

# **COST AND PERFORMANCE REPORT**

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

September 1998



**EPA**

Prepared by:

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

## SITE INFORMATION

### Identifying Information

Re-Solve, Inc. (Re-Solve), Superfund Site,  
Operable Unit (OU) 2  
North Dartmouth, Massachusetts

**CERCLIS No.** MAD980520621

**ROD Date:** September 24, 1987; Explanation  
of Significant Differences (ESD), June 11, 1993

### Treatment Application

**Type of Action:** Remedial

**EPA SITE Program Test Associated With Application?** Yes (see Reference 2 for additional information about the Superfund Innovative Technology Evaluation (SITE) demonstration)

**Period of Operation:** June 21, 1993 to  
December 21, 1994

**Quantity of Material Treated During Application:** 36,200 cubic yards (yd<sup>3</sup>) of soil and sediment

### Background

**Waste Management Practice That Contributed to Contamination:** On-site disposal of hazardous wastes

**Site History:** 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.

In 1974, the Massachusetts Division of Water Pollution Control issued Re-Solve a license to collect and dispose of hazardous waste. On December 23, 1980, the Massachusetts Division of Hazardous Waste 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. The contents of four on-site lagoons and a cooling pond and the residue from an oil spreading operation were not removed.

In December 1982, the site was proposed for inclusion on the National Priorities List (NPL) and was placed on the NPL on September 8, 1983.

### Regulatory Context [1, 2]

In Fall 1982, the U.S. Environmental Protection Agency (EPA) conducted a remedial investigation and feasibility study (RI/FS) to assess the extent of contamination at the site. The RI/FS included sampling of soil, groundwater, lagoon wastes, and sediment. An initial record of decision (ROD) for the site was signed on July 1, 1983. The remedial action specified in that ROD called for excavation and off-site disposal of approximately 15,000 yd<sup>3</sup> of soil contaminated with PCBs from the four lagoons, the cooling pond, and the oil spreading area. In 1985, EPA's contractor, the U.S. Army Corps of Engineers (USACE), completed excavation and off-site disposal of that material, referred to as OU 1. 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 supplemental RI/FS was performed from September 1983 to June 1987 to assess the extent of contamination that had migrated beyond the remediated areas and the boundaries of the site, including contamination of both soil and groundwater. A second ROD for the site, signed on September 24, 1987, called for excavation of an additional 22,500 yd<sup>3</sup> of soil contaminated with PCBs and 3,000 yd<sup>3</sup> of contaminated sediment, followed by treatment of that material by a thermal desorptions and dechlorination and management of migration (MOM) for groundwater treatment. The contaminated soil and sediment were referred to as OU 2, and the groundwater was referred to as OU 3.

In 1987, the responsible parties (RP) formed the Re-Solve Site Group and assumed responsibility for site remediation. A mixed funding consent decree, signed on May 31, 1989, required that EPA reimburse the RPs



## SITE INFORMATION (CONT.)

approximately 30 percent of the reasonable remedial action costs, not to exceed a cap of \$6.9 million. In 1991, the Re-Solve Site Group contracted with RUST Remedial Services, Inc. (RUST) to treat the contaminated soil and sediment with RUST's patented X\*TRAX™ thermal desorption unit, followed by its DECHLOR process to dechlorinate the PCBs.

In 1992, RUST conducted a pilot-scale demonstration of the DECHLOR process under the EPA SITE Program. Although during the pilot-scale demonstration, the DECHLOR process was successful in treating the concentrated PCB oil generated by the X\*TRAX™ thermal desorber, the applications analysis report for the technology demonstration indicated that the process would not be cost-effective or economically feasible on a full-scale basis, primarily because the addition of reagents during the DECHLOR process would lead to an increase in the volume of process residues (oil) requiring subsequent treatment. Consequently, on June 11, 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 thermal desorption application at OU 2 is the subject of this report. The excavation and off-site disposal (OU 1), and groundwater treatment (OU 3) are not addressed.

### Remedy Selection:

For OU 2, the selected remedy consisted of the excavation and treatment of soils and sediments contaminated with PCBs by thermal desorption, followed by off-site incineration of concentrated PCB oil recovered by the thermal desorber.

### Site Logistics/Contacts

**Site Management:** RP lead

**Oversight:** Federal

### Remedial Project Manager:

Joseph LeMay  
EPA Region 1  
John F. Kennedy Federal Building, Room 2203  
Boston, Massachusetts 02203  
Telephone: (617) 573-9622

### State Contact:

Nikki Korkatti  
Project Manager  
Massachusetts Department of Environmental Protection  
Bureau of Waste Site Cleanup  
One Winter Street, 5<sup>th</sup> Floor  
Boston, Massachusetts 02108  
Telephone: (617) 574-6840

### Treatment System Vendor:

Gary Duke  
RUST Remedial Services, Inc.  
200 Horizon Center Blvd.  
Trenton, New Jersey 08691-1904  
Telephone: (609) 588-6373

## MATRIX DESCRIPTION

### Matrix Identification

**Type of Matrix Processed Through the Treatment System:** Soils and sediments

### Contaminant Characterization [2, 3]

Primary Contaminant Groups: PCBs; volatile organic compounds (VOCs).

The Applications Analysis Report (AAR) prepared following the SITE demonstration for the technology indicated that Aroclors 1242 and 1252 were the primary PCB congeners at the site, and that PCBs were present in untreated soils at concentrations of more than 240 mg/kg.

Only limited data are available on the concentrations of VOCs in the soil at this site. Elevated levels of methylene chloride, 2-butanone (MEK), trans-1,2-dichloroethene, trichloroethene (TCE), 4-methyl-2-pentanone, tetrachloroethene (PCE), and toluene were found in the lagoon soil. Elevated levels of various organics, particularly acetone and MEK were found in soil at the cooling pond area.

## MATRIX DESCRIPTION (CONT.)

The concentrations of PCBs in lagoon soil were in the range of 500 milligrams per kilogram (mg/kg). Relatively high levels of total VOCs (2,666 mg/kg) also were found in this area.

### Matrix Characteristics That Affected Treatment Cost or Performance [2]

Table 1 presents the major characteristics of the matrix that affected cost or performