><td>Period of Operation:
November 1994 - January 1996</td></tr>
<tr><td>Location:
Vancouver, Washington</td><td>Cleanup Type:
Full-scale
(EPRI also used this application for research)</td></tr>
<tr><td>Vendor:
Information not provided</td><td rowspan="2">Technology:
Land Treatment
- Four treatment beds (housed in a temporary tent); soil pretreated using a 0.25-inch vibrating screen
- Total of four treatment series - each series involved the four treatment beds used concurrently to test different combinations of enhancements (UV oxidation, peroxide addition, and ethanol addition) and bioremediation (nutrient addition)
- Mixing rate - weekly during treatment series 1; beds changed once every 84 days
- Residence time - average of 84 days
- Depths of lifts - 6 to 12 inches</td><td>Cleanup Authority:
CERCLA
- ROD signed: May 6, 1993</td></tr>
<tr><td>PRP Representative:
Tony Morrell
BPA Ross Complex
5411 Northeast Highway 99
Vancouver, WA 98663
(360) 418-2884

EPRI Representative:
Dr. Benjamin J. Mason
ETHURA
Electric Power Research Institute
9671 Monument Drive
Grants Pass, OR 97526-8782
(541) 471-1869</td><td>EPA Remedial Project Manager:
Nancy Harney
U.S. EPA Region 10
1200 6th Avenue
Seattle, WA 98101
(206) 553-6635</td></tr>
<tr><td>Waste Source: Drips and spills from wood preserving operations</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Soil - 2,300 cubic yards</td></tr>
<tr><td>Purpose/Significance of Application: Combination of bioremediation and enhancements used to land treat contaminated soil</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
- The ROD specified primary target goals of 1 mg/kg for HPAH and 8 mg/kg for PCP.
- Because of concern about the ability to achieve the primary goal, the ROD included three alternatives (tiers) of cleanup goals. Tier 1: Enhanced land treatment - 1 mg/kg for HPAH; 8 mg/kg for PCP; Tier 2: Enhanced land treatment with installation of gravel cap on soil and institutional controls - 23 mg/kg for HPAH; 126 mg/kg for PCP; and Tier 3: Enhanced land treatment, with installation of multilayered cap on soil and institutional controls, greater than 23 mg/kg HPAH, greater than 126 mg/kg PCP.</td></tr>
</table>

Land Treatment at the Bonneville Power Administration Ross Complex, Operable Unit A, Wood Pole Storage Area Vancouver, Washington (continued)

Results:
- HPAH and PCP levels in soil were reduced by approximately 80 percent after treatment, and all soils met Tier 2 levels, at a minimum.
- Concentrations for the four treatment series ranged from 6.76 to 21.83 mg/kg for HPAHs and from 6.8 to 20.7 mg/kg for PCP.
- EPRI concluded that land treatment could not meet Tier 1 cleanup goals for all soil at the site.

Cost:
- Actual total cost of the project through November 1995 - $1,082,859 ($532,859 paid by BPA and $550,000 paid by EPRI). Includes costs for excavation, capital equipment, and operation and maintenance (O&M). Does not include cost for a gravel cap that was not completed until January 1996.
- The total cost of $1,082,859 corresponds to a unit cost of $470 per yd^3 for 2,300 yd^3 of soil treated.

Description:
The Bonneville Power Administration (BPA) owns and operates a power distribution center in Vancouver, Washington, known as the Ross Complex. The site, an active facility that BPA has operated since 1939 to distribute hydroelectric power throughout the Pacific Northwest, also has been used for research and testing, maintenance construction operations, and storage and handling of hazardous and nonhazardous waste. Operable Unit A (OU A) at the Ross complex consists of 21 contaminated areas, including the Wood Pole Storage Area. The Wood Pole Storage Area had been used to dry transmission line poles treated off site with pentachlorophenol (PCP) and creosote. The treated poles were transported to the site and placed on cross poles to dry. Contamination occurred when chemicals dripped from the poles onto the ground. A remedial investigation (RI) identified HPAHs (the sum of eight carcinogenic polycyclic aromatic hydrocarbons found in creosote) and PCP as the contaminants of concern. Under a ROD signed May 6, 1993, land treatment was selected as the remedy for the Wood Pole Storage Area. EPRI agreed to split the cost of the remediation in exchange for use of the project as a research tool to evaluate the rates of degradation under various bioremediation enhancement techniques.

The land treatment system consisted of a temporary treatment tent that housed four treatment beds. Contaminated soil first was passed through a 0.25-inch vibrating screen and then was placed in a treatment bed. Four treatment beds were used to concurrently test different bioremediation enhancement techniques including UV oxidation, peroxide addition, and ethanol addition, well as biodegradation (nutrient addition). Several combinations (configurations) of enhancements and biodegradation with nutrient addition were tested with the four test beds operated concurrently over a total of four different treatment series. All soils met Tier 2 levels; however, EPRI concluded that land treatment could not meet Tier 1 cleanup goals for all soil at the site. For this application, the performance of bioremediation with nutrient addition was found to be comparable to land treatment enhanced with hydrogen peroxide, ethanol, or UV light or with combinations of these enhancements. EPRI identified factors that could improve performance of UV-enhanced bioremediation for future applications, including: (1) using a higher-intensity UV light, (2) mixing soil more frequently, and (3) increasing the dissolution of contaminants to increase exposure to the UV rays. Initially, the nutrient solution was based on Alaska fish meal. However, test results showed that the microorganisms consumed the fish meal but did not degrade the contaminants of concern. A change was made to a new nutrient solution based of Miracle Gro™, a fertilizer containing nitrogen. EPRI noted that results improved when a relatively large volume of nutrient solution was maintained in the soils and that the treatment efficiency was relatively consistent throughout the year, independent of ambient temperature and precipitation.

Land Treatment of the UST Soil Piles at Fort Greely, Alaska

<table>
<tr><td>Site Name:
UST Soil Piles</td><td rowspan="2">Contaminants:
Semivolatile and volatile nonhalogenated hydrocarbons - gasoline, diesel fuel, and BTEX components. Maximum contaminant concentrations of 3,000 mg/kg gasoline range organics, 1,200 mg/kg diesel range organics, and 20.2 mg/kg BTEX.</td><td>Period of Operation:
Status: Complete
Report covers: 9/94 through 8/97</td></tr>
<tr><td>Location:
Fort Greely, Alaska</td><td>Cleanup Type:
Remedial Action</td></tr>
<tr><td>Vendor:
John Terwilliger
Nugget Construction, Inc.
8726 Corbin Drive
Anchorage, AK 99507
(907) 344-8365</td><td rowspan="2">Technology:
Land Treatment
- Stockpiled soil was washed and screened into stockpiles by particle size.
- The small diameter soil was placed into windrows and tilled during summer months.</td><td>Cleanup Authority:
Remedial Action under Alaska Department of Environmental Conservation UST Regulations</td></tr>
<tr><td>USACE Contact:
Bernard T. Gagnon
USACE - Alaska District
P.O. Box 898
Anchorage, AK 99506-0898
(907) 753-5718</td><td>Regulatory Point of Contact:
Rielle Markey
Alaska Department of Environmental Conservation
University Avenue
Fairbanks, AK 99709
(907) 451-2117</td></tr>
<tr><td>Waste Source:
Leaks from USTs and/or overfilling of USTs or ASTs</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Soil
- 11,939 yd^3 screened and washed
- 9,800 yd^3 land treated</td></tr>
<tr><td>Purpose/Significance of Application:
Application of land treatment to treat gasoline and diesel contaminated soil ex situ</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
- The goal of this remedial objective was to meet the ADEC Level A standards for UST-contaminated soils (as cited at 18 AAC 78.315) so that the soil could be used as final cover material for Landfill 7. The Level A standards are: DRO - 100 mg/kg, GRO - 50 mg/kg, benzene - 0.1 mg/kg, total BTEX - 10 mg/kg, and RRO - 2,000 mg/kg.</td></tr>
</table>

Land Treatment of the UST Soil Piles at Fort Greely, Alaska (continued)

Results:

- The concentrations of hydrocarbons in the contaminated UST soil stockpiles was reduced to below the ADEC Level A standards in two summers (with the exception of two samples that still contained DRO above the cleanup standard). The soil was used in the capping of the landfill.
- The average concentrations of contaminants indicate that the mass of DRO in the contaminated soil was reduced from 4,641 kg to 719 kg (approximately 85 percent), and the mass of GRO in the contaminated soil was reduced from 175 kg to nondetectable levels (approximately 100 percent) during the land treatment.
- Initial estimates, based on oxygen uptake measurements taken during a treatabililty study, showed that the remediation of the soil would take approximately 60 days of summer temperatures. The actual remediation took more than twice that long (July 1995 through July 1997).

Cost:

- The total cost of this remedial action was $696,171, consisting of $405,883 Phase I, soil screening and washing (including site preparation and mobilization) and $290,288 for Phase II, land treatment of soil.
- A total of 11,939 yd^3 of gasoline- and diesel-contaminated soil were processed in Phase I and 9,800 yd^3 (approximately 82 percent of the total volume) were treated in Phase II. The unit cost breakdown is: $34/$yd^3$ for Phase I, $29.62/$yd^3$ for Phase II, and $58.29/$yd^3$ for the total treatment.

Description:

The UST soil stockpiles are located at the 1970s landfill or "Landfill 7," located in the southeast sector of the U.S. Army Ft. Greely military facility. Ft. Greely is located approximately five miles south of Delta Junction, Alaska. The contaminated soil stockpiles were generated from the excavation of contaminated soil during a facility upgrade and site restoration activities at the Black Rapids Ski Area during the Summers of 1992 and 1993 and from the excavation of contaminated areas near buildings 602 and 606 at Ft. Greely in August 1991.

In the Fall of 1994 and Summer of 1995, Phase I of the remedial action was conducted, involving the screening and washing of the contaminated soil stockpiles and the completion of a biotreatability study on samples of the contaminated soil. The biotreatability study determined that the contaminated soil could be effectively treated via land treatment. In the Summer of 1995, the contaminated soil stockpiles were separated into windrows, to which nutrients and water were added. The windrows were tilled on a regular schedule during the summers of 1995 and 1996. Samples of the contaminated soil were collected at the end of each summer. In June 1997, closure samples were collected, which showed that the levels of contaminants in the soil had been reduced to below ADEC Level A cleanup standards in all but two of the samples. The soil was then used in the capping of Landfill 7.

Ex Situ Bioremediation at Novartis Site, Cambridge, Ontario

Site Name: Novartis	**Contaminants:** Semivolatiles - halogenated - organic pesticides/herbicides, including Metolachlor, 2,4-D, Dinoseb, Atrizine - Metolachlor - initial concentrations as high as 170 mg/kg	**Period of Operation:** 3/96 - 9/97
Location: Cambridge, Ontario, Canada		**Cleanup Type:** Demonstration
Vendor: David Raymond, Project Manager Grace Bioremediation Technologies 3465 Semenyk Court Mississauga, Ontario Canada (905) 273-5374	**Technology:** Ex situ bioremediation of soils using the DARAMEND process - main treatment area, high Metolachlor test cell and static control cell - alternated aerobic and anaerobic conditions (10 cycles)	**Cleanup Authority:** Information not provided
Additional Contacts: Information not provided		**Regulatory Point of Contact:** Information not provided
Waste Source: Contamination resulting from formulating and warehousing pesticides and herbicides	**Type/Quantity of Media Treated:** Soil - 200 tons. Excavated from the site and stockpiled for treatment.	
Purpose/Significance of Application: Demonstrate the performance of the DARAMEND process for treating Metolachlor-contaminated soils		
Regulatory Requirements/Cleanup Goals: Information on specific cleanup objectives was not included in this report. Performance and results are described in terms of reductions in concentrations of contaminants.		
Results: - Concentrations of Metolachlor in the main treatment cell were reduced from initial levels ranging from 48 to 84 mg/kg to below a detection level of 1.0 mg/kg. Concentrations in the high Metolachlor (HM) test cell were reduced from initial concentrations of 170 mg/kg to 38 mg/kg. - Within the HM test cell, only the top 30 cm of a 60 cm deep cell were tilled during the demonstration. According to the vendor, effective treatment may not have occurred throughout the cell. A sample of the top 30 cm only of the HM test cell showed Metolachlor concentrations of 11.8 mg/kg.		
Cost: - No costs were reported for the demonstration. - The vendor used data from the demonstration to estimate that the cost for treating the estimated 600 tons of contaminated soil that remained at the Novartis site would be $111,600 or $186/ton (in Canadian dollars).		

Ex Situ Bioremediation at Novartis Site, Cambridge, Ontario (continued)

Description:
The Novartis site (formerly Ciba-Geigy), located in Cambridge, Ontario, has been used for the formulation and warehousing of agricultural chemicals since 1972. The site was contaminated with organochlorine pesticides and herbicides, with Metolachlor being the primary contaminant at the site. In 1996, Grace Bioremediation Technologies (Grace) conducted a pilot-scale demonstration of an ex situ bioremediation technology as part of a grant to complete the development of the DARAMEND bioremediation process. The grant was funded by the Ontario Ministry of Environment and Energy's Environmental Technologies Program, Environment Canada's Development and Demonstration of Site Remediation Technologies Program, and by Grace. The demonstration, conducted from March 1996 to September 1997, involved 200 tons of soil from the Novartis site that had been excavated and stockpiled. The soil was contaminated with Metolachlor, Dinoseb, Atrizine, and 2,4-D.

The ex situ treatment area included three cells - the main treatment cell (180 tons), the high Metolachlor (HM) test cell (10 tons), and a static control cell (10 tons). Soils were placed in the cells which were located within a greenhouse enclosure. The demonstration was designed to cycle between aerobic conditions and anaerobic conditions to promote the degradation of the contaminants. During the demonstration, the soil was subjected to a total of ten cycles. DARAMEND amendments and inorganic amendments (for example multivalent metal) were added to the soil. The soil was covered with a tarp during the anaerobic cycle and was tilled during the aerobic cycle. Data from the treated soil in the main treatment cell showed that concentrations of contaminants were reduced to below detection levels. Metolachlor was reduced from initial concentrations ranging from 48 to 84 mg/kg to below the detection limit of 1.0 mg/kg. Levels of Metolachlor within the HM cell were reduced from 170 mg/kg to 38 mg/kg. However, according to Grace, only the top 30 cm of the 60 cm deep cell were tilled during the demonstration such that the treatment was not effective throughout the entire cell. Data from the top 30 cm only of the HM cell showed that Metolachlor levels had been reduced to 11.8 mg/kg.

The projected cost to treat the remaining 600 tons of soil at the Novartis site using this technology was $111,600 or $186/ton in Canadian dollars. Grace noted that because these costs were based on the demonstration, which included extensive process monitoring and waste analysis costs, the projected cost for a full-scale application would be significantly less.

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SOLVENT EXTRACTION ABSTRACTS

Solvent Extraction at the Sparrevohn Long Range Radar Station, Alaska

Site Name:
Sparrevohn Long Range Radar Station

Location:
Alaska

Contaminants:
Semivolatile (halogenated) - PCBs. PCB concentrations in untreated soil analyzed during the treatability study ranged from 13 to 346 mg/kg, with an average concentration of 80 mg/kg.

Period of Operation:
Status: Complete
Report covers: 6/96 through 8/96

Cleanup Type:
Indefinite Delivery Type Remedial Action

Vendor:
Prime Contractor:
Linder Construction
8220 Petersburg Street
Anchorage, AK 99507
(907) 349-6222

Treatment Vendor:
Terra Kleen Response Group
Lanny D. Weimer
3630 Cornus Lane
Ellicott City, MD 21042
(410) 750-0626

Technology:
Solvent extraction
- Stockpiled soil was treated in 85 yd^3 batches using solvent extraction in specially-constructed lined treatment cells.
- The system was operated in a fill-and-drain mode, with 1 day/treatment cycle and 8 treatment cycles/batch.
- The solvent was reclaimed on site through a molecular sieve, and burned on site after the treatment was completed.
- Solvent extraction was chosen over thermal desorption and soil washing on the basis of cost-effectiveness and the relative logistics of mobilizing treatment equipment to the isolated site.

Cleanup Authority:
Air Force Installation Restoration Program. The cleanup was negotiated by the Alaska Department of Environmental Conservation (ADEC) and target levels were agreed upon mutually by the Air Force and ADEC.

Additional Contacts:
Bernard T. Gagnon
U.S. Army Corps of Engineers, Alaska District
P.O. Box 898
Anchorage, AK 99506-0898
(907) 753-5718

Air Force Project Manager:
Patricia Striebich
611th CES/CEVR
Elmendorf Air Force Base, AK 99506
(907) 552-4506

State Point of Contact:
Ray Burger
State of Alaska Department of Environmental Conservation
Contaminated Sites Remediation Program
555 Cordova Street
Anchorage, AK 99501
(907) 563-6529

Waste Source:
Transformer storage, transformer maintenance, and drum storage

Type/Quantity of Media Treated:
Soil
- 288 yd^3
- Gravel with fines and likely little or no clay
- Moisture content 9%

Purpose/Significance of Application:
Application of an innovative technology to treat PCB-contaminated soil at a remote site in Alaska.

Solvent Extraction at the Sparrevohn Long Range Radar Station, Alaska (continued)

Regulatory Requirements/Cleanup Goals:
- A target cleanup level of 15 mg/kg for PCBs in soil was established for this application.
- The contractor was required to perform sampling of the soil at the surface and the bottom of each treatment cell.
- Concentrations of PCBs in the reclaimed solvent were required to be less than 2 mg/L before the solvent could be burned on site.

Results:
- Average concentrations of PCBs were reduced from 80 mg/kg in the untreated soil to 3.27 mg/kg after treatment.
- Concentrations of PCBs measured in samples from the tops and bottoms of each of the five batches of treated soil were reduced to below the 15 mg/kg target cleanup level.
- The concentrations of PCBs in treated soil varied among the batches by one order of magnitude. This variation was attributed to the variations in the concentrations of PCBs in the untreated soil.
- PCBs were not detected at concentrations above detection limits (0.1 mg/L) in the reclaimed solvent.
- Based on a mass balance, approximately 33.8 pounds of PCBs were transferred from the 441,000 kg of contaminated soil to 4,772 pounds of molecular sieve (used to reclaim the solvent), resulting in a contaminated material mass reduction of almost 100 to 1.

Cost:
- The total cost of this application was $828,179, including $602,530 for mobilization and demobilization, and $225,649 for the solvent extraction. This was less than one-half of the estimated cost of $1,908,545 to transfer all of the contaminated soil to the Defense Reutilization Marketing Office.
- The cost for solvent extraction corresponds to a unit cost of $780 per cubic yard of soil treated.
- Because of its remote location, the site was only accessible by air. Therefore, transportation costs for both mobilization and demobilization were a major factor in the overall cost of the project.

Description:
The Sparrevohn LRRS was constructed in 1952, and is one of ten Aircraft Control and Warning sites constructed as part of the air defense system in Alaska. The site is located approximately 200 miles west of Anchorage and is accessible only by air. It is currently operated by the Air Force as a Minimally Attended Radar facility and consists of a lower camp (elevation 1,700 feet) that includes support facilities and an upper camp (elevation 3,300 feet that houses radar equipment.

In 1986, PCB contamination was delineated at the site. In 1989, approximately 450 tons of PCB-contaminated soil from the lower camp were excavated and transported off site for disposal, and approximately 600 tons of PCB-contaminated soil from the upper camp were transported to the lower camp and stockpiled.

A treatability study was conducted on the stockpiled soil in 1995, and as a result of the study, the stockpiled soil was treated in batches using solvent extraction between June and August of 1996. Closure and site restoration activities at the site were completed in September 1996.

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THERMAL DESORPTION ABSTRACTS

Vacuum-Enhanced, Low Temperature Thermal Desorption at the FCX Washington Superfund Site
Washington, North Carolina

<table>
<tr><td>Site Name:
FCX Washington Superfund Site</td><td rowspan="2">Contaminants:
Pesticides
- Aldrin, chlordane, DDT, DDE, DDD, dieldrin, heptachlor, heptachlor epoxide, methoxychlor, benzene hexachlorides</td><td>Period of Operation:
March 1995 - March 1996</td></tr>
<tr><td>Location:
Washington, North Carolina</td><td>Cleanup Type:
Full-scale</td></tr>
<tr><td>Vendor:
Nanette Orr
McLaren/Hart Environmental Engineering Corporation
Great Woods Park
800 South Main Street
Mansfield, MA 02048
(508) 261-1515</td><td rowspan="2">Technology:
Thermal Desorption
- IRHV-200 vacuum-enhanced low temperature thermal desportion system
- Four treatment chambers each equipped with 8 infrared heaters. At 1100°F, each heater produced 137,000 BTU/hr
- Liquid seal vacuum pump used to create vacuum of 50 mmHg
- High flow recirculation blower (6,000 acfm)
- Air draw off recirculation stream (300 acfm) directed to air emissions control
- Dry particulate filters, condensors, and carbon adsorption units
- Residence time - 4 hr (batch process)
- Soil temperatire - 350°F for a minimum of 5 minutes</td><td>Cleanup Authority:
CERCLA Removal
- Action memorandum date: 9/29/88</td></tr>
<tr><td>State Contact:
Randy McElveen
North Carolina DEHNR
P.O. Box 27687
Raleigh, NC 27611
(919) 733-2801</td><td>On-Scene Coordinator (OSC):
Paul Peronard
EPA Region 4
345 Cortland Street, N.E.
Atlanta, GA 30365
(404) 562-8767</td></tr>
<tr><td>Waste Source: Buried waste pesticides</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Soil - 13,591 cubic yards</td></tr>
<tr><td>Purpose/Significance of Application: Vacuum-enhanced low-temperature thermal desorption used to treat pesticide-contaminated soil</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
- Total pesticides - 1.0 mg/kg
- For the demonstration, air emissions were to meet the EPA Region 4 Air Compliance Section standards for vented air emissions; no air emission standards were set for the full-scale operation.</td></tr>
<tr><td colspan="3">Results:
- Treated soil met the cleanup goal of 1 mg/kg total pesticides.
- A one-time stack air monitoring test was performed during the demonstration; all standards were met.</td></tr>
</table>

Vacuum-Enhanced, Low Temperature Thermal Desorption at the FCX Washington Superfund Site Washington, North Carolina (continued)

Cost:
- Total cost of $1,844,600 including $1,696,800 in costs directly associated with treatment.
- Based on 13,591 cubic yards of soil treated, the unit cost was $125 per cubic yard.

Description:
From 1945 to 1982, the Farmers Cooperative Exchange (FCX) operated a pesticide blending facility and warehouse where it packaged pesticides. The pesticides most frequently handled at the site were chlorinated organic pesticides including chlordane, methoxychlor, dichloro-diphenyl-trichloroethane (DDT), and 1,1-dichloro-2,2-bis(4-chlorophenyl) ethene (DDE). Various other chlorinated and nonchlorinated organic chemicals were used in mixing and blending of pesticides. Outdated or out-of-specification materials were buried in trenches on the FCX property. In 1985, the company filed for bankruptcy, and the building and warehouses were cleaned out. In 1986, the Fred Webb Grain Company (FWGC) purchased approximately 15 acres of the FCX property to be used to store grain under the federal government grain subsidy program. Subsequent investigations of the site performed by EPA and the state indicated that the site was contaminated with pesticides. The site was listed on the NPL in March 1989. The removal site investigation, performed in 1992, identified pesticide contamination in trenches at the site. Approximately 14,700 cubic yards of contaminated soil (total chlorinated pesticides above 1 ppm) were excavated and stock piled for on-site incineration. As a result of objections by the city to on-site incineration and in response to state issues regarding off-site disposal, EPA identified on-site thermal desorption as the remedy for the excavated contaminated soil at FCX.

Vacuum-enhanced, low temperature thermal desorption (LTTD) was used to treat the contaminated soil at the FCX site. The system operated under a vacuum of about 50 mm Hg and used an infrared heat source to desorb contaminants from the soil. By operating under a vacuum, the temperature required to desorb contaminants from the soil and the amount of oxygen present in the treatment chamber are lower than if the unit were operated under atmospheric conditions, helping to reduce the potential for formation of dioxins and furans. The model IRHV-200 mobile LTTD system used at the site included a treatment chamber, and emission control equipment including a dry particulate filter, condenser, and carbon adsorption unit. McLaren/Hart conducted two site demonstrations before full-scale operations began. The initial demonstration, conducted with a batch of clean soil, failed to heat the soil throughout. Several modification were made to the full-scale system to improve heat transfer. Samples of treated soil were collected for each 500-ton lot of soil (total of three lots). The results of the full-scale operation showed that the LTTD met the cleanup goal of 1 mg/kg total pesticides in each of the three lots. Data also showed that concentrations of dioxins and furans in the treated soil were less than in the untreated soil. McLaren/Hart used the results of the FCX application to identify a number of modifications and improvements to the LTTD system to further improve heat transfer rates and to decrease the overall length of the treatment cycles for other applications. A detailed summary of these improvements is included in the report.

Thermal Desorption at the Solvent Refined Coal Pilot Plant, Ft. Lewis, Washington

Site Name:
Solvent Refined Coal Pilot Plant (SRCPP)

Location:
Ft. Lewis, Washington

Contaminants:
Semivolatile (nonhalogenated) - polycyclic aromatic hydrocarbons (PAHs). PAHs were detected throughout the SRCPP, with individual PAH concentrations as high as 410 mg/kg, and typically not exceeding 2 mg/kg.

Period of Operation:
Status: Complete
Report covers: August through December 1996

Cleanup Type:
Remedial Action
ROD Date: October 15, 1993

Vendor:
Melody Allen
Dames & Moore, Inc.
2025 First Avenue, Suite 500
Seattle, Washington 98121
(206)728-0744

Technology:
Thermal Desorption
- Soil was pre-screened using a1 ½ -inch bar screen.
- Pre-screened soil was fed to the direct-fired, rotary kiln-type thermal desorption unit.
- Soil was treated at nominally 700-750°F with a throughput of 50-150 tons per hour.
- Off-gas was treated with a baghouse and recycled to the desorber or thermally oxidized and discharged to the atmosphere.

Cleanup Authority:
Conducted under a federal facilities agreement among the EPA, the U.S. Army, Ft. Lewis, and the State of Washington Department of Ecology

USACE Contact:
Bill Goss
U.S. Army Corps of Engineers - Seattle District
CENWS-PM-HW
P.O. Box 3755
Seattle, Washington 98124-2255
(206) 764-3267

EPA Point of Contact:
Bob Kievit
Remedial Project Manager
U.S. EPA, Region 10
Washington Operations Office
300 Desmend Street, Suite 102
Lacey, Washington 98503
Telephone: (360) 753-9014

Waste Source:
Leaks and spills

Purpose/Significance of Application:
Thermal desorption of a relatively-large amount of soil contaminated with PAHs.

Type/Quantity of Media Treated:
Soil
- 104,336 tons of soil were treated during this application, including 2,200 tons during the field demonstration.
- Soil was classified as various sand and gravel.
- Moisture content was 4%.

Regulatory Requirements/Cleanup Goals:
- Cleanup levels for this application were 1 mg/kg for the sum of the concentrations for seven carcinogenic PAHs (based on the Record of Decision) and 200 mg/kg for both diesel range and oil range fuel hydrocarbons (based on the Ft. Lewis base management).
- The PAH cleanup level was derived from Washington State Model Toxics Control Act Method B cleanup levels for ingestion of soil containing carcinogenic PAHs.
- Air emission limits for this application were established by the Puget Sound Air Pollution Control Agency as performance standards limiting the acceptable physical operating parameters for the baghouse and thermal oxidizer.

Thermal Desorption at the Solvent Refined Coal Pilot Plant, Ft. Lewis, Washington (continued)

Results:

- The LTTD system used at the SRCPP achieved soil cleanup levels and air emission standards during the treatment of the contaminated soil at a desorber temperature generally between 700 and 750°F.
- During the field demonstration test, the system treated soil contaminated with total carcinogenic PAHs at levels ranging from 0.6 mg/kg to 4.2 mg/kg to less than the 1.0 mg/kg cleanup level established for this application.
- During full operation of the LTTD system, samples of treated soil had concentrations of total carcinogenic PAHs ranging from below detection limit to 0.44 mg/kg.

Cost:

- The total cost for this application was approximately $7,100,000. The unit cost for thermal desorption treatment of contaminated soil was approximately $34 per ton treated, and for the entire RA was approximately $68 per ton treated.
- The original bid for this application was approximately $3,500,000. There were 23 modifications to the bid, resulting in a final cost that was approximately twice the original. Modifications included such items as an increase in the quantity of soil requiring treatment and additional site work.

Description:

The SRCPP occupies approximately 25 acres between Sequalitchew Lake and Hammer Marsh on North Ft. Lewis, approximately 12 miles south of the city of Tacoma, Washington. It was operated from 1974 to 1981 as a production and research facility that worked to develop a solvent extraction process to derive petroleum hydrocarbon products from coal via operations such as heat extraction and thermal cracking. Soil at the SRCPP was contaminated by leaks and spills of process materials that occurred during operations at the plant.

On the basis of the remedial investigation and pre-remediation surface soil chemistry survey, 17 areas were identified for excavation of contaminated soil. The thermal desorption system used to treat the soil consisted of a rotary thermal desorber with a baghouse and a thermal oxidizer for off-gas treatment.

Approximately 104,000 tons of contaminated soil were treated during a field demonstration test and full-scale operation of the system. Samples of treated soil had total concentrations of carcinogenic PAHs ranging from below detection limits to 0.44 mg/kg.

Thermal Desorption at Naval Air Station Cecil Field, Site 17, OU 2
Jacksonville, Florida

<table>
<tr><td>Site Name:
Naval Air Station Cecil Field, Site 17, OU 2</td><td rowspan="2">Contaminants:
Petroleum products and chlorinated solvents
- BTEX
- 1,2-dichlorobenzene as high as 18 mg/kg
- Napthalene as high as 19 mg/kg
- 2-methylnapthalene as high as 47 mg/kg</td><td>Period of Operation:
June 19 to September 25, 1995</td></tr>
<tr><td>Location:
Jacksonville, Florida</td><td>Cleanup Type:
Full-scale</td></tr>
<tr><td>Vendor:
Dustcoating, Inc.
Maple Plain, Minnesota</td><td rowspan="2">Technology:
Thermal Desorption:
- Mobile propane-fired Gencor Model 232 rotary drum dryer modified to thermally process contaminated soil
- 60-inch-diameter-by-20-foot-long rotary dryer with burner (direct-fired), a primary collector baghouse, and an afterburner system
- Nominal system throughput - 25-50 tons/hour; actual system throughput - 17 tons/hour.
- Soil temperature - 825 °F
- Average residence time - 3.5 minutes
- Afterburner temperature - 1,500 °F with a retention time of approximately two seconds</td><td>Cleanup Authority:
CERCLA
- Interim ROD dated September 30, 1994</td></tr>
<tr><td>Navy Point of Contact:
Mark Davidson
Southern Division, Naval Facilities Engineering Command
North Charleston, SC 29419-9010
(843) 820-5526</td><td>EPA Remedial Project Manager:
Debbie Vaughn-Wright
U.S. EPA Region 4
61 Forsyth Street, SW
Atlanta, GA 30303-3104
(404) 562-8539</td></tr>
<tr><td>Waste Source: Disposal of waste fuel and oil</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Soil - 11,768 tons</td></tr>
<tr><td>Purpose/Significance of Application: Mobile thermal desorption unit used to treat soil contaminated with fuel and solvents</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
- Total recoverable petroleum hydrocarbon (TRPH) level of 50 mg/kg provided that total polycyclic aromatic hydrocarbons (PAH) were less than 1 mg/kg and total volatile organic hydrocarbons were less than 50 mg/kg.
- Particulate emissions of 0.04 grains per dry standard cubic foot (gr/dscf)</td></tr>
<tr><td colspan="3">Results:
- 110 of 115 post-treatment samples met the cleanup goal of 50 mg/kg TRPH after one pass.
- For the five post-treatment samples that did not meet the cleanup goal, the five batches of soil (724.5 tons, or approximately 6% of the total) were re-treated. All samples of the re-treated soil met the cleanup goals.</td></tr>
</table>

Thermal Desorption at Naval Air Station Cecil Field, Site 17, OU 2 Jacksonville, Florida (continued)

Cost:
- The total cost for the application was $1,946,122.
- This represents a unit cost of $165 per ton of soil treated for treatment of 11,768 tons of contaminated soil.

Description:
Naval Air Station (NAS) Cecil Field, established in 1941, provides facilities, services, and material support for the operation and maintenance of naval weapons, aircraft, and other units of the operating forces. NAS Cecil Field includes several operable units (OU) and contaminated sites, including Site 17 in OU2. Site 17 reportedly was used for two or three years during the late 1960s and early 1970s for the disposal of waste fuel and oil, possibly including oil contaminated with solvents and paints. Soil at Site 17 was found to be contaminated with petroleum products and chlorinated solvents. In September 1994, EPA signed an interim Record of Decision (ROD) for Site 17 specifying that soil be excavated and treated by thermal desorption.

The thermal desorption unit used at Site 17 was a mobile unit provided by Dustcoating, Inc. of Maple Plain, Minnesota. The unit, a propane-fired Gencor Model 232 rotary drum dryer modified to thermally process contaminated soil, consisted of a 60-inch-diameter-by-20-foot-long rotary dryer with burner (direct-fired), a primary collector baghouse, and an afterburner system. The nominal system throughput for this unit was 25-50 tons/hour; the actual system throughput during this application was 17 tons/hour. The desorber treated contaminated soil at approximately 825°F with an average residence time of 3.5 minutes. An afterburner operated at a temperature of at least 1,500°F with a retention time of approximately two seconds to destroy organic compounds in the off-gas. A total of 115 post-treatment soil samples were collected and analyzed. All but five of these samples met the cleanup goal after the first pass. The five samples were retreated and all met the cleanup goal. According to the EPA RPM, no specific operational problems were identified as causing the failure to meet the cleanup goals on the first pass; however, the contractor suspects that this was caused by elevated levels of moisture in the soil.

Thermal Desorption at the Port Moller Radio Relay Station, Port Moller, Alaska

<table>
<tr><td>Site Name:
Port Moller Radio Relay Station</td><td rowspan="2">Contaminants:
Volatiles (nonhalogenated) - BTEX and Petroleum Hydrocarbons - GRO, DRO, and total recoverable petroleum hydrocarbons (TRPH). Maximum contaminant concentrations were 300,000 mg/kg TRPH and 11,000 mg/kg DRO.</td><td>Period of Operation:
Status: Complete
Report covers: 6/95 through 8/95</td></tr>
<tr><td>Location:
Port Moller, Alaska</td><td>Cleanup Type:
Remedial Action</td></tr>
<tr><td>Vendor:
Frederick Paine, Anderson Excavating and Wrecking Co. 1824 South 20th Street
Omaha, NE 68108
(402)345-8811</td><td rowspan="2">Technology:
Thermal Desorption
- Soil was pre-screened using a two-inch bar screen.
- Pre-screened soil was fed to the on-site, direct-fired thermal desorption unit.
- Soil was treated at nominally 500°F with a throughput of 40-60 tons per hour.
- Off-gas was treated with a baghouse and afterburner.
- Treated soil was used as backfill on site.</td><td>Cleanup Authority:
Managed under the Formerly Used Defense Sites Program and the Installation Restoration Program, with USACE serving as lead agency. USACE solicited review comments, as appropriate, from the U.S. Air Force and ADEC</td></tr>
<tr><td>USACE Contact:
Bernard T. Gagnon
USACE, Alaska District
P.O. Box 898
Anchorage, AK 99506-0898
(907)753-5718</td><td>State Point of Contact:
John Halverson, State of Alaska Department of Environmental Conservation, Contaminated Site Program
555 Cordova Street
Anchorage, AK 99501
(907)563-6529</td></tr>
<tr><td>Waste Source:
Oil spills (contamination was located primarily in an outfall ditch connected to a floor drain inside a building, near USTs and ASTs, and at drum and warehouse areas)</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Soil
- 9,500 yd3 of soil was treated
- Approximately 10% of soil was clayey silt; remainder was sand or sand with gravel
- Moisture content 11%</td></tr>
<tr><td>Purpose/Significance of Application:
Application of thermal desorption to treat sandy soil contaminated with diesel fuel at a remote site in Alaska.</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
- Cleanup goals for this application were based on the results of negotiations with ADEC. They consisted of the following cleanup goals: DRO (200 mg/kg), GRO (200 mg/kg), TRPH (200 mg/kg), BTEX (15 mg/kg).
- An air quality permit issued by the State of Alaska required air emissions to meet the following limits: particulate matter (<0.05 gr/dscf), and carbon monoxide (< 100 ppmv and 2.39 lbs/hr).</td></tr>
</table>

Thermal Desorption at the Port Moller Radio Relay Station, Port Moller, Alaska (continued)

Results:
- The thermal desorption unit at Port Moller achieved the cleanup goals after three months of operation.
- Of the 118 treated soil samples analyzed, 115 (97 percent) achieved the cleanup goals after one pass through the desorption unit. The three samples that did not achieve the cleanup goals after one pass were treated at relatively low soil temperatures (less than 400 ^{o}F). Those soil samples were retreated and subsequently achieved the cleanup goals.
- Air emissions testing was conducted at the site, but no data were available for review. However, analytical data from an application similar to that at Port Moller met the state's requirements for air emissions.

Cost:
- USACE Alaska Division used an innovative approach to procuring a remediation contractor for this application. That approach was based on the use of unit prices established by the government for specific activities associated with the remediation and solicitation of bids as a percentage of the unit prices.
- The actual cost of thermal desorption of contaminated soil at Port Moller was $3,325,000 (for activities directly attributed to treatment), or $350 per yd^3 of soil treated (9,500 yd^3 treated).

Description:
The Port Moller Radio Relay Station (RRS) was constructed in the late 1950s and served as a communication link between Cold Bay and Port Heiden, Alaska. Until 1969, a Defense Early Warning line facility and the White Alice Communication System facility were co-located at the site. From 1969 to 1978, the site functioned as a RRS, and the site was abandoned in 1978. The site consists of the White Alice facility (buildings and antenna) located on a plateau at an elevation of 1,000 feet, and a fuel storage and supply facility located on the shoreline at the foot of the slope leading to the plateau.

In 1994, the USACE demolished the buildings, removed the fuel tanks, constructed a landfill for the disposal of debris, installed monitoring wells, identified areas of soil contamination, and seeded the landfill and other disturbed areas. In addition, a treatability study was conducted on contaminated soil from the site to determine the relative effectiveness of treatment using thermal desorption, soil washing, and bioremediation. Thermal desorption was chosen for the full-scale site remediation based on the results of the treatability study.
The contractor mobilized the remediation equipment to Port Moller in May 1994. Approximately 9,500 yd^3 of contaminated soil were treated using an oil-fired portable thermal desorption unit, which had a rated capacity of 70 tons per hour. The soil was treated in three months of operation and the treated soil was used as backfill to grade the site.

The total cost for treatment of contaminated soil at Port Moller was $3,919,736, which includes $3,325,000 for treatment and almost $600,000 for mobilization and demobilization, due to the remote location of the site.

Thermal Desorption at the Re-Solve, Inc. Superfund Site
North Dartmouth, Massachusetts

<table>
<tr><td>Site Name:
Re-Solve, Inc. Superfund Site</td><td rowspan="2">Contaminants:
PCBs and Volatile Organic Compounds (VOCs)</td><td>Period of Operation:
June 1993 - December 1994</td></tr>
<tr><td>Location:
North Dartmouth, Massachusetts</td><td>Cleanup Type:
Full-scale</td></tr>
<tr><td>Vendor:
Gary Duke
RUST Remedial Services, Inc.
200 Horizon Center Blvd.
Trenton, New Jersey 08691-1904
(609) 588-6373</td><td rowspan="2">Technology:
Thermal Desorption
- X*TRAX™ Model 200 - thermal separation system, gas treatment system, and liquid storage and processing system
- Dryer feed rate - 120 tons/day
- Dryer temperature - 500 to 1100°F
- Treated soil temperature - 700 to 750°F (average 732°F)
- Residence time - 2 hours
- Condensate water generated by the system was treated in the on-site multi-stage treatment system (oxidation; flocculation and sedimentation; filtration; air stripping; liquid-phase carbon adsorption; vapor-phase carbon adsorption)</td><td>Cleanup Authority:
CERCLA
- ROD date: 9/24/87
- ESD date: 6/11/93</td></tr>
<tr><td>State Contact:
Nikki Korkatti
Project Manager
Massachusetts Department of Environmental Protection
Bureau of Waste Site Cleanup
One Winter Street, 5th Floor
Boston, Massachusetts 02108
Telephone: (617) 574-6840</td><td>EPA Remedial Project Manager:
Joseph LeMay
EPA Region 1
John F. Kennedy Federal Building, Room 2203
Boston, Massachusetts 02203
(617) 573-9622</td></tr>
<tr><td>Waste Source: Disposal of waste in lagoons</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Soil - 36,200 cubic yards (44,000 tons)</td></tr>
<tr><td>Purpose/Significance of Application: Thermal desorption of PCB-contaminated soil</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
- The ROD specified a cleanup level of 25 mg/kg for PCBs in soil.
- Process vent emission rate was limited to 0.38 lb/hr of total hydrocarbons (THC).
- Perimeter air monitoring was required for VOCs and dust during excavation; if action levels were exceeded, excavation was to be stopped and control measures implemented.
- Effluent was required to meet daily and monthly limits for VOCs, PCBs, and metals.</td></tr>
<tr><td colspan="3">Results:
- The treated soil met the cleanup goal of 25 mg/kg PCBs, with concentrations ranging from 0.59 mg/kg to 21 mg/kg.
- Greater than 99% of the soil met the cleanup goal after one pass through the treatment system; only 0.5 percent required retreatment.
- The process vent emissions met the air emission standard; THC emissions ranged from 0.002 to 0.296 lb/hr.
- Treated water generally met the effluent standards. For the few exceedances, the vendor determined that the concentrations would not be higher than the concentration used in developing a discharge permit; however, information was not provided on any actions by the state as a result of the exceedances.</td></tr>
</table>

Thermal Desorption at the Re-Solve, Inc. Superfund Site
North Dartmouth, Massachusetts (continued)

Cost:
- Total cost to treat the soil - $6,800,000; corresponding to a unit cost of $155/ton (44,000 tons treated).

Description:
Re-Solve operated a waste chemical reclamation facility in North Dartmouth, Massachusetts from 1956 until 1980. Hazardous materials handled at the site included polychlorinated biphenyls (PCBs), solvents, waste oils, organic liquids and solids, acids, alkalies, and inorganic liquids and solids. On December 23, 1980, the state accepted Re-Solve's offer to surrender its disposal license, on the condition that all hazardous waste be removed from the site. In late 1981, Re-Solve removed drums and other debris, including buildings, from the site; however, contents of four on-site lagoons and a cooling pond and the residue from an oil spreading operation were not removed. The site was placed on the the National Priorities List (NPL) in September 1983. The results of the Remedial Investigation indicated that soil and groundwater at the site were contaminated with PCBs and other compounds. In response to a 1983 ROD, soil contaminated with PCBs was excavated and shipped off-site for disposal. However, the results of additional investigations conducted to evaluate the effectiveness of the remedial action indicated that extensive PCB contamination remained in areas beyond the remediated lagoons, cooling pond, and oil spreading area. A second ROD for the site, signed in September 1987, called for excavation of additional contaminated soil and treatment by thermal desorption and dechlorination (DECHLOR). However, the results of a pilot-scale demonstration of the DECHLOR process indicated that the process would not be cost-effective or economically feasible on a full-scale basis. In June 1993, EPA issued an ESD to remove the DECHLOR process from the full-scale treatment system and specify the treatment of the concentrated oil contaminated with PCBs that was recovered in the X*TRAX™ system at an off-site incinerator permitted under the Toxic Substances Control Act (TSCA).

The X*TRAX™ Model 200 system consisted of three main components - thermal separation system, gas treatment system, and liquid storage and processing system. In the thermal separation system, contaminated solids were fed into a propane-fired rotary dryer, and heated indirectly to volatilize the moisture and organic contaminants; the dryer consisted of a long steel cylinder rotating inside of a furnace. The moisture, contaminants, and a small amount of dust were swept continuously from the dryer to the gas treatment system by a nitrogen carrier gas. The gas treatment system removed moisture and contaminants from the carrier gas and reconditioned the gas before recycling it to the dryer. Materials that accumulated within and later exited the system were considered residues of treatment. All treated soil met the cleanup goal of 25 mg/kg for PCBs. Greater than 99 percent of the soil met the cleanup goal after the first pass, with only 0.5 percent of the soil requiring retreatment.

Thermal Desorption at the Waldick Aerospace Devices Site Wall Township, New Jersey

<table>
<tr><td>Site Name:
Waldick Aerospace Devices Superfund Site</td><td rowspan="2">Contaminants:
- BTEX
- Total petroleum hydrocarbons (PHC)
- Volatile organic compounds (VOC) - toluene, tetrachloroethane, tetrachloroethene
- Metals (cadmium, chromium, nickel, zinc)</td><td>Period of Operation:
June - October 1993</td></tr>
<tr><td>Location:
Wall Township (Monmouth County), New Jersey</td><td>Cleanup Type:
Full-scale cleanup</td></tr>
<tr><td>Vendor:
RUST Remediation Services</td><td rowspan="2">Technology:
Low Temperature Volatilization System (LTVS)
- Primary treatment unit - rotary drum; external Hauck dual propane/fuel oil burner used to force heated air into the primary treatment unit
- Secondary treatment unit - refractory-lined horizontal cylinder with a burner
- Design capacity of 35 tons/hr; actual average system throughput was 20 tons/hr at a soil temperature of 450 to 500°F</td><td>Cleanup Authority:
CERCLA
- Original ROD date: 9/29/87
- Second ROD date: 3/29/91 (replaced in situ air stripping with low temperature thermal desorption followed by stabilization and solidification)</td></tr>
<tr><td>USACE Project Lead:
Ron Ackerman
U.S. Army Corps of Engineers
New Jersey Area Office
1 Main St. (Suite 416)
Eatontown, NJ 07724
(908) 389-3040</td><td>EPA Remedial Project Manager:
Daniel Weissman
U.S. EPA Region 2, EERD
290 Broadway, 19th Floor
New York, NY 10007
(212) 637-4384</td></tr>
<tr><td>Waste Source: Contaminated wastewater discharged directly to the ground; leaking drums of spent machine oil</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Soil - 3,450 yd^3</td></tr>
<tr><td>Purpose/Significance of Application: Thermal desorption of soil contaminated with a wide range of organics</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
- Total VOCs - 1.0 mg/kg; total PHCs - 100 mg/kg; cadmium - 3.0 mg/kg; chromium - 100 mg/kg; nickel - 100 mg/kg; zinc - 350 mg/kg
- Air emissions standards were specified in the NJDEPE air permit for the unit for particulates, sulfur oxides, nitrogen oxides, carbon monoxide, total hydrocarbons, hydrogen chloride, VOCs and metals.</td></tr>
<tr><td colspan="3">Results:
- The soil treated by the thermal desorber met the cleanup goals for total VOCs and total PHCs.
- The results of the July 1993 testing indicated that the emissions failed to meet air permit requirements, and the unit was shut down on August 26, 1993. On September 8, 1993, NJDEPE approved restarting operations after corrective measures had been implemented and the unit was reported to have met the emission standards.
- No results were provided with regard to concentrations of metals; treated soil was disposed offsite in a RCRA Subtitle C hazardous waste landfill.</td></tr>
</table>

Thermal Desorption at the Waldick Aerospace Devices Site Wall Township, New Jersey (continued)

Cost:
- Total cost of $4,995,159 including $3,610,086 for activities related to the remediation of contaminated soil and $1,385,073 for such other activities as demolition of two buildings and off-site disposal of debris, removal of three underground storage tanks and off-site disposal of equipment and debris, and abandonment of 17 wells at the site.
- The cost of $3,610,086 for activities related to the soil remediation includes $2,017,361 for the sum of costs for capital and O&M elements; this corresponds to a unit cost of $585 per yd^3 of soil treated (3,450 yd^3 treated)

Description:
The Waldick Aerospace Devices Superfund Site is a 1.7-acre hazardous waste site located in Wall Township (Monmouth County), New Jersey. The site was used primarily as a manufacturing facility that included degreasing and metal-plating operations. Wastewaters containing heavy metals and solvents were discharged directly to the ground surrounding the main building for a period of at least three years, and spent machine oil leaked onto the ground from perforated drums located near the main building. In 1982, the state ordered Waldick to conduct cleanup activities; however, sampling following these activities indicated that the soil and groundwater at the site were still contaminated with volatile organics and metals. Contaminants included VOCs; benzene, toluene, ethylbenzene, and xylene (BTEX); petroleum hydrocarbons (PHC); other nonhalogenated volatile organic compounds; and metals. While the initial Record of Decision (ROD) for this site specified in situ air stripping for contaminated soil, a second ROD, signed in March 1991, revised the remedy to replace in situ air stripping with low temperature thermal desorption followed by stabilization/solidification. At the Waldick site, contaminated soils were treated on site using low temperature thermal desorption and residuals were sent off-site for stabilization and solidification and disposal at a RCRA-permitted landfill.

A Low Temperature Volatilization System (LTVS) designed by Rust Remedial Services (Rust) was used to treat an estimated 3,450 yd^3 of soil at this site. The unit was trailer-mounted and included feed hoppers/conveyors, a primary treatment unit (rotary drum), a discharge conveyor with pugmill, cyclones, a secondary treatment unit (thermal oxidizer), a quench tower, a baghouse, packed-bed scrubbers with stacks, and a power generator operated with fuel oil. The unit had a design capacity of 35 tons/hr; the actual average system throughput was 20 tons/hr at a soil temperature of 450 to 500°F. The unit operated from June 1993 until the results of stack testing, performed in July 1993, indicated that the emissions failed to meet air permit requirements. The unit was shut down on August 26, 1993. On September 8, 1993, NJDEPE approved restarting operations after corrective measures had been implemented. Operations were restarted at the end of September to treat the remaining soil. The soil treated by the thermal desorber met the cleanup goals for total VOCs and total PHCs.

The costs for excavation of soil and disposal of residuals were relatively high compared with the capital and O&M costs for this application. Approximately $1,000,000 was spent on commercial disposal of treated soil, which may be attributed to the disposal of treated soil as a RCRA hazardous waste. In addition, the RPM indicated that the cost of the project was higher than originally estimated because the total amount of soil treated was greater than had been anticipated.

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IN SITU SOIL TREATMENT TECHNOLOGIES
(SOIL VAPOR EXTRACTION, THERMAL PROCESSES)

ABSTRACTS

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SOIL VAPOR EXTRACTION ABSTRACTS

Soil Vapor Extraction at Camp LeJeune Military Reservation, Site 82, Area A, Onslow County, North Carolina

<table>
<tr><td>Site Name:
Camp LeJeune Military Reservation,
Site 82, Area A</td><td rowspan="2">Contaminants:
Volatile Organic Compounds:
- Trichloroethene (TCE)
- Tetrachloroethene (PCE)
- Benzene</td><td>Period of Operation:
April 7 - December 21, 1995
(March 29 - April 7, 1995 - system startup and optimization performed)</td></tr>
<tr><td>Location:
Onslow County, North Carolina</td><td>Cleanup Type:
Full-scale</td></tr>
<tr><td>Vendor:
Jim Dunn
Project Manager,
MCB Camp LeJeune
OHM Remediation Services, Inc.
5445 Triangle Parkway, Suite 400
Norcross, GA 30092
(770) 734-8072</td><td rowspan="2">Technology:
Soil Vapor Extraction:
- Eight vertical vapor extraction wells and one horizontal air injection well
- 32 soil probe clusters
- Vapor-liquid separator; vapor-phase carbon vessel
- One positive displacement vacuum blower for extraction wells
- Range of total system flow rates - 268 to 499 cfm, with an average of 409 cfm; range of flow rates at the well heads - 22 to 132 cfm.
- Well head vacuums ranged from 3.9 inches to 7.0 inches Hg, with an average of 5.8 inches Hg.</td><td>Cleanup Authority:
CERCLA
- ROD signed: September 24, 1993</td></tr>
<tr><td>Naval Facilities Engineering Command Remedial Project Manager:
Katherine H. Landman
MCB Camp LeJeune
Atlantic Division, Code 1823
LANTDIV
1510 Gilbert Street
Norfolk, VA 23511-2699
(757) 322-4818</td><td>EPA Remedial Project Manager:
Gena Townsend
U.S. EPA Region 4
61 Forsyth Street
Atlanta, GA 30303-3415
Phone: (404) 562-8538</td></tr>
<tr><td>Waste Source: Disposal of waste drums and debris</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Soil - 17,500 cubic yards</td></tr>
<tr><td>Purpose/Significance of Application: SVE application using a combination of vertical extraction and horizontal injection wells</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
- The ROD identified the following cleanup goals for soil: TCE - 32.2 μg/kg, PCE - 10.5 μg/kg, benzene - 5.4 μg/kg.
- No air emission standards were specified for this application, however the State of North Carolina required the facility to provide documentation about potential air emissions for this application and to include carbon treatment for air emissions.</td></tr>
</table>

Soil Vapor Extraction at Camp LeJeune Military Reservation, Site 82, Area A, Onslow County, North Carolina (continued)

Results:
- Results of confirmation soil boring samples showed TCE and benzene at nondetectable levels in all soil boring samples. PCE was reported at levels below the cleanup goal of 10.5 μg/kg in all but one sample.
- According to LANTDIV, EPA approved shutdown of the system because the single exception was slightly above the soil remedial goals and the contaminated groundwater under the area of concern was being addressed by a pump-and-treat system.
- For the discharge stack, concentrations ranged as follows: TCE - ND to 2.2 μg/L; PCE - ND to 147.4 μg/L; benzene - ND to 10.2 μg/L; and ethylbenzene - ND to 7.4 μg/L.

Cost:
- Total cost of $469,949 was expended for remedial activities at Area A including $222,455 for capital costs and $247,485 for operation and maintenance (O&M) costs.
- The total cost of $469,940 corresponds to a unit cost of $27 per cubic yard ($yd^3$) for 17,500 yd^3 of soil treated.

Description:
Camp LeJeune Military Reservation (also known as Marine Corps Base Camp LeJeune), established in 1941, is a 170-square-mile installation near Jacksonville, North Carolina, that provides housing, training, logistical, and administrative support for Fleet Marine Force Units. Site 82 is was used for waste disposal and, in 1994, drums and debris were removed from the site. Area A was a portion of Site 82 at which residual soil and groundwater contamination remained after removal of drums and debris. Soil at Area A was contaminated with volatile organic compounds (VOC), primarily TCE, PCE, and benzene. The ROD specified SVE for remediation of contaminated soil.

The SVE system used at Area A included eight vertical vapor extraction wells (installed to a depth of 15 to 16 feet bgs), one horizontal air injection well (horizontal displacement of 330 feet; total depth of 15 feet bgs), 32 soil probe clusters (for measurement of subsurface vapors; each cluster consisted of one shallow and one deep probe at approximately 6 feet and 12 feet bgs, respectively), a vapor phase separator, a vapor-phase carbon vessel (granular activated carbon), and a vacuum extraction unit (VEU) that included a positive displacement blower that was used to apply vacuum to the extraction wells. The results of confirmation sampling showed that TCE and benzene met the cleanup goals in all soil boring samples. For 23 of 24 soil boring samples, PCE was reported at levels below the cleanup goal of 10.5 μg/kg. For one soil boring sample, PCE was reported at 29 μg/kg compared to the cleanup goal of 10.5 μg/kg. According to LANTDIV, EPA approved shutdown of the system because the single exception was slightly above the soil remedial goals and the contaminated groundwater under the area of concern was being addressed by a pump-and-treat system.

According to the Naval Facilities Engineering Command Remedial Project Manager, the SVE system at Area A was cost-effective. Significant other work was being performed at the site, including the construction and operation of a 500-gallon-per-minute (gpm) pump-and-treat plant to treat groundwater contaminated with VOCs, and helped to keep costs down because overhead and operations costs were shared. In addition, an on-site laboratory was being used for other analytical work on the base, and the shared cost of the use of that facility also helped to keep the cost of the SVE application low.

Soil Vapor Extraction at the Site ST-35, Davis-Monthan AFB, Arizona

<table>
<tr><td>Site Name:
Site ST-35, Davis-Monthan AFB</td><td rowspan="2">Contaminants:
Petroleum Hydrocarbons
- Total petroleum hydrocarbon (TPH) was detected in soil at levels up to 320,000 ppm
- Benzene was detected in soil at levels up to 110 ppm</td><td>Period of Operation:
September 1995 - July 1997</td></tr>
<tr><td>Location:
Arizona</td><td>Cleanup Type:
Full-scale cleanup</td></tr>
<tr><td>Vendor/Consultant:
Montgomery Watson
JMM, Consulting Engineers</td><td rowspan="2">Technology:
Soil Vapor Extraction (SVE)
- Six vapor extraction wells, a blower system, moisture separator, thermal oxidizer, and air treatment system
- Two 460 cubic inch internal combustion engines (ICE) were used to create the vacuum. The extracted vapors were burned as fuel in the ICEs, with supplemental fuel added as contaminant concentrations were reduced.
- System operated at an average flow rate of 123 scfm
- System removed about 1,200 lb/day of contaminant</td><td>Cleanup Authority:
Installation Restoration Program</td></tr>
<tr><td>Additional Contacts:
U.S. Air Force Air Combat Command</td><td>Regulatory Point of Contact:
Information not provided</td></tr>
<tr><td>Waste Source: Fuel Spill</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Soil
- 63,000 cubic yards
- Contamination extended to a depth of about 260 feet (ft) below ground surface (bgs)
- Sandy clay with interbedded gravels and sands in upper 260 ft
- Caliche (cemented silts and clays) layer at about 240 ft bgs impeded vertical migration of contamination</td></tr>
<tr><td>Purpose/Significance of Application: SVE application to remove TPH from soil; extracted vapors used as fuel for ICEs.</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
The objective of the SVE system was to remove contamination in the soil as cost-effectively as possible to prevent contamination of surrounding soil and groundwater.</td></tr>
<tr><td colspan="3">Results:
- Performance results for the system were reported for the first 16 months of operation (through December 1996)
- After 16 months of operations, the system had removed 585,700 pounds (lbs) of total volatile hydrocarbons (TVH); monthly contaminant removal rates ranged from 14,700 to 67,800 lbs.
- No concentration data for contaminants was reported.</td></tr>
</table>

Soil Vapor Extraction at the Site ST-35, Davis-Monthan AFB, Arizona (continued)

Cost:
- Total capital cost (estimated) - $162,000
- Total O&M cost after 22 months of operation - September 1995 through July 1997 - $45,000
- Report also includes monthly O&M costs for the first 16 months of operation - ranged from $1,818 to $2,602/month for a total of $32,700 through December 1996
- Data on cumulative O&M costs versus cumulative total volatile hydrocarbons removed showed that the cost per unit of contaminant began to increase in October 1996. The ICE engine was reconfigured with a smaller engine to reduce the need for supplemental fuel and thereby reduced the overall operating costs.
- The average O&M cost per unit of contaminant removed after 16 months of operation was $0.06/lb.

Description:

Site ST-35 at the Davis-Monthan Air Force Base (AFB), located in Arizona, was the site of a spill of JP-4 fuel. An estimated 63,000 cubic yards of soil were contaminated to a depth of about 260 ft bgs. TPH and benzene were detected in the soils at levels as high as 320,000 ppm and 110 ppm, respectively. In addition, benzene was detected in groundwater at levels as high as 510 ppb, and there was a 1 to 3 inch layer of free product floating on the groundwater. An SVE system was used to remediate the soil contamination at the site. The SVE operational objectives were to remove contamination at the site as cost-effectively as possible to prevent contamination of the surrounding soil and groundwater. No specific contaminant goals were identified in the report.

The SVE system consisted of six vapor extraction wells, a blower system, moisture separator, thermal oxidizer, and air treatment system. Vacuum was created using two 460 cubic inch ICEs. Extracted soil gas was burned as fuel in the ICEs; when contaminant concentrations in the soil gas were reduced, supplemental fuel was used to operate the ICEs. The SVE system was operated from September 1995 through July 1997. Performance data on amount of contaminant removed were available through December 1996. After 16 months of operation, a total of 585,700 lbs of TVH were removed. Monthly TVH removal rates ranged from 14,700 lbs to 67,800 lbs. In October 1996, the contaminant removal rate began to level off. The ICE was then reconfigured to reduce the need for supplemental fuel. System performance was reported to have improved following the reconfiguration, and the system was reported to be meeting its operational objectives.

The total capital cost for the system was $162,000. O&M costs through July 1997 were $45,000. Monthly O&M data were provided for the first 16 months of operation (through December 1996) and ranged from $1,818 to $2,602/month for a total of $32,700. Monthly O&M costs per unit of contaminant removed ranged from about $0.03/lb to $0.16/lb. From July to October 1996, there was a steady decrease in the O&M cost per lb of contaminant removed. However, the O&M cost began to increase in October 1996 at which time the ICE engine was reconfigured to reduce the need for supplemental fuel. The average O&M cost per unit of contaminant removed after 16 months of operation was $0.06/lb.

Soil Vapor Extraction at Defense Supply Center Richmond, OU 5
Chesterfield County, Virginia

<table>
<tr><td>Site Name:
Defense Supply Center Richmond, OU 5</td><td rowspan="2">Contaminants:
Tetrachloroethene (PCE) and Trichloroethene (TCE)
Maximum concentrations measured for soil during the RI were PCE - 1.5 mg/kg and TCE - 0.036 mg/kg</td><td>Period of Operation:
December 1 - 11, 1992</td></tr>
<tr><td>Location:
Chesterfield County, Virginia</td><td>Cleanup Type:
Pilot-scale</td></tr>
<tr><td>USACE Point of Contact:
Suzanne Murdock
Engineering and Support Center
Directorate of Engineering
Civil-Structures Division
PO Box 1600
Huntsville, AL 35816-1822
(205) 895-1635</td><td rowspan="2">Technology:
Soil Vapor Extraction:
- One extraction well (12 ft deep)
- Vacuum - 35 inches of water
- Air flow rate - 40 standard cubic feet per minute (scfm).</td><td>Cleanup Authority:
CERCLA
- ROD dated March 25, 1992
- ESD dated March 8, 1996</td></tr>
<tr><td>DSCR Remedial Project Manager:
Bill Saddington
Defense Supply Center Richmond
8000 Jefferson Davis Highway
Richmond, VA 23297-5000
(804) 279-3781</td><td>EPA Remedial Project Manager:
Todd Richardson
U.S. EPA Region 3
1650 Arch Street (MC 3HS50)
Philadelphia, PA 19103-2029
(215) 814-5264</td></tr>
<tr><td>Waste Source: Disposal of wastes in open pits</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Soil - 1,000 cubic yards</td></tr>
<tr><td>Purpose/Significance of Application: Pilot study of SVE for VOC contaminated soil</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
- Soil action levels of PCE - 0.58 mg/kg and TCE - 0.20 mg/kg</td></tr>
<tr><td colspan="3">Results:
- Results of soil samples collected following completion of the pilot study showed that the soil action levels had been achieved during the 10-day pilot test.
- Maximum concentrations reported for PCE - 0.18 mg/kg and for TCE - 0.11 mg/kg</td></tr>
<tr><td colspan="3">Cost:
- Total actual cost of the pilot study was $76,099, consisting of $18,225 for capital equipment and $57,874 for operation and maintenance.
- Unit cost of the pilot study treatment activities was $76/yd^3 (1,000 yd^3 treated).</td></tr>
</table>

Soil Vapor Extraction at Defense Supply Center Richmond, OU 5 Chesterfield County, Virginia (continued)

Description:
The Defense Supply Center Richmond (DSCR) is a 565-acre installation located in Chesterfield County, Virginia, on property owned by the Department of the Army. The mission of DSCR, built in the early 1940s, is to manage and furnish general military supplies to the Armed Forces and several civilian federal agencies. In August 1987, the site was placed on the National Priorities List (NPL). A remedial investigation (RI), conducted in November 1988, identified volatile organic compounds (VOC) in the soil and groundwater in the vicinity of a pit area. While solvents or other organics were not used in these metal cleaning operations, the pits were open and may have been used for undocumented disposal of organics from other operations at DSCR. In September 1990, DSCR entered into a federal facilities agreement (FFA) with EPA and the Commonwealth of Virginia to address contamination at operable units (OU) at the site. OU 5, the Acid Neutralization Pits source area, is the focus of this report. The record of decision (ROD), signed on March 25, 1992, specified soil vapor extraction (SVE) as the remedy for OU 5 and identified cleanup goals for PCE of 0.58 mg/kg and TCE of 0.20 mg/kg.

A pilot study of SVE was conducted from December 1 to December 11, 1992, to identify additional design parameters for a full-scale system. The study consisted of two tests, a hydraulic influence test conducted over a 24-hour period, followed by a 10-day hydrocarbon removal test. For the hydrocarbon removal test, one extraction well was used along with a carbon adsorption unit for the treatment of the off-gas. The results of soil samples collected following completion of the pilot study showed that the soil action levels had been achieved during the study. The maximum concentration reported for PCE was 0.18 mg/kg and 0.11 mg/kg for TCE. An ESD was signed in March 1996 indicating that a full-scale system was not required. Covers were installed on the pits, as required in the ROD. According to the ESD, several factors contributed to the success of the pilot test, including: the actual area of contamination was smaller than originally estimated; natural attenuation may have contributed to decreased contaminant levels; and PCE concentrations in the untreated soil were only slightly higher than the cleanup goals.

Air Sparging, In Situ Bioremediation, and Soil Vapor Extraction at the Texas Tower Site, Ft. Greely, Alaska

<table>
<tr><td>Site Name:
Texas Tower Site</td><td rowspan="2">Contaminants:
Petroleum hydrocarbons - diesel range organics (DRO). Average concentrations of DRO in soil were 500 mg/kg, and diesel range petroleum hydrocarbons in groundwater ranged from 0.085 to 18.6 mg/L.</td><td>Period of Operation:
Status: Complete
Report covers: February 1994 to February 1996</td></tr>
<tr><td>Location:
Ft. Greely, Alaska</td><td>Cleanup Type:
Corrective Action</td></tr>
<tr><td>Vendor:
James J. Landry
Senior Project Geologist
AGRA Earth and Environmental, Inc.
711 H Street, Suite 450
Anchorage, Alaska 99501-3442
(907) 276-6480</td><td rowspan="2">Technology:
Air Sparging, In Situ Bioremediation, and Soil Vapor Extraction
- System consisted of two air sparging wells drilled to 55 ft bgs, three SVE wells drilled to 52 ft bgs, and associated equipment.
- No air pollution control devices were included in this system.
- Air sparging provided 23-60 cfm of air to the saturated zone; SVE removed 400 cfm (average) from the vadose zone, at 50 inches water across the blower.
- After 18 months of operation, nutrient solution was injected into the SVE wells.</td><td>Cleanup Authority:
State of Alaska Underground Storage Tank Regulations [18AAC78]</td></tr>
<tr><td>Additional Contacts:
Cristal Fosbrook, Chief,
Environmental Restoration/ Compliance Branch
U.S. Army - Alaska, Directorate of Public Works
730 Quartermaster Road
Ft. Richardson, Alaska 99505
(907) 384-3044</td><td>USACE Point of Contact:
Bernard T. Gagnon
Environmental Engineering and Innovative Technology Advocate
U.S. Army Corps of Engineers - Alaska District
P.O. Box 898
Anchorage, Alaska 99506-0898
Telephone: (907) 753-5718</td></tr>
<tr><td>Waste Source:
Leak from fuel line</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Soil (in situ) and Groundwater
- Approximately 6,300 cubic yards of contaminated soil (a portion of the soil was in the saturated zone; this portion was not quantified).
- Soils consisted mainly of sand, gravel, cobble, and silt.
- Groundwater was encountered between 23 and 50 ft bgs, with a saturated zone approximately 27 ft thick and a hydraulic gradient of approximately 0.008 ft per ft.
- Subsurface materials encountered in all soil borings were generally uniform throughout the site, from ground surface to 65 ft bgs.</td></tr>
<tr><td>Purpose/Significance of Application:
Combination of three technologies used to treat DRO-contaminated soil and groundwater in situ.</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
- The following remedial goals were specified for soil and groundwater at the Texas Tower site: soil (total BTEX - 10 mg/kg, benzene - 0.1 mg/kg, and DRO - 100 mg/kg); groundwater (benzene - 0.005 mg/L, toluene - 1 mg/L, ethylbenzene - 0.7 mg/L, xylenes - 10 mg/L, and diesel range petroleum hydrocarbons - 0.1 mg/L) as set forth in the Alaska Department of Environmental Conservation UST regulations.</td></tr>
</table>

Air Sparging, In Situ Bioremediation, and Soil Vapor Extraction at the Texas Tower Site, Ft. Greely, Alaska (continued)

Results:

- Over two years of system operation, approximately 1,300 lbs of contaminants were extracted through the SVE wells. Those contaminants consisted of 829 lbs of DRO, 418 lbs of GRO, and 55 lbs of total BTEX compounds. The estimate above does not include contaminants removed through biodegradation, which was not measured.
- Concentrations of contaminants in treated soil and groundwater met the remedial goals in all samples with the exception of three soil sample locations and three groundwater sample locations. Because the soil samples were from locations that had not been sampled prior to the design of the treatment system, the USACE concluded that the results suggested an additional "hot spot" outside of the original treatment area. Based on the results of a "mini-risk assessment" performed by the USACE, no additional remedial activities were identified. The State of Alaska accepted the closure report for this application.
- The operations contractor cited the following reasons for why no additional remedial activities were necessary: the leaking fuel lines that had been the source of the release had been removed; highly contaminated soil had been excavated and treated off site; no compounds for which maximum contaminant levels (MCLs) have been established had been detected at concentrations above MCLs during more than two years of monitoring; and the potential for exposure from residual hydrocarbons was negligible.

Cost:

- The total proposed cost for the air sparging, in situ bioremediation, and SVE system at the Texas Tower site was $295,760, including $145,420 for construction, $117,230 for operation, and $33,110 for work plan preparation.
- A unit cost of treatment of $47 per cubic yard was calculated from the total cost of $295,760 to remediate 6,300 cubic yards of soil (in situ); a portion of this soil was in the saturated zone.
- Because the site is isolated, the USACE reported that the cost of transportation of the equipment to the site and setup at the site was a significant portion of the total cost of the project.
- Costs of operation were kept low by monitoring the operation of the remediation system remotely. The system was not staffed, except for monthly sampling events. This savings in operating cost was not quantified for this application.

Description:

The Texas Tower site consists of four buildings surrounded by a chain-link fence at the U.S. Army's Ft. Greely military facility, located approximately five miles south of Delta Junction, Alaska, near Fairbanks. During demolition of one of the buildings in 1990, a release of petroleum hydrocarbons was discovered, reportedly originating from an underground heating oil supply line. Site investigations determined that the release had impacted both subsurface soil and groundwater. In 1990, approximately 2,000 cubic yards of contaminated soil were excavated and transported off site for thermal treatment, and in 1993 the excavation was backfilled with clean soil.

In August 1993, the USACE contractor conducted a pilot test of an SVE and air sparging system, and a biotreatability test. On the basis of the results from these tests, the contractor concluded that the site was amenable to remediation by a combination of the three technologies. The full-scale system was installed between November 1993 and January 1994 and was operated from February 1994 to February 1996. Closure samples were collected in April 1996 and, based on the data from these samples and a "mini risk assessment", the State of Alaska accepted the closure report for this application.

Air Sparging and Soil Vapor Extraction at Landfill 4, Fort Lewis, Washington

Site Name:
Fort Lewis Landfill 4

Contaminants:
Volatiles (halogenated), and metals (manganese). Maximum concentrations of halogenated constituents in soil gas were: 4.1 mg/m^3 dichloroethene, 1.6 mg/m^3 trichloroethene, and 0.2 mg/m^3 vinyl chloride. Maximum concentrations of halogenated constituents in groundwater were 7 µg/L dichloroethene, 79 µg/L trichloroethene, and 7.8 µg/L vinyl chloride. Manganese was detected in groundwater at concentrations up to 13 mg/L.

Period of Operation:
Status: Ongoing
Report covers: 12/5/94 through 10/31/97

Location:
Tacoma, Washington

Cleanup Type:
Remedial Action

Vendor:
Fred Luck, P.E.
Garry Struthers Associates, Inc.
3150 Richards Road, Suite 100
Bellevue, WA 98005-4446
(206) 519-0300

Technology:
Soil vapor extraction (SVE) and air sparging (AS):

- A pilot test of three SVE wells and one AS well was operated from December 5 through 15, 1994.
- The full system consisted of six SVE, five AS wells, ten vadose zone piezometers, three dissolved oxygen sensor wells, and four passive air injection wells.
- The SVE wells were piped through a set of parallel treatment systems each consisting of a vapor/water separator, a blower, and two GAC canisters connected in series.
- Operations included various combinations of extraction and sparge flow rates, and use of injection wells.

Cleanup Authority:
The cleanup at Landfill 4 is being performed in accordance with a Federal Facilities Agreement between the Department of the Army, EPA, and the Washington Department of Ecology, and a ROD signed October 15, 1993.

USACE Contacts:
Kira Lynch and Bill Goss
U.S. Army Corps of Engineers, Seattle District
CENWS-TB-ET (Lynch)
CENWS-PM-HW (Goss)
P.O. Box 3755
Seattle, Washington 98124
(206) 764-6918 (Lynch)
(206) 764-6682 (Goss)

Regulatory Point of Contact:
Bob Kievit
EPA Remedial Project Manager, Region 10
300 Desmend Drive Suite 102
Lacey, Washington 98503
(360) 753-9014

Air Sparging and Soil Vapor Extraction at Landfill 4, Fort Lewis, Washington (continued)

Waste Source:
Leaks and spills of solvent waste to soil surfaces on and near Landfill 4; unlined liquid waste disposal pits

Purpose/Significance of Application:
Application of a combination of innovative technologies to treat halogenated organic contamination in situ in both soil and groundwater.

Type/Quantity of Media Treated:
In situ soil (both saturated and unsaturated) - volume not determined
- Sandy gravel to sandy silty gravel
- Moisture content (unsaturated soil) - 9 - 12 %

Regulatory Requirements/Cleanup Goals:
- The ROD specified four objectives for the remedy: to prevent exposure to contaminated groundwater, to restore the contaminated groundwater to its beneficial use, to minimize movement of contaminants from soil to groundwater, and to prevent exposure to the contents of the landfill.
- No soil cleanup levels were identified in the available reference material.
- The cleanup levels established for groundwater in the upper aquifer beneath the site were: TCE - 5 µg/L and vinyl chloride - 1 µg/L.
- Monitoring for manganese in groundwater also was required for areas of the site.

Results:
- Pilot test and startup phases of the remediation were used to determine the optimum system parameters for the treatment system.
- It was estimated that approximately 60 pounds of TCE were removed from as of October 30, 1997.
- Although the impact of the AS system on the degradation of TCE was not conclusively determined, it was recommended that the AS system be operated until an impact/benefit analysis for the system is completed.
- It was concluded that an additional hot spot of TCE contamination may be located upgradient and out of the area of influence of the remediation system.

Cost:
- The total cost of the pilot study for this application was $241,000.
- The negotiated cost for the full-scale remediation system was $1,710,303.

Description:
Ft. Lewis began operation in 1917. The Landfill 4 area consists of approximately 52 acres, which is divided into three cells located adjacent to a former gravel pit. These cells were used from the early 1950s to the late 1960s, reportedly, for the disposal of refuse, including domestic and light industrial solid waste and construction debris. After disposal activities was ceased, the landfill was covered with native material and has since been overgrown with vegetation.

Site investigations beginning in 1988 identified chlorinated hydrocarbon and metal contamination in the groundwater beneath the landfill. An RI/FS, conducted in 1993, led to the ROD for the site signed on October 15, 1993, which prescribed a remedy consisting of SVE and AS and monitoring of groundwater for manganese.

An SVE/AS pilot test was conducted at the site in December 1994 and the full-scale SVE/AS system was put on line in October 1996. The system had removed approximately 60 pounds of TCE (in soil gas) from the subsurface as of October 31, 1997, and currently continues to operate.

Soil Vapor Extraction at Fort Richardson Building 908 South, Anchorage, Alaska

<table>
<tr><td>Site Name:
Fort Richardson Building 908 South</td><td rowspan="2">Contaminants:
Volatile - nonhalogenated: BTEX; volatile - halogenated: chlorobenzenes; and Petroleum Hydrocarbons: GRO and DRO. Maximum contaminant concentrations were DRO (17,000 mg/kg), total BTEX (2.28 mg/kg), and total chlorobenzenes (11.93 mg/kg).</td><td>Period of Operation:
Status: Ongoing
Report covers: 2/95 through 3/96 (closure planned for Spring of 1999)</td></tr>
<tr><td>Location:
Anchorage, Alaska</td><td>Cleanup Type:
Indefinite Delivery Type Remedial Action; voluntary cleanup</td></tr>
<tr><td>Vendors:
Linder Construction
8220 Petersburg Street
Anchorage, AK 99507
(907) 349-6222

AGRA Earth & Environmental
711 H Street, Suite 450
Anchorage, AK 99501
(907) 276-6480</td><td rowspan="2">Technology:
Soil vapor extraction
- Two SVE wells screened from 7 to 50 ft bgs were installed to a total depth of 55 ft bgs.
- Soil gas extracted by a rotary blower was discharged to the ambient air after passing through a knockout drum and a particulate filter.
- The system was operated at an air flow rate of 205-220 scfm, with a vacuum at the wells of 2-7.5 inches water.</td><td>Cleanup Authority:
Alaska Department of Environmental Conservation UST Regulations (18 AAC 78)</td></tr>
<tr><td>USACE Contact:
Deirdre M. Ginter
USACE - Alaska District
P.O. Box 898
Anchorage, AK 99506-0898
(907) 753-2805</td><td>Regulatory Point of Contact:
Information not provided</td></tr>
<tr><td>Waste Source:
Leaking underground storage tank</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Soil
- Estimated as 4,600 $yd^{3.}$
- Primarily consisted of gravel with either sand or clay.
- Geology consists of surface deposits of glacial till, outwash, and silt.</td></tr>
<tr><td>Purpose/Significance of Application:
Application of SVE to treat gravelly-soil contaminated with diesel fuel.</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
- ADEC Matrix Level B cleanup levels were identified for this application. These levels are as follows: DRO (200 mg/kg), GRO (100 mg/kg), Benzene (0.5 mg/kg), Total BTEX (15 mg/kg).
- No performance objectives were established for air emissions from the blower for the application.</td></tr>
</table>

Soil Vapor Extraction at Fort Richardson Building 908 South, Anchorage, Alaska (continued)

Results:
- In a soil boring collected in March 1996 (after approximately one year of operation), the concentrations of DRO, GRO, benzene, and total BTEX were lower than their respective cleanup goals at all depths sampled.
- Analytical data from March 1995 to February 1996 indicate that DRO emissions from the blower were reduced by approximately 90 percent, and that GRO emissions were reduced by approximately 95 percent, over that time period.
- The system is planned for shutdown in the Spring of 1999, after evaluation of analytical results from confirmation samples.

Cost:
- The award cost for this application was $305,053, with $252,200 being directly attributed to construction and operation of the treatment system. This corresponds to $55 per yd^3 of soil treated.
- Since the application has not yet been completed, information about actual costs were not available, and it was not known how the actual costs will compare with the award costs.

Description:
Ft. Richardson, constructed in 1950, is located adjacent to Elmendorf Air Force Base and is eight miles from Anchorage, Alaska. Four USTs were removed in 1989 and 1990. One of these tanks, a 1,000-gallon fuel oil tank removed in September 1989 from an area adjacent to Building 908 South, was found to be leaking. Contaminated soil was excavated to 26 ft bgs, but remained at the bottom of the excavation. ADEC allowed the backfilling of the excavation with the understanding that the contamination would be remediated at a later date.

In the initial remedy selection process, low-impact bioventing was selected over aggressive bioventing and natural attenuation with or without the installation of a protective cap. However, SVE was eventually selected for implementation at Ft. Richardson because it did not require the nutrient addition or monitoring of biological activity parameters that would have been needed for bioventing. The SVE system was installed in February 1995.

An interim soil boring was drilled between the two SVE wells in March 1996, and samples from the boring showed that cleanup goals were being met in that area. The system was operating as of July 1998 and is currently slated for shutdown in the Spring of 1999 if additional sampling confirms that cleanup goals have been met throughout the area.

Soil Vapor Extraction at Sites 2 and 5
Holloman AFB, New Mexico

<table>
<tr><td>Site Name:
Sites 2 and 5 - Petroleum Oils and Lubricants Area</td><td colspan="2">Contaminants:
Volatiles (nonhalogenated)
• BTEX and TPH
• Maximum concentrations – Benzene (48,000 ug/kg), Toluene (210,000 ug/kg), Xylene (500,000 ug/kg), Ethylbenzene (180,000 ug/kg) and TPH (17,500 mg/kg)</td></tr>
<tr><td>Location:
Holloman AFB, New Mexico</td><td rowspan="2">Technology:
In-Situ Soil Vapor Extraction
• Network of 22 extraction wells (varying combinations are used)
• 2 Horsepower SVE blower motor
• Knockout tank to separate vapor and liquid phases.</td><td>Cleanup Type:
Remedial Action</td></tr>
<tr><td>Project Management:
U.S. Air Force
Drew Lessard
Restoration Program Manager
49 CES/CEVR
550 Tabosa Avenue
Holloman AFB, New Mexico 88330
(505) 475-5395</td><td>Vendor:
IT Corporation (Construction)
Foster Wheeler (Current O&M)
Ronald Versaw, P.E.
Delivery Order Manager
143 Union Boulevard
Suite 1010
Lakewood, Colorado 80228-1824</td></tr>
<tr><td>SIC Code:
9711 (National Security)</td><td>Period of Operation:
• April 1995 to present
• Treatment system currently in operation</td><td>Cleanup Authority:
State and EPA</td></tr>
<tr><td>Waste Sources:
Chronic and acute surface releases of JP-4 jet fuel, AVGAS and diesel fuel from aboveground storage tanks</td><td>Type/Quantity of Media Treated:
Soil
• Estimated 9,500 cubic yards of soil (in-situ)
• Estimated 44,000 pounds of TPH removed from the soil</td><td>Regulatory Point of Contact:
Cornelius Amindyas
NMED
2044 Galisteo
Santa Fe, New Mexico 87502
(505) 827-1561</td></tr>
<tr><td>Purpose/Significance of Application:
Treatment system has operated successfully with minimal downtime or maintenance requirements</td><td colspan="2">Regulatory Requirements/Cleanup Goals:
NMED has set the following soil cleanup criteria for POL sites at Holloman AFB:
• 1000 mg/kg TPH
• 25 mg/kg Benzene
• Removal of all floating free-phase hydrocarbons</td></tr>
</table>

Soil Vapor Extraction at Sites 2 and 5
Holloman AFB, New Mexico (continued)

Costs:	**Results:**
The total cost for this project (through August 1997) was $610,000. This translates to a cost of $64 per cubic yard of soil treated.	Confirmatory soil samples collected in 1997 indicate that soil TPH concentrations have been reduced below the regulatory guideline of 1,000 mg/kg. Previous sampling has indicated that benzene concentrations are below 25 mg/kg. Floating free-phase hydrocarbons have never been observed in the subsurface at the site.

Description:
During the 1960s and 1970s, several releases of JP-4 jet fuel, AVGAS and diesel fuel occurred in a POL storage area at Holloman AFB. Releases included chronic leaks and a 30,000-gallon spill that occurred in 1978. The site previously contained 14 aboveground POL storage tanks. All 14 tanks were removed from the site in 1987.

The site of the releases was investigated as part of the IRP program and two sites (Sites 2 and 5) were identified in the vicinity of the POL storage area. Because the two sites were similar in nature and in close proximity to each other, they were ultimately combined into one site (Site 2/5). Subsequent investigations at Site 2/5 identified an area requiring soil remediation. This area was selected based on soil cleanup criteria developed for POL sites at Holloman AFB. This area is 80 feet wide by 200 feet long. Soil borings indicated that soil contamination extended 16 below the ground surface at the site. It was determined that groundwater remediation was not required based on the quality of the groundwater and the lack of floating free-phase hydrocarbons at the site.

In 1994 and 1995, an SVE system was constructed at the site. The system includes 22 extraction wells, a 2-horsepower blower and a knockout tank to separate vapor and liquid phases in the extraction stream. The system was started in April 1995 and is currently still in operation (as of October 1998). It is estimated that 44,000 pounds of TPH have been removed from the soil at the site. Since 1995, several different extraction well configurations have been used. For a period in 1997, all 22 wells were in use simultaneously.

On several occasions since system start up, soil borings have performed at the site to determine if cleanup goals have been met at the site. The most recent sampling event (October 1997) indicated that the goals had been met. In March 1998, a Final Characterization Study was submitted to NMED for review. This study recommended that no further remedial action be conducted at Site 2/5. Approval of this recommendation was pending at the time of this report.

In addition to meeting soil cleanup criteria at Site 2/5, the SVE system has consistently operated below limits set by NMED for allowable air emissions of organic compounds.

Soil Vapor Extraction at Intersil/Siemens Superfund Site
Cupertino, California

<table>
<tr><td>Site Name:
Intersil/Siemens Superfund Site</td><td rowspan="2">Contaminants:
Trichloroethene (TCE)</td><td>Period of Operation:
May 1988 to August 23, 1993</td></tr>
<tr><td>Location:
Cupertino, California</td><td>Cleanup Type:
Full-scale</td></tr>
<tr><td>Vendor/Consultant:
Susan Colman
Geomatrix Consultants, Inc.
100 Pine Street, 10th Floor
San Francisco, CA 94111
(415) 743-7031</td><td rowspan="2">Technology:
Soil Vapor Extraction:
- Seven extraction wells (six installed in pairs - one in the shallow vadose zone the other in the deep vadose zone
- Three carbon bins to adsorb contaminants from the extracted soil vapor
- Air flow rates in individual wells ranged from 3 to 38 scfm (data on total system flow was not available)</td><td>Cleanup Authority:
CERCLA
- ROD date: September 1990</td></tr>
<tr><td>Additional Contacts:
Information not provided</td><td>EPA Remedial Project Manager:
Richard Procunier
U.S. EPA Region 9
75 Hawthorne Street
San Francisco, CA 94105
(415) 744-2219

State Contact:
Habte Kifle*
California Regional Water Quality Control Board
1515 Clay Street, Suite 1400
Oakland, CA 94612
(510) 622-2371</td></tr>
<tr><td>Waste Source: Waste from the manufacture of semiconductors and related wafer fabrication</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Soil - 280,000 cubic yards</td></tr>
<tr><td>Purpose/Significance of Application: SVE application using paired wells</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
- The ROD identified the following remedial goals for soil: total VOCs - 1 mg/kg and total SVOCs - 10 mg/kg.
- Air emissions standards for the SVE system, identified as the Bay Area Air Quality Management District, allowed an annual average of 2 pounds per day (lbs/day) of organics to be emitted.</td></tr>
<tr><td colspan="3">Results:
- Total VOCs were below the remedial goal of 1 mg/kg for 79 of 80 soil boring confirmatory samples. For one sample, total VOCs was reported as 1.1 mg/kg. However, the results of an assessment of the significance of the single exceedance indicated that, with a confidence level of greater than 95 percent, the soil remedial goal was met.
- According to Geomatrix, SVOCs were not detected in any samples.
- From May 1988 to December 1992, the removal rate for TCE decreased from approximately 15.5 lbs/day to less than 0.5 lbs/day and approximately 3,000 lbs of TCE were extracted.</td></tr>
</table>

Soil Vapor Extraction at Intersil/Siemens Superfund Site
Cupertino, California (continued)

Cost:
- Total cost of $770,000, including $550,000 in capital and $220,000 in O&M costs.
- Corresponds to a unit cost of $3 per cubic yard for 280,000 cubic yards of soil treated, and $260 per pound of contaminant removed (3,000 lbs removed).

Description:
The 12-acre Intersil/Siemens Superfund site, located in suburban Cupertino, California, includes two industrial properties used for the manufacture of semiconductors and related wafer fabrication - the Intersil facility, which operated from 1967 to 1988, and the Siemens facility, which has manufactured semiconductors at the site since 1978 and is an operating facility. The facilities used a variety of chemicals and chemical solutions in their manufacturing operations, including etching solutions, organic solvents and chemical mixtures. Soils and groundwater contaminated with volatile organic compounds (VOCs) and semivolatile organic comounds (SVOCs) were discovered on each of the sites, and several interim actions, including SVE, were implemented at the site. The site was listed on the NPL in August 1990. A Record of Decision (ROD) was signed in September 1990 that incorporated the interim remedies including SVE. This report focuses on the completed SVE application at the Intersil property. The ROD identified the following remedial goals for soil: total VOCs - 1 mg/kg and total SVOCs - 10 mg/kg. Air emissions standards for the SVE system, identified as the Bay Area Air Quality Management District, allowed an annual average of 2 pounds per day (lbs/day) of organics to be emitted.

The interim SVE system, which began operating in May 1988, included four vertical vapor extraction wells. As part of the final remedy, the SVE system was expanded in May 1991 to include three additional extraction wells. Six of the wells were installed in pairs along the eastern portion of the Intersil building - one well in the shallow vadose zone (about 10 to 50 feet deep) and the other in the deep vadose zone (about 60 to 100 feet deep). The sixth well was located along the western portion of the building. Three carbon bins were used to adsorb contaminants from the extracted soil vapor. Air flow rates in individual wells ranged from 3 to 38 scfm. According to the vendor (Geomatrix), total system flow and TCE concentrations for the total system were not available and the SVE system generally operated continuously until it was shut down (August 23, 1993). Based on the results of confirmatory soil samples, total VOCs were below the remedial goal of 1 mg/kg for 79 of 80 of the samples. For one sample, total VOCs was reported as 1.1 mg/kg. However, the results of an assessment of the significance of the single exceedance indicated that, with a confidence level of greater than 95 percent, the soil remedial goal was met. According to Geomatrix, SVOCs were not detected in any samples. From May 1988 to December 1992, the removal rate for TCE decreased from approximately 15.5 lbs/day to less than 0.5 lbs/day and approximately 3,000 lbs of TCE were extracted.

The total cost of $770,000 for this application included $550,000 in capital costs and $220,000 in O&M costs. This corresponds to a unit cost of $3 per cubic yard for 280,000 cubic yards of soil treated, and $260 per pound of contaminant removed (3,000 lbs removed).

Photolytic Destruction Technology Demonstration at NAS North Island, Site 9

<table>
<tr><td>Site Name:
NAS North Island, Site 9</td><td rowspan="2">Contaminants:
Volatile Organic Compounds (VOCs)
- Halogenated and non-halogenated VOCs, including 1,2-dichloroethene, trichloroethene, tetrachloroethene, toluene</td><td>Period of Operation:
10/12/97 - 10/18/97 - startup
10/24/97 - 1/8/98 - parametric tests
1/17/98 - 2/6/98 - steady-state tests</td></tr>
<tr><td>Location:
San Diego, CA</td><td>Cleanup Type:
Demonstration</td></tr>
<tr><td>Vendor:
Process Technologies Inc (PTI)</td><td rowspan="2">Technology:
Photolytic Destruction
- Fluidized bed concentration unit, including an absorber, desorber, and chilled-water condenser
- Photolytic destruction unit (PDU), consisting of photolytic reactors and a wet scrubber</td><td>Cleanup Authority:
CERCLA</td></tr>
<tr><td>Additional Contacts:
Naval Facilities Engineering Service
1100 23rd Avenue
Port Hueneme, CA 93043-4301</td><td>Regulatory Point of Contact:
Information not provided</td></tr>
<tr><td>Waste Source: Disposal of liquid chemical waste</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Soil vapor - estimated 1,151 lbs of VOCs</td></tr>
<tr><td>Purpose/Significance of Application: Demonstrate the effectiveness of PTI’s photolytic destruction units in treating VOC-contaminated vapor from an SVE system</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
The goal of the demonstration was to obtain cost and performance data on PTI’s system and to make comparisons to other treatment technologies demonstrated at the site. The objectives included determining the total average destruction and removal efficiencies of the system, developing cost data for a 3000 scfm PTI system, and characterizing and quantifying secondary waste streams and residuals.</td></tr>
<tr><td colspan="3">Results:
- The PTI system removed VOCs in the SVE off-gas to levels below the maximum allowable emissions of 25 ppmv. The average total DRE for VOCs was 95%.
- The report provides more detailed information comparing PTI’s technology performance to other treatment technologies.</td></tr>
<tr><td colspan="3">Cost:
- The total demonstration cost was $93,726, including work plan, moblilization/demobilization, site work, liquids collection and containment, treatment, monitoring, sampling and analysis, and residuals disposal. The report included a detailed cost breakout.
- The estimated unit cost to treat the SVE off-gas at NAS North Island’s Site 9, using a 3000 scfm system, is $3.77 per lb of VOC.</td></tr>
</table>

Photolytic Destruction Technology Demonstration at NAS North Island, Site 9 (continued)

Description:
NAS North Island Site 9, the Chemical Disposal Area, was used for the disposal of liquid chemical wastes from the 1940s to the 1970s. A wide range of contaminants were detected in soils at the site including VOCs, semi-volatile organic compounds (SVOCs), petroleum hydrocarbons, PCBs, and metals. As part of a non-time-critical removal action, an SVE system has been installed at the site in Areas 1 and 3 to remove and treat VOCs. As part of the Navy Environmental Leadership Program, PTI was selected to demonstrate their Photolytic Destruction Technology for NAS North Island, Site 9 and to make comparisons with other commercially-available treatment technologies. The PTI system was demonstrated with the existing SVE system at the site, specifically treating soil vapor from Area 3 wells. The demonstration was conducted in two phases. Phase 1 involved parametric testing to establish the optimal process configuration, and Phase 2 which involved Steady-State Testing using the system configuration from Phase 1.

The PTI system consisted of a fluidized bed concentration unit and a PDU. The three main components of the concentration unit were: an adsorber to develop a fluidized bed of adsorbent beads to extract organic vapors from the SVE vapor stream; a desorber containing a steam-heated heat exchanger that warms the adsorbent to 300 °F to evaporate the VOCs from the loaded adsorbent beads; and a chilled-water condenser to remove the water vapor and non-halogenated organics from the concentrated vapor. The PDU consisted of two main components: two photolytic reactors capable of treating up to 5 acfm each of concentrated VOC vapor and a wet scrubber to remove any trace amounts of acidic by-products from the photolytic reactor stream. The PTI system used for the demonstration was designed to treat 500 scfm of vapor from the SVE system (which was rated at 3000 scfm) and to remove a minimum of 3.6 lbs/hr of VOCs. The maximum flow rate during the demonstration was 440 scfm and the average amount of VOCs removed was 1.22 lbs/hr. The results of the Steady-State operations showed an average DRE for the PTI system of 95.44%, with the PDU alone achieving an overall DRE of 97%. In addition, the PTI system was found to be relatively quick to install and was operational 89% of the time. As a result of the demonstration, PTI recommended several design modifications to enhance system performance including redesigning the weather seals in the concentration unit to prevent rainwater and humidity from entering the adsorber, which was the primary operational problem encountered with this component during the demonstration. In addition, PTI recommended evaluating the performance of different adsorbent materials to determine which offers the most cost effective removal efficiencies. The report also presents detailed information on secondary wastes and residuals generated during the demonstration as well as a detailed discussion of operational problems encountered during the demonstration.

The total demonstration cost was $93,726, including work plan, mobilization/demobilization, site work, liquids collection and containment, treatment, monitoring, sampling and analysis, and residuals disposal. The report included a detailed cost breakout. The data from the demonstration were used to estimate the cost of implementing a 3000 scfm PTI system at NAS North Island Site 9. The estimated unit cost for such a system was $3.77 per lb of VOC treated. According to PTI, the commercialization of the technology over the next few years will lower the treatment costs further.

Soil Vapor Extraction at Seymour Recycling Corporation Superfund Site Seymour, Indiana

<table>
<tr><td>Site Name:
Seymour Recycling Corporation Superfund Site</td><td rowspan="2">Contaminants:
Volatile and Semivolatile Organic Compounds (VOCs) and (SVOCs)
- More than 35 compounds identified including tricholorethane (TCA), tetracholroethane (PCA), trichloroethene (TCE), tetracholroethene (PCE), carbon tetrachloride, and benzene</td><td>Period of Operation:
June 1992 to Present (Report covers period of June 1992 through 1996)</td></tr>
<tr><td>Location:
Seymour, Indiana</td><td>Cleanup Type:
Full-scale</td></tr>
<tr><td>Vendor:
Information not provided</td><td rowspan="2">Technology:
Soil Vapor Extraction
- 19 horizontal vapor extraction wells, 11 horizontal air inlet wells (passive), a vacuum blower, a moisture separator, and an activated carbon adsorption system
- Air flow rate - 52.9 to 122.6 cfm (average per quarter); 80 cfm (average over 2.8 years of operation)
- Operating vacuum 27 - 40 inches of water

Multimedia Cap
- Constructed over the horizontal SVE wells (24-inch vegetative cover, geotextile fabric, 12-inch thick drainage layer, 60 mil thick synthetic liner, 2-ft thick clay/till layer)

In Situ Bioremediation
- Nutrient addition - 8/86-10/86; 1/97-2/97; and 8/90
- Mechanical injection of nutrient solution (nitrogen, phosphorus, potassium, and sulfur)</td><td>Cleanup Authority:
CERCLA
- ROD date: September 30, 1987</td></tr>
<tr><td>State Contact:
Prabhakar Kasarabada
IDEM
100 N. Senate Avenue,
12th Fl. North
Indianapolis, IN 46206-6015
(317) 308-3117

PRP Lead Contractor:
Victoria Kramer
Geraghty & Miller, Inc.
88 Duryea Road
Melville, NY 11747
(516) 391-5268</td><td>Remedial Project Manager:
Jeff Gore
EPA Region 5
77 West Jackson Boulevard
Chicago, IL 60604-3590
(312) 886-6552</td></tr>
<tr><td>Waste Source: Improper waste management practices</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Soil - 200,000 cubic yards of soil, based on an area of 12 acres and a depth of 10 ft.</td></tr>
<tr><td>Purpose/Significance of Application: SVE system using horizontal wells, in combination with in situ bioremediation, under a multimedia cap.</td></tr>
</table>

Soil Vapor Extraction at Seymour Recycling Corporation Superfund Site Seymour, Indiana (continued)

Regulatory Requirements/Cleanup Goals:
- Chemical-specific soil cleanup levels were not specified for this application. Instead, requirements were specified in terms of a system design goal.
- The design goal for the SVE system was to extract a total volume of soil vapor equal to 500 pore volumes from beneath the site within 30 years. The system was to be operated to extract between 2 and 35 pore volumes per year. After 500 pore volumes of soil vapor had been extracted, the system was to be operated as a passive system.

Results:
- As of 1997, 430 pore volumes and about 30,000 pounds of VOCs had been extracted by the SVE system.

Cost:
- Capital cost for the SVE system - $1.2 million
- O&M data were provided only as a aggregate for all remediation activities at the site; therefore, O&M costs specific to the SVE system were not available.

Description:
From 1970 to early 1980, the Seymour Recycling Corporation (SRC) and its corporate predecessor, Seymour Manufacturing Company, processed, stored, and incinerated chemical wastes at the Seymour site. The site, which occupies about 14 acres, was closed when SRC failed to meet a 1978 agreement with the State of Indiana to cease receiving wastes and to institute better waste management practices. In 1980, the site was placed under receivership by a state court. In 1982, EPA signed a Consent Decree with a small group of Potentially Responsible Parties (PRPs) to complete "surface cleanup" at the site. On September 9, 1983, the site was listed on the NPL. A ROD signed in September 1986 specified an interim groundwater pump-and-treat system remedy. A second ROD, signed in September 1987, specified more comprehensive remediation of the site, including the use of SVE.

The SVE system included 19 horizontal vapor extraction wells, 11 horizontal air inlet wells (passive), a vacuum blower, a moisture separator, and an activated carbon adsorption system. Approximately 12,700 linear feet of horizontal vapor extraction piping (laterals) were installed about 30 inches below grade. Wells were spaced approximately 50 ft apart and a multimedia cap was constructed above the wells. During installation of the SVE system, five lateral extraction wells were damaged. Repair of these wells was not feasible because of possible cap damage; therefore, the damaged wells were converted to fresh-air inlet wells. Air inlet wells were maintained at atmospheric pressure and extraction wells maintained at less than atmospheric pressure. This configuration resulted in ambient air entering the inlet wells at atmospheric pressure, being drawn through the unsaturated zone, and then being exhausted through the sub-atmospheric-pressure extraction wells. With the exception of the five damaged wells described above, all wells were designed to be able to operate as either extraction or inlet wells. In situ bioremediation was included in the remedy because it was believed that not all of the compounds detected at the site would be amenable to SVE treatment. As of 1997, 430 pore volumes and about 30,000 pounds of VOCs had been extracted by the SVE system. Remedial activities at the site were ongoing at the time of this report.

Soil Vapor Extraction and Groundwater Containment at OU1, Shaw AFB, South Carolina

<table>
<tr><td>Site Name:
OU1, Shaw AFB
- POL yard
- Interim Response Area A
- Interim Response Area C</td><td rowspan="2">Contaminants:
BTEX, Petroleum Hydrocarbons, Free Product (JP-4 fuel)
- 400,000 gallons of JP-4 in the groundwater; the size of the dissolved phase plume was approximately 47 acres.</td><td>Period of Operation:
POL SVE system - December 1995 - ongoing (as of April 1998)
Interim Response Area A - February 1992 - November 1996
Interim Response Area C - April 1995 - September 1997</td></tr>
<tr><td>Location:
South Carolina</td><td>Cleanup Type:
Full-scale cleanup</td></tr>
<tr><td>Vendor:
IT Corporation</td><td rowspan="2">Technology:
POL Yard - Soil Vapor Extraction (SVE)
- vacuum extraction wells, blowers, an oil/water separator, and thermal/catalytic oxidation units.
Interim Groundwater Containment System - Area A
- Fuel recovery and a groundwater treatment system. Recovery wells, iron pretreatment, entrained oil removal, solids removal, packed air stripper. System upgraded in May 1997 with dual-phase recovery pumps, oil/water separator, equalization tank, and shallow-tray air stripper units.
Interim Groundwater Containment System - Area C
- Passive free product recovery using one recovery well</td><td>Cleanup Authority:
Installation Restoration Program</td></tr>
<tr><td>Additional Contacts:
U.S. Air Force Air Combat Command</td><td>Regulatory Point of Contact:
Information not provided</td></tr>
<tr><td>Waste Source: Fuel Spill</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Soil
- 30,000 square feet (areal extent); sands and silts; confining clay layer at 70 to 80 feet below ground surface (bgs)
Groundwater
- 47 acre plume (dissolved JP-4 fuel)</td></tr>
<tr><td>Purpose/Significance of Application: SVE system to remediate soil and two interim response action systems to contain groundwater</td></tr>
</table>

Soil Vapor Extraction and Groundwater Containment at OU1, Shaw AFB, South Carolina (continued)

Regulatory Requirements/Cleanup Goals:
- The operational objective of the SVE system was to remove contamination from the soil as cost-effectively as possible to prevent contamination of surrounding soil and groundwater.
- The operational objectives of the Interim Response for Area A was to contain the plume by removing free product as quickly and cost-effectively as possible to prevent continued contamination of surrounding soil and groundwater; the objective of dissolved phase containment was to operate efficiently over a relatively long period of time.
- The operational objective of the Interim Response for Area C, free product source removal, was to remove liquid-phase contamination as quickly and cost-effectively as possible to prevent continued contamination of surrounding soil and groundwater.

Results:
- SVE at POL Yard - Total contaminant removed through 19 months of operation (July 1997) was 518,000 lbs of JP-4 fuel, with removal rates ranging from 2,560 to 94,800 lbs/month. The system is still operating.
- Groundwater Containment Area A - Data on whether containment was achieved is not available. Total contaminant removed after 4 years of operation (through January 1996) was 114,340 gallons of JP-4 free product (monthly removal rates ranged from 0 to 9,980 gallons) and 171 gallons of dissolved phase JP-4 (monthly removal rates ranged from 0 to 10.7 gallons).
- Groundwater Containment Area C - Total contaminant removal after 1.4 years (through August 1996) was 12,766 gallons of JP-4 free product (monthly removal rates ranged from 266 to 2,145 gallons).

Cost:
The report includes detailed data on O&M costs versus amount of contaminant removed and the effects of system modifications on these costs.
- SVE system at POL Yard - Total O&M costs after 19 months of operation was $568,500 (monthly ranged from $18,000 to $57,500). The average O&M cost per unit of contaminant removed was $1.09/lb
- Groundwater Containment Area A - Total O&M costs after 4 years of operation was $995,500 (monthly ranged from $674 to $90,100). The average O&M cost per unit of contaminant removed was $8.69/gallon of JP-4. Groundwater Containment Area C - Total O&M cost was $33,000 (monthly ranged from $437 to $6,187). The average O&M cost per unit of contaminant removed was $2.59/gallon of JP-4.

Description:

OU1 at Shaw AFB, located in South Carolina, includes four IRP sites. This report focuses on the OU1 POL yard SVE system, the OU1 Area A Interim Response groundwater containment/treatment system, and the Interim Response Area C groundwater containment system (free product recovery). Contamination at OU1 included JP-4 fuel and BTEX, with an estimated 400,000 gallons of free product present in the groundwater.

The SVE system at the POL yard included 30 vacuum extraction wells, four vacuum monitoring wells, three SVE vacuum blowers, an oil/water separator, and two thermal/catalytic oxidation (CatOx) units. (Thermal oxidation was used until December 1997; replaced by CatOx). In December 1996, five VEP wells from OU1 Area B were connected to the system. The system was operated under 18 in of Hg and data are provided through July 1997. The Interim Groundwater Containment System at Area A included nine recovery wells, iron pretreatment, entrained oil removal, solids removal, packed air stripper. Treated effluent was discharged to a sewer and data are provided through November 1996. The Interim Groundwater Containment System at Area C included one recovery well for free product recovery and data are provided through August 1996. In September 1997, the Area C system was modified to a full-scale system.

Soil Vapor Extraction at Tyson's Dump Superfund Site
Upper Merion Township, Pennsylvania

<table>
<tr><td>Site Name:
Tyson's Dump Superfund Site</td><td rowspan="2">Contaminants:
Volatile Organic Compounds:
- 1,2,3-trichloropropane
- Benzene
- Trichloroethene
- Tetrachloroethene</td><td>Period of Operation:
November 1988 - September 1996</td></tr>
<tr><td>Location:
Upper Merion Township, Pennsylvania</td><td>Cleanup Type:
Full-scale</td></tr>
<tr><td>Vendor:
John S. Miller
On-Site Coordinator
Terra Vac
P.O. Box 2199
Princeton, NJ 08543-2199
(215) 354-8611</td><td rowspan="2">Technology:
Soil Vapor Extraction
- 80 vapor extraction (VE) wells, 9 dual extraction (RD) wells, and 7 bedrock extraction wells connected to a central processing plant
- Depth of VE wells- <10 feet (approximate depth to bedrock)
- Vapors treated using activated carbon adsorption
- Water extracted using the RD wells was treated by air stripping and carbon polishing
- Design air flow rate- 15,000 scfm at 13 inches of mercury (Hg) vacuum
- More than 14 enhancements were made to the system including varying the number and types of wells, heating the soil using several techniques, destroying contaminants in situ, and physically creating new flow paths</td><td>Cleanup Authority:
CERCLA
- ROD date: 12/21/84
- Revised ROD: 3/31/88
- Revised ROD: 7/20/96</td></tr>
<tr><td>PRP Contact:
Kenneth Dupuis
Ciba Specialty Chemicals Corp.
P.O. Box 71
Toms River, NJ 08754
(732) 914-2810</td><td>Remedial Project Manager:
Eugene Dennis
SARA Special Site Section
U.S. EPA Region 3
841 Chestnut Building
Philadelphia, PA 19107
(215) 566-3202</td></tr>
<tr><td>Waste Source: Spills and waste disposal in lagoons</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Soil - 30,000 cubic yards</td></tr>
<tr><td>Purpose/Significance of Application: SVE application involving more than 14 enhancements</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
- The ROD specified cleanup goals of 0.05 mg/kg each for 1,2,3-trichloropropane, benzene, trichloroethene, and tetrachloroethene.
- In addition, the cleanup goals were to be achieved within 26 months after startup of the SVE system. If cleanup goals had not been met within the first year of operation of the SVE system, supplemental measures were to implemented to improve the vacuum extraction process.</td></tr>
</table>

Soil Vapor Extraction at Tyson's Dump Superfund Site
Upper Merion Township, Pennsylvania (continued)

Results:
- The system initially removed about 10,000 lbs/month of VOC. However, between September and December 1989, extraction rates decreased to 2,000 lb/month. In response, Terra Vac implemented 14 enhancements in an attempt to improve system performance.
- While many of the SVE system enhancements (varying the number and types of wells in the system, heating the soil, destroying contaminants in situ, and physically creating new flow paths as a means to improve the diffusion rate) produced short-term improvements in the extraction rate, in all cases, the results were only temporary. (The report includes a detailed summary of all enhancements and the results of each).
- Results of soil borings taken after 32 months of operation showed that concentrations of 1,2,3-trichloropropane, benzene, trichloroethene, and tetrachloroethene remained above the cleanup goals. In a number of cases, the constituent concentrations reported were higher than pre-remediation concentrations.
- EPA subsequently determined that the SVE system was incapable of meeting the cleanup goals in a timely and cost effective manner, and amended the ROD to change the remedy to a wet soil cover.

Cost:
- The total actual cost for the SVE system was $43.4 million, including approximately $3.5 million for design and pilot studies, and $39.9 million in treatment costs, including construction and operation and maintenance costs.

Description:
Tyson's Dump Superfund site is a four-acre, abandoned septic waste and chemical waste disposal site reported to have operated from 1960 to 1970 in a sandstone quarry. Franklin P. Tyson and Fast Pollution Treatment, Inc. used lagoons on the eastern and western portions of the site to dispose of industrial, municipal, and chemical wastes. Results of soil samples from the lagoons taken during the Remedial Investigation indicated the presence of VOCs at concentrations that exceeded 500 mg/kg. A ROD was issued in 1984, specifying excavation and off-site disposal of contaminated soils. In response to the results of a study submitted by the RPs, EPA negotiated a partial consent decree to implement SVE and issued a revised ROD in 1988.

The initial design of the SVE system at Tyson's Dump included 80 vapor extraction wells, nine dual extraction wells, and seven bedrock extraction wells connected to a manifold that led to a central processing plant. Most of the VE wells were drilled to a depth of less than 10 feet (approximate depth to bedrock). Extracted vapors were treated by activated carbon adsorption, with regeneration and solvent recovery on site. Water extracted using the dual extraction wells was treated by air stripping and carbon polishing. VOC extraction rates for the system initally were about 10,000 lb/month. However, by December of 1989 the extraction rate decreased to about 2,000 lbs/month. The results of additional investigations performed by Terra Vac identified several conditions at the site that were limiting the diffusion rate of VOCs and adversely impacting the performance of the SVE system, including greater variation in the permeability, porosity, particle size, and moisture content of the soils than identified during previous investigations. In addition, DNAPL was found to be present over a larger area of the site than had previously been identified. In response, Terra Vac implemented 14 enhancements in an attempt to improve system performance. Many of the SVE system enhancements produced short-term improvements in the extraction rate. However, in all cases, the results were only temporary. After 32 months of operation, sample results showed that concentrations of 1,2,3-trichloropropane, benzene, trichloroethene, and tetrachloroethene remained above the cleanup goals. EPA subsequently determined that the SVE system was incapable of meeting the cleanup goals in a timely and cost effective manner, and amended the ROD to change the remedy to a wet soil cover.

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THERMAL PROCESSES ABSTRACTS

Contained Recovery of Oily Waste (CROW)™ Process at Brodhead Creek Superfund Site, Stroudsburg, Pennsylvania

<table>
<tr><td>Site Name:
Brodhead Creek Superfund Site</td><td rowspan="2">Contaminants:
Coal tar and coal tar residual containing:
- PAHs - benzo(a)pyrene and naphthalene
- Nonhalogenated semivolatile organic compounds (SVOCs)
- Volatile organic compounds (VOCs) - benzene
- Metals - arsenic</td><td>Period of Operation:
July 1995 - June 1996</td></tr>
<tr><td>Location:
Stroudsburg, Pennsylvania</td><td>Cleanup Type:
Full-scale</td></tr>
<tr><td>Vendor:
Mark Moeller
RETEC
9 Pond Lane, Suite 3A
Concord, MA 07142
(508) 371-1422

Lyle Johnson
Western Research Institute
365 North 9th Street
Laramie, WY 82070
(307) 721-2281</td><td rowspan="2">Technology:
CROW™ process
- Hot water injected into subsurface; water and coal tar extracted and treated using a tar-water separator
- Six injection wells and two production wells (used for extraction)
- Water from separator treated using carbon adsorption; recovered tar sent off site for treatment
- Injection pressure - 20 psig
- Extraction rate - design of 100 gpm; actual of 40 gpm</td><td>Cleanup Authority:
CERCLA
- ROD date: 3/29/91
- ESD date: 7/19/94</td></tr>
<tr><td>PRP Lead:
Jim Villaume
Senior Project Manager
Pennsylvania Power and Light (PP&L)
Two North Ninth Street
Allentown, PA 18101
(610) 774-5094</td><td>EPA Remedial Project Manager:
John Banks
U.S. EPA Region 3
841 Chestnut Street
Philadelphia, PA 19107
(215) 566-3214</td></tr>
<tr><td>Waste Source: Disposal of waste in open pit</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Free product (coal tar) - 1,500 gallons of coal tar</td></tr>
<tr><td>Purpose/Significance of Application: Recover free and residual coal tar using the CROW ™ process</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
- The ROD specified removal of 60 percent of the total free-phase coal tar from the subsurface soils. However, the results of the preremedial design investigation found that an accurate measurement of the amount of free-phase coal tar was not possible.
- An ESD was issued to change the standard. The system was required to operate until the amount of free-phase coal tar recovered was minimal.</td></tr>
</table>

Contained Recovery of Oily Waste (CROW)™ Process at Brodhead Creek Superfund Site, Stroudsburg, Pennsylvania (continued)

Results:
- Initial estimate of total volume of coal tar removed - 1,500 gallons (based on estimate of amount removed for each pore volume of water flushed through the recovery zone). In addition, no measurable material had been recovered during the last three months of operation.
- However, EPA determined that the method used for this estimate was inaccurate and therefore could not be used to determine whether the performance standard had been met. In response, the PRPs were required to collect three additional pore volumes and perform quantitative analyses per EPA requirements.
- The results showed that the recovered process water did not contain free or separable coal tar; EPA agreed that the performance standard had been met and allowed the system to be shut down.

Cost:
- Total cost - $1.9 million, including $1.2 million for treatment costs.
- Costs for this application were shared among DOE, the Gas Research Institute, and PP&L.

Description:
Citizen Gas and Electric operated a coal gasification plant at this site from 1888 until 1944. Coal tar from these operations was disposed of in open pits at the site. In October 1980, coal tar was observed to be seeping into Brodhead Creek. In December 1982, the site was placed on the National Priorities List. The results of the Remedial Investigation identified free-phase coal tar at the site. In addition, the soil and groundwater at the site were contaminated with PAHs, other SVOCs, VOCs, and metals. The ROD signed in 1991 specified the use of an enhanced recovery technology to remove free-phase coal tar from subsurface soils. The Contained Recovery of Oily Waste (CROW)™ process was selected for use at the site.

The CROW™ process involved injecting hot water into the subsurface through six wells to decrease the viscosity of the coal tar and facilitate recovery, then extracting the water and coal tar using two production wells. The extracted water and coal tar were treated using a tar-water separator. Water from the separator was treated using carbon adsorption; recovered tar was sent off site for treatment. While the design called for the system to be operated at a rate of 100 gpm, the actual rate was 40 gpm. A reason for the reduced rate included iron fouling problems in the well screens. Initial results indicated that the CROW™ process had removed 1,500 gallons of coal tar and that no measurable coal tar had been recovered during the last three months of operation. In March 1996, samples of the recovered material were taken from the storage tank. The results indicated that the contents were primarily water, and raised concerns about the method that was being used to calculate the volume of tar recovered. EPA determined that the method was not accurate, and therefore could not be used to determine whether the performance standard had been met. Additional pore volumes were collected and the results of quantitative analyses performed per EPA requirements showed that the cleanup goals had been met.

In Situ Thermal Desorption at the Missouri Electric Works Superfund Site, Cape Girardeau, Missouri

<table>
<tr><td>Site Name:
Missouri Electric Works Superfund Site</td><td rowspan="2">Contaminants:
PCBs
- Detected in surface and subsurface soils at levels as high as 58,000 mg/kg
- Areal extent of PCB contamination at levels greater than 10 mg/kg was estimated to be 6.8 acres</td><td>Period of Operation:
April 21 - June 1, 1997</td></tr>
<tr><td>Location:
Cape Girardeau, Missouri</td><td>Cleanup Type:
Demonstration</td></tr>
<tr><td>Vendor:
John Reed
Terra Therm Environmental Services
1077 Grogan’s Mill Road
The Woodlands, TX 77380
(281) 296-1000</td><td rowspan="2">Technology:
In situ thermal desorption
- 12 heater/vacuum wells installed in a triangular pattern to a depth of 12 feet
- Each well equipped with an insulated heating element; capacity to inject 350 to 700 watts/square foot at heater temperatures of 1600 to 1800°F
- Small surface heating pads placed at the center of each triangle; vapor seal constructed over entire test area
- Particulate cyclone, Thermatrix ES-125 flameless thermal oxidizer, and carbon canisters</td><td>Cleanup Authority:
CERCLA
- ROD date: 9/28/90
- Demonstration Test Plan approved 1/97</td></tr>
<tr><td>Additional Contacts:
Information not provided</td><td>EPA Point of Contact:
Remedial Project Manager
Pauletta France-Isetts
U.S. EPA Region 7
726 Minnesota Ave
Kansas City, KS 66101
(913) 551-7701</td></tr>
<tr><td>Waste Source: Leaks and spills from storage of PCB waste oils</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Soil - 52 cubic yards</td></tr>
<tr><td>Purpose/Significance of Application: Demonstrate the performance of in situ thermal desorption to treat PCB-contaminated soil</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
Soil cleanup goal for PCBs - 2 mg/kg
DRE - 99.9999%</td></tr>
<tr><td colspan="3">Results:
- PCB concentrations in all 94 soil samples taken during the demonstration were below the 2 mg/kg cleanup goal; 83 of the samples were reported below the detection limit
- Results of stack testing showed that the DRE for PCBs was 99.9999998%, meeting the goal of 99.9999%</td></tr>
<tr><td colspan="3">Cost:
- No costs were reported for the demonstration.
- The vendor used data from the demonstration to estimate that the cost for a full-scale application is between $120 and $200 per cubic yard for “most standard sites.”</td></tr>
</table>

In Situ Thermal Desorption at the Missouri Electric Works Superfund Site, Cape Girardeau, Missouri (continued)

Description:
From 1953 until 1992, the Missouri Electric Works Inc. (MEW) operated a 6.4 acre site, located in an industrial area in Cape Girardeau, Missouri. MEW sold, serviced, and maintained electric motors, transformers, and transformer controls at this facility. Historical operations included salvaging transformer oil and materials from old equipment; copper wire was sold and the transformer oil was filtered and reused. It was estimated that 28,000 gallons of oil were released at the site. The results of a Remedial Investigation (RI), conducted between September 1989 and March 1990, showed PCBs in the surface and subsurface soils (as high as 58,000 mg/kg in soils found on site and 2,030 mg/kg in off-site soils). The areal extent of PCB concentrations in the soil that were greater than 10 mg/kg was estimated to be 295,000 square feet (ft^2) or 6.8 acres. A Record of Decision (ROD), signed in 1990, specified excavation of PCB-contaminated soil followed by incineration, and extraction and treatment of groundwater. However, the MEW PRP Steering Committee proposed in situ thermal desorption of the soil, and an Explanation of Significant Differences (ESD) was issued for this site in January 1995 which included thermal desorption as an acceptable process for treating site soils. In January 1997, EPA and MDNR accepted a Demonstration Test Plan for this technology.

TerraTherm's in situ thermal desorption (ISTD) technology was demonstrated at MEW to treat subsurface soil contamination in an area near a former PCB storage pad. The objectives of the demonstration were to clean soils to below cleanup levels and achieve a destruction and removal efficiency (DRE) of greater than 99.9999% for PCBs. Twelve heater/vacuum wells were installed in a triangular pattern, spaced 5 ft apart. A vapor seal was constructed over the entire test area to insulate and reduce heat loss, and to seal the surface of the test area against vapor emissions. The MU-125 mobile process unit used for the demonstration was equipped with a particulate cyclone, a Thermatrix ES-125 flameless thermal oxidizer, and two carbon canisters in series. Three distinct temperature phases were recorded during the heating process. During the third (superheating) phase soil temperatures rose to over 1000°F. The vendor used this data to estimate that about 50% of the total soil volume reached a temperature of over 1100°F. The results of soil samples taken after completion of the 42-day demonstration showed that the concentration of PCBs in all samples was below the 2 mg/kg cleanup goal and that PCB concentrations were below the detection limit in the majority of samples. Results of stack testing showed that the DRE for PCBs was 99.9999998%, meeting the goal of 99.9999%.

The vendor used data from the demonstration to estimate that the cost for a full-scale application is between $120 and $200 per cubic yard for "most standard sites." According to the RPM, the Missouri Electric Works Steering Committee has retained another experienced vendor to perform the full-scale work at the Missouri Electric Works site. The vendor submitted a lower cost proposal than TerraTherm.

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GROUNDWATER PUMP AND TREAT (CHLORINATED SOLVENTS)

ABSTRACTS

Pump and Treat of Contaminated Groundwater at the Des Moines TCE Superfund Site, OU 1, Des Moines, Iowa

<table>
<tr><td>Site Name:
Des Moines TCE Superfund Site, Operable Unit 1 (OU 1)</td><td rowspan="2">Contaminants:
Chlorinated solvents
- Maximum concentrations detected during 1985 RI included TCE (8,467 ug/L), 1,2-DCE (2,000 ug/L), and vinyl chloride (95 ug/L)</td><td>Period of Operation:
Status: Ongoing
Report covers: 12/87 - 10/96</td></tr>
<tr><td>Location:
Des Moines, Iowa</td><td>Cleanup Type:
Full-scale cleanup (interim results)</td></tr>
<tr><td>Vendor:
Tonka Equipment Company</td><td rowspan="2">Technology:
Pump and Treat
- Groundwater is extracted using 7 wells, located on site, at an average total pumping rate of 1,041 gpm
- Extracted groundwater is treated with air stripping and discharged to a surface water under a NPDES permit</td><td>Cleanup Authority:
CERCLA Remedial
- ROD Date: 7/21/86</td></tr>
<tr><td>Additional Contacts:
None</td><td>EPA Point of Contact:
Mary Peterson, RPM
U.S. EPA Region 7
726 Minnesota Avenue
Kansas City, KS 66101
(913) 551-7882</td></tr>
<tr><td>Waste Source:
Land application of waste sludges, including use of waste sludges on road surfaces for dust control</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Groundwater
- 4,900 million gallons treated as of December 1996
- DNAPL suspected in groundwater at this site
- Groundwater is found at 10-25 ft bgs
- Extraction wells are located in 1 aquifer, which is influenced by a nearby surface water
- Hydraulic conductivity reported as 535 ft/day</td></tr>
<tr><td>Purpose/Significance of Application:
Met goals for off-site plume within two years of operation; nearly five billion gallons treated.</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
- The cleanup goal for this site is to reduce the TCE concentration in groundwater on the west side of the Raccoon River to 5 ug/L or less for four consecutive months. At this time, on-site goals have not been specified.
- As a secondary goal, the remedial system is designed to create an inward gradient toward the site to contain and treat the on-site plume.</td></tr>
<tr><td colspan="3">Results:
- The pump and treat system met the cleanup goal for TCE within two years of system operation, and an inward hydraulic gradient appears to have been achieved within the first month of operation that encompasses the entire contaminant plume. Pumping continued after that time to maintain containment and provide for potential reductions in contaminant concentrations in on-site wells. However, on-site wells continue to show concentrations of TCE at greater than 5 ug/L.
- By February 1997, the pump and treat system had removed nearly 30,000 pounds of contaminants from the groundwater.</td></tr>
<tr><td colspan="3">Cost:
- Estimated costs for pump and treat were $2,596,000 ($1,587,000 in capital and $1,009,000 in O&M), which correspond to $0.53 per 1,000 gallons of groundwater extracted and $80 per pound of contaminant removed.</td></tr>
</table>

Pump and Treat of Contaminated Groundwater at the Des Moines TCE Superfund Site, OU 1, Des Moines, Iowa (continued)

Description:
An iron foundry operated on this property from approximately 1910 until Dico Corporation purchased the property in the early 1940s. Dico manufactured metal wheels and brakes at the site from 1961 through 1993. In September 1976, testing by the DMWW and EPA detected TCE in the city's north gallery groundwater infiltration system, which served as a source of drinking water for the city. Investigations by EPA suggested that solvent sludges used on road and parking lot surfaces could be the cause of the subsurface contamination. The site was placed on the NPL in September 1983 and a ROD was signed in July 1986.

The groundwater extraction system consists of seven wells installed in the plume east of the Raccoon River on the Dico property to a depth of 40 ft. These wells were designed for full containment and partial aquifer restoration (to achieve off-site groundwater goals). Extracted groundwater is treated using an air stripper and discharged under a NPDES permit. The pump and treat system met the off-site cleanup goal for TCE within two years of system operation, and plume containment appears to have been achieved.

Pump and Treat of Contaminated Groundwater at the Former Firestone Facility Superfund Site, Salinas, California

<table>
<tr><td>Site Name:
Former Firestone Facility Superfund Site</td><td rowspan="2">Contaminants:
Chlorinated solvents and volatiles - nonhalogenated
- Contaminants included 1,1-DCE, TCE, PCE, 1,1-DCA, 1,1,1-TCA, benzene, toluene, and xylene
- Maximum concentration for 1,1-DCE detected in 1983-1984 was 120 ug/L</td><td>Period of Operation:
2/86 - 11/92</td></tr>
<tr><td>Location:
Salinas, California</td><td>Cleanup Type:
Full-scale cleanup</td></tr>
<tr><td>Vendor:
Construction: Monterey Mechanical; Woodward/Clyde
Operations: International Technology Corporation (ITC)</td><td rowspan="2">Technology:
Pump and Treat
- Groundwater is extracted using 25 wells, located on- and off-site, at an average total pumping rate of 480 gpm
- Extracted groundwater is treated with oil/water separation, air stripping, and carbon adsorption, and discharged to a surface water under a NPDES permit</td><td>Cleanup Authority:
CERCLA Remedial
- ROD Date: 9/30/89</td></tr>
<tr><td>State Point of Contact:
Dr. Wei Lui
CA RWQCB
Central Coast Region
81 Higuera St., Ste. 200
San Luis Obispo, CA 93401-5427
(805) 542-4648</td><td>EPA Point of Contact:
Elizabeth Adams, RPM
U.S. EPA Region 9
75 Hawthorne St.
San Francisco, CA 94105
(415) 744-2261</td></tr>
<tr><td>Waste Source:
Accidental releases of chemicals to soil and groundwater from a RCRA-permitted facility.</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Groundwater
- 1,800 million gallons treated
- Groundwater is found at near ground surface at the site
- Extraction wells are located in 3 aquifers, which are influenced by production wells in the area
- Hydraulic conductivity ranges from 100 to 1,200 ft/day</td></tr>
<tr><td>Purpose/Significance of Application:
Met goals within seven years of operation; site had relatively high hydraulic conductivity and was located near high-volume agricultural wells.</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
- Remedial goals were identified based on chemical-specific ARARs that included maximum contaminant levels (MCLs) and health-based restrictions. Remedial goals were established for 1,1-DCE (6 ug/L), 1,1-DCA (5 ug/L), TCE (3.2 ug/L), PCE (0.7 ug/L), benzene (0.7 ug/L), toluene (20 ug/L), and xylene (70 ug/L).
- A secondary goal of the system was to prevent migration of contaminants into the adjoining property.</td></tr>
<tr><td colspan="3">Results:
- 1,1-DCE was identified as the index contaminant to identify compliance with remedial goals for this site. Monitoring results showed that concentrations of this contaminant decreased from as high as 120 ug/L in 1986 to 4.8 ug/L in 1994 and 6 ug/L in 1995. From 1986 to 1992, 496 pounds of total VOCs had been removed from the groundwater.
- By 1987, monitoring data indicated that plume containment had been achieved. There had been some migration of contaminants noted in 1986, but an addition of five off-site wells in the deep aquifer in 1987 prevented further migration.</td></tr>
</table>

Pump and Treat of Contaminated Groundwater at the Former Firestone Facility Superfund Site, Salinas, California (continued)

Cost:

- Actual costs for pump and treat were $12,884,813 ($4,133,543 in capital and $8,751,270 in O&M), which correspond to $7 per 1,000 gallons of groundwater extracted and $26,000 per pound of contaminant removed.

Description:

The former Firestone facility operated as a tire manufacturing plant from 1963 until 1980. During pre-closure investigations of the facility's solid waste management units in 1983, 11 areas were investigated, and results showed that soil and groundwater were contaminated. A plume of VOCs was identified in the groundwater that extended 2.5 miles down-gradient. The site was placed on the NPL in July 1987 and a ROD was signed in September 1989.

The extraction system originally consisted of 25 wells installed both on- and off-site. In July 1987, five additional wells were installed off-site in the deep aquifer to prevent plume migration, and in October 1989, five additional wells were installed off-site in the intermediate zone to treat contamination in that area. The system design was performed using a computer model. The remedial goals at this site were met within approximately seven years of treatment. Site operators frequently adjusted the extraction system to maximize the removal of contaminants from the groundwater and maintain the highest possible level of contaminants in the influent stream to the treatment system.

Pump and Treat of Contaminated Groundwater at the JMT Facility RCRA Site, Brockport, New York

Site Name:
JMT Facility RCRA Site (formerly Black & Decker RCRA Site)

Location:
Brockport, New York

Contaminants:
Chlorinated solvents
- Maximum concentrations detected in March 1988 were TCE (70,000 ug/L) and 1,2-DCE (23,000 ug/L)

Period of Operation:
Status: Ongoing
Report covers: 5/88 - 12/97

Cleanup Type:
Full-scale cleanup (interim results)

Vendor:
Hydro Group, Inc. (1988-1997)
1011 Route 22
Bridgewater, NJ 08807
(908) 704-8882
O'Brien & Gere Operations, Inc. (1997-Present)
5000 Brittonfield Parkway
Syracuse, NY 13221
(315) 437-8800

Technology:
Pump and Treat
- Groundwater is extracted using 1 well, located on site, at an average total pumping rate of 11.2 gpm
- Extracted groundwater is treated with air stripping and discharged to a surface water under a SPDES permit
- An interceptor drain was artificially created in the bedrock around the extraction well using controlled blasting techniques

Cleanup Authority:
RCRA
- Corrective Action

State Point of Contact:
Larry Thomas
New York State Department of Environmental Conservation (NYSDEC)
50 Wolf Road
Albany, NY 12233-7252
(518) 457-9253

Site Contact:
Paul William Hare
Corporate Environmental Programs
General Electric Company
One Computer Drive South
Albany, NY 12205
(518) 458-6613

EPA Point of Contact:
Michael Infurna
U.S. EPA Region 2
290 Broadway
New York, NY 10007-1866
(212) 264-6150

Waste Source:
Leaks from surface impoundments/ drying beds

Type/Quantity of Media Treated:
Groundwater
- 50.1 million gallons treated as of December 1997
- DNAPL suspected in groundwater at this site
- Groundwater is found at 10 ft bgs
- The extraction well is located in 1 aquifer; the geology at this site was reported as very complex
- Hydraulic conductivity ranges from 0.65 to 0.93 ft/day

Purpose/Significance of Application:
RCRA corrective action site with relatively low groundwater flow; greater than 90% reduction in average concentrations of contaminants.

Pump and Treat of Contaminated Groundwater at the JMT Facility RCRA Site, Brockport, New York (continued)

Regulatory Requirements/Cleanup Goals:
- Cleanup goals were set at state groundwater standards as follows: TCE (5 ug/L), cis-1,2-DCE (5 ug/L), TCA (5 ug/L), and vinyl chloride (2 ug/L).
- The cleanup goals must be met in the single recovery well at the site and in point-of-exposure wells, of which there are currently 17.
- A goal of the recovery system is to achieve hydraulic containment of the plume.

Results:
- Concentrations of contaminants decreased by more than 80% from 1987 to 1997, but remain above cleanup goals.
- Although contaminants have been detected in off-site wells, NYSDEC and the owner/operator have concluded that the plume had been contained and the off-site contamination was believed to be residual contamination prior to pump and treat. The addition of a new extraction well and a treatment system is currently being evaluated.
- From 1988 to 1996, the system removed 842 pounds of contaminants from the groundwater.

Cost:
- Estimated costs for pump and treat were $2,163,000 ($879,000 in capital and $1,284,000 in O&M), which correspond to $47 per 1,000 gallons of groundwater extracted and $2,569 per pound of contaminant removed.
- Building an enclosure for the treatment system was a substantial cost (about 23% of capital); however, the efficiency of the overall system has improved, especially in the winter months, and less time is needed for shutdown due to inclement weather.

Description:
The JMT Facility was operated as an appliance manufacturing facility by G.E. Company from 1949 to 1984 and by Black and Decker from 1984 to 1986. JMT Properties, Inc., is the current owner of the site and leases the facility to Kleen-Brite. Kleen-Brite uses the facility for packaging and distributing household products such as laundry detergent and bleach. G.E. and Black and Decker operated an on-site RCRA treatment, storage, and disposal facility (TSDF) under interim status. In 1984, routine sampling revealed elevated levels of halogenated VOCs in the groundwater at the site. In August 1987, Black and Decker closed the regulated units and, in early 1988, initiated a corrective measures program for groundwater. In 1987, Black and Decker submitted a RCRA Post-Closure Permit application to NYSDEC; the permit was issued in April 1994.

The groundwater extraction system consists of one recovery well installed in 1987 as an interceptor well at the leading edge of the plume; the well placement was designed to prevent additional contaminants from migrating off site. To increase the degree of hydraulic conductivity and the interconnection in the bedrock fractures in the extraction well area, an interceptor drain was artificially created in the bedrock around the extraction well. The drain was created using controlled blasting techniques and rubblizing the upper portion of the bedrock. Data indicate that the pump and treat system has reduced the contaminant concentrations in the plume, however concentrations in much of the plume remain above the cleanup goals.

Pump and Treat of Contaminated Groundwater at the Keefe Environmental Services Superfund Site, Epping, New Hampshire

<table>
<tr><td>Site Name:
Keefe Environmental Services Superfund Site</td><td rowspan="2">Contaminants:
Chlorinated solvents
- Maximum concentrations included PCE (140 ug/L), TCE (210 ug/L), 1,1-DCE (1,200 ug/L)
Volatiles- nonhalogenated
- Maximum concentrations included benzene (160 ug/L)</td><td>Period of Operation:
Status: Ongoing
Report covers: 4/93 - 5/97</td></tr>
<tr><td>Location:
Epping, New Hampshire</td><td>Cleanup Type:
Full-scale cleanup (interim results)</td></tr>
<tr><td>Vendor:
David Didian
Woodward & Curran, Inc. (W&C)
41 Hutchins Drive
Portland, ME 04101
(207) 774-2112</td><td rowspan="2">Technology:
Pump and Treat
- Groundwater is extracted using 5 wells, located off site, and 1 trench, located on site, at an average total pumping rate of 23.4 gpm
- Extracted groundwater is treated with coagulation/flocculation and air stripping
- Treated groundwater is discharged to the groundwater through an infiltration trench and spray irrigation system</td><td>Cleanup Authority:
CERCLA Remedial
- ROD Date: 3/21/88
- ESD Date: 6/90</td></tr>
<tr><td>State Point of Contact:
Tom Andrews
NHDES
6 Hazen Drive
Concord, NH 03301
(603) 271-2910</td><td>EPA Point of Contact:
Darryl Luce, RPM
U.S. EPA Region 1
JFK Federal Building
One Congress Street
Boston, MA 02203
(617) 573-5767</td></tr>
<tr><td>Waste Source:
Storage of drums and containers, unauthorized dumping, leaking lagoon</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Groundwater
- 46 million gallons treated as of May 1997
- Extraction wells are located in 2 aquifers, which are not influenced by a nearby surface water
- Hydraulic conductivity ranges from 0.025 to 42.5 ft/day</td></tr>
<tr><td>Purpose/Significance of Application:
Performed optimization study after two years of operation; relatively low groundwater flow</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
- Cleanup standards were established for the upper overburden and bedrock aquifers on site and the sand and gravel aquifer off site. These standards were required to have been met in all monitoring wells in the respective aquifers for two consecutive sampling rounds.
- Cleanup standards were identified for 1,2-DCA (5 ug/L), 1,2-DCE (7 ug/L), TCE (5 ug/L), PCE (5 ug/L), and benzene (5 ug/L).
- The treatment system was required to meet the cleanup goals for groundwater re-injected into the aquifer.
- The extraction system must capture and contain the contaminant plume.</td></tr>
<tr><td colspan="3">Results:
- Average contaminant concentrations at the site have decreased 76% from April 1993 to October 1996. However, individual contaminant concentrations have not been reduced to below the cleanup goals.
- The P&T system has removed approximately 68 pounds of contaminants through February 1997.
- The treatment system has consistently met the performance standards established for this application.
- Plume containment has been achieved.</td></tr>
</table>

Pump and Treat of Contaminated Groundwater at the Keefe Environmental Services Superfund Site, Epping, New Hampshire (continued)

Cost:

- Actual cost data for this application show that approximately $2,408,000 ($1,582,539 in capital costs and $826,000 in O&M) were expended through May 1997, which correspond to $52 per 1,000 gallons of groundwater extracted and $35,000 per pound of contaminant removed.
- The mass removed through the treatment system may be significantly lower than the total mass extracted from the groundwater because of volatilization and other loses prior to the treatment plant; therefore, the cost per pound removed may be less than shown above.

Description:

Keefe Environmental Services operated from 1978 until 1981 as a spent solvent bulking, recovery, and reclamation facility. The facility consisted of drum storage areas, large bulk storage tanks, equipment shelters, a bulking area, and a 700,000-gallon, synthetically-lined waste lagoon. In 1979, a groundwater monitoring program began, and chlorinated solvents were detected. The site was added to the NPL in 1983 and a ROD was signed in March 1988. An ESD was issued in June 1990.

The current extraction system consists of four wells in the upper overburden aquifer, one well in the bedrock aquifer, and a collection trench. This extraction system was modified in 1995 (two years after startup) to optimize performance. Two wells were added and two others removed; locations for the new wells were selected to increase extraction rates. The treatment system consists of a coagulation/flocculation unit, an air stripping tower, and a vapor-phase carbon adsorption unit; the maximum design flow rate is 60 gpm. After four years of operation, the P&T system has reduced average contaminant concentrations within the plume and contained the plume from further migration. The site has not, however, met cleanup goals.

Groundwater Pump and Treat and Soil Vapor Extraction at DOE's Lawrence Livermore National Laboratory Site 300, GSA OU

<table>
<tr><td>Site Name:
Lawrence Livermore National Laboratory (LLNL)Site 300 - General Services Area (GSA) Operable Unit (OU)</td><td rowspan="2">Contaminants:
Volatile Organic Compounds:
- Trichloroethene (TCE)
- DNAPLs</td><td>Period of Operation:
6/91 - ongoing
(Data reported through July 1997)</td></tr>
<tr><td>Location:
Livermore, CA</td><td>Cleanup Type:
Full-scale</td></tr>
<tr><td>Vendor/Consultants:
Lockheed-Martin Energy Systems Inc.
Oak Ridge, TN

Weiss Associates
Emeryville, CA</td><td rowspan="2">Technology:
Eastern GSA pump and treat (P&T)
- Three extraction wells
- Treatment includes 5-micron particulate filter and three aqueous phase GAC units in series with a 50 gpm capacity
Central GSA pump and treat (P&T)
- 19 extraction wells - extract groundwater and soil vapor simultaneously
- Treatment includes shallow tray air stripper (50 gpm); 5-micron particulate filter; two vapor-phase GAC units; air emissions stack housed in a portable treatment unit
Central GSA Soil Vapor Extraction (SVE)
- Seven extraction wells
- 2-hp vacuum pump
- Four vapor-phase GAC units in series</td><td>Cleanup Authority:
CERCLA
- Removal action - 1991
- ROD date: not provided</td></tr>
<tr><td>Additional Contacts:
Michael G. Brown
Deputy Director
DOE/OAK Operations Office
L-574
Lawrence Livermore National Laboratory
Lawrence, CA 94551
(510) 423-7061

John P. Ziagos
Site 300 Program Leader
L-544
Lawrence Livermore National Laboratory
Lawrence, CA 94551
(510) 422-5479</td><td>Regulatory Point of Contact:
Information not provided</td></tr>
<tr><td>Waste Source: Waste buried in shallow trenches; disposal of wastewater in dry wells; leaks and spills</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Through July 1997:
Groundwater - a total of 93.8 million gallons of groundwater; 9.9 kg of VOC mass removed
Soil - 399,000 cubic feet of soil vapor; 30.5 kg of VOC mass removed</td></tr>
<tr><td>Purpose/Significance of Application: Combined use of groundwater pump and treat and SVE to remediate TCE and DNAPLs</td></tr>
</table>

Groundwater Pump and Treat and Soil Vapor Extraction at DOE's Lawrence Livermore National Laboratory Site 300, GSA OU (continued)

Regulatory Requirements/Cleanup Goals:
- Groundwater - reduce VOC concentrations to MCLs in all contaminated groundwater including a cleanup goal of 5 ug/L for TCE. The discharge limit is 0.5 ug/L for total VOCs.
- Soil - soil vapor of 0.36 ppmv; soil vapor remediation will continue until: 1) it is demonstrated that VOC removal from the vadose zone is no longer technically or economically feasible and 2) the VOC inhalation risk inside Building 875 is adequately managed.

Results:
- Maximum TCE groundwater concentrations had been reduced from pre-remediation levels ranging from as high as 240,000 ug/L at the site to levels of 13 ug/L (eastern GSA) and 33 ug/L (central GSA) as of May 1997. These levels are above the cleanup goal of 5 ug/L.
- Maximum TCE soil vapor concentrations had been reduced from a pre-remediation level of 450 ppmv to 2 ppmv as of May 1997, above the cleanup goal of 0.36 ppmv.
- The discharge limits have been met while the system was operating.

Cost:
- Total cost for GSA OU - $36.6 million, including $6.2 million for the Eastern GSA P&T and $32.4 million for the Total Central GSA P&T and SVE systems. The costs include preconstruction and construction activities and post-construction O&M.

Description:
Lawrence Livermore National Laboratory Site 300 is a DOE experimental test facility located near Livermore California. Craft shops and equipment fabrication and repair facilities in the General Services Area (GSA) used solvents as degreasing agents. In the eastern portion of the GSA, craft shop debris was buried in shallow trenches. In the central portion, rinse waters from operations were disposed of in dry wells. The results of site investigations, begun in 1982, identified VOC contamination in the soil and groundwater. Groundwater TCE concentrations have been detected as high as 74 ug/L in the eastern GSA and 240,000 ug/L in the central GSA. Groundwater TCE plumes have been identified in both areas. The highest pre-remediation concentration of TCE in soil in the central GSA were 360,000 ug/L. Remediation began in 1991 as a removal action. A Record of Decision was signed moving the cleanup to the remedial phase.

The remedy at the eastern portion of the GSA, begun in 1991, involves groundwater extraction using three wells and treatment using carbon adsorption. The system originally used air sparging; however, as VOC concentrations in the groundwater decreased, air sparging was replaced with carbon adsorption. After six years of operation, the system has removed 5.1 kg of VOC mass, treated 93 million gallons of groundwater and reduced the maximum TCE concentration in groundwater to 13 ug/L. The remedy for the central portion of the GSA included both groundwater extraction and treatment and SVE. The groundwater system, operated since 1993, had 19 extraction wells and includes air stripping for vapors and carbon adsorption for treatment of groundwater. After four years of operation, the system has removed 4.8 kg of VOC mass, treated 787,000 gallons of groundwater, and reduced maximum TCE levels to 33 ug/L. The SVE system, operated since 1993, has removed 30.5 kg of VOC mass and reduced TCE concentrations in the soil vapor to 2 ppmv. Levels of VOC remained above the cleanup goals as of 1997. Cyclic pumping is used to maximize VOC mass removal efficiency from all three systems. Results of modeling used to predict the timeframe for cleanup indicated that the SVE system would require 10 years and groundwater extraction and treatment 55 years.

The total cost for the three technologies at the GSA OU as of 1997 is $36.6 million. This includes preconstruction and construction activities and post-construction O&M. The costs for the Eastern GSA P&T system is $6.2 million. The cost for the Central GSA P&T and SVE systems is $32.4 million.

Pump and Treat of Contaminated Groundwater at the Mystery Bridge at Hwy 20 Superfund Site, Dow/DSI Facility, Evansville, Wyoming

Site Name:
Mystery Bridge at Hwy 20 Superfund Site, Dow/DSI Facility - Volatile Halogenated Organic (VHO) Plume

Location:
Evansville, Wyoming

Contaminants:
Chlorinated solvents
- Maximum concentrations detected in September 1989 were trans-1,2-DCE (500 ug/L), TCE (430 ug/L), PCE (540 ug/L), and 1,1,1-TCA (500 ug/L)

Period of Operation:
Status: Ongoing
Report covers: March 1994 through October 1997

Cleanup Type:
Full-scale cleanup (interim results)

Vendor:
Thomas J. Mueller, P.E.
Western Water Consultants, Inc.
611 Skyline Road
P.O. Box 4128
Laramie, WY 82071
(307) 742-0031

State Point of Contact:
Don Fisher
Solid and Haz. Waste Div.
Wyoming Dept. of Environmental Quality
1222 W. 25th Street
Cheyenne, WY 82002
(307) 672-6457

Technology:
Pump and Treat and Soil Vapor Extraction
- Groundwater is extracted using 3 wells, located on site, at an average total pumping rate of 103 gpm
- Extracted groundwater is treated with air stripping and reinjected using an infiltration trench with 600 ft of surface area
- SVE is used as a source control activity

Cleanup Authority:
CERCLA Remedial
- ROD Date: 9/24/90

EPA Point of Contact:
Lisa Reed Lloyd, RPM
U.S. EPA Region 8
999 18th Street, Suite 500
Denver, CO 80202-2466
(303) 312-6537

Waste Source:
Various contaminant releases, spills, and leaks

Purpose/Significance of Application:
Remedial strategy includes use of pump and treat for the on-site plume and natural attenuation for the off-site plume.

Type/Quantity of Media Treated:
Groundwater
- 192.8 million gallons treated as of December 1997
- Groundwater is found at 14-42 ft bgs
- Extraction wells are located in 1 aquifer at the site
- Hydraulic conductivity was reported as 340 ft/day

Regulatory Requirements/Cleanup Goals:
- The remedial goal is to reduce the levels of contaminants in the on-site, up-gradient portion of the groundwater plume to below MCLs such that the remainder of the plume off site meets MCLs through natural attenuation within a reasonable time limit.
- Remedial goals were established for TCE (5 ug/L), PCE (5 ug/L), trans-1,2-DCE (100 ug/L), cis-1,2-DCE (70 ug/L), 1,1-DCE (7 ug/L), and 1,1,1-TCA (200 ug/L).

Pump and Treat of Contaminated Groundwater at the Mystery Bridge at Hwy 20 Superfund Site, Dow/DSI Facility, Evansville, Wyoming (continued)

Results:
- Contaminant concentrations in all wells have declined significantly, yet remain above MCLs. Concentrations of contaminants in three out of four source area wells fell below their respective MCLs in the last two sampling events in 1996; in the fourth well, the total contaminant concentration was 9.4 ug/L.
- Wells in the down-gradient portion of the plume declined from March 1993 to December 1996, but in at least one well (225 ft down-gradient of the site boundary) individual contaminant concentrations remain significantly above their respective MCLs.
- Approximately 21 pounds of contaminants have been removed from the groundwater at this site.

Cost:
- Actual costs for groundwater remediation were $918,000 ($305,000 in capital and $613,000 in O&M), which correspond to $5.65 per 1,000 gallons of groundwater extracted and $44,000 per pound of contaminant removed.

Description:
Since 1958, the Dow/DSI facility was used as a base for oil field service operations. Dow/DSI used mobile pumps, tanks, and other equipment to perform services for the oil and gas industry. It is believed that wash water from equipment cleaning operations contained chlorinated solvents. In addition, a tank at the site was used to store large volumes of toluene, which was used for cleaning purposes and oil well servicing activities. In 1986, residents complained of poor water and air quality. In response, EPA conducted an Expanded Site Investigation, which led to the discovery of contaminants in the groundwater. The site was placed on the NPL in August 1990 and a ROD was issued in September 1990.

The remedial strategy at this site was to actively treat the on-site groundwater plume using pump and treat with air stripping, and to allow natural attenuation to reduce contaminant levels in the off-site portion of the plume to levels below the MCLs. In four years of operation, contaminant concentrations in all wells have declined significantly, yet remain above MCLs.

Groundwater Containment at Site LF-12, Offutt AFB, Nebraska

<table>
<tr><td>Site Name:
Site LF-12, Offutt AFB</td><td rowspan="2">Contaminants:
Volatile Organic Compounds (VOCs)
- Levels of VOCs in soil vapor included 18 ppm acetone, 0.077 ppm toluene, and 0.031 ppm xylene
- Contaminants in groundwater included 500 ppb TCE, 16,000 ppb DCE, 3.3 ppb chloroform, and 7 ppb bromodichloromethane</td><td>Period of Operation:
Not available; system was operating in January 1997</td></tr>
<tr><td>Location:
Nebraska</td><td>Cleanup Type:
Full-scale cleanup</td></tr>
<tr><td>Vendor:
Information not provided</td><td rowspan="2">Technology:
Hydrualic containment consists of three recovery wells. The system operates at an average flow rate of 105 gpm. Groundwater is treated with air stripping and effluent is discharged to a local POTW.</td><td>Cleanup Authority:
Installation Restoration Program</td></tr>
<tr><td>Additional Contacts:
U.S. Air Force Air Combat Command</td><td>Regulatory Point of Contact:
Information not provided</td></tr>
<tr><td>Waste Source: Disposal of refuse, waste solvents, and sewage sludge.</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Groundwater - Quantity treated not provided. Groundwater is encountered between 9 and 18 feet below ground surface.</td></tr>
<tr><td>Purpose/Significance of Application: Containment of groundwater using active pumping</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
Information on cleanup objectives was not included in this report.</td></tr>
<tr><td colspan="3">Results:
Limited performance data are available for this application. The volume of contaminant removed as of January 1997 was 12.81 gallons. The average concentration of TCE in the extracted groundwater was 151 ppb.</td></tr>
<tr><td colspan="3">Cost:
The capital cost for the system was $540,000. The O&M costs average $20,000 per year. Monthly O&M data were not provided.</td></tr>
</table>

Groundwater Containment at Site LF-12, Offutt AFB, Nebraska (continued)

Description:
Site LF-12 is located at Landfill 4 at Offutt AFB in Nebraska. An estimated 40,000 cubic yards of refuse, waste solvents, and sewage sludge were disposed at Landfill 4, resulting in contamination of soil and groundwater at the site. Low levels of VOCs, including acetone, toluene, and xylene, were detected in the soil vapor. TCE (500 ppb), DCE (16,000 ppb), chloroform (3.3 ppb), and bromodichloromethane (7 ppb) were detected in the groundwater.

A hydraulic containment system was installed at the site, and was operating as of January 1997. Information on the start date for the system was not provided. The system consists of three recovery wells, and operates at an average flow rate of 105 gpm. Groundwater is treated with air stripping and effluent is discharged to a local POTW. Only limited cost and performance data are available for this application. The volume of contaminant removed as of January 1997 was 12.81 gallons. The average concentration of TCE in extracted groundwater was 151 ppb.

The capital cost for the system was $540,000, including design, labor, equipment, materials, and startup. O&M costs average $20,000 per year and include electrical, monitoring, equipment and materials, and operations. No data on actual monthly O&M costs were provided.

Pump and Treat of Contaminated Groundwater at the Old Mill Superfund Site, Rock Creek, Ohio

Site Name:
Old Mill Superfund Site
(this site consists of two parcels of land - the Henfield property and the Kraus property)

Location:
Rock Creek, Ohio

Contaminants:
Chlorinated solvents
and volatiles - nonhalogenated
- Maximum concentrations detected in one plume (Henfield) were TCE (6,100 ug/L), PCE (300 ug/L), trans-1,2-DCE (460 ug/L0, and VC (14 ug/L)
- Maximum concentrations detected in other plume (Kraus) were ethylbenzene (19,000 ug/L) and xylenes (43,000 ug/L)

Period of Operation:
Status: Ongoing
Report covers: 9/89 - 7/97

Cleanup Type:
Full-scale cleanup (interim results)

Vendor:
Construction: Aptus Environmental Services, Inc.
Coffeyville, KS 67337
Operation & Maintenance:
Omprakash Patel
Roy F. Weston, Inc.
3 Hawthorn Pkwy, Suite 400
Vernon Hills, IL 60061-1450
(847) 918-4051

Technology:
Pump and Treat
- Groundwater is extracted using 3 wells and 5 trenches at an average total pumping rate of 3.1 gpm
- Extracted groundwater is treated with air stripping and carbon adsorption
- Treated groundwater is discharged to a surface water under a NPDES permit

Cleanup Authority:
CERCLA Remedial
- ROD Date: 8/7/85

State Point of Contact:
Mike Eberle
Ohio EPA
(216) 963-1126

EPA Point of Contact:
Ron Muraawski, RPM
U.S. EPA Region 5
77 W. Jackson Blvd.
Chicago, IL 60604-3590
(312) 886-2940

Waste Source:
Illegal waste disposal

Purpose/Significance of Application:
Relatively high unit cost, due to small quantity of groundwater extracted and low groundwater flow.

Type/Quantity of Media Treated:
Groundwater
- 13 million gallons treated as of 1997
- Groundwater is found at 5 ft bgs
- Extraction wells are located in 2 aquifers
- Hydraulic conductivity ranges from 0.22 to 1.25 ft/day

Regulatory Requirements/Cleanup Goals:
- Remedial goals were established for contaminants of concern that must be met throughout the site. These goals were based on achieving a carcinogenic risk level of 1×10^{-5}, and consist of 1,2-DCE (1.9 ug/L), TCE (15 ug/L), PCE (8.2 ug/L), and ethylbenzene (8,000 ug/L).
- Treatment system performance standards were established to meet NPDES permit requirements.
- The system was required to contain the plume and prevent off-site migration of contaminants.

Pump and Treat of Contaminated Groundwater at the Old Mill Superfund Site, Rock Creek, Ohio (continued)

Results:
- The 1997 annual sampling data indicate that the P&T system has contained the plume, but that contaminant concentrations in much of the plume remain above remedial goals. In addition, two hot spots remain problematic at this site, with TCE concentrations of 1,700 and 1,400 ug/L as of March 1997.
- The P&T system removed approximately 124 pounds of contaminants from 1990 to 1997.
- Treatment performance standards have been met consistently during this application.

Cost:
- Actual costs for the P&T system were approximately $3,236,000 ($1,596,000 in capital and $1,640,000 in O&M), which correspond to $250 per 1,000 gallons of groundwater extracted and $26,100 per pound of contaminant removed.
- The actual capital cost was approximately 22% higher than the original bid cost, due to a need to add collection trenches.

Description:
The Old Mill Superfund site includes two parcels of land, the Henfield and Kraus properties. The site was used for illegal disposal of drummed wastes for an undetermined number of years. In 1979, U.S. EPA and Ohio EPA found approximately 1,200 drums of waste including oils, resins, and PCBs on the Old Mill site. Drum and soil removal were completed in 1982 as a Superfund emergency removal action. Limited information is provided about site investigation activities, however, data are presented showing VOCs in the groundwater based on 1984 sampling data. The site was listed on the NPL in September 1983 and a ROD was signed in August 1985.

The P&T system has been designed to remediate plumes from both the Henfield and Kraus properties. The system consists of three deep recovery wells and five collection trenches. Extracted groundwater from both plumes is treated in one treatment plant, which consists of an 18-inch diameter air stripping tower and a granular activated carbon unit. In 1989 and 1994, the collection system was modified by adding collection trenches at the Kraus property needed to maintain containment. After eight years of P&T operation, the cleanup goals for this site have not been met. According to the RPM, the P&T system at this site does not appear to have the typical effect on groundwater contamination. New contaminants have been identified after the initial investigation and contaminant concentrations have increased at times during operations. The reasons for these events is not known at this time.

Pump and Treat of Contaminated Groundwater at the SCRDI Dixiana Superfund Site, Cayce, South Carolina

<table>
<tr><td>Site Name:
SCRDI Dixiana Superfund Site</td><td rowspan="2">Contaminants:
Chlorinated solvents
- Maximum concentrations detected during intial investigations were PCE (600 ug/L), TCE (130 ug/L), 1,1,1-TCA (560 ug/L), 1,1-DCE (470 ug/L), and 1,1,1,2-PCA (25 ug/L)</td><td>Period of Operation:
Status: Ongoing
Report covers: 8/92 - 3/97</td></tr>
<tr><td>Location:
Cayce, South Carolina</td><td>Cleanup Type:
Full-scale cleanup (interim results)</td></tr>
<tr><td>Vendor:
EPA Contractor: Ebasco Services, Inc.
PRP Project Coordinator: de maximis, Inc.
PRP contractor: S&ME, Inc.
PRP Operations Contractor: O&M, Inc.</td><td rowspan="2">Technology:
Pump and Treat
- Groundwater is extracted using 15 wells and a 300-ft shallow extraction trench, at an average total pumping rate of 40 gpm
- Extracted groundwater is treated with air stripping and discharged to a POTW</td><td>Cleanup Authority:
CERCLA Remedial
- ROD Date: 9/26/86</td></tr>
<tr><td>State Point of Contact:
Yanqing Mo
South Carolina DHEC
Bureau of Hazardous and Solid Waste
2600 Bull Street
Columbia, SC 29201</td><td>EPA Point of Contact:
Yvonne Jones, RPM
U.S. EPA Region 4
345 Courtland St., N.E.
Atlanta, GA 30365
(404) 562-8793</td></tr>
<tr><td>Waste Source:
Spills from poor waste handling practices, leaking drums</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated
Groundwater
- 20.6 million gallons treated as of March 1997
- Groundwater is found at 14 ft bgs
- Extraction wells are located in 4 aquifers, and all 4 aquifers are contaminated
- Hydraulic conductivity ranges from 5 to 45 ft/day</td></tr>
<tr><td>Purpose/Significance of Application:
Remediation at a site with complex hydrogeology, consisting of eight distinct hydrogeological units.</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
- Reduce the concentration of contaminants in the groundwater to primary drinking water standards or maximum contaminant levels (MCLs).
- Cleanup goals were established for 1,1,1-TCA (200 ug/L),TCE (5 ug/L), 1,1,2-TCA (5 ug/L), PCE (5 ug/L), 1,1,2,2-TCA (5 ug/L), 1,1-DCE (7 ug/L), chloroform (100 ug/L), carbon tetrachloride (5 ug/L), benzene (5 ug/L), and dichloromethane (5 ug/L)
- A secondary goal is to hydraulically contain the migration of contaminants in the groundwater.</td></tr>
</table>

Pump and Treat of Contaminated Groundwater at the SCRDI Dixiana Superfund Site, Cayce, South Carolina (continued)

Results:
- Groundwater monitoring results indicate that contaminant concentrations have not been reduced to below cleanup goals. Concentrations in the well with the highest concentration, however, have been reduced by approximately 81% since 1992.
- The plume was not contained from 1992 until November 1995. Hydrodynamic control of the plume has been maintained since November 1995.
- The P&T system has removed approximately 7 pounds of contaminants from the groundwater from 1992 to 1996.

Cost:
- Actual costs during the EPA-lead portion of the P&T system operation were approximately $1,439,700 ($1,189,700 in capital and $250,000 in O&M), which correspond to $464 per 1,000 gallons of groundwater extracted and $200,000 per pound of contaminant removed.
- Costs for the PRP-lead portion of the operation were $294,000 for capital and $180,000 for O&M.

Description:
South Carolina Recycling and Disposal Inc (SCRDI) operated this site as an industrial waste storage facility until 1978. The starting date of operations at this facility is not known. Waste materials stored on site included solvents, phenols, specialty chemicals, hydrogen peroxide, and pyridine. In 1978, SCRDI applied for a waste management permit from the South Carolina Department of Health and Environmental Control (SCDHEC). After a site visit, the permit was denied because of poor waste management practices, such as materials stored in leaking containers, drums stored in exposed conditions, and improper waste handling procedures. In June 1980, SCDHEC implemented a preliminary groundwater study to determine the extent of subsurface contamination. Analytical results from this study indicated that halogenated organic and metal contamination was found on site. The site was placed on the NPL in August 1982 and a ROD was signed in September 1986.

Two distinct remedial systems have operated at this site; one operated from August 1992 to June 1994 (EPA-lead portion), and the other from November 1995 to present (PRP-lead portion). A Supplemental Site Investigation (SSI) was performed in 1994 and a remedial system optimization study was performed in 1995; as a result the system was modified to include 15 extraction wells, a 300 ft shallow collection trench, and a shallow stacked tray air stripper.

The EPA portion of this application was based on RI results which did not accurately characterize the site. Based on these results, wells were screened in two lower groundwater units, but not in an upper, contaminated unit. In addition, during the EPA portion, wells were screened across two units, which allowed contaminants to migrate from one unit to the other, previously uncontaminated unit.

Groundwater Containment at Site OT-16B, Shaw AFB, South Carolina

<table>
<tr><td>Site Name:
Site OT-16B, Shaw AFB</td><td rowspan="2">Contaminants:
Organic Compounds - Chlorinated Solvents:
- Trichloroethene (TCE)
- Tetrachloroethene (PCE)
- one plume contains PCE and TCE; one plume contains TCE only</td><td>Period of Operation:
2/95 - 12/96</td></tr>
<tr><td>Location:
South Carolina</td><td>Cleanup Type:
Full-scale cleanup</td></tr>
<tr><td>Vendor:
IT Corporation</td><td rowspan="2">Technology:
Hydrualic containment through active pumping. One recovery well.</td><td>Cleanup Authority:
Installation Restoration Program</td></tr>
<tr><td>Additional Contacts:
U.S. Air Force Air Combat Command</td><td>Regulatory Point of Contact:
Information not provided</td></tr>
<tr><td>Waste Source: Fuel Spill</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Groundwater and free product - A total of 40.5 gallons of PCE and TCE were removed during this interim action.</td></tr>
<tr><td>Purpose/Significance of Application: Groundwater containment of chlorinated solvents using active pumping.</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
The operational objective of the interim action was to achieve hydraulic containment of the plume and to operate as efficiently as possible over a relatively long period of time.</td></tr>
<tr><td colspan="3">Results:
- Data on whether plume containment was achieved was not available. Therefore, the report presents results in terms of the efficiency of the contaminant that has been removed by the system through August 1997.
- A total of 40.5 gallons of TCE and PCE (14.2 gallons TCE and 26.3 gallons PCE) were removed during the interim action. Monthly removal rates ranged from 0.16 gallons to 4.85 gallons of contaminant.</td></tr>
<tr><td colspan="3">Cost:
The capital cost for the interim groundwater containment system was $1,960,000. The total cumulative O&M costs from February 1995 through August 1997 were about $50,000. Monthly O&M costs ranged up to $10,436. The average O&M cost per gallon of contaminant removed was $1,512.</td></tr>
</table>

Groundwater Containment at Site OT-16B, Shaw AFB, South Carolina (continued)

Description:
Site OT-16B , located at the Shaw AFB in South Carolina, is part of Operable Unit 2 at the site. The groundwater at Site OT-16B is contaminated with volatile organic compounds (VOCs) and two contaminant plumes were identified in the Upper Black Creek Aquifer at the site. One plume contained TCE and PCE ; the other contained TCE only. As part of an interim action at the site, a system was installed to provide hydraulic containment of these contaminant plumes through active pumping. The interim action system consisted of one recovery well which was operated from February 1995 through December 1996.

Data on whether the plumes had been contained was not available. Therefore, the performance data presented in the report focuses on the efficiency of contaminant removal by the system. Performance and cost data were provided from system startup in February 1995 through August 1997. During this time, a total of 40.5 gallons of TCE and PCE were removed from the groundwater, with monthly removal rates ranging from 0.16 gallons to 4.85 gallons. The total O&M costs through August 1997 was about $50,000. The average O&M cost per unit of contaminant removed was $1,512.

Groundwater Containment at
Sites SD-29 and ST-30, Shaw AFB, South Carolina

<table>
<tr><td>Site Name:
Sites SD-29 and ST-30, Shaw AFB</td><td rowspan="2">Contaminants:
Petroleum Hydrocarbons, Free Product (JP-4 fuel), Chlorinated Solvents
- estimated 60 gallons of JP-4 fuel spilled at SD-29; total petroleum hydrocarbon levels up to 592 ppm in soil at ST-30
- Free product in groundwater at both sites</td><td>Period of Operation:
3/95 - 2/96</td></tr>
<tr><td>Location:
South Carolina</td><td>Cleanup Type:
Full-scale</td></tr>
<tr><td>Vendor:
IT Corporation</td><td rowspan="2">Technology:
Interim action free product recovery systems at SD-29 and ST-30. The systems used pneumatic products skimmer pumps until 1/96. At that time, passive skimmer bailers were placed in the wells to reduce operating costs. Contaminated groundwater was treated using an air stripper.</td><td>Cleanup Authority:
Installation Restoration Program</td></tr>
<tr><td>Additional Contacts:
U.S. Air Force Air Combat Command</td><td>Regulatory Point of Contact:
Information not provided</td></tr>
<tr><td>Waste Source: Fuel spill and leaking supply line</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Groundwater and free product - A total of 102 gallons of free product were recovered</td></tr>
<tr><td>Purpose/Significance of Application: Interim action to recover free product from groundwater</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
The operational objective of the interim action free product source removal was to remove liquid-phase contamination as quickly and cost-effectively as possible to prevent continued contamination of surrounding soil and groundwater.</td></tr>
<tr><td colspan="3">Results:
- A total of 102 gallons of free-phase JP-4 fuel was recovered during the year the system was operated (97 gallons from ST-30 and 5 gallons from SD-29). Monthly removal rates ranged from 0 to 50 gallons of free product. By October 1995, the removal rates had decreased to below 5 gallons/month. By February 1996, the removal rate had become negligible and the system was shut down.</td></tr>
<tr><td colspan="3">Cost:
The capital cost for the SD-29 groundwater containment system was $394,000. Data on the capital cost for the ST-30 system were not available.
Data on O&M costs were reported as a total for both systems. The total cumulative cost for the SD-29 and ST-30 was $17,000. Monthly O&M costs ranged from $0 to $6,021. In January 1996, after removal rates had decreased, passive bailers were installed in the wells to reduce operating costs. The operating cost for February 1996 was $500.
The average O&M cost was $166/gallon of JP-4 recovered.</td></tr>
</table>

Groundwater Containment at Sites SD-29 and ST-30, Shaw AFB, South Carolina (continued)

Description:
Sites SD-29 and ST-30 at Shaw AFB, located in South Carolina, were the locations of soil and groundwater contamination as a result of leaks and spills of JP-4 fuel. An estimated 60 gallons of JP-4 fuel were spilled at site SD-29 when an oil/water separator pump failed. Eighty tons of soil were excavated from the site. In addition, the groundwater was determined to be contaminated with free phase JP-4 fuel, dissolved fuel components, and dissolved chlorinated solvents. A leaking jet fuel supply line was the source of contamination at the ST-30 site. Free phase JP-4 fuel was identified in the groundwater. Interim action groundwater containment systems were installed to remove free product and prevent continued contamination of surrounding soil and groundwater. The systems were operated from March 1995 through February 1996.

The groundwater containment systems included pneumatic product skimmer pumps to recover free product. These pumps were used until January 1996, when the removal rate has decreased and the system was evaluated to determine if operating costs could be reduced. Passive skimmer bailers were then installed to reduce operating costs. The system was shut down in February 1996, after the removal rates had remained negligible for several months. During the year of operation, a total of 102 gallons of JP-4 was recovered - 97 gallons from ST-30 and 5 gallons from SD-29. Monthly removal rates ranged from 0 to 50 gallons per month.

The total capital cost for the SD-29 system was $394,000. No data on capital costs were available for the ST-30 system. Data on O&M costs were reported as a total for the SD-29 and ST-30 systems. The total cumulative costs for the year of operation was $17,000. Monthly O&M costs ranged from $0 to $6,021. The operating cost for February 1996 was $500. The average O&M cost per unit of contaminant removed was $166/gallon of JP-4.

Pump and Treat of Contaminated Groundwater at the Solid State Circuits Superfund Site, Republic, Missouri

<table>
<tr><td>Site Name:
Solid State Circuits Superfund Site</td><td rowspan="2">Contaminants:
Chlorinated solvents
- Contaminants of greatest concern at this site are TCE, 1,1-DCA, 1,1-DCE, methylene chloride, 1,1,1-TCA, and vinyl chloride
- Maximum concentration of TCE was 290,000 ug/L</td><td>Period of Operation:
Status: Ongoing
Report covers: 1993 - 3/97</td></tr>
<tr><td>Location:
Republic, Missouri</td><td>Cleanup Type:
Full-scale cleanup (interim results)</td></tr>
<tr><td rowspan="2">Vendor:
Steve Chatman
Chatman & Associates
647 Massachusetts Ave., Ste. 211
Lawrence, KS 66044-2250
(785) 843-1006</td><td rowspan="3">Technology:
Pump and Treat
- Groundwater is extracted using 7 wells, 4 located on site and 3 located off site, at an average total pumping rate of 34 gpm
- Three wells have depths of 90 ft bgs, two wells of approximately 300 ft bgs, one of 600 ft bgs, and one of 985 ft bgs
- Groundwater extracted from on-site wells is treated with air stripping and discharged to a POTW
- Groundwater extracted from off-site wells is discharged without treatment to a POTW</td><td>Cleanup Authority:
CERCLA Remedial
- ROD Date: 9/27/89</td></tr>
<tr><td>EPA Point of Contact:
Steve Auchterlonie, RPM
U.S. EPA Region 7
726 Minnesota Avenue
Kansas City, KS 66101
(913) 551-7778</td></tr>
<tr><td>State Point of Contact:
Candice Hamil
Missouri Dept. Of Nat. Resources
205 Jefferson Ave., P.O. Box 176
Jefferson City, MO 65101
(314) 751-3176 or (800) 334-6946</td><td>Facility Engineer:
Greg Vierkant
Lucent Technologies
2101 West Chesterfield Blvd.
Suite C100-110
Springfield, MO 65807-8672
(417) 882-2211</td></tr>
<tr><td>Waste Source:
Storage of stripper and plating wastes in sump pit</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Groundwater
- 257 million gallons treated as of March 1997
- DNAPL suspected in groundwater on site
- Extraction wells are located in 3 aquifers, which are influenced by a nearby surface water
- Groundwater is characterized as a leaky artesian system occurring in karst formations, with three units identified at the site
- Hydraulic conductivity ranges from <0.01 to 1.62 ft/day</td></tr>
<tr><td>Purpose/Significance of Application:
Groundwater characterized as a leaky artesian system occurring in a karst formation.</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
- The remedial goals for this site are to reduce the TCE concentration in groundwater to 5 ug/L and maintain hydraulic control over the groundwater contaminant plume.
- Performance goals were that TCE levels in individual discharge points to the POTW were below 200 ug/L, and that average water levels and pump rates from specific wells be within specified ranges; these latter requirements were to ensure hydraulic containment.</td></tr>
</table>

Pump and Treat of Contaminated Groundwater at the Solid State Circuits Superfund Site, Republic, Missouri (continued)

Results:
- TCE concentrations in some of the wells have decreased from 1987 to 1996, and are below the cleanup goal in one well, however, TCE concentrations in most wells remain well above the cleanup goal.
- From March 1988 through March 1997, 2,754 pounds of TCE were removed from the groundwater.
- Plume containment has been achieved for this site.

Cost:
- Actual costs for the P&T system were approximately $2,510,400 ($893,700 in capital and $1,616,700 in O&M), which correspond to $10 per 1,000 gallons of groundwater extracted and $913 per pound of contaminant removed.
- The capital costs do not include the costs for installation of the four deeper wells; these costs were accounted for as part of the RI/FS and are not included in the total cost shown above.

Description:
From 1968 through November 1973, Solid State Circuits manufactured circuit boards and used TCE as a cleaning solvent in portions of its manufacturing process. Since 1973, the site was occupied by a number of tenants, including Micrographics, Inc., a photographic processing firm. In November 1979, a fire partially destroyed the building, and the debris was pushed into the basement under the remaining portion of the building. In June 1982, the Missouri Department of Natural Resources collected samples of water from the city's three municipal wells and detected elevated concentrations of TCE in one well located 500 ft from the site. In 1984, MDNR investigated the site and found elevated levels of TCE in the fill dirt and rubble from the basement, in a 540 ft deep well in the basement, and in shallow groundwater outside the building. The site was placed on the NPL in June 1986 and a ROD was signed in September 1989.

The groundwater is characterized as a leaky artesian system occurring in karst formations, with three units identified at the site, with shallow and deep bedrock zones extending up to 1,500 ft bgs. The groundwater extraction system consists of seven wells, one of which is a municipal well. Extracted groundwater is treated using air stripping. After nine years of operation, cleanup goals for TCE have not been achieved. Site operators are evaluating innovative technologies to enhance the remedial effort, such as air sparging using a horizontal well.

Pump and Treat of Contaminated Groundwater at the Sol Lynn/Industrial Transformers Superfund Site, Houston, Texas

<table>
<tr><td>Site Name:
Sol Lynn/Industrial Transformers Superfund Site</td><td rowspan="2">Contaminants:
Chlorinated solvents
- Maximum concentration of TCE detected in 1988 was 1,200 mg/L</td><td>Period of Operation:
Status: Ongoing
Report covers: 10/93 - 10/96</td></tr>
<tr><td>Location:
Houston, Texas</td><td>Cleanup Type:
Full-scale cleanup (interim results)</td></tr>
<tr><td>Vendor:
Clearwater Systems, Inc.
P.O. Box 822
New Caney, TX 77357
(713) 399-1980

Installation, Startup, and Operation Subcontractor:
Maxim Technologies, Inc.</td><td rowspan="2">Technology:
Pump and Treat
- Groundwater is extracted using 12 wells at an average total pumping rate of 8 gpm
- Extracted groundwater is treated with filtration (for iron), pH adjustment, air stripping, carbon adsorption, and filtration
- Treated groundwater is reinjected through 14 wells</td><td>Cleanup Authority:
CERCLA Remedial
- ROD Date: 9/23/88</td></tr>
<tr><td>State Point of Contact:
James Sher
TNRCC, Mail Code 144
12100 Park Circle
Austin, TX 78753
(512) 239-2444

Site Management:
John Kovski
Radian International LLC
9801 Westheimer, Suite 500
Houston, TX 77042
(713) 914-6426</td><td>EPA Point of Contact:
Ernest R. Franke, RPM
U.S. EPA Region 6
1445 Ross Ave., Suite 1200
Dallas, TX 75202-2733
(214) 665-8521</td></tr>
<tr><td>Waste Source:
Disposal of punctured trichloroethene drums on the ground surface</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Groundwater
- 13 million gallons treated as of October 1996
- DNAPL was suspected in groundwater at this site
- Groundwater is found at 20-25 ft bgs
- Extraction wells are located in 3 aquifers
- Hydraulic conductivity ranges from 0.14 to 25.5 ft/day</td></tr>
<tr><td>Purpose/Significance of Application:
Relatively high unit cost for treatment, due to high capital costs and small quantity of groundwater extracted.</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
- A remedial goal was established for TCE of 5 ug/L, based on the maximum contaminant level, that must be met throughout all affected aquifers.
- A goal for the extraction system is hydraulic containment of the plume.</td></tr>
</table>

Pump and Treat of Contaminated Groundwater at the Sol Lynn/Industrial Transformers Superfund Site, Houston, Texas (continued)

Results:
- From 1994 to 1996, concentrations of contaminants were reduced in some wells, but remain above the cleanup goal in the silty, shallow, and intermediate zone wells. In some shallow zone wells, concentrations have increased to higher than 1,000 ug/L over this period. Through 1996, approximately 4,960 pounds of contaminants have been removed from the groundwater. Further plume delineation was being performed at the time of this report.
- Hydraulic containment of the plume has not been achieved, according to the TNRCC manager.

Cost:
- Actual costs for pump and treat were $2,547,387 ($2,104,910 in capital and $442,477 in O&M), which correspond to $196 per 1,000 gallons of groundwater extracted and $514 per pound of contaminant removed.

Description:
Sol Lynn owned and operated this site as Industrial Transformers, a scrap metal and electrical transformer reclamation facility, from 1971 through 1978. Sol Lynn then leased the property to Ken James, who operated the site as Sila King, Inc., a chemical supply business, in 1979 and 1980. During the fall of 1971, the city of Houston Water Pollution Control Division discovered that workers at Industrial Transformers poured oil out of electrical transformers onto the ground during transformer dismantling. In 1981, reports of strong odors originating from the site were brought to the attention of the Texas Department of Water Resources. Upon inspection, approximately 75 punctured drums were found scattered about the property. A remedial investigation conducted from 1984 through 1991 showed elevated levels of PCBs in surficial soils and TCE in shallow soils and groundwater, and that the plume had migrated off site. The Sol Lynn/Industrial Transformer site was listed on the NPL in March 1989 and a ROD was signed in September 1988.

The extraction system used at this site consists of 12 wells - five wells in the silty zone, six wells in the shallow sand zone, and one well in a lower, intermediate aquifer. Eight of the 12 wells are located across the centerline of the plume along the site's northern boundary. This placement serves to intercept contaminated groundwater as it moves across the site and to draw back the off-site plume. As of 1996, concentrations of contaminants were reduced in some wells, but remain above the cleanup goal in the silty, shallow, and intermediate zone wells. Although remediation is not complete, the site engineers shut down the extraction system in October 1996. Extraction well pipes were leaking and fouled, and the extraction system lost plume containment. Currently, the site is being reevaluated. Aquifer usage, alternative remedial actions, and plume boundaries are being examined.

Pump and Treat of Contaminated Groundwater with Containment Wall at the Solvent Recovery Services of New England, Inc. Superfund Site Southington, Connecticut

<table>
<tr><td>Site Name:
Solvent Recovery Services of New England, Inc. Superfund Site</td><td rowspan="2">Contaminants:
Chlorinated solvents; semivolatiles - nonhalogenated; PCBs; and heavy metals
- Maximum concentrations detected in 1991 included TCE (41,000 ug/L), cis-1,2-DCE (110,000 ug/L), 1,1,1-TCA (320,000 ug/L), PCBs (85 ug/L), barium (3,510 ug/L), cadmium (76.9 ug/L), chromium (111 ug/L), lead (175 ug/L), and manganese (37,200 ug/L)</td><td>Period of Operation:
Status: Ongoing
Report covers: July 1995 through June 1998</td></tr>
<tr><td>Location:
Southington, Connecticut</td><td>Cleanup Type:
Full-scale cleanup (interim results)</td></tr>
<tr><td>Vendor:
NTCRA 1 Design Contractor:
Blasland, Bouck, & Lee, Inc (BBL)
Syracuse, NY
NTCRA 1 Const. Contractor:
BBL Environmental Services
NTCRA 1 Operations Contractor:
Handex of New England
PRP Oversight Contractor:
de maximis, Inc.
Bruce Thompson
PRP Project Manager
37 Carver Circle
Simsbury, CT 06070
(860) 651-1196</td><td rowspan="2">Technology:
Pump and Treat and Vertical Barrier Wall
- Groundwater is extracted using 12 wells at an average total pumping rate of 20 gpm
- Extracted groundwater is treated with addition of chemical (caustic), clarification, filtration, UV/oxidation, and activated carbon
- Treated groundwater is discharged to a surface water
- A sheet pile wall, 700 ft long, is located at the downgradient portion of the plume</td><td>Cleanup Authority:
CERCLA Removal
- Non-Time Critical Removal Action Memorandum: 4/1/93</td></tr>
<tr><td>State Point of Contact:
Mark Beskind
Connecticut Department of Environmental Protection
79 Elm Street
Hartford, CT 06106-5127
(860) 424-3018</td><td>EPA Point of Contact:
Karen Lumino, RPM
U.S. EPA Region 1
JFK Federal Building
One Congress Street
Boston, MA 02203
(617) 573-9635</td></tr>
<tr><td>Waste Source:
Waste lagoons, open pit incineration, incineration residuals handling, drum storage</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Groundwater
- 32.5 million gallons treated as of June 1998
- DNAPL was observed in several monitoring wells on site
- Depth to groundwater was not provided for this site
- Extraction wells are located in 2 aquifers, which are both heterogeneous and anisotropic
- Hydraulic conductivity ranges from 0.023 to 300 ft/day</td></tr>
<tr><td>Purpose/Significance of Application:
UV/oxidation has been effective at treating water contaminated with pure phase contaminants, including a mix of VOCs, PCBs, and metals.</td></tr>
</table>

Pump and Treat and Containment of Contaminated Groundwater at the Solvent Recovery Services of New England, Inc. Superfund Site Southington, Connecticut (continued)

Regulatory Requirements/Cleanup Goals:
- No cleanup goals or standards have been established as of the time of this report. A ROD is expected to be finalized in 1999, at which time cleanup standards will be set. The ROD is expected to incorporate a waiver of groundwater standards within the NAPL zone due to technical impracticability.
- A primary goal of the extraction system is to prevent migration of all contaminated overburden groundwater from the operations area at the site.

Results:
- Contaminant levels within the containment wall have not been reduced as DNAPL continues to dissolve into the aqueous phase.
- During the past three years, containment of the plume has been maintained the majority of the time, and wells down-gradient of the plume have not had increased contaminant levels. Containment was lost less than four days over the three years of operation.
- From July 1995 to July 1997, approximately 4,344 pounds of VOCs have been removed from the groundwater.

Cost:
- Actual costs for pump and treat were $5,556,900 ($4,339,600 in capital and $1,217,300 in O&M), which correspond to $265 per 1,000 gallons of groundwater extracted and $1,280 per pound of contaminant removed.
- Expedited review of design documents helped to minimize costs for this application.

Description:
Solvent Recovery Services of New England, Inc. (SRS) reclaimed spent industrial solvents for reuse or blending from 1955 until March 1991. Chemicals from site activities and process sludge were disposed of in two on-site unlined lagoons from 1955 until 1967, when they were closed. For several years thereafter, wastes were burned in an open pit incinerator at the southeastern corner of the operations area, and incinerator ash was used as fill at the facility. Operating practices for handling of spent solvents resulted in spills and leaks to the soils. From 1980 to 1982, EPA conducted numerous investigations of the SRS site. The site was placed on the NPL in September 1983 and a non-time critical removal action memorandum was signed in April 1993.

The groundwater containment system consists of 12 extraction wells and a down-gradient steel sheet pile wall that extends to the bedrock. Eleven wells are located along the interior of the wall, and one well is located in the center of the containment area. Containment of the plume has been maintained 98% of the time over a three year period. UV/oxidation has been effective at treating water contaminated with pure phase contaminants, including a mix of VOCs, PCBs, and metals, to levels that meet state discharge standards.

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GROUNDWATER PUMP AND TREAT (NONCHLORINATED CONTAMINANTS)

ABSTRACTS

Pump and Treat of Contaminated Groundwater at the Baird and McGuire Superfund Site, Holbrook, Massachusetts

<table>
<tr><td>Site Name:
Baird and McGuire Superfund site</td><td rowspan="3">Contaminants:
Volatiles - nonhalogenated (BTEX); semivolatiles - nonhalogenated; polycyclic aromatic hydrocarbons (PAHs, acenaphthene, naphthalene, 2,4-dimethylphenol); organic pesticides/herbicides (dieldrin, chlordane); heavy metals (lead); and nonmetallic elements (arsenic)
- Maximum initial concentrations measured at the site were VOCs (>1,000 ug/L), SVOCs (>10,000 ug/L); concentrations of specific contaminants not provided</td><td>Period of Operation:
Status: Ongoing
Report covers: 4/93 - 2/97</td></tr>
<tr><td>Location:
Holbrook, Massachusetts</td><td>Cleanup Type:
Full-scale cleanup (interim results)</td></tr>
<tr><td>Vendor:
Metcalf & Eddy Services
Walsh Contracting
Barletta Engineering

Treatment System Operator:
Tim Beauchemin
U.S. Army Corps of Engineers
696 Virginia Road
Concord, MA 01742-2751
(978) 318-8616</td><td>Technology:
Pump and Treat
- Groundwater is extracted using 6 wells, located on site, at an average total pumping rate of 60 gpm
- Extracted groundwater is treated with chemical treatment (addition of ferric chloride, lime slurry, phosphoric and sulfuric acids, and ammonium sulfate), clarification, aeration, filtration, and carbon adsorption
- Treated groundwater is reinjected through infiltration basins</td><td>Cleanup Authority:
CERCLA Remedial
- ROD Date: 9/30/86</td></tr>
<tr><td>State Point of Contact:
Harish Panchol
Massachusetts DEQE
(617) 292-5716</td><td>EPA Point of Contact:
Chet Janowski, RPM
U.S. EPA Region 1
John F. Kennedy Federal Building
One Congress Street
Boston, MA 02203
(617) 573-9623</td></tr>
<tr><td>Waste Source:
Surface impoundment/lagoon, hazardous materials storage, discharge to septic system, discharge to wetlands</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Groundwater
- 80 million gallons treated as of February 1997
- LNAPL observed in several monitoring wells on site
- Groundwater is found at 10-15 ft bgs
- Extraction wells are located in 3 aquifers, which are influenced by a nearby surface water
- Hydraulic conductivity ranges from 0.5 to 45 ft/day</td></tr>
<tr><td>Purpose/Significance of Application:
Groundwater contaminated with a wide variety of contaminants; relatively expensive remediation, with high capital costs for treatment system.</td></tr>
</table>

Pump and Treat of Contaminated Groundwater at the Baird and McGuire Superfund Site, Holbrook, Massachusetts (continued)

Regulatory Requirements/Cleanup Goals:

- Cleanup goals were established to be maximum contaminant levels (MCLs) as defined by the primary drinking water standards and the state of Massachusetts drinking waster quality criteria. Cleanup goals were established for benzene (5 ug/L), toluene (2,000 ug/L), ethylbenzene (680 ug/L), xylene (440 ug/L), 2,4-dimethyl phenol (2.12 ug/L), naphthalene (0.62 ug/L), acenaphthene (0.52 ug/L), dieldrin (0.000071 ug/L), chlordane (0.00046 ug/L), arsenic (0.05 ug/L), and lead (0.05 ug/L).
- Additional goals were to remediate the contaminated aquifer within a reasonable time to prevent present or future impacts to groundwater drinking water supplies, and to protect the Cochato River from future contaminant migration by establishing hydraulic containment of the plume.

Results:

- During the first two years of operation, the pump and treat system reduced average VOC and SVOC concentrations. From 1994 to 1995, average VOC concentrations decreased by 16% and average SVOC concentrations by 48%. However, contaminant concentrations in some individual wells did not decline over this period and concentrations have not been reduced to below treatment goals. As of December 1995, 2,100 pounds of organic contaminants have been removed from the groundwater.
- Contaminants have been detected in down-gradient monitoring wells and plume containment has not been achieved. A 1995 study made recommendations for achieving plume containment.

Cost:

- Actual costs for pump and treat were $22,726,000 ($14,958,000 in capital and $7,768,000 in O&M), which correspond to $284 per 1,000 gallons of groundwater extracted and $10,822 per pound of contaminant removed.
- Operating costs are relatively high because of the need to analyze for a large number of contaminants and the need for an operator to be on-site 24 hours per day.

Description:

Baird and McGuire Inc. conducted chemical mixing operations at this site from 1912 to 1983. Contamination of an on-site public drinking water well was first detected in 1982 by the town of Holbrook. Also in 1982, a citizen complaint of an oily substance in the Conchato River, which runs along the eastern boundary of the site led to an inspection by DEQE. This inspection revealed that a tank farm was not lined or diked, sewage waste, process waste, and surface water runoff were collected in an open cesspool; and a black oily substance was being discharged to on-site wetlands. During emergency removal actions by EPA in 1983 and 1985, a plume of VOCs and SVOCs was identified in the groundwater beneath the site. The site was added to the NPL in October 1982 and a ROD was signed in September 1986.

The groundwater extraction system consists of six wells placed in the part of the plume where the highest levels of contamination were detected. Groundwater treatment includes equalization and removal of free floating product, chemical treatment (with ferric chloride and lime in one stage, and phosphoric and sulfuric acids and ammonium sulfate in a second stage), flocculation/clarification, aeration, pressure filtration, and carbon adsorption, prior to discharge to infiltration basins. Above-ground biological treatment (using activated sludge) was included in the original design for this site, but was found to be not necessary, and deleted from the treatment system. After three years of operation, the system has not met the cleanup goals established for this site. In addition, the report discusses the impacts of having concurrent groundwater and soil remediation activities at this site.

UV Oxidation at the Bofors Nobel Superfund Site
Muskegon, Michigan

<table>
<tr><td>Site Name:
Bofors Nobel Superfund Site - Operable Unit 1</td><td rowspan="3">Contaminants:
VOCs and SVOCs
• Benzene, Benzidine, 2-Chloroaniline, 1,2-Dichloroethene, Trichloroethene, 3,3-Dichlorobenzidine, Aniline, Vinyl Chloride
• Selected Maximum concentrations in ug/kg – Benzene (60,000), 2-Chloroaniline (63,000), Aniline (10,000), 3,3-Dichlorobenzidine (2,600)</td><td rowspan="4">Technology:
Groundwater Extraction and On-Site treatment by UV Oxidation
• Groundwater is extracted from 13 wells at the site.
• Total flow rate from the network of wells ranges from 390 to 500 gpm.
• Extracted water was initially sent through a chemical precipitation step. This step has since been removed from the system.
• Treatment steps include: dual-media filtration, UV Oxidation, GAC treatment (polishing), pH adjustment, stripping for ammonia removal and neutralization.
• Treated water is discharged to an-onsite surface water body (Big Black Creek)</td></tr>
<tr><td>Location:
Muskegon, Michigan</td></tr>
<tr><td>Cleanup Type:
Groundwater Remediation</td></tr>
<tr><td>Project Management:
U.S. Army Corps of Engineers
Carl Platz
Grand Haven Area Office
P.O. Box 629
Grand Haven, Michigan 49417
(616) 842-5510</td><td>Period of Operation:
• Full-Scale Treatment System Operation since September 1994.
• Treatment Currently ongoing and expected to last 50+ years.</td></tr>
<tr><td>SIC Code:
2869 (Industrial Organic Chemicals)</td><td>Cleanup Authority:
CERCLA and State
ROD date
– September 17, 1990</td></tr>
<tr><td>Vendor:
Kevin Dulle
Sverdrup Environmental
400 South 4th Street
St. Louis, Missouri 63102
(314) 436-7600</td><td>Type/Quantity of Media Treated:
Groundwater
• 700 million gallons extracted since 1994.
• 7,500 pounds of organic contaminants removed from extracted groundwater</td><td>Waste Sources:
Disposal of process wastes in 10 unlined impoundments at the site</td></tr>
<tr><td colspan="2">Regulatory Requirements/Cleanup Goals:
The following list contains current discharge limits for selected contaminants. All limits have been established by MDEQ and are maximum allowable concentrations, based on weekly effluent sampling.
Purgeable Halocarbons - 5 ug/L (each)
Purgeable Aromatics - 5 ug/L (each)
Aniline - 5 ug/L
2-Chloroaniline - 10 ug/L</td><td>Regulatory Points of Contact:
John Fagiolo
USEPA Region V
77 West Jackson Blvd
Mail Code: SR6J
Chicago, Illinois 60604
(312) 886-0800

Dennis Eagle
MDEQ-ERD
Knapps Centre
P.O. Box 30426
Lansing, Michigan 48909
(517) 373-8195</td></tr>
<tr><td colspan="3">Purpose/Significance of Application:
The extraction and treatment system has successfully contained migration of contaminants from the site and consistently met discharge requirements since system startup in 1994.</td></tr>
</table>

UV Oxidation at the Bofors Nobel Superfund Site
Muskegon, Michigan(continued)

Results:	**Costs:**
• The extraction and treatment system is containing the groundwater contamination plume at the site. • Contaminant concentrations in the treatment system effluent have been consistently below surface water discharge limitations for the site.	The total capital cost for construction of the treatment system was $12,200,000. Yearly O&M costs average $763,000. Over three years, the capital plus O&M costs translate to $19.61 per 1,000 gallons of groundwater treated, or $1,830 per pound of organic contaminants removed. Yearly O&M costs translate to $3.27 per 1000 gallons of groundwater treated, or $305 per pound of organic contaminants removed.

Description:

For approximately 20 years, chemical process waste liquids and sludge were routinely disposed in 10 unlined surface impoundments at the site. In addition, impoundment berms occasionally failed, releasing sludge into nearby surface water bodies. In 1978, thirteen extraction wells were installed at the site to collect contaminated groundwater down gradient of the impoundments. Collected water was treated in an existing system located at a nearby facility, and was subsequently sent the local POTW for additional treatment. A Record of Decision (ROD) was signed in September 1990, specifying construction of a new on-site treatment system with UV oxidation as the primary treatment technology.

Under direction of the USACE, treatability testing and treatment system design were performed in 1991 and 1992. In 1992 a contract was awarded for construction of the treatment system. In September 1994, construction of the system was completed and full-scale treatment was begun. The treatment system originally consisted of: metals precipitation pretreatment, dual media filtration, UV oxidation treatment for removal of organics, GAC treatment (polishing), pH adjustment, stripping to remove ammonia and neutralization. After one year of operation, the metals precipitation step was determined to be unnecessary, and was removed from the treatment train. Treated water is discharged to an on-site surface water body (Big Black Creek).

The treatment system is currently in operation and is successfully containing groundwater contamination at the site. It is estimated that significant reductions in groundwater contaminant concentrations will not be realized until the sources of contamination (impoundment soils and sludge) are removed or isolated.

Pump and Treat of Contaminated Groundwater at the City Industries Superfund Site Orlando, Florida

Site Name:
City Industries Superfund Site

Location:
Orlando, Florida

Contaminants:
Chlorinated solvents and BTEX
- Initial contaminants of concern included 1,1,1-DCA, 1,1-DCE, methylene chloride, vinyl chloride, PCE, TCE, 1,1,1-TCA, benzene, toluene, ethylbenzene, acetone, MEK, MIBK, and phthalates
- Maximum concentrations detected in 1988 included 1,1-DCE (6,000 ug/L), acetone (146,000 ug/L), and MIBK (78,000 ug/L)

Period of Operation:
Status: Ongoing
Report covers: May 1994 through May 1997

Cleanup Type:
Full-scale cleanup (interim results)

Vendor:
Design: Jerry Peters
PEER Consultants P.C.
12300 Twinbrook Pkwy, Suite 410
Rockville, MD 20852
(301) 816-0700
Construction and O&M: ERM-EnviroClean, Inc.
250 Phillips Blvd #280
Ewing, NJ 08618
(609) 895-0050

Technology:
Pump and Treat with Air Stripping
- Extraction system consists of 13 recovery wells installed across the width of the initial contaminant plume
- Treatment includes an equalization/neutralization tank followed by an air stripping tower
- A network of 41 monitoring wells and 13 recovery wells are used to monitor quarterly changes in groundwater quality
- The actual average pumping rate for the system has been 195 gpm

Cleanup Authority:
CERCLA Remedial
- ROD Date: 3/29/90

State Point of Contact:
Don Harris
Florida DEP (FDEP)
Twin Towers Office Bldg.
2600 Blair Stone Road
Tallahassee, FL 32301
(904) 488-0190

EPA Point of Contact:
Pam Scully, RPM
U.S. EPA Region 4
345 Courtland St., N.E.
Atlanta, GA 30365
(404) 562-8898

Waste Source:
Improper disposal practices and unauthorized dumping

Type/Quantity of Media Treated:
Groundwater
- 151.7 million gallons treated as of May 1997
- No NAPL have been observed in monitoring wells on site
- Extraction wells are located in one aquifer at the site
- Hydraulic conductivity reported as 6.3936 ft/day

Purpose/Significance of Application:
The hydrogeology at this site is relatively simple and hydraulic conductivity relatively high, conditions which should lead to a successful application for pump and treat technology.

Pump and Treat of Contaminated Groundwater at the City Industries Superfund Site Orlando, Florida (continued)

Regulatory Requirements/Cleanup Goals:

- Cleanup goals are to remediate groundwater to levels set by the FDEP for the following constituents: acetone (700 ug/L), benzene (1 ug/L), 1,1-DCA (5 ug/L), 1,1-DCE (7 ug/L), cis-1,2-DCE (70 ug/L), trans-1,2-DCE (70 ug/L), ethylbenzene (700 ug/L), methylene chloride (5 ug/L), MEK (200 ug/L), MIBK (350 ug/L), PCE (3 ug/L), toluene (2,000 ug/L), 1,1,1-TCA (200 ug/L), TCE (3 ug/L), total phthalates (3 ug/L), and vinyl chloride (1 ug/L).
- The primary goal of the system is to achieve hydraulic containment of the plume.

Results:

- From May 1994 through May 1997, total concentrations of contaminants have been reduced 86% from 3,121 to 444 ug/L. However, concentrations of all VOCs remain above cleanup goals. In addition, concentrations of acetone, 1,1-DCE, and MIBK remain at persistently elevated concentrations. Through May 1997, approximately 2,700 pounds of contaminants have been removed from the groundwater.
- No contaminants have been detected in down-gradient monitoring wells since the beginning of remedial operations, and the plume has been contained.

Cost:

- Estimated costs for pump and treat were $1,674,800 ($1,094,800 in capital and $580,000 in O&M), which correspond to $10.60 per 1,000 gallons of groundwater extracted and $590 per pound of contaminant removed.

Description:

The City Industries site operated as a hazardous waste Treatment, Storage, and Disposal Facility (TSDF) from 1971 until 1983. From 1981 through 1983, EPA and county officials cited the facility for multiple violations of RCRA. In 1983, EPA, FDEP, and the county ordered the business to close, and the owner of the site abandoned the property. FDEP completed a multi-phased remedial investigation in May 1986. The site was listed on the NPL in March 1989 and a ROD was signed in March 1990.

The extraction system used at the site consists of 13 recovery wells installed across the width of the initial contaminant plume. Treatment includes an equalization/neutralization tank followed by an air stripping tower. Total concentrations of VOCs have declined 86% at this site, but remain above cleanup levels. The hydrogeology at this site is relatively simple and hydraulic conductivity relatively high, conditions which should lead to a successful application for pump and treat technology. According to the RPM, contaminant levels at the site in late 1997 and 1998 are lower than shown in the May 1997 monitoring data.

Pump and Treat of Contaminated Groundwater at the King of Prussia Technical Corporation Superfund Site Winslow Township, New Jersey

<table>
<tr><td>Site Name:
King of Prussia Technical Corporation Superfund Site</td><td rowspan="2">Contaminants:
Chlorinated solvents, BTEX, Heavy metals
- Contaminants of concern include 1,1-DCA, trans-1,2-DCE, 1,1,1-TCA, TCE, PCA, PCE, benzene, toluene, ethylbenzene, beryllium, chromium, copper, and nickel
- Maximum initial concentrations included PCE (2,500 ug/L), trans-1,2-DCE (12 ug/L), 1,1,1-TCA (2,200 ug/L), and chromium (1,040 ug/L)</td><td>Period of Operation:
Status: Ongoing
Report covers: April 1995 through December 1997</td></tr>
<tr><td>Location:
Winslow Township, New Jersey</td><td>Cleanup Type:
Full-scale cleanup (interim results)</td></tr>
<tr><td>Vendor:
Treatment System Vendor: Andco Environmental Processes, Inc.
Operations: Geraghty and Miller, Inc.</td><td rowspan="2">Technology:
Pump and Treat
- Groundwater is extracted using 11 wells at an average total pumping rate of 175 gpm in the upper aquifer and 25 gpm in the lower aquifer
- Extracted groundwater is treated with an electrochemical system for removal of heavy metals, and air stripping and granular activated carbon for removal of organics
- Treated groundwater is reinjected through infiltration trenches and galleries</td><td>Cleanup Authority:
CERCLA Remedial
- ROD Date: 9/9/90</td></tr>
<tr><td>Additional Contact:
Frank Opet
PRP Coordinator
Johnson Matthey
2001 Nolte Drive
West Deptford, NJ 08066
(609) 384-7222</td><td>EPA Point of Contact:
Jon Gorin, RPM
U.S. EPA Region 2
290 Broadway, 19th Floor
New York, NY 10007-1866
(212) 637-4361</td></tr>
<tr><td>Waste Source:
Discharge of waste to surface impoundment/lagoon; unauthorized dumping</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Groundwater
- 151.5 million gallons treated as of December 1997
- Groundwater is found at 15-35 ft bgs (shallow aquifer) and from 50-250 ft bgs (deep aquifer)
- Extraction wells are located in two aquifers
- Hydraulic conductivity ranges from 55 to 100 ft/day</td></tr>
<tr><td>Purpose/Significance of Application:
Treatment system consists of a treatment train designed for removal of metals and organics.</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
- The remedial goal for the site is to reduce contaminant concentrations to below maximum contaminant levels (MCLs) set by the New Jersey Safe Drinking Water Act and the primary drinking water standards. Cleanup goals were established for beryllium (4 ug/L), cadmium (10 ug/L), chromium (50 ug/L), copper (1,000 ug/L), mercury (2 ug/L), nickel (210 ug/L), zinc (5,000 ug/L), 1,1-DCA (2 ug/L), trans-1,2-DCE (10 ug/L), 1,1,1-TCA (26 ug/L), TCE (1 ug/L), PCA (1.4 ug/L), PCE (1 ug/L), benzene (1 ug/L), toluene (2,000 ug/L), and ethylbenzene (50 ug/L).
- The extraction system was designed to create an inward hydraulic gradient to contain the plume.</td></tr>
</table>

Pump and Treat of Contaminated Groundwater at the King of Prussia Technical Corporation Superfund Site Winslow Township, New Jersey (continued)

Results:
- Cleanup goals for metals and VOCs have been met in the deep aquifer and for all but some wells in the shallow aquifer (two for VOCs and four for metals). Groundwater monitoring data indicate that the plume appears to have been contained.
- From March 1995 through December 1997, the treatment system removed 1,510 pounds of organics and 3,910 pounds of metals, for a total mass removal of 5,420 pounds.

Cost:
- Actual costs for pump and treat were approximately $2,816,000 ($2,031,000 in capital and $785,000 in O&M), which correspond to $19 per 1,000 gallons of groundwater extracted and $520 per pound of contaminant removed.

Description:
The King of Prussia Technical Corporation operated as a waste disposal and recycling facility from January 1971 until early 1974, with six lagoons used to process industrial waste. EPA estimates that the company processed at least 15 million gallons of acid and alkaline wastes at this site. Drums of VOCs were buried at the site. In addition, trash and hazardous waste are suspected to have been dumped at the site illegally between 1976 and 1988 after the company stopped operations. Soil and groundwater contamination were detected by the state in 1976, and the site was added to the NPL in September 1983. A ROD was issued for this site in September 1990.

Groundwater is extracted at this site using six wells in the shallow aquifer and five wells in the deep aquifer. Extracted groundwater is treated with an electrochemical system for removal of heavy metals, and air stripping and granular activated carbon for removal of organics. Treated groundwater is reinjected through infiltration trenches and galleries. Cleanup goals for metals and VOCs have been met in the deep aquifer and for all but some wells in the shallow aquifer. As of December 1997, groundwater elevations have achieved steady-state under the current pumping scheme. The groundwater flow and contaminant transport will be reevaluated using models to evaluate remediation enhancements, including adding or removing extraction wells. In addition, the site operator is considering pumping changes.

Pump and Treat of Contaminated Groundwater at the LaSalle Electrical Superfund Site, LaSalle, Illinois

<table>
<tr><td>Site Name:
LaSalle Electrical Superfund Site</td><td rowspan="2">Contaminants:
PCBs and chlorinated solvents
- Maximum concentrations detected in 1980-1981 were PCBs (760,000 ug/L), TCE (13,341 ug/L), trans-1,2-DCE (7,152 ug/L), 1,1,1-TCA (3,123 ug/L), and vinyl chloride (500 ug/L)</td><td>Period of Operation:
Status: Ongoing
Report covers: 12/92 - 5/97</td></tr>
<tr><td>Location:
LaSalle, Illinois</td><td>Cleanup Type:
Full-scale cleanup (interim results)</td></tr>
<tr><td>Vendor:
Ecology & Environment, Inc.
ThermoCor Kimmons</td><td rowspan="2">Technology:
Pump and Treat
- Groundwater is extracted using 3 infiltration trenches, at an average total extraction rate of 17 gpm
- Extracted groundwater is treated with oil/water separation, air stripping, and carbon adsorption, and discharged to a POTW</td><td>Cleanup Authority:
CERCLA Remedial
- ROD Date: 3/30/88</td></tr>
<tr><td>Additional Contacts:
None</td><td>State Point of Contact:
Rich Lange
Illinois EPA (IEPA)
2200 Churchill Road
P.O. Box 19276
Springfield, IL 62794-9276
(815) 223-1126</td></tr>
<tr><td>Waste Source:
Spills from capacitor cleaning and spreading polychlorinated biphenyl (PCB)-laden waste oils as a dust suppressant</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Groundwater
- 23 million gallons treated as of May 1997
- DNAPL observed in groundwater on site
- Groundwater is found at 3-5 ft bgs
- Contaminants are primarily found in a shallow aquifer at the site
- Hydraulic conductivity ranges from <0.01 to 0.22 ft/day</td></tr>
<tr><td>Purpose/Significance of Application:
Relatively high unit cost; system consists of collection trenches instead of extraction wells; relatively low groundwater flow.</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
- The goal of this remedy is to restore the groundwater to primary drinking water standards; these are PCBs (0.5 ug/L), 1,2-DCE (5 ug/L), 1,1-DCA (5 ug/L), TCE (5 ug/L), PCE (100 ug/L), 1,1,1-TCA (200 ug/L), and vinyl chloride (2 ug/L).
- Containment was not a specific goal of this remediation.</td></tr>
<tr><td colspan="3">Results:
- Groundwater monitoring results for the deep aquifer (through March 1996) and shallow aquifer (through May 1997) indicate that total contaminant concentrations have not been reduced below cleanup goals. At specific monitoring wells, contaminant concentrations fluctuate with precipitation rates.
- From 1993 to September 1997, the system removed approximately 127 pounds of contaminants from the groundwater; 1,1,1-TCA makes up the majority of the mass removed by the treatment system.</td></tr>
</table>

Pump and Treat of Contaminated Groundwater at the LaSalle Electrical Superfund Site, LaSalle, Illinois (continued)

Cost:

- Actual costs for pump and treat are approximately $6,138,576 ($5,314,576 in capital and $824,000 in O&M), which correspond to $266 per 1,000 gallons of groundwater extracted and $48,000 per pound of contaminant removed.

Description:

LaSalle Electrical Utilities operated this site as a manufacturing facility for electrical equipment from 1940 to 1978. PCBs and chlorinated solvents were used in the manufacturing process during this time. As a result of complaints, government agencies issued several orders in 1975 against the company for its manufacturing and waste handling practices. In 1980 and 1981, Illinois EPA performed sampling at the site which confirmed the presence of PCB and VOC contamination in soils and groundwater. The site was placed on the NPL in December 1982 and a ROD was signed in March 1988.

The groundwater collection system is a passive design that uses three infiltration trenches instead of wells. The three trenches form an H-pattern, and drain to a wet well, which in turn is pumped to the treatment unit. The trenches were installed horizontally at a depth of approximately 17 to 25 ft bgs. Approximately 127 pounds of contaminants (primarily 1,1,1-TCA) have been removed from the groundwater over 45 months, however the system has not achieved the cleanup goals. As of May 1997, no design modifications were being considered for this site.

Pump and Treat of Contaminated Groundwater at the Mid-South Wood Products Superfund Site, Mena, Arkansas

<table>
<tr><td>Site Name:
Mid-South Wood Products Superfund Site</td><td rowspan="2">Contaminants:
Semivolatiles - halogenated: pentachlorophenol (PCP); PAHs; heavy metals (chromium); and nonmetallic elements (arsenic)
- Maximum concentrations detected during RI include PCP (10,230 ug/L), fluoranthene (263 ug/L), chrysene (37 ug/L), benzo(a)anthracene (35 ug/L), Cr (183 ug/L), and As (18 ug/L)</td><td>Period of Operation:
Status: Ongoing
Report covers: 9/89 - 12/97</td></tr>
<tr><td>Location:
Mena, Arkansas</td><td>Cleanup Type:
Full-scale cleanup (interim results)</td></tr>
<tr><td>Vendor:
Bill Fletcher
B&F Engineering, Inc.
928 Airport Road
Hot Springs National Park, AR 71913
(501) 767-2366</td><td rowspan="2">Technology:
Pump and Treat
- Groundwater is extracted using 15 wells, at an average total pumping rate of 24 gpm
- Extracted groundwater is treated with oil/water separation, filtration, and carbon adsorption, and discharged to a surface water under a NPDES permit</td><td>Cleanup Authority:
CERCLA Remedial
- ROD Date: 11/14/86</td></tr>
<tr><td>State Point of Contact:
Mike Arjmandi
Arkansas Department of Pollution Control & Ecology
P.O. Box 8913
8001 National Drive
Little Rock, AR 72219-8913
(501) 682-0852</td><td>EPA Point of Contact:
Shawn Ghose, RPM
U.S. EPA Region 6
(6SF-AP)
1445 Ross Avenue
Dallas, TX 75202-2733
(214) 665-6782</td></tr>
<tr><td>Waste Source:
Improper disposal, on-site spills</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Groundwater
- 100.6 million gallons treated as of December 1997
- DNAPL and LNAPL observed in groundwater at the site
- Extraction wells are located in 2 aquifers
- Hydraulic conductivities were not provided for this site</td></tr>
<tr><td>Purpose/Significance of Application:
Groundwater contaminated with wood treating chemicals; system optimization performed after eight years of operation; groundwater contamination had been reduced to one localized area of concern.</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
- The cleanup goal stated in the ROD was to treat the groundwater contamination to levels that posed no health or environmental risk. Remedial goals were specified for PCP (0.20 mg/L), benzo(a)anthracene (0.01 mg/L), benzo(a)pyrene (0.01 mg/L), benzo(b+k)fluoranthene (0.01 mg/L), chrysene (0.01 mg/L), arsenic (0.05 mg/L), and chromium (0.05 mg/L).
- The performance goal for the recovery system was to provide containment of the plume on site.</td></tr>
</table>

Pump and Treat of Contaminated Groundwater at the Mid-South Wood Products Superfund Site, Mena, Arkansas (continued)

Results:
- Groundwater contamination has been reduced to one localized area of concern. Between April 1989 and May 1996, average concentrations of total contaminants in the groundwater were reduced 32%, from 0.14 to 0.09 mg/L, with concentrations of contaminants reduced to below cleanup goals in 29 of 35 wells monitored in May 1996. It is estimated that the pump and treat system will operate for a minimum of five more years to reach the specified goals.
- Monitoring data indicate that the plume has been contained. Because contamination was found along rock fractures and not in a continuous plume, plume size reduction could not be measured. During the first seven years of operation, 363 kg of PCP were removed by the system; data were not provided to estimate mass removal for other contaminants.

Cost:
- Estimated costs for pump and treat were $1,212,600 ($465,300 in capital and $747,300 in O&M), which correspond to $13 per 1,000 gallons of groundwater extracted and $1,500 per pound of PCP contaminant removed.

Description:
The Mid-South Wood Products site was originally developed in the late 1930s to produce untreated wood posts. In 1955, the facility added pressure treating to its process, and from 1967 to 1977, the site was operated as a PCP and creosote wood treatment facility. In 1977, the PCP plant was abandoned and a new plant was built to treat the lumber with a chromated copper arsenate (CCA) wood treating process. From 1978 to 1981, the Arkansas Department of Pollution Control & Environment sampled drinking wells near the site, investigating the source of a fish kill that occurred in November 1976. The source was ultimately determined to be an unauthorized release of wastewater from a waste pond at the site. Further contamination of the site resulted when liquids and sludge from the pond were sprayed on and around land farm areas at the site. The site was placed on the NPL in 1983 and a ROD was signed in November 1986.

An interim extraction system was built in late 1984 and operated from early 1985 until 1989. The system consisted of three pairs of extraction wells and French drains, and was designed to collect contaminated groundwater from shallow depths where flow and contamination were expected to be the greatest. An expanded extraction system, which began operating in the summer of 1989, consisted of nine shallow extraction wells and six deep extraction wells (drilled into bedrock formations at depths up to 170 ft bgs). In February 1997, three major changes were made to optimize system operations. Five recovery wells were removed from operation, five other wells began a period of on-off operation (three months on, three months off), and the sampling frequency for 12 monitoring wells was decreased. Groundwater contamination at the site has been reduced but has not yet met all remedial goals. It is estimated that the pump and treat system will operate for a minimum of five more years to reach the specified goals.

Pump and Treat of Contaminated Groundwater at the Odessa Chromium I Superfund Site, OU 2 Odessa, Texas

<table>
<tr><td>Site Name:
Odessa Chromium I Superfund Site, Operable Unit 2 (OU 2)</td><td rowspan="2">Contaminants:
Heavy Metals (Chromium)
- Maximum concentration of Cr detected during 1985 sampling event was 72 mg/L</td><td>Period of Operation:
Status: Ongoing
Report covers: 11/93 - 1/98</td></tr>
<tr><td>Location:
Odessa, Texas</td><td>Cleanup Type:
Full-scale cleanup (interim results)</td></tr>
<tr><td>Vendor:
Design and Management: IT Corporation (ITC)
Construction and Oversight: WATEC</td><td rowspan="2">Technology:
Pump and Treat
- Groundwater is extracted using 6 wells at an average total pumping rate of 60 gpm
- Extracted groundwater is treated for Cr removal with chemical treatment (ferrous ion, produced on site), pH adjustment, flocculation, precipitation, and multimedia filtration
- Treated groundwater is reinjected through 6 injection wells</td><td>Cleanup Authority:
CERCLA Remedial
- ROD Date: 9/8/86</td></tr>
<tr><td>State Point of Contact:
Lel Medford
Texas Natural Resources Conservation Commission
P.O. Box 13087
Austin, TX 78711
(512) 239-2440</td><td>EPA Point of Contact:
Ernest Franke, RPM
U.S. EPA Region 6
First Interstate Bank Tower at Fountain Place
1445 Ross Avenue, Suite 1200
Dallas, TX 75202-2733
(214) 655-8521</td></tr>
<tr><td>Waste Source:
Improper disposal practices</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Groundwater
- 125 million gallons treated as of January 1998
- Groundwater is found at 30-45 ft bgs
- Extraction wells are located in 1 aquifer, which is influenced by production wells in the area
- Hydraulic conductivity ranges from 1.7 to 5.1 ft/day</td></tr>
<tr><td>Purpose/Significance of Application:
Includes on-site treatment for chromium; relatively low groundwater flow; contamination in one aquifer</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
- Remediate groundwater so that chromium levels are less than the maximum contaminant level (MCL) or primary drinking water standard.
- Prior to 1990, the drinking water standard for chromium was 0.05 mg/L; in 1990, EPA revised the drinking water standard to 0.10 mg/L.
- Treated effluent that is reinjected into the aquifer must have a chromium level of less than 0.05 mg/L.
- The remedial system was required to create an inward gradient toward the site to contain the plume.</td></tr>
<tr><td colspan="3">Results:
- Groundwater monitoring results indicate that chromium concentrations have been reduced compared to initial levels, but not to levels below the cleanup goal of 0.10 mg/L.
- Average chromium concentrations were reduced by 48% from January 1992 to January 1997.
- From December 1993 to 1996, 1,143 pounds of chromium have been removed from the groundwater.
- Treated effluent has met the required performance standard throughout treatment.
- Plume containment has been achieved since 1995; this was achieved after two monitoring wells were converted to recovery wells, and two other recovery wells were taken off line.</td></tr>
</table>

Pump and Treat of Contaminated Groundwater at the Odessa Chromium I Superfund Site, OU 2 Odessa, Texas (continued)

Cost:

- Actual costs for the P&T application were approximately $2,742,000 ($1,954,000 in capital and $728,000 in O&M), which correspond to $30 per 1,000 gallons of groundwater extracted and $2,400 per pound of contaminant removed.
- The ROD specified that the ferrous iron used in the treatment system be produced electrochemically, which limited the number of vendors to two and potentially increased the cost of the treatment system.
- The costs for design, construction, and operation of the P&T system were split 90:10 by EPA and TNRCC, respectively.

Description:

Metal plating and chrome plating facilities operated at this site from 1954 to 1977, producing chromium- and other metals-containing wastewater. In 1977, the TNRCC investigated citizen complaints of poor drinking water quality in private wells and discovered elevated levels of chromium in the groundwater. The chromium contamination was attributed to the discharge of chromium-containing wastewater into unlined dirt ponds, directly to the soils, and into a septic tank drain field; contaminants also are suspected to have migrated to the aquifer through an abandoned open well bore on the site. The Odessa I site was added to the NPL in September 1984, and a ROD for OU 2 was signed in September 1986. OU 1, not addressed by this case study, concerned providing for an alternate water supply to replace water previously supplied by contaminated wells.

The extraction system used at this site consisted of six extraction wells constructed in the Trinity Sand Aquifer to a depth of 138 ft bgs, each with a design yield of 14,400 gpd. Extracted groundwater was treated with ferrous iron (produced on site in an electrochemical cell), pH adjustment and aeration, clarification, and multi-media filtration. While chromium concentrations have been reduced to below the MCL in three wells, as of December 1996, groundwater cleanup goals have not been achieved throughout the site.

There were several startup problems that delayed full-scale operation at this site, including clogging of injection wells and filters by iron and calcium. These problems were solved through system modification and no longer interfere with operations.

Pump and Treat of Contaminated Groundwater at the Odessa Chromium IIS Superfund Site, OU 2 Odessa, Texas

<table>
<tr><td>Site Name:
Odessa Chromium IIS Superfund Site, Operable Unit 2 (OU 2)</td><td rowspan="2">Contaminants:
Heavy Metals (Chromium)
- Maximum concentration of Cr detected during 1986 sampling event was 50 mg/L (perched zone aquifer)</td><td>Period of Operation:
Status: Ongoing
Report covers: 11/93 - 12/97</td></tr>
<tr><td>Location:
Odessa, Texas</td><td>Cleanup Type:
Full-scale cleanup (interim results)</td></tr>
<tr><td>Vendor:
Design and Management: IT Corporation (ITC)
Construction and Oversight: WATEC</td><td rowspan="2">Technology:
Pump and Treat
- Groundwater is extracted using 10 wells at an average total pumping rate of 58.5 gpm
- Extracted groundwater is treated for Cr removal with chemical treatment (ferrous ion, produced on site), pH adjustment, flocculation, precipitation, and multimedia and cartridge filtration
- Treated groundwater is reinjected through 9 injection wells</td><td>Cleanup Authority:
CERCLA Remedial
- ROD Date: 3/18/88</td></tr>
<tr><td>State Point of Contact:
Lel Medford
Texas Natural Resources Conservation Commission
P.O. Box 13087
Austin, TX 78711
(512) 239-2440</td><td>EPA Point of Contact:
Ernest Franke, RPM
U.S. EPA Region 6
First Interstate Bank Tower at Fountain Place
1445 Ross Avenue, Suite 1200
Dallas, TX 75202-2733
(214) 655-8521</td></tr>
<tr><td>Waste Source:
Unlined wastewater-holding ponds and waste drum burial</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Groundwater
- 121 million gallons treated as of December 1997
- Groundwater is found at 30-45 ft bgs
- Extraction wells are located in 2 aquifers, which are influenced by production wells in the area
- Hydraulic conductivity ranges from 1.6 to 5.1 ft/day</td></tr>
<tr><td>Purpose/Significance of Application:
Includes on-site treatment for chromium; relatively low groundwater flow; contamination in two aquifers.</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
- Remediate groundwater so that chromium levels are less than the maximum contaminant level (MCL) or primary drinking water standard.
- Prior to 1990, the drinking water standard for chromium was 0.05 mg/L; in 1990, EPA revised the drinking water standard to 0.10 mg/L.
- Treated effluent that is injected into the aquifer must have a chromium level of less than 0.10 mg/L.
- The remedial system was required to create an inward gradient toward the site to contain the plume.</td></tr>
</table>

Pump and Treat of Contaminated Groundwater at the Odessa Chromium IIS Superfund Site, OU 2 Odessa, Texas (continued)

Results:
- Groundwater sampling results show that chromium levels have been reduced to less than 0.10 mg/L in the Trinity Aquifer but not in the Ogallala Aquifer. Results from January 1997 show that concentrations have been reduced in the Ogallala Aquifer (since startup), but not to levels below 0.10 mg/L.
- The P&T system removed 131 pounds of chromium from the groundwater from 1993 to December 1996.
- Effluent chromium levels have met the required performance standard of 0.10 mg/L throughout system operation.
- The plume has been contained in both aquifers.

Cost:
- Actual costs for the P&T system were approximately $2,487,700 ($1,927,500 in capital and $560,200 in O&M), which correspond to $26 per 1,000 gallons of groundwater extracted and $19,000 per pound of contaminant removed.
- The ROD specified that the ferrous iron used in the treatment system be produced electrochemically, which limited the number of vendors to two and potentially increased the cost of the treatment system.
- The costs for design, construction, and operation of the P&T system were split 90:10 by EPA and TNRCC, respectively.

Description:
Basin Radiator & Supply operated a radiator repair facility at this site from 1960 to the early 1970s. Wastewater containing chromium was discharged to unlined ponds, and waste radiator sludge containing chromium corrosion inhibitors was buried on the site. In 1977, the TNRCC discovered elevated levels of chromium in the groundwater during investigations conducted in response to citizen complaints of contaminated well water. This site later became known as the Odessa II South (S) site. The Odessa IIS site was placed on the NPL in June 1986, and a ROD was signed for the site in March 1988.

The extraction system used at this site consisted of six extraction wells constructed in the Trinity Sand Aquifer and four extraction wells in the Ogallala Formation. Extracted groundwater was treated with ferrous iron (produced on site in an electrochemical cell), pH adjustment and aeration, clarification, and multi-media and cartridge filtration. While chromium concentrations have been reduced to below the MCL in the Trinity Aquifer, groundwater cleanup goals have not been achieved in the Ogallala Formation.

There were several startup problems that delayed full-scale operation at this site, including clogging of injection wells and encrustation of the multimedia filter by iron and calcium. These problems were solved through system modification and no longer interfere with operations.

Groundwater Containment at Site FT-01, Pope AFB, North Carolina

<table>
<tr><td>Site Name:
Site FT-01, Pope AFB</td><td rowspan="2">Contaminants:
Total Petroleum Hydrocarbon (TPH), free product (JP-4 fuel):
- TPH concentrations in soil reported as high as 44,000 ppm
- 24,000 gallons of free product in groundwater</td><td>Period of Operation:
11/93 - ongoing (as of 4/98); projected completion in 2001
Data reported through November 1996</td></tr>
<tr><td>Location:
North Carolina</td><td>Cleanup Type:
Full-scale cleanup</td></tr>
<tr><td>Vendor/Consultant:
Parsons Engineering Science</td><td rowspan="2">Technology:
Free product recovery system consisting of four recovery wells and one trench. JP-4 is recovered using a pneumatic skimmer pump and stored in a product recovery tank.</td><td>Cleanup Authority:
Installation Restoration Program</td></tr>
<tr><td>Additional Contacts:
U.S. Air Force Air Combat Command</td><td>Regulatory Point of Contact:
Information not provided</td></tr>
<tr><td>Waste Source: Fuel Spill</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Groundwater and free product - the areal extent of the plume was estimated at 1.5 acres. Groundwater is encountered between 2 and 5 feet below ground surface. The total amount of free product removed as of November 1996 was 5,163 gallons of JP-4.</td></tr>
<tr><td>Purpose/Significance of Application: Recovery of free product from groundwater</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
The operational objective of the free product recovery was to remove liquid-phase contamination as quickly and cost-effectively as possible to prevent continued contamination of surrounding soil and groundwater.</td></tr>
<tr><td colspan="3">Results:
Data on system performance were available for the first three years of operation (through November 1996). The total amount of JP-4 product recovered during this time was 5,163 gallons. Monthly removal rates ranged from 1 to 650 gallons.</td></tr>
<tr><td colspan="3">Cost:
The capital cost for the system was $289,000. The total cumulative O&M costs from November 1993 through November 1996 was $66,600. According to the report, accurate month-to-month O&M data were not available; however, the average monthly O&M costs were reported as $1,800. After three years of operation, the average O&M costs per unit of contaminant removed was $12.90/gallon of JP-4.</td></tr>
</table>

Groundwater Containment at Site FT-01, Pope AFB, North Carolina (continued)

Description:
Site FT-01 is located at the Pope AFB in North Carolina. Soil and groundwater at the site were contaminated with JP-4 fuel. TPH concentrations as high as 44,000 ppm were detected in soil at the site. The areal extent of groundwater contamination was estimated to be 1.5 acres with an estimated 24,000 gallons of free product floating on the groundwater. In September 1993, 3,175 tons of contaminated soil were removed from the site. In November 1993, a free product recovery system were installed at the site to recover JP-4 fuel.

The free product recovery system included four recovery wells and one trench. A pneumatic skimmer pump was used to recover the JP-4, which was then stored in a product recovery tank. The system was operational at the time of this report (April 1998) and is expected to operate through 2001. Data on cost and performance are available for the first three years of operation (through November 1996). During this time, 5,163 gallons of JP-4 fuel was recovered, with the monthly removal rates ranging from 1 to 650 gallons. The report includes a graph of JP-4 recovered versus time. As of November 1996, the curve had not flattened, indicating that the operational objectives of the system were still being met.

The total capital cost for this system was $289,000. The total O&M costs through November 1996 were $66,600. Although accurate monthly O&M costs were not available, the average monthly O&M cost was $1,800. The average O&M cost per unit of JP-4 fuel recovered was $12.90 per gallon.

Groundwater Containment at Site SS-07, Pope AFB, North Carolina

<table>
<tr><td>Site Name:
Site SS-07, Blue Ramp Spill Site, Pope AFB</td><td rowspan="2">Contaminants:
Volatile Organic Compounds (VOCs), free product (JP-4 fuel)
- VOCs in soil detected as high as 1,000 ppm
- 75,000 gallons of JP-4 fuel estimated to be floating on groundwater</td><td>Period of Operation:
11/93 - ongoing (as of 4/98)
Data reported through November 1996</td></tr>
<tr><td>Location:
North Carolina</td><td>Cleanup Type:
Full-scale cleanup</td></tr>
<tr><td>Vendor/Consultant:
Parsons Engineering Science</td><td rowspan="2">Technology:
Free product recovery system consisting of a dual pump recovery system with one free product cut-off trench. JP-4 was recovered using pneumatic skimmer pumps and stored in a product recovery tank. The system operates at an average flow rate of 1 gallon per minute (gpm).</td><td>Cleanup Authority:
Installation Restoration Program</td></tr>
<tr><td>Additional Contacts:
U.S. Air Force Air Combat Command</td><td>Regulatory Point of Contact:
Information not provided</td></tr>
<tr><td>Waste Source: Fuel Spill</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Groundwater - Groundwater is encountered between 22.5 and 27 feet below ground surface.</td></tr>
<tr><td>Purpose/Significance of Application: Recovery of free product using active pumping</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
The operational objective of the free product recovery was to remove liquid-phase contamination as quickly and cost-effectively as possible to prevent continued contamination of surrounding soil and groundwater.</td></tr>
<tr><td colspan="3">Results:
Data on system performance were available for the first three years of operation (through November 1996). The total amount of JP-4 product recovered during this time was 3,516 gallons. Monthly removal rates ranged from one to 340 gallons.</td></tr>
<tr><td colspan="3">Cost:
The capital cost for the system was $394,000. The total cumulative O&M costs from November 1993 through November 1996 was $96,200. According to the report, accurate month-to-month O&M data were not available; however, the average monthly O&M costs were reported as $2,600. After three years of operation, the average O&M costs per unit of contaminant removed was $27.36/gallon of JP-4.</td></tr>
</table>

Groundwater Containment at Site SS-07, Pope AFB, North Carolina (continued)

Description:
Site SS-07, the Blue Ramp Spill Site, is located at the Pope AFB in North Carolina. Soil and groundwater at the site were contaminated with JP-4 fuel and VOCs. VOC concentrations as high as 1,000 ppm were detected in the vadose zone at the site, and the areal extent of the soil vapor plume was estimated to be 25 acres. Dissolved VOCs were detected in the groundwater and an estimated 75,000 gallons of free product was floating on the groundwater. In November 1993, a free product recovery system were installed at the site to recover JP-4 fuel.

The groundwater free product recovery system was a dual pump recovery system with one free product cut-off trench. JP-4 is recovered with pneumatic pumps and stored in a product recovery tank. The trench was extended in 1993 and again in 1995. The system was operational at the time of this report (April 1998) and is expected to operate for 40 years. Data on cost and performance are available for the first three years of operation (through November 1996). During this time, 3,516 gallons of JP-4 fuel was recovered, with the monthly removal rates ranging from 1 to 340 gallons. The report includes a graph of JP-4 recovered versus time. After April 1995, the curve began to flatten, indicating that the removal rate for the system is slowing. According to the report, it is recommended that the system be evaluated to determine how to increase product removal.

The total capital cost for this system was $394,000. The total O&M costs through November 1996 were $96,200. Although accurate monthly O&M costs were not available, the average monthly O&M cost was $2,600. The average O&M cost per unit of JP-4 fuel recovered was $27.36 per gallon.

Pump and Treat and Containment of Contaminated Groundwater at the Sylvester/Gilson Road Superfund Site Nashua, New Hampshire

<table>
<tr><td>Site Name:
Sylvester/Gilson Road Superfund Site</td><td rowspan="2">Contaminants:
Chlorinated solvents; volatiles - nonhalogenated; and heavy metals (selenium)
- Maximum concentrations detected in 1980 included methylene chloride (122,500 ug/L), chloroform (81,000 ug/L), tetrahydrofuran (1,000,000 ug/L), methyl ethyl ketone (80,000 ug/L), and toluene (140,000 ug/L)</td><td>Period of Operation:
Status: Ongoing
Report covers: 1982 through December 1995</td></tr>
<tr><td>Location:
Nashua, New Hampshire</td><td>Cleanup Type:
Full-scale cleanup (interim results)</td></tr>
<tr><td>Vendor:
Construction:
Weston
O&M:
Joe Fritsch
Metcalf & Eddy
57 Gilson Road
Nashua, NH 03062</td><td rowspan="2">Technology:
Pump and Treat; Vertical Barrier Wall; Cap; and Soil Vapor Extraction
- Groundwater was extracted using 14 wells, located on site, at an average total pumping rate of 265 gpm
- Extracted groundwater was treated with addition of chemicals (lime slurry), flocculation, clarification, mixed-media pressure filtration, air stripping (at elevated temperature (175 °F), and biological treatment (biological treatment was used for only 50 of the 265 gpm extracted)
- Treated groundwater was reinjected on- and off-site through recharge trenches
- A slurry wall, 4 ft wide, 4,000 ft long, and as much as 100 ft deep, encloses the 20-acre site
- A 40-mil HDPE synthetic cap covers the area inside the slurry wall
- The SVE system included 66 wells and a boiler/incinerator for destruction of VOCs</td><td>Cleanup Authority:
CERCLA Remedial
- ROD Dates: 7/29/82 and 9/22/83</td></tr>
<tr><td>State Point of Contact:
Tom Andrews
NHDES
6 Hazen Drive
Concord, MA 03301
(603) 271-2910</td><td>EPA Point of Contact:
Darryl Luce, RPM
U.S. EPA Region 1
JFK Federal Building
1 Congress Street
Boston, MA 02203
(617) 573-5767</td></tr>
<tr><td>Waste Source:
Waste disposal, drum burial, waste storage</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Groundwater
- 1,200 million gallons treated as of December 1995
- LNAPL (toluene) observed in several monitoring wells on site
- Depth to groundwater was not provided for this site
- Extraction wells are located in 3 hydrogeologic units which are influenced by a nearby surface water
- Hydraulic conductivity in the upper unit ranges from 30 to 50 ft/day</td></tr>
<tr><td>Purpose/Significance of Application:
ACLs have been met for all contaminants, with one exception. The exception has an ACL which is less than the state standard and below the analytical detection limit for that constituent.</td></tr>
</table>

Pump and Treat and Containment of Contaminated Groundwater at the Sylvester/Gilson Road Superfund Site Nashua, New Hampshire (continued)

Regulatory Requirements/Cleanup Goals:

- The remedial goal for this site were set as alternate concentration limits (ACLs) within the containment structure. ACLs were set at 10% of the maximum concentration detected, and consisted of the following: vinyl chloride (95 ug/L), benzene (340 ug/L), chloroform (1,505 ug/L), 1,1,2-TCA (1.7 ug/L), MEK (8,000 ug/L), chlorobenzene (110 ug/L), methylene chloride (12,250 ug/L), toluene (2,900 ug/L), 1,1-DCA (1.5 ug/L), trans-1,2-DCA (1,800 ug/L), 1,1,1-TCA (200 ug/L), methyl methacrylate (350 ug/L), selenium (2.6 ug/L), and phenols (400 ug/L).
- Risk-based concentration levels were set for groundwater outside of the containment structure.
- A performance goal for the remedial system was to prevent the contaminant plume from further migration.

Results:

- As of December 1995, the remedial action appears to have attained ACLs for all contaminants except 1,1-DCA. The levels of 1,1-DCA are less than the state standard of 81 ug/L and below the analytical detection limit; EPA is reportedly considering adjusting the ACL set for this contaminant. From 1986 through 1995, the system removed 427,000 pounds of contaminants from the groundwater.
- A net inward flow into the containment structure has been maintained, thus reducing downward migration of contaminants.

Cost:

- Actual costs for the remedial application at this site were $27,600,000 ($9,100,000 in capital and $18,500,000 in O&M), which correspond to $23 per 1,000 gallons of groundwater extracted and $64 per pound of contaminant removed.
- The high O&M costs for this site were attributed to the 300 gpm treatment system and the number of staff required to operate it. For many years, the site was staffed with 15 full-time personnel who operated the site 24 hours/day.

Description:

The Sylvester/Gilson Road site is a 2-acre site. Approximately six acres of the site was used as a sand borrow pit for an undetermined number of years. Illegal dumping was first discovered in 1970. Although the total amount of hazardous waste disposed at the site had not been determined, documents show that approximately 900,000 gallons of hazardous waste were discarded at the site during a 10-month period in 1979. It was estimated that the site was used for hazardous waste disposal for five years. In 1981, initial remedial investigations by the state showed high concentrations of heavy metals and organic compounds in the groundwater under the site. A ROD for this site was signed in July 1982 and a supplemental ROD in September 1983. In July 1990, EPA issued a ESD for this application.

The remedial application at this site consisted of a pump-and-treat system, vertical barrier wall, cap, and soil vapor extraction system. Groundwater was extracted using 14 wells, located on site, and treated with addition of chemicals, flocculation, clarification, mixed-media pressure filtration, air stripping, and biological treatment. A slurry wall encloses the 20-acre site, and a HDPE synthetic cap covers the area inside the slurry wall. To address an area with LNAPL (toluene) that was identified part-way through the application, a SVE system was installed that included 66 extraction wells. As of December 1995, the remedial action appears to have attained ACLs for all contaminants except 1,1-DCA.

Pump and Treat of Contaminated Groundwater at the United Chrome Superfund Site Corvallis, Oregon

<table>
<tr><td>Site Name:
United Chrome Superfund Site</td><td rowspan="2">Contaminants:
Heavy Metals (Chromium)
- Testing in 1983-1984 showed concentrations of chromium up to 3,619 mg/L in the shallow aquifer and up to 30 mg/L in the deep aquifer</td><td>Period of Operation:
Status: Ongoing
Report covers: August 1988 through March 1997</td></tr>
<tr><td>Location:
Corvallis, Oregon</td><td>Cleanup Type:
Full-scale cleanup (interim results)</td></tr>
<tr><td>Vendor:
Operations:
CH2M Hill, Inc.</td><td rowspan="2">Technology:
Pump and Treat
- Currently, groundwater is extracted using 9 wells in the upper aquifer and one well in the deep aquifer
- Pumping rates ranged from 4-11.5 gpm for the upper aquifer and 1.5-15.8 gpm for the deep aquifer
- Extracted groundwater was treated with a reduction and precipitation system until November 1994; since that time, extracted groundwater has been discharged to a POTW without on-site treatment</td><td>Cleanup Authority:
CERCLA Remedial
- ROD Date: 9/12/86</td></tr>
<tr><td>State Point of Contact:
Tom Penpraze
Utilities Division Manager
Public Works Dept.
City of Corvallis
P.O. Box 1083
Corvallis, OR 97339-1083</td><td>EPA Point of Contact:
Al Goodman, RPM
U.S. EPA Region 10
811 Southwest Sixth Ave.
Portland, OR 97204
(503) 326-3685</td></tr>
<tr><td>Waste Source:
Discharge to unlined disposal pit</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Groundwater
- 62 million gallons treated as of March 1997
- Groundwater is found at 0-10 ft bgs
- Extraction wells are located in two aquifers, with flow from the upper to lower aquifer and lower to upper at times during the year
- Hydraulic conductivity ranges from 0.5 to 60 ft/day</td></tr>
<tr><td>Purpose/Significance of Application:
Extracted groundwater was treated on-site at the beginning of this application; however, because concentrations dropped over time, on-site treatment was discontinued.</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
- Cleanup goals require a concentration for chromium of 10 mg/L in the upper aquifer and 0.10 mg/L in the deep aquifer.
- The system is also required to hydraulically contain the contaminant plume.</td></tr>
<tr><td colspan="3">Results:
- Chromium concentrations in both aquifers have been reduced. In the upper aquifer, average chromium concentrations have been reduced from 1,923 mg/L in August 1988 to 18 mg/L in March 1997. In the deep aquifer, average chromium concentrations have been reduced from 1.4 mg/L in August 1991 to 0.11 mg/L in March 1997. Cleanup goals for chromium have been met in 11 or 23 wells in the upper aquifer and six of seven wells in the deep aquifer.
- Approximately 31,363 pounds of chromium have been removed from the upper aquifer and 96 pounds from the deep aquifer, for a total of 31,459 pounds as of March 1997.</td></tr>
</table>

Pump and Treat of Contaminated Groundwater at the United Chrome Superfund Site Corvallis, Oregon (continued)

Cost:
- Actual costs for pump and treat were $4,637,160 ($3,329,840 in capital and $1,307,320 in O&M), which correspond to $75 per 1,000 gallons of groundwater extracted and $140 per pound of contaminant removed.
- Annual operating costs dropped by an order of magnitude when use of the treatment system was discontinued in 1992.

Description:
United Chrome products is a former industrial hard chrome plating facility that manufactured and repaired hard chrome plated parts from 1956 until early 1985. In 1956, a disposal pit for liquid waste was dug in the area west of the former on-site building, and chromium-laden wastewater was discharged to the pit from 1956 to 1982. In June 1983, EPA conducted a field investigation at the site, discovering chromium contamination in on-site surface water and soils. The site was placed on the NPL in September 1984 and a ROD was signed in September 1986.

Groundwater contamination was addressed in two phases. Phase 1 was directed at remediation of the upper aquifer and began in August 1988. Phase 2 was directed at remediation of the deep aquifer and began in September 1991. Currently, groundwater is extracted using nine wells in the upper aquifer and one well in the deep aquifer. Until November 1994, extracted groundwater was treated on site; since that time, extracted groundwater has been discharged to a POTW without on-site treatment. Chromium concentrations in both aquifers have been reduced, but have not yet met cleanup goals. Future operations of the groundwater extraction systems will be determined following a 1998 investigation of the remaining soil in the area of the former plating tanks and the disposal pit.

Pump and Treat of Contaminated Groundwater at the U.S. Aviex Superfund Site, Niles, Michigan

<table>
<tr><td>Site Name:
U.S. Aviex Superfund Site</td><td rowspan="2">Contaminants:
Chlorinated solvents and volatiles - nonhalogenated
- Maximum concentrations detected in 1985 sampling event were 1,1,1-TCA (200,000 ug/L), 1,2-DCA (1,600 ug/L), and diethyl ether (DEE, at 5,700 ug/L)</td><td>Period of Operation:
Status: Ongoing
Report covers: 7/93 - 12/96</td></tr>
<tr><td>Location:
Niles, Michigan</td><td>Cleanup Type:
Full-scale cleanup (interim results)</td></tr>
<tr><td>Vendor:
EPA Contractor:
Jack Brunner
Tetra Tech EM Inc.
200 East Randolph Dr, Suite 4700
Chicago, IL 60601
(312) 856-8700
Air Stripping Tower: LANTAC
Construction Subcontractor: ATEC Associates Inc.
2777 Finley Road, Unit 4
Downers Grove, IL 60515</td><td>Technology:
Pump and Treat
- Groundwater is extracted using 5 wells, located on site, at an average total pumping rate of 232 gpm
- Extracted groundwater is treated with air stripping and discharged to a surface water under a NPDES permit</td><td>Cleanup Authority:
CERCLA Remedial
- ROD Date: 9/7/88</td></tr>
<tr><td>State Point of Contact:
Carl Chavez
MDEQ
P.O. Box 30426
Lansing, MI 48909-7926
(517) 373-8174</td><td></td><td>EPA Point of Contact:
Ken Glatz, RPM
U.S. EPA Region 5
77 West Jackson Blvd.
Chicago, IL 60604-3507
(312) 886-1434</td></tr>
<tr><td>Waste Source:
Ruptured drums, leaking underground pipe</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Groundwater
- 329 million gallons treated as of December 1996
- DNAPL suspected in groundwater at this site
- Groundwater is found at 20 ft bgs
- Extraction wells are located in 1 aquifer
- Hydraulic conductivity ranges from 9.1 to 45.4 ft/day</td></tr>
<tr><td>Purpose/Significance of Application:
Performed modeling for system optimization (MODFLOW and Randomwalk).</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
- Remediate the groundwater to levels established by MDEQ and the maximum contaminant levels (MCLs) established by the SDWA.
- Cleanup goals include DEE (43 ug/L), 1,1,1-TCA (200 ug/L), 1,2-DCA (5 ug/L), 1,1-DCE (7 ug/L), TCE (5 ug/L), PCE (0.88 ug/L), benzene (5 ug/L), toluene (2,000 ug/L), ethylbenzene (680 ugL), and xylene (440 ug/L).
- A secondary goal of the system is to create an inward hydraulic gradient to contain the contaminant plume.</td></tr>
</table>

Pump and Treat of Contaminated Groundwater at the U.S. Aviex Superfund Site, Niles, Michigan (continued)

Results:
- The average concentration of total contaminants has decreased from 158 to 67 ug/L over 3 1/2 years of operation; however, contaminant concentrations have declined but remain above cleanup goals.
- Approximately 664 pounds of contaminants have been removed from the groundwater from September 1993 to December 1996.
- Plume containment has been maintained in this application; however, additional contamination has been identified outside of the original plume. This has been attributed to historically elevated levels not discovered during the RI/FS.

Cost:
- Actual costs for the P&T system from 1993-1996 were approximately $1,942,000 ($1,332,000 in capital and $610,000 in O&M), which correspond to $5 per 1,000 gallons of groundwater extracted and $2,925 per pound of contaminant removed.

Description:
The site was operated as a non-lubricating automotive fluids manufacturer from the early 1960s until 1978. Fluid manufacturing included repackaging of bulk products and formulation of new products from bulk ingredients. In July 1972, an underground pipe carrying diethyl ether (DEE) broke during excavation activities, releasing an unknown quantity to the soil and groundwater. In November 1978, a fire ruptured chemical-storing drums. The water used to extinguish the fire washed unknown amounts of chlorinated hydrocarbons onto unpaved areas. After the 1978 release, U.S. Aviex performed a groundwater investigation. The site was placed on the NPL in 1983 and a ROD was signed in 1988.

The pump and treat system currently in use at U.S. Aviex consists of five extraction wells installed to 100 ft bgs, and an air stripper 56 ft tall, 4 ft in diameter, and packed with plastic media. Groundwater monitoring data indicate that while maximum contaminant concentrations have dropped (up to 99% for 1,1,1-TCA), they remain above cleanup goals. In addition, contamination has been detected in wells down-gradient of the plume identified in the RI/FS, and EPA is in the process of further characterizing the plume.

Pump and Treat of Contaminated Groundwater at the Western Processing Superfund Site, Kent, Washington

<table>
<tr><td>Site Name:
Western Processing Superfund Site</td><td rowspan="2">Contaminants:
Chlorinated solvents; volatiles - nonhalogenated (toluene); PAHs; and metals
- Maximum initial concentrations of chlorinated solvents and metals were trans-1,2-DCE (390 mg/L), TCE (250 mg/L), cadmium (2.5 mg/L), nickel (280 mg/L), and zinc (510 mg/L)</td><td>Period of Operation:
Status: Ongoing
Report covers: 10/88 - 12/96</td></tr>
<tr><td>Location:
Kent, Washington</td><td>Cleanup Type:
Full-scale cleanup (interim results)</td></tr>
<tr><td>Vendor:
Contractors:
OHM Remediation Services, Corp. (Formerly CWM)
Landau Associates, Inc.</td><td rowspan="2">Technology:
Pump and Treat and Vertical Barrier Wall
- Groundwater is extracted on-site using 15 wells at an average total pumping rate of 190 gpm; this water is treated with air stripping and reinjected through an infiltration system
- Prior to 1996, groundwater was extracted using 210 shallow, vacuum-operated recovery well points
- A slurry wall (vertical barrier wall), 40 ft deep, encloses the 13-acre site
- Groundwater is extracted off-site using 3 wells at an average total pumping rate of 40 gpm; this water is treated with filtration and air stripping prior to reinjection or discharge to a POTW</td><td>Cleanup Authority:
CERCLA Remedial
- ROD Date: 9/85</td></tr>
<tr><td>PRP Contact:
Paul Johansen
Western Processing
20015 72nd Avenue South
Kent, Washington 98032
(425) 393-2565

State Point of Contact:
Christopher Maurer, P.E.
Washington Department of Ecology</td><td>EPA Point of Contact:
Lee Marshall, RPM
U.S. EPA Region 10
1200 Sixth Avenue(ECL-116)
Seattle, WA 98010
(206) 553-2723</td></tr>
<tr><td>Waste Source:
Unauthorized dumping, spills, and leaks from surface impoundments</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Groundwater
- 974 million gallons treated as of December 1996
- LNAPL observed and DNAPL suspected in groundwater at this site
- Groundwater is found at 5-10 ft bgs
- Extraction wells are located in 2 aquifers; the aquifers are influenced by a nearby surface water
- Hydraulic conductivity ranges from 1 to 100 ft/day</td></tr>
<tr><td>Purpose/Significance of Application:
Met goals for off-site plume within eight years of operation; shallow well points replaced recently with deeper wells to provide for containment; relatively large and expensive system.</td></tr>
</table>

Pump and Treat of Contaminated Groundwater at the Western Processing Superfund Site, Kent, Washington (continued)

Regulatory Requirements/Cleanup Goals:

- Groundwater cleanup goals were established in terms of surface water quality goals for Mill Creek (adjacent to the site), based on federal ambient water quality criteria. These goals were required to be met within three years. Surface water goals were established for cadmium (1.1 ug/L), chromium (207 ug/L), copper (11.8 ug/L), lead (3.2 ug/L), mercury (0.012 ug/L), nickel (158 ug/L), silver (0.12 ug/L), zinc (120 ug/L), cyanide (5.2 ug/L), and hardness (100 ug/L).
- Remedial goals for the off-site aquifer were established for cis-1,2-DCE (70 ug/L) and trans-1,2-DCE (70 ug/L).
- An ESD, issued in 1995, changed the focus of the remediation from site restoration to containment.

Results:

- Monthly monitoring data indicated that the surface water quality in Mill Creek met the established criteria by mid-1990. Further, concentrations for TCE, vinyl chloride, and zinc decreased in on-site wells by two orders of magnitude from 1988 to 1995. However, elevated concentrations of contaminants remain in on-site wells. As of June 1995, concentrations were reported as high as TCE (55,200 ug/L), DCE (14,600 ug/L), vinyl chloride (5,490 ug/L), cadmium (1,360 ug/L), and zinc (117,000 ug/L).
- The system achieved the cleanup goal for DCE in all three of the extraction wells located in the off-site plume. Concentrations of DCE have decreased in the off-site plume from above 2,000 ug/L in 1988 to less than 70 ug/L in January 1996. In addition, containment for the off-site plume has been achieved.
- A total of 102,000 pounds of contaminants have been removed from the groundwater during eight years of operation.

Cost:

- Actual costs for pump and treat were $48,730,000 ($16,032,629 in capital, including the slurry wall, and $32,697,483 in O&M), which correspond to $50 per 1,000 gallons of groundwater extracted and $478 per pound of contaminant removed.

Description:

This site operated as a waste processing facility from 1961 to 1983. Over 400 businesses transported industrial wastes to the site to be stored, reclaimed, or buried. Processes used at the site included recovery of metals from sludges and liquid wastes, spent solvent recovery, reprocessing of pickle liquor, and waste oil reclamation. In March 1981, during a RCRA audit, EPA first discovered violations of regulations governing waste storage, drum management, surface impoundments, and waste piles. Remedial investigations were conducted between 1983 and 1985. An initial ROD was issued in September 1985, and an amended ROD in September 1986.

Groundwater is extracted on-site using 15 well; this water is treated with air stripping and reinjected through an infiltration system. Prior to 1996, groundwater was extracted using 210 shallow, vacuum-operated recovery well points. Groundwater is extracted off-site using 3 wells; this water is treated with filtration and air stripping prior to reinjection or discharge to a POTW. The original approach to this site was an aggressive effort to fully restore the site to original conditions within seven years. Restoration was a priority and high costs were incurred to achieve this goal, including high operating costs. After eight years of pump and treat, the goal of restoration was changed to containment based on the technical impracticability of achieving full restoration.

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INNOVATIVE GROUNDWATER TREATMENT TECHNOLOGIES

ABSTRACTS

Enhanced Bioremediation of Contaminated Groundwater - Balfour Road Site, Brentwood, CA; Fourth Plain Service Station Site, Vancouver, WA; Steve's Standard and Golden Belt 66 Site, Great Bend, KS

<table>
<tr><td>Site Name:
Balfour Road Site
Fourth Plain Service Station Site
Steve's Standard and Golden Belt 66 Site</td><td rowspan="2">Contaminants:
Benzene, toluene, ethylbenzene, and xylenes (BTEX) and total petroleum hydrocarbons (TPH)</td><td>Period of Operation:
Balfour Road: December 1995 to present (report covers the period through October 1997)
Fourth Plain: July 1996 to present (report covers the period through October 1997)
Steve's Standard: July 1996 to present (report covers the period through October 1997)</td></tr>
<tr><td>Location:
Brentwood, CA
Vancouver, WA
Great Bend, KS</td><td>Cleanup Type:
Full-scale (Balfour Road and Fourth Plain)
Demonstration (Steve's Standard)</td></tr>
<tr><td>Vendor:
Steve Koenigsberg
Craig Sandefur
Regenesis Bioremediation Products, Inc.
27130A Paseo Espada, Suite 1407
San Juan Capistrano, CA 92675
(714) 443-3136</td><td rowspan="2">Technology:
Enhanced Bioremediation of Groundwater using ORC®
- ORC® (oxygen release compound) is a proprietary formulation based on magnesium peroxide and is available from Regenesis
- ORC® is applied to the groundwater using different methods and dosages (dosage based on several factors including the estimated mass of contaminant at the site and the specific properties of the aquifer)
- Details of the application method and dosage for each site are included in the report</td><td>Cleanup Authority:
State voluntary cleanup</td></tr>
<tr><td>Construction/Design:
Thomas Morin (Fourth Plain)
Environmental Partners Inc.
10940 NE 33rd Place, Suite 110
Bellevue, WA 98004
(206) 889-4747
Additional contacts in the report</td><td>State Contacts:
Joel Weiss
California Regional Water Quality Control Board
Central Valley Region
(916) 255-3077 (Balfour Road)
Carol Fleshes
Washington Department of Ecology
(206) 649-7000 (Fourth Plain)
Emily McGuire
Kansas Department of Health and Environment
(913) 296-7005 (Steve's Standard)</td></tr>
<tr><td>Waste Source: Various waste disposal practices, including leaks at service stations</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Groundwater - estimated 20,400 square feet for Fourth Plain; estimates were not provided for Balfour Road or Steve's Standard</td></tr>
<tr><td>Purpose/Significance of Application: Evaluate the cost and performance of ORC® to remediate groundwater at three petroleum-contaminated sites</td></tr>
</table>

Enhanced Bioremediation of Contaminated Groundwater - Balfour Road Site, Brentwood, CA; Fourth Plain Service Station Site, Vancouver, WA; Steve's Standard and Golden Belt 66 Site, Great Bend, KS

Regulatory Requirements/Cleanup Goals:
- Balfour Road - federal MCLs for groundwater.
- Fourth Plain - benzene - 0.005 mg/L, total BTEX - 0.095 mg/L and TPH -1.0 mg/L.
- Steve's Standard - no cleanup goals; demonstration project.

Results:
- Balfour Road and Fourth Plain sites - the cleanup goals had not been met at either the Balfour Road or Fourth Plain sites as of October 1997. The geometric mean concentration and mass of benzene, total BTEX, and TPH had been reduced by approximately 50 percent.
- Steve's Standard - over the first seven months of operation, the concentration and mass of benzene, total BTEX, and TPH had been reduced; however, over the next nine months, concentrations appeared to stabilize or rise slightly; a continuing source was identified at the site.

Cost:
- Total cost - $41,600 for Bafour Road; $37,300 for Fourth Plain; $96,000 for Steve's Standard.
- Treatment cost - $33,500 for Bafour Road; $35,700 for Fourth Plain; $93,400 for Steve's Standard (two service stations located next to each other).

Description:
Contamination at each site resulted from leaks in underground petroleum storage tanks and supply pipelines at or near retail dispensing locations. Refined petroleum product was released to the subsurface soil and groundwater at each site for unknown periods of time, until being detected in the 1990's. The three sites were cleaned up under their respective state voluntary cleanup programs. Oversight was performed by the respective state agency without involvement of EPA. Enhanced bioremediation using ORC® was selected by the lead contractors for each of the sites because it was expected to reduce the mass of contaminants in the aquifer by more than 50 percent in only six months, thereby reducing risk to human health and the environment from exposure to contaminated groundwater, and because it required a smaller capital investment and lower operating expenses than alternative technologies such as pump and treat. Regenesis indicated that enhanced bioremediation using ORC® was not expected to treat the groundwater to the federal maximum contaminant levels (MCL), but that the treatment would reduce substantially the dissolved-phase mass of contaminants present in the aquifer, as well as reduce sources characterized as moderate smear zones.

Enhanced bioremediation was performed at the three sites, using application of ORC®. ORC® is a proprietary formulation based on magnesium peroxide and is available from Regenesis Bioremediation Products, Inc. According to Regenesis, the quantity of ORC® required for a site is based on several factors including the estimated mass of contaminant at the site (dissolved-phase concentration) and the specific properties of the aquifer such as porosity and thickness. Details on the specific applications of this technology at each of the three sites in included in the report. As of October 1997, the cleanup goals had not been met at either the Balfour Road or Fourth Plain sites; however the geometric mean concentration and mass of benzene, total BTEX, and TPH had been reduced by approximately 50 percent in the aquifers in only 6 months for roughly $50,000 per site. In addition, at the Steve's Standard site, the concentration and mass of benzene, total BTEX, and TPH had been reduced in portions of the aquifer. The report presents a detailed summary of the progress at each site and the plans for future activities at the sites.

Coagulation/Flocculation/Dissolved Air Flotation and Oleofiltration™ at the Coastal Systems Station, AOC 1, Panama City, Florida

<table>
<tr><td>Site Name:
Coastal Systems Station, AOC 1</td><td rowspan="2">Contaminants:
Total Petroleum Hydrocarbon (TPH)
- concentrations in the bioslurper process wastewater ranged from 5,000 to 21,000 mg/kg
Metals - copper, lead, zinc</td><td>Period of Operation:
August 1997
(Demonstration conducted for a total of 448 hours)</td></tr>
<tr><td>Location:
Panama City, FL</td><td>Cleanup Type:
Demonstration</td></tr>
<tr><td>Vendor:
CRF/DAF:
Great Lakes Environmental Inc
315 S. Stewart Ave
Addison, IL 60101

Oleofiltration™:
North American Technologies Group Inc
4719 Bellaire Blvd, Suite 301
Bellaire, TX 77401</td><td rowspan="2">Technology:
CRF/DAF (Chemical reaction and flocculation and dissolved air flotation):
- DAF system (Model DAF-5) was a skid-mounted unit containing a flotation chamber, including a skimmer, sump, and air dissolving tank
- CRF system (Model CRF-15) included a two-stage chemical reaction tank, a polymer mix preparation tank, pumps, and mixers
- Oleofiltration™ treatment system included a conventional oil/water separator, coalescing unit, and ceramic granule filtration system</td><td>Cleanup Authority:
RCRA</td></tr>
<tr><td>Additional Contacts:
Naval Facilities Engineering Service
1100 23rd Avenue
Port Hueneme, CA 93043-4301</td><td>Regulatory Point of Contact:
Information not provided</td></tr>
<tr><td>Waste Source: Fire-fighting training using ignitable hydrocarbons</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Wastewater - 126,400 gallons</td></tr>
<tr><td>Purpose/Significance of Application: Demonstrate the effectiveness of CRF/DAF and Oleofiltration™ in treating TPH and metals from wastewater from a full-scale bioslurper system</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
The objective of the demonstration was to determine the ability of the two water treatment systems to remove emulsified oil/grease from a bioslurper wastewater stream. A secondary objective was to determine if the CRF/DAF system could effectively remove metals.</td></tr>
<tr><td colspan="3">Results:
- The CRF/DAF system removed more than 98% of TPH from the wastewater stream containing an influent concentration of 5,000 mg/kg TPH as compared to the Oleofilter™ which removed between 56% and 90% TPH.
- The CRF/DAF system removed 98.9% of lead and zinc and more than 90% of copper from the wastewater stream whereas the Oleofilter™ removed 75% lead and 71% zinc. In addition, the percent removal of metals by the Oleofilter™ was reported to have varied significantly from sample to sample. Copper concentrations in the influent to the Oleofilter™ were below detection limits; therefore, a percent removal could not be calculated.</td></tr>
</table>

Coagulation/Flocculation/Dissolved Air Flotation and Oleofiltration™ at the Coastal Systems Station, AOC 1, Panama City, Florida (continued)

Cost:
- The results of the demonstration were used to estimate full-scale costs. Short-term (6-month) operating costs were calculated for both systems, assuming that the equipment was leased. The estimated cost per month to lease and operate each system was $7,580 for the CRF/DAF (for a six-month total of $45,500) and $3,650 for the Oleofilter™ (for a six-month total of $21,900)
- Excluding lease rates, the monthly operating costs for the CRF/DAF and Oleofilter™ systems are estimated to be $3,650 and $1,150, respectively.
- Based on these estimates, the CRF/DAF system costs about twice as much to lease and operate as the Oleofilter™ system.

Description:
The Coastal Systems Station is located in Panama City, Florida along the St. Andrews Bay. AOC 1 is a former fire-fighting training area used from 1955 to 1978, where waste oil and other ignitable such as diesel, gasoline, JP-5 jet fuel, and paint thinner were used during fire training exericse. An estimated 63,000 gallons of flammable hydrocarbons were in this area and light, nonaqueous-phase liquid (LNAPL) was identified during the RCRA Facility Investigation. The Navy selected bioslurping to remove LNAPL from the subsurface. During a pilot-scale test, it was determined that the wastewater generated from the system contained high levels of emulsified hydrocarbons as well as high concentrations of copper, lead, and zinc; high levels also were expected in the full-scale bioslurping system. To identify a cost-effective treatment technology for the full-scale bioslurping system wastewater, the Navy selected two technologies, CRF/DAF and Oleofiltration™, for demonstration. The concentrations in the bioslurper wastewater during the demonstration were TPH as high as 27,000 ppm, and copper, lead, and zinc as high as 228 ppm, 1,430 ppm, and 6,210 ppm, respectively.

The CRF system included a two-stage chemical reaction tank, a polymer mix preparation tank, pumps, and mixers. The skid-mounted DAF system included a flotation chamber, including a skimmer, sump, and air dissolving tank. The 10 gpm capacity Oleofiltration™ treatment system included a conventional oil/water separator, coalescing unit, and ceramic granule filtration system. For the CRF/DAF system, the influent water flow rate was 1.5 to 6.5 gpm. The retention time for the two-stage CRF unit was 37 to 160 minutes for Stage 1 and 22 to 94 minutes for Stage 2. The retention time for the DAF unit was 13 to 55 minutes. For the Oleofiltration™ treatment system, the influent flow rate ranged from 5 to 7.5 gpm with a retention time of 25 to 37 minutes.

Pump and Treat and Permeable Reactive Barrier to Treat Contaminated Groundwater at the Former Intersil, Inc. Site, Sunnyvale, California

Site Name:
Former Intersil, Inc. Site

Location:
Sunnyvale, California

Contaminants:
Chlorinated solvents
- Maximum concentrations detected in 1986 were TCE (13,000 ug/L), cis-1,2-DCE (19,000 ug/L), Vinyl chloride (1,800 ug/L), and Freon-113 (16,000 ug/L)

Period of Operation:
Status: PRB Ongoing
Report covers:
- P&T: 11/87 - 2/95
- PRB: 2/95 - 11/97

Cleanup Type:
Full-scale cleanup (interim results)

Vendor:
Construction and Operations:
Scott Warner
Geomatrix Consultants, Inc.
100 Pine St., 10th floor
San Francisco, CA 94111
(415) 434-9400
P&T: Reidel Environmental Services/Delta Cooling Towers
PRB: EnviroMetal

Technology:
Pump and Treat and Permeable Reactive Barrier
- Groundwater was extracted using three wells and one trench well at an average total pumping rate of 8 gpm
- Extracted groundwater was treated with air stripping and discharged to an on-site storm sewer under a NPDES permit
- The permeable reactive barrier (PRB, treatment wall) is 100% granular iron, 4 ft thick, 40 ft wide, and approximately 13 ft deep; 2 slurry walls are used to route groundwater through the PRB

Cleanup Authority:
State cleanup
- Site cleanup requirements order: 10/15/86

Additional Contacts:
Deborah Hankins, Ph.D.
Intersil, Inc.
114 Sansome St., 14th floor
San Francisco, CA 94104
(415) 274-1904

State Point of Contact:
Habte Kifle
CA RWQCB
2101 Webster Street, #500
Oakland, CA 94612
(510) 286-0467

Waste Source:
Leakage from sub-grade neutralization system

Purpose/Significance of Application:
Used P&T for eight years, and replaced this technology with PRB; PRB used for three years.

Type/Quantity of Media Treated:
Groundwater
- 38 million gallons treated as of November 1996 (36 million by pump-and-treat and 2 million by PRB)
- Extraction wells are located in 1 aquifer, to a depth of 18 ft (depth to groundwater not provided)
- Transmissivity reported as 370 ft^2/day (hydraulic conductivity not provided)

Regulatory Requirements/Cleanup Goals:
- The cleanup goal for the site is to reduce contaminant concentrations throughout the aquifer to levels below the maximum contaminant levels (MCLs) set by the state of California and primary drinking water standards.
- Remedial goals were identified for vinyl chloride (0.5 ug/L), cis-1,2-DCE (6 ug/L), TCE (5 ug/L), and Freon-113 (1,200 ug/L).
- Effluent from the treatment system was required to meet the remedial goals prior to discharge.
- A secondary goal was identified to create an inward gradient to contain the plume.
- The primary goal for the PRB is to reduce contaminant levels in groundwater passing through the wall to the cleanup goals for the site.
- The secondary goal for the PRB is to contain the contaminant plume upgradient of the wall.

Pump and Treat and Permeable Reactive Barrier to Treat Contaminated Groundwater at the Former Intersil, Inc. Site, Sunnyvale, California (continued)

Results:
- The contaminant plume has been reduced in size at this site, however, contamination remains elevated at three hot spots.
- Average total contaminant concentrations have decreased from 1,609 ug/L in 1986 to 31 ug/L in 1997.
- By 2/95, the P&T system had removed 56 kg of contaminants from the groundwater; from 2/95 to 8/96, the PRB had removed 7 kg of contaminants from the groundwater.
- The contaminant plume has been contained.

Cost:
- Estimated costs for the P&T system from 1987 to 1995 were approximately $1,343,800 ($325,000 in capital and $1,018,800 in O&M), which correspond to $38 per 1,000 gallons of groundwater extracted and $10,900 per pound of contaminant removed.
- Estimated costs for the PRB system through 11/96 were approximately $762,000 ($5955,000 in capital and $167,000 in O&M), which correspond to $38 per 1,000 gallons of groundwater extracted and $49,400 per pound of contaminant removed.

Description:
Intersil operated at the site as a semi-conductor manufacturer from the early 1970s until 1983. The site is currently owned by Sobrato Development Company, and was released to another tenant in 1995. In 1972, Intersil installed a concrete, epoxy-lined, in-ground acid neutralization system at the facility to neutralize wastewater before discharge to a sanitary sewer. In 1982, the California Regional Water Quality Control Board (RWQCB) requested sampling of shallow groundwater and soil near the neutralization holding tank, and Intersil identified chlorinated solvents in the shallow groundwater and soil. Under a state program, a site cleanup requirements order was issued in October 1986.

A pump and treat (P&T) system was operated at this site from 1987 until 1995. The system consisted of three extraction and one trench wells. The wells were installed to a depth of 18 ft and had a design yield of 6 gpm. Extracted groundwater was treated with an air stripper designed to handle a maximum of 40 gpm.In 1993, Intersil examined alternative groundwater remediation technologies based on achievement of two goals. Intersil wanted to minimize the cost of treatment while increasing treatment effectiveness, given that the mass removal by the P&T system had asymptotically declined, and to return the site to leasable/sellable conditions. The selected alternative, approved by the RWQCB, was a PRB. The treatment technologies used at this site have removed contaminant mass and reduced concentrations in the aquifer; however, site cleanup goals have not yet been met.

Pump and Treat and In Situ Bioremediation of Contaminated Groundwater at the French Ltd. Superfund Site, Crosby, Texas

<table>
<tr><td>Site Name:
French Ltd. Superfund Site</td><td rowspan="2">Contaminants:
Chlorinated solvents and Volatiles - nonhalogenated
- Contaminants of concern in the groundwater were benzene, toluene, chloroform, 1,2-DCA, and vinyl chloride
- Initial maximum concentrations were benzene (19,000 ug/L), 1,2-DCA (920,000 ug/L), and vinyl chloride (8,200 ug/L)</td><td>Period of Operation:
Status: Ongoing
Report covers: January 1992 through December 1995</td></tr>
<tr><td>Location:
Crosby, Texas</td><td>Cleanup Type:
Full-scale cleanup (interim results)</td></tr>
<tr><td>Vendor:
Prime Contractor:
Jon McLeod
CH2M Hill
(512) 346-2001
Treatment System Vendor:
Mike Day, President
Applied Hydrology Associates, Inc.
Denver, CO</td><td rowspan="2">Technology:
Pump and Treat with activated sludge for extracted groundwater; in situ bioremediation for contaminated groundwater
- Active remediation conducted from January 1992 through December 1995 consisted of extraction and above-ground treatment, enhanced aquifer flushing through pressure injection of clean water, and accelerated in situ bioremediation through the addition of oxygen, phosphorus, and nitrate.
- Source control was achieved by installation of cutoff (sheet-pile) walls around lagoon and DNAPL source areas.
- Since December 1995, active pumping was stopped and natural attenuation has been used to reduce remaining concentrations of contaminants. Limited pumping began in March 1998.</td><td>Cleanup Authority:
CERCLA Remedial
- ROD Date: 3/24/88</td></tr>
<tr><td>State Point of Contact:
Emmanuel Ndame
TNRCC
(512) 239-2444

PRP: Richard Sloan
ARCO Chemical Company
FLTG Project Coordinator
15010 FM 2100, Ste. 200
Crosby, TX 77532
(713) 328-3541</td><td>EPA Point of Contact:
Ernest Franke, RPM
U.S. EPA Region 6
1445 Ross Avenue
Dallas, TX 75202-2733
(214) 665-6739</td></tr>
<tr><td>Waste Source:
Unlined disposal pit (lagoon)</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Groundwater
- 306 million gallons of groundwater and surface treated as of December 1995
- Groundwater is found at 10-12 ft bgs
- Extraction wells are located in two aquifers
- Hydraulic conductivity ranges from 0.283 to 2.835 ft/day</td></tr>
<tr><td>Purpose/Significance of Application:
Regulatory requirements for this site based on use of modeling results to show effects of natural attenuation at the site boundary 10 years after pump and treat completed.</td></tr>
</table>

Pump and Treat and In Situ Bioremediation of Contaminated Groundwater at the French Ltd. Superfund Site, Crosby, Texas (continued)

Regulatory Requirements/Cleanup Goals:

- According to the 1988 ROD, "groundwater recovery and treatment will continue until modeling shows that a reduction in the concentration of volatile organics to a level which attains the 10^{-6} human health criteria at the site boundary can be achieved through natural attenuation in 10 years or less." In response, remedial goals were established for vinyl chloride (2 ug/L), benzene (5 ug/L), toluene (1,000 ug/L), 1,2-DCA (100 ug/L), and chloroform (100 ug/L).
- A primary goal of the remedial system was plume containment, accompanied by in situ bioremediation and source control using sheet-pile walls.

Results:

- A modeling study conducted in late 1995 demonstrated that natural attenuation would reduce groundwater contaminant concentrations below the remedial goals at the site boundary within 10 years after system shut-off. As a result, EPA allowed the groundwater recovery and treatment operations to be shut down in December 1995.
- Average concentrations of 1,2-DCA, vinyl chloride, and benzene had been reduced to approximately 1 ug/L in the twp aquifers at the site by October 1995. As of December 1995, the pump and treat system had removed 517,000 pounds of contaminants (measured as TOC) from the groundwater. No data were available to quantify the amount of contaminants destroyed through bioremediation.

Cost:

- Actual costs for pump and treat and in situ bioremediation were $33,689,000 ($15,487,000 in capital and $18,202,000 in O&M), which correspond to $110 per 1,000 gallons of groundwater extracted and $15 per pound of contaminant removed. The unit cost does not account for the amount of contaminants destroyed through bioremediation.

Description:

The French Limited site was used for sand mining in the 1960s and 1970s. During the period from 1966 through 1971, the site was permitted to accept industrial waste material for disposal in a seven-acre lagoon created from an open sand pit. About 80 million gallons of waste material was disposed of in the main waste lagoon. The facility's permit was revoked and the site was closed in 1973. The site was placed on the NPL in 1981, and a remedial investigation was performed at the site from 1983 to 1986 through a cooperative agreement. A ROD was signed in May 1987, and amended in March 1988.

Active remediation was conducted at the site from January 1992 through December 1995 by groundwater extraction and above-ground treatment, enhanced aquifer flushing through pressure injection of clean water, and accelerated in situ bioremediation through the addition of oxygen, phosphorus, and nitrate. Source control was achieved by installation of sheet-pile walls around lagoon and DNAPL source areas. As of December 1995, active pumping was stopped and natural attenuation has been used to reduce remaining concentrations of contaminants. Limited pumping began in March 1998.

Pump and Treat and Air Sparging of Contaminated Groundwater at the Gold Coast Superfund Site, Miami, Florida

<table>
<tr><td>Site Name:
Gold Coast Superfund Site</td><td rowspan="2">Contaminants:
Chlorinated solvents and volatiles - nonhalogenated (toluene)
- Maximum initial concentrations were methylene chloride (100 ug/L), 1,1-DCA (2,000 ug/L), trans-1,2-DCE (3,000 ug/L), TCE (48,000 ug/L), PCE (100,000 ug/L), and toluene (545 ug/L)</td><td>Period of Operation:
7/90 - 3/94: pump and treat
11/94 - 2/95: air sparging</td></tr>
<tr><td>Location:
Miami, Florida</td><td>Cleanup Type:
Full-scale cleanup</td></tr>
<tr><td>Vendors:
Construction: Simmons Consulting, Inc.
Treatment System Vendor: Lantec
Operations: Simmons Consulting, Inc., and The Balijet Corp./Edward E. Clark Engineers-Scientists, Inc.</td><td rowspan="2">Technology:
Pump and Treat and Air Sparging
- Groundwater was extracted using five wells, located on site, at an average total pumping rate of 44 gpm
- Extracted groundwater was treated with air stripping and reinjected into the aquifer through three injection wells
- Groundwater was sparged with a portable sparger and contaminants were allowed to volatilize</td><td>Cleanup Authority:
CERCLA Remedial
- ROD Date: 9/11/87</td></tr>
<tr><td>State Point of Contact:
Marvin Collins
Florida Department of Environmental Protection (FDEP)
Tallahassee, FL
(850) 488-0190</td><td>EPA Point of Contact:
Brad Jackson, RPM
U.S. EPA Region 4
3456 Courtland Street, N.E.
Atlanta, GA 30365
(404) 562-8975</td></tr>
<tr><td>Waste Source:
Direct discharge of solvent reclamation blowdown to soil; improper storage of waste</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Groundwater
- 80 million gallons treated as of February 1996
- DNAPL observed in groundwater on site
- Groundwater is found at 5 ft bgs
- Extraction wells are located in one aquifer and are influenced by a nearby surface water
- Hydraulic conductivity was reported as 1,000 ft/day</td></tr>
<tr><td>Purpose/Significance of Application:
Met goals within four years of operation; included pump and treat and air sparging</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
- The remedial goal was to reduce contaminant concentrations throughout the aquifer to levels below the maximum contaminant levels (MCLs) set by the FDEP, DERM, and primary drinking water standards.
- Remedial goals were identified for 1,1-DCA (5 ug/L), trans-1,2-DCE (70 ug/L), methylene chloride (5 ug/L), PCE (0.7 ug/L), TCE (3 ug/L), and toluene (340 ug/L).
- Effluent from the treatment system was required to meet the remedial goals prior to re-injection.
- A secondary goal was identified to create an inward gradient toward the site to contain the plume.</td></tr>
</table>

Pump and Treat and Air Sparging of Contaminated Groundwater at the Gold Coast Superfund Site, Miami, Florida (continued)

Results:
- Groundwater monitoring results indicate that contaminant concentrations have been reduced below treatment goals; from 1991 to 1994, 1,961 lbs of TCE and PCE were removed from the groundwater.
- Optimization efforts were used to focus cleanup on the problem areas at the site; excavation of soil suspected to contain DNAPLs and groundwater sparging were performed to complete cleanup of problem areas.
- Performance monitoring results indicate that effluent requirements have been met throughout the operation of the treatment system.
- No contaminants were detected in downgradient monitoring wells during remedial operations, indicating that the plume was contained throughout the remedial action.

Cost:
- Actual cost data were provided by the responsible parties for this application.
- Costs for pump and treat were $694,325 ($249,005 in capital and $445,320 in O&M), which correspond to $9 per 1,000 gallons of groundwater extracted and $354 per pound of contaminant removed.

Description:
Gold Coast Oil Corporation operated as a spent oil and solvent recovery facility from 1970 to 1982. Recovery operations at the 2-acre site included distillation of lacquer thinner and mineral spirits; blowdown from these operations was discharged directly onto the soil. In 1980, the FDEP detected soil and groundwater contamination in on-site soil (heavy metals and organics) and an off-site groundwater well (VOCs). The site was placed on the NPL in September 1983 and a ROD was signed in September 1987.

Five extraction wells were constructed in the Biscayne Aquifer at the site. Three wells were installed to a depth of 15 ft, with a design yield of 10 gpm; two wells were installed to a depth of 30 ft, with a design yield of 35 gpm. Extracted groundwater was treated using two air stripping towers in series, with each tower 36 ft high, 3 ft diameter, and packed to 26 ft with IMPAC, a material that enhances stripping of VOCs from water. Treated groundwater was re-injected into the aquifer through three injection wells.

Cleanup standards were met at this site within approximately four years of operation. Cleanup was achieved after excavation of soil suspected to contain DNAPLs and groundwater sparging were performed.

Pump and Treat and In Situ Bioremediation of Contaminated Groundwater at the Libby Groundwater Superfund Site, Libby, Montana

<table>
<tr><td>Site Name:
Libby Groundwater Superfund Site</td><td rowspan="2">Contaminants:
Semivolatiles - halogenated (PCP); and PAHs
- Maximum concentrations detected during 1986 RI/FS were PCP (3,200 ug/L), acenaphthene (100 ug/L), acenaphthylene (200 ug/L), benzo(a)anthracene(1 ug/L), and naphthalene (500 ug/L)</td><td>Period of Operation:
Status: Ongoing
Report covers: September 1991 through December 1996</td></tr>
<tr><td>Location:
Libby, Montana</td><td>Cleanup Type:
Full-scale cleanup (interim results)</td></tr>
<tr><td>Vendor:
Design: Woodward-Clyde Consultants
4582 South Ulster Street
Stanford Place 3, Suite 1000
Denver, CO 80237
Operations:
Ralph Heinert
Champion Intl. Corp.
Highway 2 South
P.O. Box 1590
Libby, MT 59923
(406) 293-6238</td><td rowspan="2">Technology:
Pump and Treat and In Situ Bioremediation
- Groundwater is extracted using 5 wells (3 of which are no longer in service), at an average total pumping rate of 16 gpm
- NAPLs are separated from the extracted groundwater, and the groundwater is then routed to 2 fixed-film bioreactors in series
- Nutrients (nitrogen and phosphorus) are added prior to bioreactors and oxygen is added within the bioreactors
- Treated water is reinjected through 2 gravity injection systems (9 wells total)</td><td>Cleanup Authority:
CERCLA Remedial
- ROD Date: 12/30/88</td></tr>
<tr><td>State Point of Contact:
Neil Marsh
Montana DEQ
Remediation Division
(406) 444-0487</td><td>EPA Point of Contact:
Jim Harris, RPM
U.S. EPA Region 8
301 S. Park Drive
P.O. Box 10096
Helena, MT 59626
(406) 441-1150 ext. 260</td></tr>
<tr><td>Waste Source:
Improper storage and disposal of wood preserving products</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Groundwater
- 15.1 million gallons treated as of December 1996
- DNAPL and LNAPL observed in several monitoring wells on site
- Groundwater is found at 10-20 ft bgs
- Extraction wells are located in 1 aquifer, which is influenced by a nearby surface water and production wells
- Hydraulic conductivity ranges from 100 to 1,000 ft/day</td></tr>
<tr><td>Purpose/Significance of Application:
Combination of pump and treat and in situ bioremediation at site with LNAPL, DNAPL, and dissolved-phase contaminants.</td></tr>
</table>

Pump and Treat and In Situ Bioremediation of Contaminated Groundwater at the Libby Groundwater Superfund Site, Libby, Montana (continued)

Regulatory Requirements/Cleanup Goals:

- Remedial goals, developed based on a risk assessment and updated MCLs, were established for non-carcinogenic PAHs: naphthalene (1,460 ug/L), acenaphthene (2,100 ug/L), fluorene (1,460 ug/L), anthracene (11,000 ug/L), pyrene (1,100 ug/L), and fluoranthene (1,460 ug/L); carcinogenic PAHs: benzo(a)anthracene (0.1 ug/L), chrysene (0.2 ug/L), benzo(b)fluoranthene (0.2 ug/L), benzo(a)pyrene (0.2 ug/L), dibenzo(a,h)anthracene (0.3 ug/L), and indeno(1,2,3-cd)pyrene (0.4 ug/L); arsenic (50 ug/L); benzene (5 ug/L); and PCP (1 ug/L).
- The goal of the source area extraction system is to remove oil-contaminated groundwater and NAPL from the area of the waste pit and remove as much NAPL as possible.
- The goal of the in situ bioremediation and pump and treat system is to reduce PAH and PCP concentrations in the upper aquifer to levels below remedial goals.

Results:

- As of December 1996, concentrations in many parts of the plume had declined to either remedial goals or detection limits. However, there are areas of groundwater contamination in which levels of PAHs and PCP remain near original levels.
- DO levels have been measured as an indication of the extent of influence on the intermediate injection system and as an indicator for PAH and PCP in the groundwater.
- The source area treatment system had removed 37,570 pounds of PAHs from the groundwater from 1992 to 1996.

Cost:

- Estimated costs for treatment through 1996 were $5,628,600 ($3,010,000 in capital and $2,618,600 in O&M), which correspond to $374 per 1,000 gallons of groundwater extracted and $150 per pound of contaminant removed. These costs do not account for the volume of groundwater treated or the mass removed through in situ bioremediation. No estimates have been made for these two items.

Description:

The Libby Montana site has been used as a lumber mill and wood-treating facility since 1946. From 1946 to 1969, the site used various compounds, including creosote and PCP, in their wood-treating operations. The mill was operated by the St. Regis Company until 1985 when it was purchased by Champion International. In 1979, homeowners detected a creosote odor in their well water. EPA monitoring in 1981 confirmed groundwater contamination from the Libby site. The site was placed on the NPL in September 1983 and a ROD was signed in December 1988.

The remedial strategy at this site was to address the source area by removing NAPL and to stimulate bioremediation in the down-gradient upper aquifer plume. The three components to the aquifer remedial system are a source area extraction system, intermediate injection system, and boundary injection system. As of December 1996, concentrations in many parts of the plume had declined to either remedial goals or detection limits. However, there are areas of groundwater contamination in which levels of PAHs and PCP remain near original levels. The site operators believe that no additional modifications could be made to improve the system's performance or to reduce the time required to remediate the intermediate injection area.

Permeable Reactive Barrier to Treat Contaminated Groundwater at the Moffett Federal Airfield, Mountain View, California

<table>
<tr><td>Site Name:
Moffett Federal Airfield</td><td rowspan="2">Contaminants:
Chlorinated solvents
- Maximum concentrations detected during 1991 investigations include TCE (20,000 ug/L) and PCE (500 ug/L)</td><td>Period of Operation:
Status: Ongoing
Report covers: 4/96 - 7/97</td></tr>
<tr><td>Location:
Mountain View, California</td><td>Cleanup Type:
Voluntary pilot-scale study</td></tr>
<tr><td>Vendor:
Tim Mower
Tetra Tech EM Inc.
1099 18th Street, Suite 1960
Denver, CO 80202
(303) 312-8874
Chuck Reeter
Naval Facilities Engineering Service Center
1100 23rd Ave., Code 411
Port Hueneme, CA 93043-4370
(805) 982-4991</td><td rowspan="2">Technology:
Permeable Reactive Barrier (PRB)
- The PRB is a funnel-and-gate iron treatment wall system consisting of 2 sheet pile walls, permeable zones up- and down-gradient of the wall, and the reactive zone
- The PRB is composed of 100% granular iron, is 6 ft thick, 10 ft wide, and 18 ft high beginning 5 ft below ground surface
- Average flow rate through the wall was estimated as 0.5 ft/day (alternate estimates also provided)</td><td>Cleanup Authority:
Not applicable</td></tr>
<tr><td>EPA Point of Contact:
Lynn Suer
EPA Region 9
75 Hawthorne Street
San Francisco, CA 94105
(415) 744-2396</td><td>Navy Point of Contact:
Stephen Chao (Navy Project Manager)
Bldg. 210
Department of the Navy
EFA-West
900 Commodore Drive
San Bruno, Ca 94066</td></tr>
<tr><td>Waste Source:
Leaking underground and aboveground storage tanks, waste sumps; on-site migration of contaminants from Silicon Valley plume</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Groundwater
- 0.284 million gallons treated as of July 1997
- DNAPL suspected in groundwater on site
- Groundwater is found at 5 ft bgs
- Extraction wells are located in 5 hydrogeologic units, which include upward hydraulic gradients
- Hydraulic conductivity ranges from 0.3 to 400 ft/day</td></tr>
<tr><td>Purpose/Significance of Application:
Use of PRB technology in a pilot study for treatment of chlorinated solvents; included extensive sampling conducted at locations within the wall.</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
- The objectives of the pilot project are to (1) demonstrate and validate the PRB technology in remediating groundwater contaminated with chlorinated hydrocarbons; (2) evaluate the long-term effectiveness of the barrier from a hydraulic stand point; and (3) develop cost and performance data.</td></tr>
</table>

Permeable Reactive Barrier to Treat Contaminated Groundwater at the Moffett Federal Airfield, Mountain View, California (continued)

Results:
- Data from sampling events in January, April, and July 1997 showed that chlorinated solvent concentrations were being reduced as the groundwater moves through the reactive zone. For example, TCE concentrations measured in upgradient wells during April 1997 were reduced to below the detection limit within the reactive zone. PCE and 1.2-DCE also were reduced to below the detection limit within the reactive zone.
- A tracer test performed in July 1997 showed that flow patterns within the wall are complex, with some lateral flow, and that flow velocities are lower than expected based on previous site characterization and modeling.

Cost:
- Actual costs for PRB use over one year at this site were $405,000 ($373,000 in capital and $32,000 in O&M), which correspond to $1,400 per 1,000 gallons of groundwater treated.

Description:
Moffett Federal Airfield is a former Navy facility providing support, training, operation, and maintenance associated with Navy aircraft. Aircraft engine repairs and aircraft maintenance have been performed on site for many years. Contaminant identification and cleanup activities have been underway at Moffett since 1987. Specific activities that contributed to the source at MFA included dry cleaning operations. The Navy and Department of Defense Environmental Security Technology Certification Program (ESTCP) are funding this PRB as a voluntary pilot study for treating a portion of a large plume that crosses the Moffett facility.

The PRB installed in 1986 is a funnel and gate iron treatment wall system. Components include two sheet pile walls, permeability zones up- and down-gradient of the wall, and the reactive zone. Analytical data showed that chlorinated solvent concentrations were being reduced as the groundwater moves through the reactive zone. A final technology evaluation report for this pilot study was planned to be completed by August 1998. Proposals are being presented to continue the sampling process annually or semi-annually.

Dual Auger Rotary Steam Stripping at Pinellas Northeast Site, Largo, Florida

Site Name:
Pinellas STAR Center
Northeast Site

Contaminants:
- Chlorinated solvents and volatiles - nonhalogenated 1,1-dichloroethane, 1,1-DCE, benzene, ethylbenzene, 1,2-DCE, methylene, chloride, toluene, TCE, tetrachloroethene, vinyl chloride, total xylenes, and chloromethane
- Concentrations ranging from 500-5,000 ppm
- DNAPL suspected to occur as an immiscible phase

Period of Operation:
December 1996 through April 1997

Location:
Largo, Florida

Cleanup Type:
Demonstration (ITRD Technology Demonstration)

Vendor:
In-Situ Fixation, Inc. (ISF)
Chandler, Arizona

Technology:
In Situ Air and Steam Stripping
- ISF dual auger system consists of a Caterpillar 245D trackhoe modified to operate two, 35-ft long, hollow kelly bars with 5-ft diameter augers
- Air and/or steam injected through hollow kelly bars while augers drill into subsurface, to liberate VOCs
- Catalytic oxidation unit and acid-gas scrubber were used to treat the extracted VOCs
- 48 treatment holes drilled to a depth of approximately 32 feet
- Technology focused on treating saturated silty sands (below the water table) contaminated with high concentrations of VOCs (500-5,000 ppm)

Cleanup Authority:
RCRA

Additional Contacts:
David Ingle
DOE/GJO Environmental Restoration Program Manager
(813) 541-8943

Regulatory Point of Contact:
EPA Region 4 and State:
Florida Department of Environmental Protection

Waste Source:
Leakage of solvents from drum/container Storage

Type/Quantity of Media Treated:
Soil and Groundwater
- Water table present approximately 3-4 feet below ground surface
- Soils consist of saturated beach-type silty sands with permeabilities ranging between 10^{-3} to 10^{-5} cm/s
- Approximately 2,000 yd^3 of soil treated

Purpose/Significance of Application:
Demonstration of in situ air stripping technology used to supplement an ongoing system of pump and treat with air stripping

Regulatory Requirements/Cleanup Goals:
- The objective of this demonstration was to evaluate the performance of the ISF dual auger system in treating contaminated soil and groundwater.

Dual Auger Rotary Steam Stripping at Pinellas Northeast Site, Largo, Florida (continued)

Results:
- Demonstrated ability to remove large amounts of contaminants from soil and groundwater in a treatment column
- Removed an average of 77% of the VOCs in the groundwater and soil, and reduced the maximum contaminant concentrations by an average of 71%
- Treatment of over 2,000 yd^3 of soil and groundwater and the removal of approximately 1,200 pounds of VOCs

Cost:
Total cost of remediation project was $981,251, including:
- Preproject operation visit - $2,400
- Mobilization and preparatory work - $95,000
- Monitoring, sampling, testing, and analysis - $59,000
- Physical treatment - $773,651 (equipment, labor, supplies and materials, and fuel)
- Disposal - $200 (hydraulic oil)
- Demobilization - $51,000

Description:
The Pinellas STAR Center operated from 1956 to 1994, manufacturing neutron generators and other electronic and mechanical components for nuclear weapons under contract to the U.S. Department of Energy (DOE) and its predecessor agencies. The Northeast Site is associated with the location of a former waste solvent staging and storage area. In the late 1950s to the late 1960s an existing swampy area at the site was used to dispose drums of waste and construction debris.

A field demonstration using a dual auger rotary steam stripping technology was conducted at the site from December 1996 through April 1997. The demonstration was part of a program at the Pinellas STAR Center to evaluate several innovative remediation technologies that could enhance the cost or performance of the existing pump and treat system. In the demonstration, air and/or steam was injected through hollow kellys while the augers drill into the subsurface, liberating VOC contamination during the churning and mixing of the soil. This study identified operational issues, such as mechanical problems, catalyst overheating, and fugitive emissions that required system adjustments and operational changes. These issues slowed the progress of the remediation effort, but the system was overall very effective in liberating large quantities of VOCs from the site soil and groundwater. During the 3-month operating period, 48 auger holes were drilled to a depth of approximately 32 ft below land surface, resulting in treatment of approximately 2,000 yd^3 of the planned 10,000 yd^3 treatment volume. Overall, approximately 1,200 lbs of VOCs were removed from the soil and groundwater in the holes treated in this project.

The cost of this remediation project was $981,251, with most of the costs being equipment operating costs. The operational costs of the ISF system ranged from $50/$yd^3$ to $400/$yd^3$ of treated soil and groundwater, or about $300/lb to $500/lb of contaminant removed. The ISF system was able to meet many of the performance evaluation criteria; however, the off-gas treatment capacity of the catalytic oxidation unit along with initial operational problems slowed the system's expected treatment rates for the site.

In Situ Anaerobic Bioremediation at Pinellas Northeast Site, Largo, Florida

<table>
<tr><td>Site Name:
Pinellas STAR Center
Northeast Site</td><td rowspan="2">Contaminants:
- Chlorinated solvents, including trichloroethene, methylene chloride, dichloroethene, and vinyl chloride
- Concentrations ranged from 10-400 mg/kg
- DNAPL suspected to occur in localized areas</td><td>Period of Operation:
February 7, 1997 to June 30, 1997</td></tr>
<tr><td>Location:
Largo, Florida</td><td>Cleanup Type:
Demonstration (ITRD Technology Demonstration)</td></tr>
<tr><td>Vendor/Consultant:
Lockheed Martin Specialty Components</td><td rowspan="2">Technology:
In Situ Anaerobic Bioremediation
- Three, 8-ft deep gravel-filled, surface infiltration trenches and two, 240-ft long horizontal wells with 30-ft screened intervals
- Groundwater extracted from upper horizontal well and recirculated via surface trenches and lower horizontal well at a rate of about 1.5 gpm
- Benzoate, lactate, and methanol added to recirculated water to serve as nutrients for dechlorinating bacteria
- 250,000 gallons of water circulated during pilot study over five month period</td><td>Cleanup Authority:
RCRA</td></tr>
<tr><td>Additional Contacts:
David Ingle, Site Management
DOE/GJO Environmental Restoration Program Manager
(813) 541-8943</td><td>Regulatory Point of Contact:
EPA Region 4 and State:
Florida Department of Environmental Protection</td></tr>
<tr><td>Waste Source:
Leakage of solvents or resins from drum/container storage</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Groundwater
- Water table present approximately 3-4 feet below ground surface
- Aquifer characterized as sandy
- Hydraulic conductivity of surficial aquifer in study is relatively heterogeneous; zones of reduced hydraulic conductivity occur at depths between 10 to 14 feet and 22 to 29 feet
- Approximately 250,000 gallons of water were treated</td></tr>
<tr><td>Purpose/Significance of Application:
Demonstration of in situ anaerobic bioremediation technology used to supplement an ongoing system of pump-and-treat with air stripping</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
- The objectives of this demonstration included evaluating the use of nutrient injection to enhance in situ anaerobic biological degradation of chlorinated VOCs in areas of moderate contaminant concentrations and obtaining operating and performance data on this technology.</td></tr>
<tr><td colspan="3">Results:
- Evaluated use of nutrient injection to enhance in situ anaerobic biological degradation of chlorinated VOCs in areas of moderate contaminant concentrations
- Obtained operating and performance data to optimize the design and operation of a full-scale system
- VOC concentrations reduced 60% - 91% within four to eight weeks after nutrient arrival
- Contaminant reduction probably result of groundwater mixing and contaminant redistribution
- Limiting factors for successful, cost effective implementation are ability to deliver appropriate nutrients to all contaminated areas and hydraulic travel times</td></tr>
</table>

In Situ Anaerobic Bioremediation at Pinellas Northeast Site, Largo, Florida (continued)

Cost:
Total cost of pilot remediation project was $397,074, including:
- Mobilization and preparatory work - $35,000
- Monitoring, sampling, testing, and analysis - $238,310
- Groundwater collection and control - $87,536
- Biological treatment - $23,748
- General requirements - $12,480

Description:
The Pinellas STAR Center operated from 1956 to 1994, manufacturing neutron generators and other electronic and mechanical components for nuclear weapons under contract to the U.S. Department of Energy and its predecessor agencies. The Northeast site is associated with the location of a former waste solvent staging and storage area. In the 1950s and 1960s, an existing swampy area at the site was used for staging and burial of construction debris and drums, some of which contained solvents. The site consists of a shallow groundwater aquifer contaminated with a variety of VOCs, including chlorinated solvents such as trichloroethene, methylene chloride, dichloroethene, and vinyl chloride.

From February 7, 1997 to June 30, 1997 a demonstration using in situ anaerobic bioremediation was conducted at the site. The demonstration was part of a program at the Pinellas STAR Center to evaluate several innovative remediation technologies that could enhance the cost or performance of an existing pump-and-treat system. The pilot system was located in an area of the site that had total chlorinated contaminant concentrations in groundwater generally ranging from 10-400 mg/kg, with one monitoring well having concentrations in excess of 2,900 mg/kg. The bioremediation pilot system consisted of three 8-ft deep gravel-filled, surface infiltration trenches and two 240-ft long horizontal wells with 30-ft screened intervals. The horizontal wells, directly underlying and parallel to the middle surface trench, were at 16- and 26-ft depths. The study area was about 45 feet by 45 feet and extended from the surface down to a thick, clay confining layer 30 feet below the surface. Groundwater was extracted from the upper horizontal well and recirculated via the surface trenches and the lower horizontal well while benzoate, lactate, and methanol were added to the recirculated water to serve as nutrients for the dechlorinating bacteria.

During this period, groundwater was extracted and recirculated at a rate of about 1.5 gpm. Approximately 250,000 gallons of water, based on soil porosity of about two pore volumes, were circulated during the pilot study. Tracer and nutrient monitoring data indicated that nutrients were delivered to 90% of the central treatment area during operations. Where nutrient breakthrough was observed, significant declines in total chlorinated VOC concentrations were generally observed.

The cost of the pilot system totaled approximately $400,000, with over half the costs associated with sampling and analyses. Most of the sampling and analyses were discretionary and were used to verify the system concept and design. This level of sampling would not be needed during a full-scale bioremediation project. System construction costs were about $90,000, while operating costs were about $30,000 or $0.12 per gallon of water treated. The extensive modeling, hydrogeologic, nutrient transport, and operating cost data developing during this pilot system operation suggest that the Northeast Site could be remediated using nutrient injection in approximately 2-3 years at a cost of about $4-6M.

PerVap™ Membrane Separation Groundwater Treatment at Pinellas Northeast Site, Largo, Florida

<table>
<tr><td>Site Name:
Pinellas Northeast Site</td><td rowspan="2">Contaminants:
Volatile Organic Compounds:
Trichloroethene (TCE)
Methlyene Chloride
1,2-Dichloroethene</td><td>Period of Operation:
6/14/95 - 3/2/96</td></tr>
<tr><td>Location:
Largo, Florida</td><td>Cleanup Type:
Demonstration
(ITRD Technology Demonstration)</td></tr>
<tr><td>Vendor:
Membrane Technology and Research, Inc. (MTR) and the Advanced Technology Group of Hoechst Celanese Corp</td><td rowspan="2">Technology:
Membrane Filtration:
- Membrane separation (pervaporation) using the PerVap™ technology.
- organic permeable, hydrophobic membrane used to remove organic contaminants from water
- MTR PerVap pilot system was skid-mounted; capacity of 1-2 gallons/minute on a batch basis</td><td>Cleanup Authority:
RCRA</td></tr>
<tr><td>Additional Contacts:
DOE Environmental Restoration Program Manager:
David Ingle
(813) 541-8943

Lockheed Martin Specialty Components
Barry Rice
(813) 545-6036</td><td>Regulatory Point of Contact:
EPA Region 4 and State: Florida Department of Environmental Protection</td></tr>
<tr><td>Waste Source: Disposal of drums of waste and construction debris</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Groundwater - 125 batches or 6,200 gallons</td></tr>
<tr><td>Purpose/Significance of Application: Demonstration of the PerVap™ technology for treating VOC-contaminated groundwater at the Northeast Site</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
- The objectives of the demonstration were to achieve greater than 99% removal of VOCs, eliminate the need for pretreatment of groundwater, and to produce no air emissions. For effluent to the POTW, there was a discharge limit of 850 ug/L total toxic organics.
- No air permitting or air permit modifications were required for this demonstration because the demonstration was performed at an existing SWMU.</td></tr>
<tr><td colspan="3">Results:
- Removal efficiency was highly variable (ranging from 90% when membranes were not clogged to zero when membranes were clogged). The goal of 99% removal was not maintained during the demonstration.
- The clogging was attributed to oxidation of aqueous iron. Because of persistent clogging problems with the membranes, groundwater pretreatment was required. Several pretreatment alternatives were tried; however, the effectiveness and applicability of each was determined to be site-specific.
- The discharge limits were not achieved and water was treated using the existing groundwater treatment system.
- No air emissions were detected; however, a very strong odor was noted during operation.</td></tr>
</table>

PerVap Membrane Separation Groundwater Treatment at Pinellas Northeast Site, Largo, Florida (continued)

Cost:

- Total cost for pilot system - $88,728, including pre-demonstration consultation, mobilization and demobilization, monitoring, sampling and analysis, treatment, and disposal. The total cost includes $29,000 in costs for MTR who agreed to provide the pilot system and engineering services to Lockheed Martin on a fixed-price basis ($5,000 for the first month and $3,000/month for eight months)
- Cost per unit of groundwater treated during the pilot test - $0.01-0.015/gallon
- Projected cost for full-scale - capital cost of $250,000 and operating cost of $0.01/gallon.

Description:

The Pinellas Northeast site, located at the DOE Pinellas Plant in Largo, Florida, includes the East Pond and was identified as a Solid Waste Management Unit in a RCRA Facility Assessment conducted by EPA Region 4. The East Pond was excavated in 1968 and used as a borrow pit. The area was used to store construction debris and waste, including solvents, in drums and containers. In 1986 shallow groundwater at the site was determined to be contaminated with a variety of VOCs . The predominant contaminants at the site were TCE, methylene chloride, and 1,2-dichloroethene, detected at levels as high as 360,000 ppb, 1,200,000 ppb, and 58,000 ppb, respectively. Vinyl chloride and toluene were also detected at relatively high concentrations.

The groundwater pump and treat system at the site includes seven recovery wells connected to an air stripper. Effluent is discharged to a POTW. Because the aquifer is anaerobic and contains high levels of dissolved solids and iron, the extracted groundwater must be pretreated prior to the air stripper. The purpose of the demonstration was to determine if the pervaporation system would be able to treat the groundwater directly without pretreatment and would be able to concentrate contaminants in a condensate that could be recycled, thereby reducing waste disposal costs as well as air emissions.

The MTR PerVap™ pilot system was a self-contained, field transportable pervaporation system that had been adapted for use in removing organics from aqueous liquid streams. Contaminated groundwater, pumped into a surge tank, was passed through a cloth filter into the 50 gallon process feed tank. The pervaporation cycle, begun when the feed tank was full, consisted of pumping a 50-gallon batch of water across a heater (to raise the temperature to 50° C), through two membranes modules in series, then back to the feed tank. A vacuum was applied across the membrane modules creating a pressure gradient to facilitate the transfer of VOCs across the membranes. The resultant vapor stream or permeate (about 1,500 ml/batch) was then cooled to condense the liquid which was then sent to a chilled permeate storage container. The treated water was discharged to a POTW. The capacity of the pilot system was 1-2 gal/min and a typical pervaporation cycle was 1-2 hours. The residuals produced by the system were filters and permeate, which were disposed of as hazardous waste, and used membranes, which were returned to MTR.

Optimal operating parameters could not be established during the demonstration. Because of membrane clogging problems caused by precipitants from the groundwater, the removal efficiencies were highly variable during the demonstration. Several groundwater pretreatment methods were evaluated an attempt to alleviate the clogging, including nitrogen blanketing, adding a chelator, adding a dispersant, and changing the pH of the water. The use of a nitrogen blanketing and the dispersant produced the best results, but were not compatible with the existing groundwater treatment system. Therefore, while cost effective pretreatment was available, the applicability is subject to site- specific constraints. In addition, the POTW discharge limit was not achieved and the water was treated using the existing groundwater treatment system.

Pump and Treat, In Situ Bioremediation, and In Situ Air Sparging of Contaminated Groundwater at Site A, Long Island, New York

<table>
<tr><td>Site Name:
Site A (actual name confidential)</td><td rowspan="2">Contaminants:
Volatiles - nonhalogenated (BTEX)
- Maximum initial concentrations were benzene (430 ug/L), toluene (350,000 ug/L), ethylbenzene (5,600 ug/L), and xylenes (45,000 ug/L)</td><td>Period of Operation:
Status: Ongoing
Report covers: 7/95 - 10/96</td></tr>
<tr><td>Location:
Long Island, New York</td><td>Cleanup Type:
Full-scale cleanup (interim results)</td></tr>
<tr><td>Vendor:
Treatment System Vendor:
RETEC Associates
Site Management:
RETEC Associates (1993-1997)
Land Tech Remedial, Inc. (1997-present)</td><td rowspan="3">Technology:
Pump and Treat; In Situ Bioremediation; Air Sparging, Soil Vapor Extraction
- Groundwater was extracted using 5 wells, located on site, at an average total pumping rate of 18 gpm
- Extracted groundwater was treated with air stripping and gravity separation
- Nutrients were added to the treated water to adjust nitrogen and phosphorus levels, and then the water is reinjected into the aquifer through a reinjection trench located upgradient of the plume
- Air was injected through 44 sparging wells at points approximately 10 ft below the water table, in a pulsed system operation, and effluent vapors are collected with 20 SVE wells (16 vertical and 4 horizontal)</td><td>Cleanup Authority:
CERCLA Remedial
- ROD Date: 6/24/91</td></tr>
<tr><td>State Point of Contact:
Carl Hoffman
New York State DEC
Bureau of Hazardous Site Control
50 Wolf Road
Albany, NY 13323-7010</td><td rowspan="2">EPA Point of Contact:
Maria Jon, RPM
U.S. EPA Region 2
290 Broadway, 19th Floor
New York, NY 10007-1866
(212) 637-3967</td></tr>
<tr><td>Site Contact:
Stephen Hoelsher
Phillips Petroleum
13 DI Phillips Bldg
Bartlesville, OK 74004
(918) 661-3769</td></tr>
<tr><td>Waste Source:
Leaking drums and spills of petroleum and solvent materials</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Groundwater
- 8.4 million gallons treated as of October 1996
- LNAPL observed in several monitoring wells on site
- Groundwater is found at 15-18 ft bgs
- Extraction wells are located in 1 aquifer, which is influenced by a nearby surface water
- Hydraulic conductivity reported as 53.5 ft/day</td></tr>
<tr><td>Purpose/Significance of Application:
Relatively high unit cost; system included groundwater extraction, air sparging, and SVE wells.</td></tr>
</table>

Pump and Treat, In Situ Bioremediation, and In Situ Air Sparging of Contaminated Groundwater at Site A, Long Island, New York (continued)

Regulatory Requirements/Cleanup Goals:

- Remediate the groundwater to meet maximum contaminant levels (MCLs) established by the NYSDEC, which are the primary drinking water standards.
- Cleanup goals were established for benzene (0.0007 mg/L), toluene (0.005 mg/L), ethylbenzene (0.005 mg/L), and xylene (0.005 mg/L).
- A primary goal of the extraction system is to contain the contaminant plume and prevent it from discharging to the harbor; the goal is for both horizontal and vertical containment.
- A primary performance goal for in situ bioremediation is to maintain specified levels for pH, nitrogen, phosphorus, and DO.

Results:

- Maximum BTEX levels have declined from 153 to 27 mg/L; however, cleanup goals have not been met. Monitoring data from 1997 indicate that elevated BTEX levels persist in wells along the western portion of the site.
- Plume containment appears to have been achieved, and performance standards were generally met for nitrogen, phosphorus, and DO; there were several exceptions where nitrogen, phosphorus, and DO were outside the specified ranges.
- From July 1995 to July 1996, the system removed approximately 5,314 pounds of BTEX from the groundwater (air sparging removed approximately 85% of the BTEX and P&T the remaining 15%).

Cost:

- Actual costs for the treatment system were approximately $1,941,560 ($1,503,133 in capital and $358,427 in O&M), which correspond to $200 per 1,000 gallons of groundwater extracted and $365 per pound of contaminant removed.

Description:

Site A operated as a petroleum bulking facility from 1939 until 1980, and it operated as a petroleum bulking and chemical mixing facility from 1980 to 1984. In 1984, in response to a toluene spill, EPA and the NYSDEC investigated the site, and discovered contamination by organics and metals in the soil, and organics in the groundwater, surface water, and air. The site was placed on the NPL in June 1986 and a ROD was signed in June 1991.

The groundwater extraction system consists of five wells installed in the areas of highest contamination within the plume, all screened at depths of approximately 10 ft below the water table. One well was placed in an area where free-phase BTEX product was observed in the western portion of the site. Extracted groundwater is treated with air stripping. After stripping, water is treated through pH adjustment and addition of nutrients, and then re-injected into the aquifer. In addition, oxygen is injected into the aquifer through 44 air sparging points. Effluent vapors from the sparging points are collected by 20 SVE wells.

Groundwater cleanup goals for this site have not been met after two years and three months of operation. However, the remedy has contained the plume, reduced average BTEX concentrations, and recovered free-phase product.

In Situ Permeable Reactive Barrier for Treatment of Contaminated Groundwater at the U.S. Coast Guard Support Center, Elizabeth City, North Carolina

Site Name:
U.S. Coast Guard Support Center

Location:
Elizabeth City, North Carolina

Contaminants:
Chlorinated solvents and heavy metals
- Maximum concentrations detected during initial investigations included TCE (>4,320 ug/L) and hexavalent chromium (Cr^{+6} (>3,430 ug/L))

Period of Operation:
Status: Ongoing
Report covers: 7/96 - 7/97

Cleanup Type:
Full-scale cleanup (interim results)

Vendor:
Design: University of Waterloo
Contractor: Parsons Engineering Science, Inc.
Licensing: Environmental Technologies, Inc.
Installation: Horizontal Technologies, Inc.

Technology:
Permeable Reactive Barrier (PRB)
- The PRB (treatment wall) is 100% granular iron, 2 ft wide, 152 ft long, begins 4-8 ft below ground surface (bgs) and extends to 24 ft bgs
- The PRB consists of 450 tons of granular zero-valent iron

Cleanup Authority:
RCRA Corrective Action - part of an Interim Corrective Measure

USCG Project Manager:
Jim Vardy, P.E.
U.S. Coast Guard
CEU Cleveland Env. Engr.
Building 19
Elizabeth City, NC 27909
(919) 335-6847

U.S. EPA Contact:
Robert Puls
U.S. EPA, Robert S. Kerr
Environmental Research Center
Nat. Risk Mgmt. Research Lab.
P.O. Box 1198
Ada, OK 74821
(580) 436-8543

State Point of Contact:
Surabhi Shah
North Carolina DENR
Hazardous Waste Section
401 Oberlin Rd., Ste. 150
Raleigh, NC 27605

Waste Source:
Spills and leaks to the subsurface through floor drains and holes in building floor

Purpose/Significance of Application:
Use of PRB to treat groundwater contaminated with TCE and hexavalent chromium; extensive sampling conducted to evaluate PRB.

Type/Quantity of Media Treated:
Groundwater
- 2.6 million gallons (estimated) treated
- DNAPL suspected in groundwater at the site
- Groundwater is found at 6 ft bgs
- The PRB is located in 1 aquifer at the site; this aquifer is influenced by a nearby surface water
- Hydraulic conductivity ranges from 11.3 to 25.5 ft/day

Regulatory Requirements/Cleanup Goals:
- Cleanup goals for this site are primary drinking water standards, with the following specific cleanup goals for the aquifer down-gradient of the wall: TCE (5 ug/L) and Cr^{+6} (0.1 ug/L).
- A secondary goal of the PRB is to contain the contaminated part of the plume up-gradient of the reactive zone.

Permeable Reactive Barrier for Treatment of Contaminated Groundwater at the U.S. Coast Guard Support Center, Elizabeth City, North Carolina (continued)

Results:
- Cr^{+6} concentrations were below the cleanup goal in all down-gradient monitoring wells in November 1996 and September 1997 sampling events. However, TCE concentrations were above the cleanup goal in four of the six down-gradient wells in September 1997.
- A pilot study performed in 1994 and 1995 was successful at demonstrating the effectiveness of the PRB technology at this site; these results lead to the selection of PRB as the remedy for this RCRA corrective action.
- The data indicate that the TCE plume may not be contained; however, the reason for the elevated TCE concentrations in some down-gradient wells has not been confirmed.

Cost:
- Estimated costs for PRB were $585,000 ($500,000 in capital and $85,000 in O&M), which correspond to $225 per 1,000 gallons of groundwater treated.
- According to the USCG site contact, by using a PRB, the USCG will save nearly $4,000,000 in construction and long-term maintenance costs, when comparing PRB with a typical pump and treat system.

Description:
The Support Center, Elizabeth City (SCEC), is a USCG facility providing support, training, operation, and maintenance associated with USCG aircraft. The facility included an electroplating shop which operated for more than 30 years, ceasing operation in 1984. In December 1988, a release was discovered during demolition of a former plating shop. Soil excavated beneath the floor of the former plating shop was found to contain high levels of chromium. Subsequent investigations indicated that the groundwater had been impacted by chromium and chlorinated solvents. Multiple sources were suspected of having contributed to the groundwater contamination. A full-scale PRB was constructed as part of an Interim Corrective Measures (ICM) associated with a voluntary RCRA Facility Investigation (RFI), with the electroplating shop identified in the facility's RCRA Part B permit as a Solid Waste Management Unit (SWMU).

The PRB used at this site consists of 450 tons of granular zero-valent iron keyed into an underlying low conductivity layer at a depth of approximately 22 ft bgs. The required residence time in the treatment zone has been estimated as 21 hours, based on a highest concentration scenario. The average velocity through the wall was reported as 0.2 to 0.4 ft/day. Analytical data from the first year of full-scale operation show that the cleanup goal for Cr^{+6} has been met, but not the goal for TCE. Several possible reasons are provided for the elevated TCE levels.

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ON-SITE INCINERATION

ABSTRACTS

Incineration at the Baird and McGuire Superfund Site Holbrook, Massachusetts

<table>
<tr><td>Site Name:
Baird and McGuire Superfund Site</td><td rowspan="2">Contaminants:
Dioxins, volatile organic compounds (VOCs), polynuclear aromatic hydrocarbons (PAHs), pesticides, and heavy metals, including lead and arsenic</td><td>Period of Operation:
March 1995 to March 1997</td></tr>
<tr><td>Location:
Holbrook, Massachusetts</td><td>Cleanup Type:
Remedial action</td></tr>
<tr><td>Site General Contractor:
OHM Remediation Services Corporation
16406 U.S. Route 224 East
Findlay, OH 45839
(419) 423-3526</td><td rowspan="2">Technology:
• Removal of moisture from soil using rotary dryer
• Combustion of contaminants in dry soil using rotary kiln
• System designed to treat 25 tons of contaminated soil per hour
• Ash and flue gases discharged from kiln
• Residuals generated from incinerator returned to excavated areas on site</td><td>Cleanup Authority:
CERCLA
• ROD signed in September 1986 (soil)
• ROD signed in September 1989 (sediment)
• U.S. Corps of Engineers Lead</td></tr>
<tr><td>SIC Code:
2879 (Pesticides)
2841 (Soaps)
2842 (Floor Wax)
2869 (Solvents)</td><td>Point of Contact:
Chet Janowski
U.S. EPA Region 1
John F. Kennedy Building
One Congress Street
Boston, MA 02203</td></tr>
<tr><td>Waste Source:
Land disposal of process wastes</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Soil (210,000 tons) and sediment (1,500 cubic yards)</td></tr>
<tr><td>Purpose/Significance of Application:
Treats wide range of contaminants in soil and sediment, including dioxin, VOCs, PAHs, and Pesticides</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
Destruction and Removal Efficiency (DRE) of 99.99% for principal organic hazardous constituents (POHCs) as required by Resource Conservation and Recovery Act (RCRA) incinerator regulations in 40 CFR part 264, subpart O</td></tr>
<tr><td colspan="3">Results:
Trial burn data indicate that all DRE emission standards were met</td></tr>
</table>

Incineration at the Baird and McGuire Superfund Site
Holbrook, Massachusetts

(Continued)

Description:
Between 1912 and 1983, the site was operated as a chemical mixing and batching company. During a remedial investigation at the site, dioxin concentrations in the soil were measured as high as 27.8 μg/kg. A Record of Decision (ROD) signed in 1986 specified on-site incineration as the selected remedy for the contaminated soils at the site. A second ROD signed in 1989 specified on-site incineration as the selected remedy for the contaminated sediments of the nearby Cochato River.

The incineration system included a rotary dryer for removal of moisture from the soil. The dried soil was fed to the rotary kiln where the contaminants in the soil were volatilized and destroyed. From March 1995 through March 1997, the incinerator processed approximately 210,000 tons of contaminated soil and 1,500 cubic yards of contaminated sediment. All of the residuals generated from the incineration and subsequent ancillary operations, including ash and wastewater treatment sludge, were landfilled on site. Treatment performance and emissions data collected during this application indicated that all required performance standards and emissions requirements were achieved.

The total cost for remediation using the incineration system was approximately $133,000,000.

Incineration at the Bayou Bonfouca Superfund Site
Slidell, Louisiana

<table>
<tr><td>Site Name:
Bayou Bonfouca Superfund Site</td><td rowspan="2">Contaminants:
Polynuclear aromatic hydrocarbons: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, ideno(1,2,3-cd)-pyrene, and chrysene</td><td>Period of Operation:
November 1993 - July 1995</td></tr>
<tr><td>Location:
Slidell, Louisiana</td><td>Cleanup Type:
Remedial action</td></tr>
<tr><td>Vendor:
IT Corporation
312 Directors Drive
Knoxville, TN 37923
(423) 690-3211</td><td rowspan="2">Technology:
• Sediment transported through a feed system that included dewatering and mixing
• Incineration system consisting of rotary kiln and secondary combustion chamber (SCC)
• SCC operated between 1,600 °F and 1,800 °F
• Exhaust gases from SCC directed through gas cleaning system
• Residual ash was landfilled, and an engineered cap was placed over residual ash and surface soil</td><td>Cleanup Authority:
CERCLA and State: Louisiana
• Phase I ROD signed August 1985
• Phase II ROD signed March 1987
• State-lead</td></tr>
<tr><td>SIC Code:
2491 (Wood Preserving)</td><td>Point of Contact:
Mark Hansen
U.S. EPA Region 6
1445 Ross Avenue, Suite 1200
Dallas, TX 75202
(214) 665-7548</td></tr>
<tr><td>Waste Source:
Bayou sediments - creosote waste</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Sediment (46,500 cubic yards)
Contaminated material from waste piles (5,000 cubic yards)</td></tr>
<tr><td>Purpose/Significance of Application:
Underestimated volume of contaminated soil by a factor of three, prompting EPA to reevaluate remedial plans. Completed 18 months ahead of schedule</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
Destruction and Removal Efficiency (DRE) of 99.9999% for all constituents of concern as required by Resource Conservation and Recovery Act (RCRA) incinerator regulations at 40 CFR part 264, subpart O</td></tr>
<tr><td colspan="3">Results:
Monitoring and trial burn data indicate that all DRE and emission standards have been met</td></tr>
</table>

Incineration at the Bayou Bonfouca Superfund Site
Slidell, Louisiana

(Continued)

Description:
Between 1892 and 1970, the Bayou Bonfouca site operated as a former creosote works facility. During this period, numerous creosote releases occurred. In 1970, a fire at the plant released large amounts of creosote into the environment. Sediment at the Bayou Bonfouca site was contaminated with PAHs.

In August 1985, a Phase I Record of Decision (ROD) was signed, specifying excavation and off-site landfilling of creosote waste piles. In March 1987, a Phase II ROD was signed. The remedial actions for the Phase II ROD included the excavation and on-site incineration of sediment and the contents of surface waste piles with placement of an engineered cap over residual ash and surface soils. During 1988, a detailed design investigation showed that the volume of contaminated sediment was underestimated by a factor of three. The volume increase resulted in a cost increase and prompted EPA to issue an Explanation of Significant Difference (ESD) in February 1990.

The selected incineration system consisted of a feed system, a rotary kiln, a secondary combustion chamber (SCC) and a gas cleaning system. Sediment was dewatered and then mixed before being fed to the incinerator. During its operation, the incinerator processed approximately 250,000 tons (over 170,000 cubic yards) of contaminated sediments. Treatment performance and emissions data collected during this application indicated that all performance standards and emissions requirements were met.

The actual cost for remediation using the incineration system was approximately $84,000,000 including total capital costs of $54,000,000, and total operation and maintenance costs of $30,000,000.

Incineration at the Bridgeport Refinery and Oil Services Superfund Site Logan Township, New Jersey

<table>
<tr><td>Site Name:
Bridgeport Refinery and Oil Services Superfund Site</td><td rowspan="2">Contaminants:
Polychlorinated biphenyls (PCBs), volatile organic compounds (VOCs), and metals
• benzene
• cadmium
• methylene chloride
• chromium
• toluene
• barium
• acetone
• zinc
• lead</td><td>Period of Operation:
December 1991 to January 1996</td></tr>
<tr><td>Location:
Logan Township, New Jersey</td><td>Cleanup Type:
Remedial action</td></tr>
<tr><td>Vendor:
ENSCO, Inc.</td><td rowspan="2">Technology:
On-site Incineration
• Incineration using direct-fired rotary kiln
• Screening and mixing of contaminated sediments prior to incineration
• Quenching of kiln ash in water bath
• Treatment of wastewater from system on-site and discharge to nearby creek
• Combustion of remaining VOCs and PCBs in secondary combustion chamber (SCC)</td><td>Cleanup Authority:
CERCLA
• ROD signed 1984
• EPA-lead, managed by U.S. Army Corps of Engineers</td></tr>
<tr><td>SIC Code:
NA</td><td>Point of Contact:
Don Lynch
U.S. EPA Region 2
290 Broadway
New York, NY 10007-1866
212-637-4419</td></tr>
<tr><td>Waste Source:
Lagoon Sediments--waste oil storage and reprocessing operations waste</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:

Lagoon sediments and sludges, debris, levee material, lagoon oil, and soil (172,000 tons)</td></tr>
<tr><td>Purpose/Significance of Application:
Inadequate design caused in numerous mechanical problems; incineration operation suspended twice because of mechanical problems; problems with demulsifying complicated dewatering of sediment</td></tr>
</table>

Incineration at the Bridgeport Refinery and Oil Services Superfund Site Logan Township, New Jersey

(Continued)

Regulatory Requirements/Cleanup Goals:
- Destruction and Removal Efficiency (DRE) of 99.99% for VOCs as required by Resource Conservation and Recovery Act (RCRA) incinerator regulations in 40 CFR Part 264, Subpart O; The DRE of 99.9999% for PCBs and ash residual as required by Toxic Substances Control Act (TSCA) regulations in 40 CFR Part 761

Results:
- Emissions and trial burn data indicate that all DRE and emission standards have been met

Description:
Between the 1960s and continuing through 1981, an on-site lagoon was used for disposal of wastes from waste oil reprocessing operations conducted on site. Lagoon sediment was contaminated with PCBs at concentrations greater than 500 mg/kg, as well as VOCs and metals.

In 1984, EPA signed a Record of Decision (ROD) specifying on-site incineration as the selected remedy for the sludge, sediment, soil, debris, and lagoon oil at the site. Remedial actions were managed by the U.S. Army Corps of Engineers (COE) under the oversight of EPA Region II.

The material to be incinerated was excavated from the lagoon, and screened and mixed before incineration. The material was then conveyed into a rotary kiln by a screw auger. The PCBs and VOCs were volatilized and partially destroyed in a direct-fired rotary kiln. The incineration system also included a secondary combustion chamber (SCC) to provide further destruction of any VOCs and PCBs. Kiln ash was quenched in a water bath. Wastewater from the incinerator was treated in an on-site wastewater treatment system and discharged to a nearby creek. Exhaust gas from the kiln was directed to an air pollution control system (APCS). The APCS consisted of a cyclone separator for removal of larger particulates; a secondary combustion chamber (SCC) for destruction of any remaining VOCs and PCBs.

During its 50 months of operation, the incinerator processed over 172,000 tons of sediment, sludge, debris, oil, and soils. Treatment performance and emissions data collected during this remedial action indicated that all performance standards and emissions requirements were achieved.

The actual cost for remediation using the incineration system was approximately $187,000,000 (includes costs associated with treatment of lagoon water and removal of tank farm).

Incineration at the Celanese Superfund Site
Shelby, North Carolina

<table>
<tr><td>Site Name:
Celanese Superfund Site</td><td rowspan="2">Contaminants:
Ethylene glycol, volatile organic compounds, metals, polynuclear aromatic hydrocarbons, and phenol
• Trichloroethylene, benzene, phenols, lead, chromium, and antimony
• Maximum concentrations of ethylene glycol (12,000 mg/kg) antimony (3,000 mg/kg), lead (2,041 mg/kg) and chromium (40 mg/kg).</td><td>Period of Operation:
April 1991 to December 1991</td></tr>
<tr><td>Location:
Shelby, North Carolina</td><td>Cleanup Type:
Remedial action</td></tr>
<tr><td>Vendor:
Terry Elmaggar
GDC Engineering, Inc.
822 Neosho Avenue
Baton Rouge, LA 70802
(504) 383-8556</td><td rowspan="2">Technology:
On-Site Incineration
• Solids pretreated with screening and mixing with sawdust
• Incineration system consisting of rotary kiln and secondary combustion chamber (SCC)
• Soil residence time of 45 minutes, kiln temperature of 1,500°F; SCC temperature of 1,900°F
• Treated soil and sludge (incineration ash) discharged into a wet ash collection system</td><td>Cleanup Authority:
CERCLA and State: North Carolina
• ROD Date: 3/28/89
• PRP-Lead</td></tr>
<tr><td>SIC Code:
2824 (Manufacturing manmade organic fibers)</td><td>Point of Contact:
McKenzie Mallary
U.S. EPA Region 4
Atlanta Federal Center
100 Alabama Street
Atlanta, GA 30303-3104
(404) 562-8802</td></tr>
<tr><td>Waste Source:
Disposal of waste sludges</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Sludge and Soil
• 4,660 tons of sludge and soil
• Moisture content: sludge - 25%</td></tr>
<tr><td>Purpose/Significance of Application:
Lowest volume incinerated for all of the case studies</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
• Destruction and Removal Efficiency (DRE) of 99.99% for each constituent of concern as required by Resource Conservation and Recovery Act (RCRA) incinerator regulations in 40 CFR part 264, subpart O</td></tr>
<tr><td colspan="3">Results:
• Emissions and trial burn data indicate that all DRE and emission standards were met
• Analytical data of residuals indicate that cleanup goals were met</td></tr>
</table>

Incineration at the Celanese Superfund Site
Shelby, North Carolina

(Continued)

Description:
The site began operation in April 1960 and is still operating. Between 1960 and the early 1980s, plant wastes from the production of polyester raw-material were disposed of in burn pits and sludge was buried in trenches. Between 1970 and 1978, drums of waste chemicals and solvents were stored on site. A site investigation was conducted in 1981. A Record of Decision (ROD), signed in March 1989, specified on-site incineration as the remediation technology for the excavated sludge and soil. Site cleanup goals and DRE standards of 99.99% for constituents of concern were specified in the ROD.

On-site incineration began in April 1991. During its period of operation, the incinerator processed 4,660 tons of sludge and soil. The treatment system consisted of a rotary kiln and an SCC. An enclosed conveyor moved the soil and debris to the kiln for treatment. Treated ash from the incinerator was discharged to a wet ash collection system. The system used an air pollution control system that consisted of a baghouse and a packed-bed scrubber. Incineration achieved the soil cleanup goals specified in the ROD.

The total cost of the remedial action was approximately $5,800,000, including $3,925,000 in capital costs and $1,875,000 in operation and maintenance costs.

Incineration at the Coal Creek Superfund Site
Chehalis, Washington

<table>
<tr><td>Site Name:
Coal Creek Superfund Site</td><td rowspan="2">Contaminants:
Polychlorinated biphenyls and lead. Also other metals, including:
• lead
• copper
• barium
• mercury
• cadmium
• zinc</td><td>Period of Operation:
January 1994 to May 1994</td></tr>
<tr><td>Location:
Chehalis, Washington</td><td>Cleanup Type:
Remedial action</td></tr>
<tr><td>Vendor:
Matthew Beatty
Roy F. Weston, Inc.
1 Weston Way
West Chester, PA 19380-1499
215-692-3030</td><td rowspan="2">Technology:
On-Site Incineration
• Soil screened prior to being fed to incinerator
• Incineration system consisting of a rotary kiln and a secondary combustion chamber (SCC)
• SCC system temperature of 2,100 °F; gas from SCC cooled by water sprays before being sent through air pollution control system
• Process water was treated by carbon filtration system then discharged on-site</td><td>Cleanup Authority:
CERCLA
• ROD signed October 1990
• Consent Decree entered 1992
• RP-lead with EPA oversight</td></tr>
<tr><td>SIC Code:
4953 (Refuse Systems)</td><td>Point of Contact:
Bob Kievit
U.S. EPA Region 10
1200 Sixth Avenue
Seattle, WA 98101
360-753-9014</td></tr>
<tr><td>Waste Source:
Disposal areas - oil containing PCBs</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Soil (9,715 tons)</td></tr>
<tr><td>Purpose/Significance of Application:
Because of previous performance, and because it had a TSCA permit, the incinerator was allowed to demonstrate DRE compliance without spiking</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
• Destruction and Removal Eficiency (DRE) of 99.9999% for PCBs as required by Toxic Substances Control Act (TSCA) regulations in 40 CFR part 761</td></tr>
</table>

Incineration at the Coal Creek Superfund Site
Chehalis, Washington

(Continued)

Results:
- Emissions and performance data indicated that all DRE and emission standards were met

Description:
Between 1949 and 1983, the Coal Creek site was used for scrapping, salvaging, and repairing electrical equipment. During this time, oil containing PCBs was drained on to the ground.

In October 1990, a Record of Decision (ROD) was signed, specifying excavation and on-site incineration of soil with greater than 50 mg/kg PCBs. In 1992, the responsible parties (RP) entered into a Consent Decree with EPA, agreeing to implement the remedial action described by the ROD.

Remedial Action began in January 1994. The incineration system consisted of a feed system, a rotary kiln, a secondary combustion chamber (SCC), and an air pollution control system (APCS). The soil was screened before being fed to the incinerator. Over a 5-month period, the incinerator processed approximately 9,700 tons of soil. Treatment performance and emissions data collected during this application indicated that all performance standards and emissions requirements were met.

The actual cost for remediation using the incineration system was approximately $8,100,000.

Incineration at the FMC Corporation - Yakima Pit Superfund Site Yakima, Washington

<table>
<tr><td>Site Name:
FMC Corporation - Yakima Pit Superfund Site</td><td rowspan="2">Contaminants:
• DDD, DDE, DDT, dieldrin, endosulfan, ethion, malathion, parathion, cadmium, chromium, and zinc.
• DDD concentrations of 76 mg/kg, DDE concentration of 210 mg/kg, and DDT concentrations of 210 mg/kg
• The maximum concentrations of contaminants (mg/kg) detected in soil were DDD (76), DDE (28), DDT (210), dieldrin (40), endosulfan (7,000), ethion (180), malathion (170,000), parathion (3,300), cadmium (6), chromium (320), and zinc (1,020).</td><td>Period of Operation:
January 1993 - May 1993</td></tr>
<tr><td>Location:
Yakima, Washington</td><td>Cleanup Type:
Remedial action</td></tr>
<tr><td>Vendor:
VESTA Technology Ltd.
1670 West McNab Road
Ft. Lauderdale, FL 33309</td><td rowspan="2">Technology:
On Site Incineration
• Solids crushed and mixed with soil
• Incineration system consisting of co-concurrent rotary kiln and secondary combustion chamber (SCC)
• Enclosed twin screw conveyor transported soil and debris to the unit
• Soil had a through part rate of 60 kg/min with kiln temperature of 650 ^{o}C, the SCC temperature of 1,107 ^{o}C.
• Ash discharged onto conveyers, sampled and analyzed, and then landfilled.</td><td>Cleanup Authority:
CERCLA
• ROD Date: 9/14/90
• EPA-lead</td></tr>
<tr><td>SIC Code:
2879 (Pesticides and Agricultural Chemicals)</td><td>Point of Contact:
Lee Marshall
U.S. EPA Region 10
1200 Sixth Avenue
Seattle, Washington 98101
(206) 553-2723</td></tr>
</table>

Incineration at the FMC Corporation - Yakima Pit Superfund Site Yakima, Washington

(Continued)

Waste Source: Pesticide production wastes disposed of in an unlined pit	**Type/Quantity of Media Treated:** Soil and Debris • 5,600 cubic yards
Purpose/Significance of Application: Initially, was estimated in the ROD that between 900 and 4,000 cubic yards of material were contaminated. However, contamination extended deeper than previously anticipated and, as a result, over 5,600 cubic yards of material was excavated for incineration.	

Regulatory Requirements/Cleanup Goals:

- Destruction and Removal Efficiency (DRE) of 99.99 for all constituents of concern as required by Resource Conservation and Recovery Act (RCRA), 40 CFR Part 264 Subpart O.

Results:

- Monitoring and trial burn data indicate that all DRE and emission standards have been met.
- Analytical data of residuals indicate that cleanup goals have been met

Cost Factors:

- The actual cost for remediation using the incineration system was approximately $6,000,000.

Description:

Between 1952 and 1969, wastes contaminated with pesticides were disposed of on the site in an unlined waste disposal pit. It was estimated that 2,000 pounds of material was disposed of on the site in the pit contaminating soil with 1,1-dichloro-2,2-bis(p-chlorophenyl)ethane (DDD), 1,1-dichloro-2,2-bis(p-chlorophenyl)ethylene (DDE), 1,1,1-trichloro-2,2-bis(p-chlorophenyl)ethane (DDT), and dieldrin.

A Record of Decision (ROD) signed in September 1990 specified on-site incineration as the remedial technology. Site cleanup goals and destruction and removal efficiency (DRE) standards were established for constituents of concern.

On-site incineration began in January 1993 and was completed in May 1993. The treatment system consisted of a rotary kiln and an SCC. Enclosed twin screws moved the soil to the kiln for treatment. Ash was collected and flue gas was completely incinerated. Incineration has achieved the soil cleanup goals specified in the ROD.

The actual cost for remediation using the incineration system was approximately $6,000,000.

Incineration at the Former Nebraska Ordinance Plant Site
Mead, Nebraska

<table>
<tr>
<td>Site Name:
Former Nebraska Ordnance Plant – Operable Unit 1</td>
<td>Contaminants:
Explosives and Propellants
• TNT, RDX, TNB, DNT, DNB, HMX, Tetryl, o-NT and m-NT
• Maximum concentrations in mg/kg – TNT (133,000), RDX (23,270), TNB (430) and DNT (119.3)</td>
<td>Period of Operation:
• Mini and Trial Burn Operation – September 1997
• Full-Scale Operation – October to December 1997</td>
</tr>
<tr>
<td rowspan="2">Project Management:
U.S. Army Corps of Engineers
Formerly Used Defense Sites Program
Edwin Louis
Kansas City District
700 Federal Building
Kansas City, Missouri 68144-3869
(816) 983-3563</td>
<td rowspan="2">Technology:
On-Site Incineration
• Soil stream was fed through a grizzly screen to remove large debris
• Incineration system consisting of a co-current, rotary kiln and one secondary combustion chamber (SCC)
• Kiln operated at an exit gas temperature of 1150 to 1800 ^{o}F; SCC operated 1800 ^{o}F
• Hot flue gases exiting the kiln were quenched using water spay nozzles
• Solids exiting the kiln were stockpiled for compliance sampling</td>
<td>Cleanup Type:
Remedial Action</td>
</tr>
<tr>
<td>Cleanup Authority:
CERCLA and State
ROD date – August 29, 1995</td>
</tr>
<tr>
<td rowspan="2">Waste Sources:
Discharge of contaminated rinse water and burning of explosives</td>
<td rowspan="2">Type/Quantity of Media Treated:
Soil and Debris
• 16,449 tons (13,009 cubic yards) of soil and debris
• Average Moisture Content: 16.82 %
• Average BTU value per pound: 1220
• Average Soil Density - 93.7 pounds per cubic foot</td>
<td>SIC Code:
9711B (Ordnance Production and Storage) and 9711C (Ordnance Testing and Maintenance)</td>
</tr>
<tr>
<td rowspan="2">Regulatory Points of Contact:
Craig Bernstein
USEPA Region VII
726 Minnesota Avenue
Kansas City, Kansas 66101
(913) 551-7688

Troy Bendenkamp
NDEQ
Suite 400, The Atrium
1200 N. Lincoln Street
Lincoln, Nebraska 68509-8922
(402) 471-2214</td>
</tr>
<tr>
<td>Purpose/Significance of Application:
Project completed in extremely short time period, including all permitting requirements</td>
</tr>
</table>

Incineration at the Former Nebraska Ordinance Plant Site
Mead, Nebraska

(Continued)

Regulatory Requirements/Cleanup Goals:
Destruction and Removal Efficiency (DRE) of 99.99% for POHC
The following limits were set for treated soil after incineration in mg/kg:
- TNT – 17.2
- RDX – 5.8
- TNB – 1.7
- DNT – 0.9
- TNB – 1.7
- HMX – 1,715.2
- Tetryl – 343
- NT – 343

Results:
- Emission and trial burn data indicated that all DRE and emissions standards were met
- Treated soil sampling indicated that all soil cleanup goals were met

Costs:
The total cost for this project was $10,700,001. The technology cost was $6,479,245 ($394 per ton of contaminated material).

Description:
During several intervals between 1942 and 1959, the Nebraska Ordnance Plant (NOP) site was used for loading, assembly and testing of bombs, boosters and shells. During site cleaning activities, explosives-containing wash water was discharged into surface water drainage ditches at the site. In addition, contamination was observed in soil at the Burning/Proving Grounds at the site. A Record of Decision (ROD) was signed in August 1995, specifying on-site incineration as the remedial technology for addressing shallow contaminated soil at the site. Shallow contaminated soil at the former NOP (soil between 0 and 4 feet below the ground surface) was identified as Operable Unit (OU) 1. Site soil cleanup goals were specified in the ROD.

Because the former NOP site was designated as part of the Formerly Used Defense Site (FUDS) program, the USACE was responsible for managing remedial actions at this site.

Site work for construction of the incinerator was commenced in February 1997. Incinerator start up and shake down were performed in August and September 1997. Mini burn and trial burn tests were conducted in September 1997. After receiving approval from EPA and NDEQ of the proposed operating limits, the incinerator was put into full production in October 1997. Treatment was completed in December 1997. The incineration system consisted of a co-current, rotary kiln followed by a secondary combustion chamber (SCC). After confirming that treated soil met the cleanup criteria, the soil was returned to an excavation at the site. Demobilization of the incinerator from the site was completed in May 1998.

Incineration at the MOTCO Superfund Site
Texas City, Texas

<table>
<tr><td>Site Name:
MOTCO Superfund Site</td><td rowspan="2">Contaminants:
Styrene tars, VOCs, PCBs, and metals:
benzene, vinyl chloride, 1,1,2-trichloroethane, lead, cadmium, mercury, and chromium</td><td>Period of Operation:
May 1990 to December 1991</td></tr>
<tr><td>Location:
Texas City, Texas</td><td>Cleanup Type:
Remedial action</td></tr>
<tr><td>Vendor:
IT Corporation
312 Directors Drive
Knoxville, TN 37923
(423) 690-3211</td><td rowspan="2">Technology:
• Two incineration systems: the Hybrid Thermal Treatment System® HTTS-2 and HTTS-3; HTTS-2 designed to process solids, sludges, tars, aqueous wastes, and organic liquids; and HTTS-3 designed to process aqueous wastes and organic liquids

• Solids transferred to feed preparation building where materials were mixed and screened

• The HTTS-2 consisted of two chambers (the kiln and SCC) and a gas cleaning system consisting of a quench system, gas conditioner, wet scrubber system, and a vane separator; the HTTS-3 consisted of a combustion chamber and a gas cleaning system

• Solids, sludges, and aqueous wastes fed to the HTTS-2 kiln by a screw conveyor; organic liquid wastes used as primary fuels in the kiln

• Residual ash from kiln collected, landfilled, and capped on site</td><td>Cleanup Authority:
CERCLA and State: Texas
• ROD signed 3/15/85
• RP-lead; EPA oversight</td></tr>
<tr><td>SIC Code:
2865 (Industrial organic chemicals)</td><td>Point of Contact:
Ashby McMullan
Texas Natural Resources Conservation Commission
(512) 239-1000</td></tr>
<tr><td>Waste Source:
On site pits - styrene tars and chemical wastes - wood preserving wastes</td><td colspan="2">Type/Quantity of Media Treated:
Soil, sludge, organic liquids, and aqueous wastes
• 10,471 tons aqueous wastes
• 7,568 tons organic liquids
• 283 tons sludges and tars
• 4,699 tons soil</td></tr>
</table>

Incineration at the MOTCO Superfund Site
Texas City, Texas

(Continued)

Purpose/Significance of Application:
Mechanical problems were encountered, caused in part by lack of accurate waste characterization; onsite incineration halted in December 1991 because of dispute between the contractor and RP; remedy changed to off-site incineration in part because of dispute and mechanical problems

Regulatory Requirements/Cleanup Goals:
Destruction and Removal Efficiency (DRE) of 99.99% for each principal organic hazardous constituent as required by Resource Conservation and Recovery Act (RCRA) incinerator regulations in 40 CFR part 264, subpart O; 99.9999% DRE for PCBs as required by Toxic Substances Control Act (TSCA) regulations in 40 CFR part 761

Results:
Emissions and performance data indicate that all DRE and emissions standards have been met

Description:
The MOTCO site was established in 1959 for the recycling of styrene tars. From 1961 to 1968, on-site pits that held styrene tars were used for the disposal of chemical wastes from local industries. In March 1985, a Record of Decision (ROD) that required source control was signed, and in September 1989, a ROD that addressed off-site migration of contaminants was signed.

The remedy selected for the first Operable Unit (OU-1) was off-site treatment and disposal of contaminated material; however, the ROD specified that on-site incineration was a viable alternative to be evaluated during the design phase. A later Consent Decree required on-site incineration and established incinerator requirements.

The site operated two incineration systems. The first system was called the Hybrid Thermal Treatment System® 2 (HTTS®-2), and the second system was referred to as HTTS-3. The HTTS-2 consisted of a rotary kiln, a secondary combustion chamber (SCC), and a gas cleaning system. This incineration system processed solids, sludges, tars, aqueous wastes, and organic liquids. The HTTS-3 consisted of a combustion chamber and gas cleaning system identical to the SCC and gas cleaning system of the HTTS-2. The HTTS-3 processed only aqueous wastes and organic liquids.

In December 1991, the HTTS-3 had passed the trial burn and was performing under interim operating conditions, and the HTTS-2 was in the process of conducting a trial burn when the contractors stopped incineration and filed a lawsuit against the responsible party (RP) for breach of contract. Due to the dispute and several technical problems (including slagging), on-site incineration did not resume.

In January 1993, an Explanation of Significant Differences (ESD) specified off-site incineration of the remaining sludges, tars and organic liquid. The remaining soil was to be capped on site.

The cost incurred during the on-site incineration was approximately $76 million consisting of $20 million in capital costs and $56 million in operating costs.

Incineration at the Old Midland Products Superfund Site
Ola, Arkansas

<table>
<tr>
<td>Site Name:
Old Midland Products
Superfund Site</td>
<td rowspan="2">Contaminants:
Pentachlorophenol and polynuclear aromatic hydrocarbons, and VOCs
• Benzo(a)anthracene, benzo(a)pyrene, benzo(k)fluoranthene, chrysene, fluoranthene, 2-methyl naphthalene, phenanthrene, benzene, toluene, trichloroethylene, xylene, and chloroform.
• PCP concentrations up to 5,900 mg/kg and PAH concentrations up to 38,000 mg/kg</td>
<td>Period of Operation:
June 1992 - May 1993</td>
</tr>
<tr>
<td>Location:
Ola, Arkansas</td>
<td>Cleanup Type:
Remedial action</td>
</tr>
<tr>
<td>Vendor:
Chemical Waste Management, Inc.
ENRAC South Division
P.O. Box 579
Ola, AR 72853-0579</td>
<td rowspan="2">Technology:
On-Site Incineration
• Solids pretreated with shredding, screening, and mixing with cement kiln dust
• Incineration system consisting of rotary kiln and secondary combustion chamber (SCC)
• Enclosed conveyor transported contaminated soil and debris to the unit
• Kiln temperature of 1,425°F, SCC temperature of 2,091°F
• Treated soil and debris (incinerator ash) discharged onto conveyors and taken to an ash storage area</td>
<td>Cleanup Authority:
CERCLA and State: Arkansas
• ROD Date: 3/24/88
• State-lead</td>
</tr>
<tr>
<td>SIC Code:
2491 (Wood Preserving)</td>
<td>Points of Contact:
Carlos Sanchez
U.S. EPA Region 6
1445 Ross Avenue
Suite 1200
Dallas, TX 75202
(214) 665-8507

Clark McWilliams
State of Arkansas
Department of Pollution Control and Ecology
P.O. Box 8913
Little Rock, AR 72219
(501) 682-0850</td>
</tr>
</table>

Incineration at the Old Midland Products Superfund Site
Ola, Arkansas

(Continued)

Waste Source:
Disposal lagoons - wood preserving waste

Purpose/Significance of Application:
Initially, dioxins and furans were believed to be present in the soil. Later, concentrations of dioxins and furans were determined to be very low and none were in the form of 2,3,7,8-TCDD.

Type/Quantity of Media Treated:
Sludge and Soil
- 102,000 tons of sludge and soil
- Moisture content: sludge - 43.6%

Regulatory Requirements/Cleanup Goals:
- Destruction and Removal Efficiency (DRE) of 99.9999% for all constituents of concern as required by Resource Conservation and Recovery Act (RCRA) incinerator regulations in 40 CFR part 264, subpart O

Results:
- Monitoring and trial burn data indicate that all DRE and emission standards have been met
- Analytical data of residuals indicate that cleanup goals have been met

Description:
Between 1969 and 1979, the site operated as a wood preserving plant. Effluents from the treatment process containing PCP and PAHs were discharged to seven on-site lagoons. A series of inspections at the site were performed by the Arkansas Department of Pollution Control and Ecology and the U.S. EPA between 1981 and 1986. A Record of Decision (ROD) was signed March 1988, specified on-site incineration as the remedial technology for the sludge, soil, and sediments. Site cleanup goals and DRE standards were specified for constituents of concern.

On-site incineration began in June 1992 and was completed in May 1993. The treatment system consisted of a rotary kiln and an SCC. An enclosed conveyor moved the soil and debris to the kiln for treatment. Treated ash from the incinerator was discharged to a conveyor and conveyed to a collection area. During its period of operation, the incinerator processed 102,000 tons of sludge and soil. Incineration achieved the soil cleanup goals specified in the ROD.

The total cost of the remedial action was approximately $17,114,000.

Incineration at the Petro Processors Superfund Site
Baton Rouge, Louisiana

<table>
<tr><td>Site Name:
Petro Processors Superfund Site</td><td rowspan="2">Contaminants:
Chlorinated Hydrocarbons, Polynuclear Aromatic Hydrocarbons (PAHs), Heavy Metals, and Oils
• Hexachlorobutadiene and hexachlorobenzene</td><td>Period of Operation:
November 1994 to Present</td></tr>
<tr><td>Location:
Baton Rouge, Louisiana</td><td>Cleanup Type:
Remedial action</td></tr>
<tr><td>Site General Contractor:
Bill Dawson
NPC Services, Inc.
3867 Plaza Tower Drive
Baton Rouge, Louisiana 70816
(504) 778-6206</td><td rowspan="2">Technology:
On-Site Incineration
• Combustion of fumes and liquids from groundwater treatment system
• Incineration system consisting of a horizontal, direct-fired kiln
• Air fan delivers fumes and centrifugal pump delivers liquids to the unit
• Kiln temperature of 2,000°F to 2,400°F
• Blowdown from the system is pH adjusted with lime and discharged</td><td>Cleanup Authority:
CERCLA and State: Louisiana
• ROD Date: No ROD, Consent Decree took the place of the ROD
• RP-lead</td></tr>
<tr><td>SIC Code:
4953 (Refuse Systems)</td><td>Point of Contact:
Cynthia Kaleri
Remedial Project Manager
U.S. EPA Region VI
1445 Ross Avenue
Dallas, Texas 75202-2733
(214) 665-6772</td></tr>
<tr><td>Waste Source:
Disposal of petrochemical wastes in on-site lagoons</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Liquids and Fumes
• 213,376 gallons of LNAPLs to date</td></tr>
<tr><td>Purpose/Significance of Application:
Incinerator treats liquid organics and air stripper fumes from a groundwater treatment system</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
• Destruction and Removal Efficiency (DRE) of 99.99% for organic constituents of concern as required by Resource Conservation and Recovery Act (RCRA) incinerator regulations in 40 CFR part 264, subpart O</td></tr>
<tr><td colspan="3">Results:
• Emissions and trial burn data indicate that all DRE and emission standards have been met to date</td></tr>
<tr><td colspan="3">Cost Factors:
• Total cost of the incinerator is approximately $59,221,500 to date
• Approximate Total Capital Costs: $44,552,600 (including equipment, site preparation, construction/engineering, startup); Projected Future Capital Costs: $6,971,000
• Approximate Total Operating Costs: $14,668,900 (including maintenance, project management, sampling and analysis, supplies); Projected Future Monthly Operating Costs: $300,000</td></tr>
</table>

Incineration at the Petro Processors Superfund Site
Baton Rouge, Louisiana

(Continued)

Description:
Between 1961 and 1980, the Petro Processors Superfund Site operated as a petrochemical waste disposal area. A remedial investigation determined that soil and groundwater at the site were contaminated. A Consent Decree entered into Federal Court on February 16, 1984 specified that a plan of action be developed for the site. The plan included a groundwater treatment system which utilized an incinerator to treat liquid organics and air stripper fumes. Site cleanup goals and DRE standards were specified for the organic constituents of concern.

The treatment system began operation in November 1994 and is ongoing at the time of this report. The incineration system consists of a horizontal, direct-fired incinerator. A centrifugal pump and an combustion air fan deliver the liquid and fume waste, respectively, to the incinerator. The incinerator is equipped with an air pollution control system consisting of a quench tank; an HCl absorber/caustic scrubber tower; a particulate scrubber; and a entrainment separator.

The total cost of the Remedial Action is approximately $59,221,500 to date. Capital costs accounted for approximately $44,552,600 with a projected future cost of $6,971,000. Operation and maintenance costs accounted for approximately $14,668,900 with a projected future monthly cost of $300,000.

Incineration at the Rocky Mountain Arsenal Superfund Site Commerce City, Colorado

<table>
<tr><td>Site Name:
Rocky Mountain Arsenal Superfund Site</td><td rowspan="2">Contaminants:
Organochloric and organophosphoric pesticides and metals
• ardrin
• dieldrin
• vapona
• copper
• zinc
• arsenic</td><td>Period of Operation:
July 1993 - July 1995</td></tr>
<tr><td>Location:
Commerce City, Colorado</td><td>Cleanup Type:
Interim response</td></tr>
<tr><td>Vendor:
T-Thermal Sub-X® Liqui-Datur® Incinerator manufactured by T-Thermal Incorporated and cross-licensed by Nittetu Chemical Engineering, Limited</td><td rowspan="2">Technology:
On-Site SQI Incineration
• High-temperature oxidation in a down-fired, SQI
• High-energy venturi scrubber for particulate emission control
• Packed tower caustic scrubber for neutralization of exhaust gases
• Residuals transported to off-site handling facility</td><td>Cleanup Authority:
CERCLA and State: Colorado
• U.S. Army, PRP, and EPA enter into Federal Facilities Agreement 2/89 - includes 13 interim response actions
• ROD signed 12/9/96
• DoD Lead</td></tr>
<tr><td>SIC Code:</td><td>Point of Contact:
Colonel Eugene H. Bishop
Program Manager
Rocky Mountain Arsenal
Commerce City, CO 80022-2180
(303) 289-0467 - Public Affairs Office
(303) 286-8032 - SQI Information Hotline</td></tr>
<tr><td>Waste Source:
Evaporation basin used to store manufacturing wastewaters</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Liquids
• 10.9 million gallons</td></tr>
<tr><td>Purpose/Significance of Application:
Innovative design used to capture metal particulates; recovered enough copper to recycle it</td></tr>
</table>

Incineration at the Rocky Mountain Arsenal Superfund Site Commerce City, Colorado

(Continued)

Regulatory Requirements/Cleanup Goals:

- Destruction and Removal Efficiency (DRE) of 99.99% for all constituents of concern as required by Resource Conservation and Recovery Act (RCRA) incinerator regulations in 40 CFR part 264, subpart O

Results:

Monitoring and trial burn data indicate that all DRE and emission standards have been met

Description:

RMA was established in 1942 and historically has been used for manufacturing and demilitarizating chemical incendiary weapons. Portions of RMA were leased for the private production of agricultural chemicals including pesticides from 1947 to 1982. Between 1957 and 1982 an evaporation pond (Basin F) was used for disposal of various wastewaters from the site's manufacturing process and wastes from demilitarization activities.

The Army and the on-site chemical manufacturer were designated as responsible parties in a Federal Facilities Agreement (FFA) entered into in 1989. The FFA specified 13 interim response actions (IRAs), including the remediation of Basin F. A Record of Decision (ROD) for all operable units at the site was signed December 9, 1996.

The Army selected SQI to dispose of Basin F liquids. The SQI system included an atomizing liquid injection system; an incinerator chamber; a quench chamber; a spray dryer; a venturi scrubber for particulate matter control; a packed-tower scrubber for neutralization of off-gases; and a residuals handing facility.

Full-scale operation of the SQI began in July 1993 and incineration of approximately 10.9 million gallons of Basin F liquid was completed by July 1995. The SQI was decommissioned, dismantled, and sold for parts, per the FFA, upon completion of the project. All applicable and relevant or appropriate requirements were met throughout the project.

The actual cost for remediation of Basin F was approximately $93,000,000, including $73,000,000 in capital costs and $80,000,000 in operation and maintenance costs.

Incineration at the Rose Disposal Pit Superfund Site
Lanesborough, Massachusetts

<table>
<tr><td>Site Name:
Rose Disposal Pit Superfund Site</td><td rowspan="2">Contaminants:
Primary Contaminant Groups: PCBs, volatile organic compounds (VOCs) including TCE, benzene, and vinyl chloride
• PCBs at were detected at concentrations up to 440,000 mg/kg. The average PCB concentration was 500 mg/kg</td><td>Period of Operation:
February 1994 - July 1994</td></tr>
<tr><td>Location:
Lanesborough, Massachusetts</td><td>Cleanup Type:
Remedial action</td></tr>
<tr><td>Vendor:
Mark Phillips
Maximillian Technology
Pittsfield, MA
(413) 494-3027</td><td rowspan="2">Technology:
On-site incineration
• Soil was pretreated with crushing and shredding to achieve a homogenized incinerator feed
• Incineration system consisting of rotary kiln and secondary combustion chamber (SCC)
• SCC temperatures averaged 2000 °F
• Ash was discharged, and returned to the excavated areas on site</td><td>Cleanup Authority:
CERCLA
• ROD Date: 9/30/96, 11/21/89
• EPA-lead</td></tr>
<tr><td>SIC Code:
NA</td><td>Point of Contact:
Pam Shields
U.S. EPA Region 1</td></tr>
<tr><td>Waste Source:
Disposal of manufacturing wastes in an open trench</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Soil (51,000 tons)</td></tr>
<tr><td>Purpose/Significance of Application:</td></tr>
</table>

Incineration at the Rose Disposal Pit Superfund Site
Lanesborough, Massachusetts

(Continued)

Regulatory Requirements/Cleanup Goals:
Destruction and Removal Efficiency (DRE) of 99.9999% for PCBs as required by Toxic Substances Control Act 40 CFR part 76 subpart D

Results:
Treatment performance and air monitoring data collected during this application indicated that all required performance and standards emissions were achieved.

Description:
Between 1951 and 1959, the 14-acre residential lot received wastes from a nearby manufacturer. Soil at the site was contaminated with PCBs as well as volatile organic compounds (VOCs). A Record of Decision signed September 23, 1988 and November 21, 1989 specified on-site incineration as the remedial technology for the soil and sediments. Site cleanup goals and DRE standards were specified for constituents of concern.

On-site incineration began in February 1994 and was completed in July 1994. the treatment system consisted of a rotary kiln and an SCC. Kiln ash was treated and stored and treated gas was exhausted to a stack. Incineration has achieved the soil cleanup goals specified in the ROD.

No information was available on costs for the remedial action.

Incineration at the Rose Township Dump Superfund Site
Holly, Michigan

<table>
<tr><td>Site Name:
Rose Township Dump Superfund Site</td><td rowspan="2">Contaminants:
PCBs, metals, and volatile and semivolatile organic compounds

• Most common contaminants (and maximum concentrations) were toluene (4,700 mg/kg), ethylbenzene (430 mg/kg), chlorobenzene (570 mg/kg), xylene (1,400 mg/kg), naphthalene (31 mg/kg), pentachlorophenol (32 mg/kg), acetone (76 mg/kg), and total phthalates (91 mg/kg)</td><td>Period of Operation:
September 1992 - October 1993</td></tr>
<tr><td>Location:
Holly, Michigan</td><td>Cleanup Type:
Remedial Action</td></tr>
<tr><td>Vendor:
OHM Remediation Services Corp.
16406 U.S. Route 224 East
Findlay, OH 45840</td><td rowspan="2">Technology:
On-Site Infrared Incineration
• Excavated material screened and blended with fuel oil prior to incineration
• PCBs and VOCs volatilized and partially destroyed in primary combustion chamber
• Kiln ash quenched by water-cooled screw
• Exhaust gas from kiln directed to air pollution control system, consisting of secondary combustion chamber (SCC)
• Wastewater treated on-site and discharged under NPDES permit</td><td>Cleanup Authority:
CERCLA and State: Michigan
• ROD signed 9/30/87
• EPA-lead</td></tr>
<tr><td>SIC Code:
N/A</td><td>Point of Contact:
Kevin Addler
US EPA Region V
77 West Jackson Boulevard
Chicago, IL
Phone: 312-886-7078

State Contact:
Brady Boyce
Michigan Department of Environmental Quality
301 S. Capitol Street
Lansing, MI 48933
Phone: 517-373-4824</td></tr>
</table>

Incineration at the Rose Township Dump Superfund Site
Holly, Michigan

(Continued)

Waste Source:
Waste disposal areas in landfills and surface impoundments — wastes included spent solvents, paint sludges, lead battery sludges, waste oils

Purpose/Significance of Application:
Operating in winter led to weather-related difficulties resulting in suspension of the operation until spring.

Type/Quantity of Media Treated:
Soil
- 34,000 tons of surface and subsurface soil

Regulatory Requirements/Cleanup Goals:
- Destruction and Removal Efficiency (DRE) of 99.9999% for principal organic hazardous materials as required by Resource Conservation and Recovery Act (RCRA) regulations in 40 CFR part 264, subpart O; DRE of 99.9999% for PCBs as required by Toxic Substances Control Act (TSCA) regulations in 40 CFR part 761

Results:
- EPA determined that demonstration of a 99.9999% DRE for PCBs was not necessary during the trial burn because (1) substantial hazards were associated with transporting and storing concentrated PCB oils, and (2) the unit had demonstrated the ability to adequately destroy PCBs in order to obtain its TSCA permit

Description:
From 1966 to 1968 approximately 5,000 drums containing spent solvents, paint sludges, lead battery sludges, and waste oils were buried in a 12-acre area at the Rose Township Dump site. Bulk wastes were also discharged to the surface or into shallow lagoons or pits in the area. On September 30, 1987, EPA signed a Record of Decision (ROD) specifying on-site incineration as the selected remedy for contaminated soil at the site. A consent decree was signed by 12 potentially responsible parties (PRPs) and EPA in 1988 to remediate the site.

The incinerator used to process soils at the site was the OHM Mobile Infrared Thermal Destruction Unit (TDU). The PCBs and VOCs were volatilized and partially destroyed in the primary combustion chamber. Off-gases from the preliminary combustion chamber were routed to a secondary combustion chamber (SCC) for further destruction of any remaining VOCs and PCBs. Kiln ash was quenched by a water-cooled screw. During the on-site incineration remedial action, 34,000 tons of contaminated soil were incinerated. Treatment performance and emissions data collected during this application indicated that all performance standards and emissions requirements were achieved.

The total cost for remediation using the incineration system was approximately $12 million.

Incineration at the Sikes Disposal Pits Superfund Site
Crosby, Texas

<table>
<tr><td>Site Name:
Sikes Disposal Pits Superfund Site</td><td rowspan="2">Contaminants:
Organic and Phenolic Compounds
• Naphthalene, chlorobenzene, creosote, toluene, xylene, dichloroethane, and vinyl chloride
• Maximum concentrations in mg/kg - naphthalene (58), chlorobenzene (2.3), toluene (5), dichloroethane (20), and vinyl chloride (1).</td><td>Period of Operation:
February 1992 to June 1994</td></tr>
<tr><td>Location:
Crosby, Texas</td><td>Cleanup Type:
Remedial action</td></tr>
<tr><td>Vendor:
Mike Gust
International Technology Corporation
2790 Mosside Boulevard
Monroeville, PA 15146-2792
(800) 444-9586</td><td rowspan="2">Technology:
On-Site Incineration
• Soil and debris pretreated with shredding and mixing with lime
• Incineration system consisting of rotary kiln and two secondary combustion chambers (SCCs)
• Enclosed conveyor transported contaminated soil and debris to the unit
• Soil residence time of 45 minutes, kiln temperature of 1,300°F, SCC temperature of 1,800°F
• Treated soil and debris (incinerator ash) discharged into rotary mixer, where it is sprayed with water</td><td>Cleanup Authority:
CERCLA and State: Texas
• ROD Date: 9/18/86
• State-lead</td></tr>
<tr><td>SIC Code:
Not Applicable</td><td>Point of Contact:
Earl Hendrick
Remedial Project Manager
U.S. EPA Region 6
1445 Ross Avenue
Dallas, Texas 75202-2733
(214) 665-8519</td></tr>
<tr><td>Waste Source:
Disposal Pits - drummed and bulk wastes</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Soil and Debris
• 496,000 tons of soil and debris
• Moisture Content: soil - 10 - 12%
• Soil Density (in situ): 1.58 - 1.72 g/cm^3</td></tr>
<tr><td>Purpose/Significance of Application:
Third largest Remedial Action Contract ever awarded to incinerate nearly 1/2 million tons of contaminated soil and debris</td></tr>
</table>

Incineration at the Sikes Disposal Pits Superfund Site
Crosby, Texas

(Continued)

Regulatory Requirements/Cleanup Goals:

- Destruction and Removal Efficiency (DRE) of 99.99% for principal organic constituents of concern as required by Resource Conservation and Recovery Act (RCRA) incinerator regulations, 40 CFR part 264, subpart O

Results:

- Emissions and trial burn data indicated that all DRE and emissions standards were met
- Analytical data of residuals indicated that cleanup goals were met

Description:

Between 1961 and 1967, the Sikes Disposal Pits Superfund Site was the location of the unpermitted disposal of drummed and bulk wastes into unlined sand pits. A remedial investigation determined that soil at the site was contaminated with VOCs and PAHs. A Record of Decision (ROD), signed in September 1986, specified on-site incineration as the remedial technology for the soil and debris. Site cleanup goals and DRE standards were specified for the organic constituents of concern.

Remedial Activities began in October 1990 when IT/Davy began clearing the site. On-site incineration using the IT Corporation Hybrid Thermal Treatment System® began in February 1992 and concluded in June 1994. Following demobilization and site cleanup, remedial activities ceased in December 1994. The treatment system consisted of a rotary kiln and two SCCs. An enclosed conveyor moved the soil and debris to the kiln for treatment. Ash from the incinerator was discharged to a rotary mixer where it was quenched with water. Incineration achieved the soil cleanup goals specified in the ROD.

The total cost of the Remedial Action was approximately $115,000,000. Capital costs accounted for approximately $20,000,000. Annual operation and maintenance costs accounted for approximately $24,000,000.

Incineration at the Times Beach Superfund Site
Times Beach, Missouri

<table>
<tr><td>Site Name:
Times Beach Superfund Site</td><td rowspan="2">Contaminants:
Dioxins
• 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) in soil and debris
• TCDD concentrations up to 1,800 µg/kg</td><td>Period of Operation:
March 1996 to June 1997</td></tr>
<tr><td>Location:
Times Beach, Missouri</td><td>Cleanup Type:
Remedial action</td></tr>
<tr><td>Vendor:
Con Murphy
International Technology Corporation
97 North Outer Road, Suite 8
Eureka, MO 63025
(314) 938-9711</td><td rowspan="2">Technology:
On-Site Incineration
• Solids pretreated by shredding, screening, and mixing with lime
• Incineration system consisting of rotary kiln and secondary combustion chamber (SCC)
• Enclosed conveyor transported contaminated soil and debris to the unit
• Soil residence time of 1 hour, kiln temperature of 1,250°F, SCC temperature of 1,750°F
• Treated soil and debris (incinerator ash) discharged into cooler, where it was sprayed with water</td><td>Cleanup Authority:
CERCLA and State: Missouri
• ROD Date: 9/29/88
• PRP-lead</td></tr>
<tr><td>SIC Code:
2834 (Pharmaceutical Preparations)</td><td>Point of Contact:
Robert W. Feild
Remedial Project Manager
U.S. EPA Region 7
726 Minnesota Avenue
Kansas City, KS 66101
(913) 551-7697</td></tr>
<tr><td>Waste Source:
Road Oiling - Application of TCDD-containing waste oils to roadways for dust control</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Soil and Debris
• 240,000 tons of soil and debris
• Moisture content: soil - geometric mean value of 7.8%</td></tr>
<tr><td>Purpose/Significance of Application:
Incinerator acts as the sole treatment unit in the State of Missouri for TCDD-contaminated soil and debris; system treated soil and debris from 27 sites</td></tr>
</table>

Incineration at the Times Beach Superfund Site
Times Beach, Missouri

(Continued)

Regulatory Requirements/Cleanup Goals:
- On-site Soil - Background concentrations of 20 µg/kg or less
- Destruction and Removal Efficiency (DRE) of 99.9999% for TCDD as required by Resource Conservation and Recovery Act (RCRA) incinerator regulations in 40 CFR part 264, subpart O

Results:
- Emissions and trial burn data indicate that all DRE and emission standards have been met
- 1,900 tons of incinerator ash required re-incineration because it did not meet landfilling criteria
- Analytical data of residuals (including re-incinerated ash) indicate that cleanup goals have been met thus far

Description:
Between 1970 and 1972, a pharmaceutical and chemical company produced wastes that contained TCDD from the production of hexachlorophene. A waste oil company mixed this waste with waste oil and used the mixture to spray roads in Times Beach and the surrounding areas to control dust. A remedial investigation determined that soil was contaminated at 27 sites in the State of Missouri; Times Beach served as a central treatment facility for these sites. A Record of Decision (ROD), signed in September 1988, specified on-site incineration as the remediation technology for the excavated soil and debris. Site cleanup goals and DRE standards were specified for TCDD.

On-site incineration using the IT Corporation Hybrid Thermal Treatment System® began in March 1996 and was completed in June 1997. The treatment system consisted of a rotary kiln and an SCC. An enclosed conveyor moved the soil and debris to the kiln for treatment. Treated ash from the incinerator was discharged to a cooler where it was quenched with water. During its operation, the incinerator at Time Beach processed 240,000 tons of soil and debris. Incineration achieved the soil cleanup goals specified in the ROD, including 1,900 tons of incinerator ash that met soil cleanup goals only after re-incineration.

The total cost of the Remedial Action was approximately $200,000,000.

Incineration at the Vertac Chemical Corporation Superfund Site Jacksonville, Arkansas

<table>
<tr><td>Site Name:
Vertac Chemical Corporation Superfund Site</td><td rowspan="2">Contaminants:
Dioxins and Volatile Organic Compounds

• TCDD; chlorinated benzene; chlorinated phenols; 2,4-D; and 2,4,5-T.
• TCDD concentrations up to 50 mg/L</td><td>Period of Operation:
January 1992 - September 1994</td></tr>
<tr><td>Location:
Jacksonville, Arkansas</td><td>Cleanup Type:
Remedial action</td></tr>
<tr><td>Vendor:
MRK Industries</td><td rowspan="2">Technology:

On-Site Incineration
• Solids pretreated by triple rinsing, shredding, and drying
• Incineration System consisting of rotary kiln an dsecondary combustion chamber (SCC)
• Enclosed conveyor transported contaminated material to the unit
• Residence time was approximately 40 minutes, kiln temperature of 2,000 ^{o}F and SCC temperature of 2,200 ^{o}F
• Treated materials (incineration ash and residual) were collected and disposed of off site in a Subtitle C hazardous waste disposal facility.</td><td>Cleanup Authority:
CERCLA, SARA, RCRA, and State: Arkansas
• ROD Date: NA
• State-lead</td></tr>
<tr><td>SIC Code:
2879 (Pesticides and Agricultural Chemicals)</td><td>Point of Contact:
Mike Arjmandi
Arkansas Department of Pollution Control & Ecology
P.O. Box 8913
8001 National Drive
Little Rock, AR
72219-8913
(501) 682-0852</td></tr>
<tr><td>Waste Source:
Drummed still bottom waste - herbicide manufacturing waste</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Storage Drums, Drummed Waste, and Soil
• 9,804 tons of waste
• 1,027 tons of soil</td></tr>
<tr><td>Purpose/Significance of Application:
Two temporary restraining orders were filed to stop the incineration project over public concern about the incinerator</td></tr>
</table>

Incineration at the Vertac Chemical Corporation Superfund Site Jacksonville, Arkansas

(Continued)

Regulatory Requirements/Cleanup Goals:
- Destruction and Removal Efficiency (DRE) of 99.9999% for all constituents of concern as required by Resource Conservation and Recovery Act (RCRA) incinerator regulations, 40 CFR part 264, subpart O.

Results:
- Emissions and trial burn data indicated that all DRE and emissions standards were met.

Cost Factors:
The incineration system at the site consisted of a rotary kiln and a secondary combustion chamber, followed by an air pollution control system.

Description:
Between 1948 and 1987, the Vertac site operated as a herbicide manufacturer within the city limits of Jacksonville, Arkansas. The by-product TCDD was placed in drums and stored on-site. Investigations at the site conducted by the U.S. EPA and the Arkansas Department of Pollution Control and Ecology (ADPC&E) as part of Vertac's participation in the 1978 National Dioxin Survey revealed TCDD concentrations as high as 40 mg/L in production wastes and eventually resulted in the site being placed on the National Priorities List (NPL) in 1983.

A Consent Decree was entered into by EPA, ADPC&E, and two RPs in January 1982, which required an independent consultant to assess the management of wastes being stored on the site and to develop a proposed disposal method. The proposed remedy was implemented in the summer of 1984 by court order over the objection of EPA who deemed the proposal unsatisfactory.

On-site incineration began in January of 1992 and was completed in September 1994.

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DEBRIS AND SURFACE CLEANING TECHNOLOGIES, AND OTHER MISCELLANEOUS TECHNOLOGIES

ABSTRACTS

Transportable Hot-Gas Decontamination System at Alabama Army Ammunition Plant Site, Alpine, Alabama

<table>
<tr><td>Site Name:
Alabama Army Ammunition Plant</td><td rowspan="2">Contaminants: Chlorinated Explosives contaminated materials and debris, including TNT-, RDX-, and Tetryl-contaminated materials</td><td>Period of Operation:
12/4/95 - 3/15/96</td></tr>
<tr><td>Location:
Alpine, Alabama</td><td>Cleanup Type:
Demonstration and validation tests</td></tr>
<tr><td>Vendor:
L&L Special Furnace Co., Inc.
Aston, PA</td><td rowspan="3">Technology:
Transportable Hot-Gas Decontamination (HGD) furnace
- Natural gas or propane-fired, box-type furnace with integrated ceramic-fiber lining
- Manually loaded and unloaded batch process
- Furnace components are skid mounted, approximately 16 ft by 8 ft
- Heated by 1 million Btu per hour, high velocity nozzle-mix Eclipse Burner equipped with UV sensor and Industrial Risk Insurers (IRI) class gas safety system
- Combustion air to burner set at a fixed rate that maintains excess air capacity to promote lower furnace chamber temperatures between 300 and 600° F
- Capacity to treat 3,000 lb of contaminated materials
- Gases directed into thermal oxidizer combustion chamber</td><td rowspan="2">Cleanup Authority:
Validation test conducted under guidelines for treatability studies.</td></tr>
<tr><td>Prime Contractor:
Roy F. Weston, Inc.
1 Weston Way
W. Chester, PA 19380</td></tr>
<tr><td>Additional Contacts:
U.S. Army Environmental Center
Environmental Technology Division
Edgewood Area
Aberdeen Proving Ground, MD 21010-5401</td><td>Regulatory Point of Contact:
Information not provided</td></tr>
<tr><td>Waste Source:
Contamination of process-related equipment, sewers, piping, and structures resulting from manufacture, storage, testing, and disposal of explosives</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Explosives-contaminated piping and debris</td></tr>
<tr><td>Purpose/Significance of Application:
Demonstration and validation testing to determine effectiveness of treating explosives-contaminated materials using the Hot-Gas Decontamination System</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
No permitted limits for system emissions or operating conditions for this demonstration.</td></tr>
</table>

Transportable Hot-Gas Decontamination System at Alabama Army Ammunition Plant Site, Alpine, Alabama (continued)

Results:
- Verified effectiveness of HGD system equipment in decontaminating explosives.
- Defined optimum processing times and temperatures for TNT-, RDX-, and Tetryl-contaminated materials.
- Collected air emissions data to support future system permitting efforts.
- Achieved complete removal of TNT, RDX, Tetryl, and their breakdown constituents to levels below method detection levels (250°F/hour ramp to 600°F treatment temperature with a 1-hour goal).

Cost:
- Total capital equipment cost of the HGD system was $689,500.
- Total operating costs were $3,337.
- Total estimated validation costs are approximately $90,000.

Description:
The United States Army Environmental Center (USAEC) has been conducting laboratory investigation and pilot-scale studies of the hot-gas decontamination (HGD) process since 1978. The results from these investigations and studies verified the effectiveness of the HGD technology for treating chemical agents and explosives, however, post-test recommendations indicated that equipment designed specifically for the HGD concept would improve system efficiencies and process optimization goals. As a result, USAEC contracted the design and procurement of system equipment specifically for the treatment of explosives-contaminated materials by the HGD process. The resultant equipment design was delivered to USAEC's test site at the Alabama Army Ammunition Plant (ALAAP) located in Alpine, Alabama for demonstration and validation testing.

The demonstration and validation testing was conducted between December 4, 1995, and March 15, 1996. System trials proved the HGD Equipment to be fully functional and capable of maintaining anticipated treatment temperatures. The HGD Equipment system was optimized to enable the complete destruction of explosives contamination at a furnace ramp rate of 250°F/hr, treatment temperature of 600°F, and a treatment time of 1 hour. In general, the HGD system is designed to meet all applicable regulatory performance standards contained in following sections of 40 CFR:
- RCRA incinerator standards (40 CFR, Part 264, Subpart 0)
- Miscellaneous Unit Standards (40 CFR, Part 264, Subpart X)
- Boiler and Industrial Furnaces Standards (40 CFR, Part 266, Subpart H)
- TSCA incinerator standards (40 CFR, Part 761.70 (b))

Centrifugal Shot Blast System at Chicago Pile 5 Research Reactor
Argonne National Laboratory, Argonne, Illinois

<table>
<tr><td>Site Name:
Chicago Pile 5 (CP-5) Research Reactor
Argonne National Laboratory</td><td rowspan="2">Contaminants:
Radioactive-contaminated paint</td><td>Period of Operation:
1/28/97 to 2/4/97</td></tr>
<tr><td>Location:
Argonne, Illinois</td><td>Cleanup Type:
Demonstration</td></tr>
<tr><td>Vendor:
Mike Connacher
Concrete Cleaning, Inc
(509) 226-0315</td><td rowspan="2">Technology:
Centrifugal Shot Blast:
- Shot blast unit manufactured by George Fisher (GOFF®). Unit operated with two 1/4 horsepower, variable speed drives, and has a 13-inch cutting width. The vendor advertised production rate is 200-250 ft^2/hr.
- HEPA-filter dust collection system manufactured by George Fisher (GOFF®). Six primary roughing filter cartridges, one secondary HEPA filter unit; vendor rated vacuum flow of 850 cubic ft/min</td><td>Cleanup Authority:
Project performed as part of DOE's Large-Scale Demonstration Project, Office of Science and Technology, Deactivation and Decommissioning Focus Area</td></tr>
<tr><td>Additional Contacts:
Susan C. Madaris
Test Engineer
Florida International University
(305) 348-3727

Richard Baker
DOE
(630) 252-2647</td><td>Regulatory Point of Contact:
Information not provided</td></tr>
<tr><td>Waste Source: Contaminated paint coating on concrete floor</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Radioactively contaminated concrete floor - 800 ft^2 of concrete flooring covered with contaminated paint</td></tr>
<tr><td>Purpose/Significance of Application: Demonstrate a modified centrifugal shot blast unit and compare results with those for mechanical scabbing</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
The objective of the demonstration was to evaluate the performance of the modified centrifugal shot blast system to remove contaminated paint coating from 800 ft^2 of concrete flooring and to compare the results of this technology with those from the baseline technology of mechanical scabbing.</td></tr>
<tr><td colspan="3">Results:
- Use of the dust collection system significantly reduced the amount of airborne dust generated during the blasting process and has the potential to lead to the use of less respiratory protection and PPE requirements; the unit is self-propelled and has the potential to reduce operator fatigue; the unit can be adjusted to remove the coating layer only, specific layers of coating, or coating and up to ½ inch of concrete; the end-point condition of the surface in the demonstration was smooth, bare concrete.
- Reduced total fixed beta/gamma contamination levels from pre-demonstration levels as high as 5,300 dpm/100 cm^2 to below background levels (1,500 dpm/100 cm^2).
- Problems were encountered with the dust collection system assembly and disassembly and with steel shot escaping the unit. According to DOE, additional improvements are needed to make the unit safer and more efficient for use at a DOE facility.
- The main advantage of the modified centrifugal shot blast system over the baseline technology is the ability to simultaneously collect dust and debris using a dust collection system attached to the shot blast unit.</td></tr>
</table>

Centrifugal Shot Blast System at Chicago Pile 5 Research Reactor Argonne National Laboratory, Argonne, Illinois (continued)

Cost:
- The report presents a detailed cost analysis of this technology compared to the baseline technology.
- Cost analysis results show the total cost for centrifugal shot blast was higher than mechanical scabbing (about $23,000 versus about $13,000) and had higher costs for mobilization/demobilization and decontamination for the 800 ft^2 demonstration. However, because the incremental cost for centrifugal shot blast is lower, this technology was projected to be less expensive than the baseline for areas greater than 1,900 ft^2.

Description:
Concrete Cleaning, Inc. demonstrated a modified centrifugal shot blast system for removing radioactive contaminated paint from concrete flooring. This demonstration was part of the Chicago Pile-5 (CP-5) Large-Scale Demonstration Project sponsored by DOE, Office of Science and Technology, Deactivation and Decommissioning Focus Area, to demonstrate the benefits of using innovative and improved decontamination and decommissioning technologies. CP-5 was a heavy-water moderated and cooled, highly enriched, uranium-fueled thermal reactor designed to supply neutrons for research and was operated for 25 years before being shut down in 1979.

For this demonstration, Concrete Cleaning modified a standard centrifugal shot blast machine (manufactured by George Fisher) to increase efficiency and speed of substrate removal. Concrete Cleaning considers the modifications to be proprietary and has applied for a patent. The shot blast machine was equipped with a HEPA filter dust collection system that had been modified to replace the refuse pan provided by the manufacturer. The system was modified with a funnel-drum lid system that directed the waste directly into a standard waste drum. This modification reduced the potential for airborne releases by eliminating the need to transfer waste from the pan into the drum for disposal. As the unit was moved across the floor, the shot and substrate debris were vacuumed through the shot blast unit, and passed through an abrasive recycling system. The heavier shot was returned to the unit while the spent shot (too small in size to reuse) was sent to the dust collection system. The demonstration showed that the main advantage of the Concrete Cleaning centrifugal shot blast technology compared to mechanical scabbing was the simultaneous collection of dust and debris. The report includes a detailed comparison of the two technologies. In addition, the results of radiological surveys performed before and after the demonstration showed that blasting had reduced total fixed beta/gamma contamination levels from pre-demonstration levels as high as 5,300 dpm/100 cm^2 to below background levels (1,500 dpm/100 cm^2).

Several problems were encountered during the demonstration. Steel shot escaping from the unit presented a potential projectile hazard, the magnetic roller was not effective in collecting steel shot left on the floor, and there were problems with the dust collection system assembly and disassembly. According to DOE, additional improvements are needed to make the unit safer and more efficient for use at a DOE facility. The report includes results of a detailed cost analysis comparing the centrifugal shot blast technology with mechanical scabbing. While the baseline technology was less expensive for the scope and conditions of the demonstration, for areas larger than about 1,900 ft^2, the centrifugal shot blast technology was projected to be less expensive because of lower incremental costs.

Rotary Peening with Captive Shot at Chicago Pile 5 Research Reactor
Argonne National Laboratory, Argonne, Illinois

<table>
<tr><td>Site Name:
Chicago Pile 5 (CP-5) Research Reactor
Argonne National Laboratory</td><td>Contaminants:
Radioactive-contaminated paint</td><td>Period of Operation:
1/28/97 to 2/4/97</td></tr>
<tr><td>Location:
Argonne, Illinois</td><td rowspan="3">Technology:
Rotary Peening with Captive Shot:
- 3M Heavy Duty Roto Peen (HDRP) flaps supporting tungsten carbide shot mounted on a rotating hub
- EDCO CPM-4 concrete planer - cutting width of 5.5 inches and capable of rotating the Roto Peen at 1,800 rpm
- Pentek VAC-PAC® model 24 vacuum system - 600 ft^3/min; primary roughing filter cartridges with 95% efficiency at 1 micron; secondary HEPA filter with 99.97% efficiency at 0.3 micron
- Pb Sentry vacuum monitor (for vacuum pressure)</td><td>Cleanup Type:
Demonstration</td></tr>
<tr><td>Vendor:
Peter J. Fritz
Michael W. Lovejoy
3M Abrasive Systems Division
(612) 736-3655/(612) 733-7181

West Environmental
Pentek, Inc
EDCO</td><td>Cleanup Authority:
Project performed as part of DOE's Large-Scale Demonstration Project, Office of Science and Technology, Deactivation and Decommissioning Focus Area</td></tr>
<tr><td>Additional Contacts:
Ed Wiese
Cedric Andres
Argonne National Laboratory
(630) 252-2000</td><td>Regulatory Point of Contact:
Information not provided</td></tr>
<tr><td>Waste Source: Radioactive-contaminated paint coating on concrete floor</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Radioactively contaminated concrete floor - 425 ft^2 of concrete flooring covered with contaminated paint</td></tr>
<tr><td>Purpose/Significance of Application: Demonstrate Rotary Peening with captive shot and compare results with those for mechanical scabbing</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
The objective of the demonstration was to evaluate the performance of Rotary Peening with Captive Shot to remove contaminated paint coating from 425 ft^2 of concrete flooring and to compare the results of this technology with those from the baseline technology of mechanical scabbing.</td></tr>
<tr><td colspan="3">Results:
- Reduced radiological levels in 5 of 6 areas tested to below background levels. For one location, levels were reduced from 70,000 to 16,000 dpm/100 cm^2. A possible reason for the remaining radioactivity was a crack in the floor that trapped contamination (could not be removed superficially).
- Removed paint coatings at a rate of 71 ft^2/hr with a two-person crew and a 5.5-inch cutting width.
- Vacuum system performed sufficiently to maintain airborne radioactivity levels at background levels.
- Removed floor's paint coating with minimal concrete removal, resulting in minimal waste generation.
- The main advantage of the modified centrifugal shot blast system over the baseline technology is the ability to simultaneously collect dust and debris using a dust collection system attached to the shot blast unit.</td></tr>
</table>

Rotary Peening with Captive Shot at Chicago Pile 5 Research Reactor Argonne National Laboratory, Argonne, Illinois (continued)

Cost:
- The report presents a detailed cost analysis of this technology compared to the baseline technology.
- Cost analysis results show the total cost for Roto Peen with captive shot was 50% lower than the baseline of mechanical scabbing (about $4,500 versus about $9,500). The major contributor to the savings was that the Roto Peen with captive shot blast did not require a temporary enclosure (about $2,400).

Description:
3M's Rotary Peening with Captive Shot system was demonstrated at the Chicago Pile 5 (CP-5) Research Reactor at Argonne National Laboratory. This demonstration was part of the Chicago Pile-5 (CP-5) Large-Scale Demonstration Project sponsored by DOE, Office of Science and Technology, Deactivation and Decommissioning Focus Area, to demonstrate the benefits of using innovative and improved decontamination and decommissioning technologies. CP-5 was a heavy-water moderated and cooled, highly enriched, uranium-fueled thermal reactor designed to supply neutrons for research and was operated for 25 years before being shut down in 1979.

The 3M Heavy Duty Roto Peen (HDRP) flap consists of tungsten carbide shot attached to a flexible, heavy duty material and mounted on an aluminum rotating hub. As the hub rotates, the shot particles on each flap impact against the surface and mechanically fracture and remove coatings. A concrete planer (EDCO Model CPM-4), used to drive the Roto Peen, had a cutting width of 5.5 inches and was capable of rotating the Roto Peen at 1,800 rpm. The dust collection system was a Pentek VAC-PAC® model 24 vacuum system. A Pb Sentry vacuum monitor (proprietary design by West Environmental) was used to interrupt the electrical supply to the concrete planer when a variation in vacuum pressure at the CPM-4 was detected. The demonstration showed that the main advantage of the Roto Peen with captive shot technology compared to mechanical scabbing was the simultaneous collection of dust and debris. The report includes a detailed comparison of the two technologies. In addition, the Roto Peen technology reduced radiological levels to below background levels in all but one area. For one location, levels were reduced from 70,000 to 16,000 dpm/100 cm^2. The elevated readings were attributed to a possible crack in the floor which trapped contamination and could not be removed superficially. The technology removed paint coatings at a rate of 71 ft^2/hr, and removed floor's paint coating with minimal concrete removal, resulting in minimal waste generation.

The report includes results of a detailed cost analysis comparing the centrifugal shot blast technology with mechanical scabbing. Cost analysis results show that the total cost for Roto Peen with captive shot was 50% lower than the baseline of mechanical scabbing. The major contributor to the savings was that the Roto Peen with captive shot blast did not require a temporary enclosure.

Roto Peen Scaler with VAC-PAC® System at Chicago Pile 5 Research Reactor Argonne National Laboratory, Argonne, Illinois

<table>
<tr><td>Site Name:
Chicago Pile 5 (CP-5) Research Reactor
Argonne National Laboratory</td><td rowspan="2">Contaminants:
Radioactive-contaminated paint</td><td>Period of Operation:
12/9/96 - 12/12/96</td></tr>
<tr><td>Location:
Argonne, Illinois</td><td>Cleanup Type:
Demonstration</td></tr>
<tr><td>Vendor:
Pentek Inc.</td><td rowspan="2">Technology:
Roto Peen Scaler with VAC-PAC® System
- Hand-held (6.5 lb) tool with a cutting width of 2 inches
- Pneumatically driven
- Works with a variety of cutting media and cutting wheels
- Dust collection system - portable Pentek VAC-PAC® System; high-efficiency HEPA filter (scaler can be used with or without this system)</td><td>Cleanup Authority:
Project performed as part of DOE's Large-Scale Demonstration Project, Office of Science and Technology, Deactivation and Decommissioning Focus Area</td></tr>
<tr><td>Additional Contacts:
Susan C. Madaris
Leonel E. Lagos
Test Engineers
Florida International University
(305) 348-3727/1810</td><td>Regulatory Point of Contact:
Information not provided</td></tr>
<tr><td>Waste Source: Contaminated paint coating on concrete floor</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Radioactively contaminated concrete floor - 650 ft^2 of concrete flooring covered with contaminated paint</td></tr>
<tr><td>Purpose/Significance of Application: Demonstrate Roto Peen Scaler with VAC-PAC® System and compare results to those for mechanical scabbing</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
The objective of the demonstration was to evaluate the performance of the Roto Peen Scaler with VAC-PAC® System to remove contaminated paint coating from 650 ft^2 of concrete flooring and to compare the results of this technology with those from the baseline technology of mechanical scabbing.</td></tr>
<tr><td colspan="3">Results:
- Removed paint coating at an average rate of 40.6 ft^2/hr/scaler; capable of removing coatings to within ½ inch of walls and obstructions - can be used in confined areas.
- Reduced total fixed beta/gamma contamination levels from pre-demonstration levels as high as 13,500 dpm/100 cm^2 (hot spot) to below background levels, with the hot spot reduced to 5,900 dpm/100 cm^2.
- Use of the dust collection system significantly reduced the amount of airborne dust generated during the scaling process and has the potential to lead to the use of less respiratory protection and PPE requirements</td></tr>
<tr><td colspan="3">Cost:
- The report presents a detailed cost analysis of this technology compared to the baseline technology.
- Cost analysis results show the total cost for Roto Peen Scaler with VAC-PAC® System was 40% lower than the baseline of mechanical scabbing (about $6,500 versus about $11,000). The major contributor to the savings was that the Roto Peen Scaler with VAC-PAC® System did not require a temporary enclosure.</td></tr>
</table>

Roto Peen Scaler with VAC-PAC® System at Chicago Pile 5 Research Reactor Argonne National Laboratory, Argonne, Illinois (continued)

Description:
The Pentek, Inc. Roto Peen Scaler with VAC-PAC® System was demonstrated at the Chicago Pile 5 (CP-5) Research Reactor at Argonne National Laboratory. This demonstration was part of the Chicago Pile-5 (CP-5) Large-Scale Demonstration Project sponsored by DOE, Office of Science and Technology, Deactivation and Decommissioning Focus Area, to demonstrate the benefits of using innovative and improved decontamination and decommissioning technologies. CP-5 was a heavy-water moderated and cooled, highly enriched, uranium-fueled thermal reactor designed to supply neutrons for research and was operated for 25 years before being shut down in 1979.

The Roto Peen Scaler with VAC-PAC® System is a hand-held tool weighing 6.5 lbs, with a cutting width of 2 inches. The scaler is designed to work with a variety of cutting media, including cutting wheels and the 3M Heavy Duty Roto Peen flaps. The unit can be used with or without the Pentek VAC-PAC® System. The VAC-PAC® is portable and has a patented controlled-seal drum fill system that allows the operator to fill, seal, and replace the waste drum under vacuum conditions. The demonstration showed that the main advantage of the Roto Peen Scaler with the VAC-PAC® System, compared to mechanical scabbing, was the simultaneous collection of dust and debris. The report includes a detailed comparison of the two technologies. In addition, the technology removed paint coating at an average rate of 40.6 ft^2/hr/scaler and was able to remove coatings to within ½ inch of walls and obstructions. The scaler also reduced radiological levels to below background levels and use of the dust collection system significantly reduced the amount of airborne dust generated during the scaling process.

The report includes results of a detailed cost analysis comparing the Roto Peen Scaler with VAC-PAC® System with mechanical scabbing. Cost analysis results show that the total cost for Roto Peen Scaler with VAC-PAC® System was 40% lower than the baseline of mechanical scabbing. The major contributor to the savings was that the Roto Peen Scaler with VAC-PAC® System did not require a temporary enclosure.

Polyethylene Macroencapsulation at Envirocare of Utah, Inc.
Salt Lake City, Utah

<table>
<tr><td>Site Name:
Envirocare of Utah</td><td rowspan="2">Contaminants:
Radioactive waste</td><td>Period of Operation:
Fiscal Year 1996</td></tr>
<tr><td>Location:
Salt Lake City, Utah</td><td>Cleanup Type:
Demonstation</td></tr>
<tr><td>Vendor:
Envirocare of Utah, Inc.</td><td rowspan="2">Technology:
Polyethylene Macroencapsulation:
- Davis-Standard 4.5-in single-screw extruder feed hopper, two-stage rotating augerlike screw, heat-controlled barrel, and output die assembly:
- Extruder equipped with five electric clamshell-type barrel heating zones and two die heating zones with thermocouple controllers and cooling loop
- Output capacity of 2000 lb/hr
- Temperature of melted polyethylene exiting extruder - 300-350°F
- Virgin polymer (LDPE) with a melt index of 2 g/min initially used for demonstration; changed to LDPE with melt index of 9 g/min</td><td>Cleanup Authority:
RCRA
- Cooperative agreement</td></tr>
<tr><td>Additional Contacts:
Technical Program Officer
Thomas E. Williams
DOE-ID
(208) 526-2460

Principal Investigator
Pat Trudel
DOE-ID
(208) 526-0169</td><td>Regulatory Point of Contact:
Information not provided</td></tr>
<tr><td>Waste Source: Lead bricks</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Radioactively contaminated lead bricks/disposed of 500,000 lb of macroencapsulated waste</td></tr>
<tr><td>Purpose/Significance of Application: Determine production-scale feasibility of this technology for mixed lead waste</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
- Waste must meet the RCRA Land Disposal Restrictions for debris (40 CFR 268.2) prior to disposal (encapsulation).</td></tr>
<tr><td colspan="3">Results:
- Initial use of an LDPE with a low melt index (2 g/min) and recycled platics proved impractical. The polyethylene was too viscous (requiring manual assistance to mix with wastes) and the properties of the plastics varied from batch to batch, making use for production-scale impratical.
- A change to a LDPE with a melt-index of 9 g/min (blend of 2 g/min and 60 g/min) proved to be optimal for production-scale.</td></tr>
</table>

Polyethylene Macroencapsulation at Envirocare of Utah, Inc.
Salt Lake City, Utah (continued)

Cost:
- Costs were shared between Envirocare and DOE under the terms of the cooperative agreement. Envirocare paid for equipment and supplies, facility construction and modification, permitting and personnel training, and provided facilities for the treatment and disposal of wastes. DOE paid for the treatment and disposal of the encapsuated waste. DOE's cost for disposal of about $1 million for 500,000 lb or $1.92/lb
- An estimate of current costs for polymer macroencapsulation are $90 to $100/cubic foot. Polyethylene macroencapsulation operating costs at DOE sites average about $800/55-gal drum.

Description:
Envirocare of Utah, Inc. (Envirocare) located in Salt Lake City, Utah, is licensed and RCRA-permitted to treat and dispose of low-level radioactive and mixed waste. Under a cooperative agreement between the DOE Idaho Operations Office (DOE-ID) and Envirocare , a demonstration of a polyethylene macroencapsulation extrusion process, developed by DOE at Brookhaven National Laboratory, was conducted at Envirocare's Utah facility to evaluate the technology for mixed waste lead and debris. The company obtained the required RCRA-permit modification to operate this technology, and, under the cooperative agreement, waste streams from 23 DOE sites were shipped to Envirocare.

The polyethylene macroencapsulation extrusion process heats, mixes, and extrudes the polyethylene into the waste container in one operation. The four basic components of the extruder are the feed hopper, rotating auger-like screw, heat-controlled barrel, and output die assembly. The polyethylene is masticated by the rotating screw, heated gradually, and mixed. The melted polyethylene is conveyed from the extruder at 300-350°F and poured directly into the waste container where it flows around and into the waste matrix voids to encapsulate the waste. The polyethylene melt has sufficient heat capacity to provide a fusion bond at the cold polyethylene interface resulting in a continuous monolithic pour. For the demonstration, Envirocare used a Davis-Standard 4.5 inch single-screw extruder with an output capacity of 2000 lb/hr. A virgin polymer (LDPE) with a relatively low melt index of 2 g/min was chosen for this demonstration because Envirocare planned to augment the polymer feed with recycled plastics. During the demonstration, Envirocare determined that the use of this polymer was not well suited for production-scale operations for two reasons: (1) the extrudate was overly viscous and would not flow around the waste without manual assistance and (2) the recycled plastics had inconsistent properties from batch to batch, and therefore would not be efficient for production-scale operations. Envirocare experimented with composite LDPE mixtures with varying melt indexes before determining that LDPE with a melt index of 9 g/min (blend of materials with melt indexes of 2 and 60 g/min) provided the optimum feed stock for production-scale operations. (Envirocare found that using LDPE with high melt indexes ranging from 24 to 60 g/min were prone to cracking.) During the demonstration and throughout the cooperative agreement, Envirocare has continued to expand its process capabilities; the process has been proven effective for package sizes ranging from 5-gal buckets to 55-gal drums in 110-gal overpacks. Based on the results of the demonstration, Utah state regulators have developed specific waste acceptance criteria for the macroencapsulation process. Details of these criteria are presented in the report, along with an analysis of technology applicability and alternatives.

Through the cooperative agreement, Envirocare paid for equipment and supplies, facility construction and modification, permitting and personnel training, and provided facilities for the treatment and disposal of wastes. DOE paid for the treatment and disposal of approximately 500,00 lb of mixed waste lead and debris (lead bricks) that had been macroencapsulated using this process. The cost for this disposal was about $1 million or $1.92/lb. This amount includes substantial treatability study activities and costs for Envirocare to experiment with scale-up and process improvements. An estimate of current costs for polymer macroencapsulation are $90 to $100/cubic foot. Polyethylene macroencapsulation operating costs at DOE sites average about $800/55-gal drum.

Cap at DOE's Lawrence Livermore National Laboratory
Site 300, Pit 6 Landfill OU

<table>
<tr><td>Site Name:
Lawrence Livermore National Laboratory (LLNL) Site 300 - Pit 6 Landfill Operable Unit (OU)</td><td rowspan="2">Contaminants:
Volatile Organic Compounds:
- Trichloroethene (TCE)
Radionuclides:
- Tritium</td><td>Period of Operation:
Installed Summer 1997; groundwater monitoring scheduled for 30 years (post-closure care)</td></tr>
<tr><td>Location:
Livermore, CA</td><td>Cleanup Type:
Full-scale</td></tr>
<tr><td>Vendor/Consultants:
Lockheed-Martin Energy Systems Inc.
Oak Ridge, TN

Weiss Associates
Emeryville, CA</td><td rowspan="2">Technology:
Cap
Multilayer cap that consists of (top to bottom):
- Topsoil and vegetative layer (2-feet)
- Geocomposite drainage layer/biotic barrier (high-density polyethylene (HPDE) netting between synthetic filter fabric)
- HDPE/geosyntheic clay layer (60-mil HDPE liner over bonded bentonite clay layer)
- General fill (compacted native soil; 2-feet thick)
- Georigid reinforcement (HDPE flexible grid material; two to three layers separated by 6-inches of general fill)</td><td>Cleanup Authority:
CERCLA - Removal Action
Federal Facility Agreement</td></tr>
<tr><td>Additional Contacts:
Michael G. Brown
Deputy Director
DOE/OAK Operations Office
L-574
Lawrence Livermore National Laboratory
Lawrence, CA 94551
(510) 423-7061

John P. Ziagos
Site 300 Program Leader
L-544
Lawrence Livermore National Laboratory
Lawrence, CA 94551
(510) 422-5479</td><td>Regulatory Point of Contact:
Information not provided</td></tr>
<tr><td>Waste Source: Waste debris and biomedical waste from operations at Site 300</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Cap - 2.4 acre multilayer cap over a landfill</td></tr>
<tr><td>Purpose/Significance of Application: Multilayer capping of a landfill</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
The CERCLA compliance criteria analysis for the Pit 6 landfill removal action include overall protection of human health and the environment; compliance with the Applicable or Relevant and Appropriate Requirement (ARARs), long-term effectiveness and permanence; reduction in toxicity, mobility, and volume; short-term effectiveness; and implementability.</td></tr>
</table>

Cap at DOE's Lawrence Livermore National Laboratory
Site 300, Pit 6 Landfill OU (continued)

Results:
- A summary is included in the report comparing the CERCLA objectives to the performance of the landfill. The cap is meeting the objectives for protection of human health and the environment, reduction of mobility of the waste, short-term effectiveness and implementability.
- While the landfill cap construction meets all ARARs, capping alone may not meet State requirements for protection of beneficial uses of groundwater. In addition, a cap does not reduce the toxicity and volume of buried waste and contaminated groundwater. At the time of this report, the post-closure monitoring plan was still being written.

Cost:
- Total cost of constructing the landfill cap was $1,500,000, including design, mobilization and preparatory work and site work.
- Total cost of the removal action was $4,100,000, including costs for preliminary/preconstruction activities, construction activities and projected costs for 30 years of landfill O&M and groundwater monitoring.

Description:
Lawrence Livermore National Laboratory Site 300 is a DOE experimental test facility located near Livermore California. Pit 6 Landfill OU was the location of buried waste including laboratory and shop debris and biomedical waste, including radioactive wastes. From 1964 to 1973, approximately 1,900 cubic yards of waste were disposed of in three unlined debris trenches and six animal pits. The trenches, located near the center of the landfill, were each about 100 feet long, 10 feet deep, and 12 to 20 feet wide. The animal pits, located in the northern part of the landfill, were each about 20 to 40 feet long, 16 feet deep, and nine feet wide. VOC and tritium were detected in soil and groundwater at the site. TCE concentrations in the groundwater have declined from levels as high as 250 ug/L in 1989 to 15 ug/L in 1997 (slightly above the federal and state MCL of 5 ug/L). Trace concentrations of chloroform, cis-1,2-dichloroethene, and tetrachloroethene are also present in the groundwater. The maximum activity of tritium currently detected in groundwater is 1,540 pCi/L, below the MCL of 20,000 pCi/L.

In the summer of 1997, a 2.4 acre multilayer cap was placed over the three trenches and six animal pits. The cap extended more than 25 feet beyond the perimeter of the trenches and pits due to uncertainties in the exact location of the waste and to cover areas where VOCs in the subsurface had potential to cause worker inhalation exposure. The cap consists of a vegetative/topsoil layer, a geocomposite drainage layer underlain by a geosynthetic liner over a bonded bentonite clay layer, and compacted general fill which includes georigid reinforcement. A summary is included in the report comparing the CERCLA objectives to the performance of the landfill which indicates that the cap is meeting the objectives for protection of human health and the environment, reduction of mobility of the waste, short-term effectiveness and implementability. While the landfill cap construction meets all ARARs, capping alone may not meet State requirements for protection of beneficial uses of groundwater. In addition, a cap does not reduce the toxicity and volume of buried waste and contaminated groundwater. A Post-Closure Monitoring Plan was being written at the time of the report and will establish a Detection Monitoring Program and a Corrective Action Monitoring Program. Several observations and lessons learned from this application related to implementation are included in the report, along with information on technology advancements.

Total cost of constructing the landfill cap was $1,500,000, including design, mobilization and preparatory work and site work. Total cost of the removal action was $4,100,000, including costs for preliminary/preconstruction activities, construction activities and projected costs for 30 years of landfill O&M and groundwater monitoring.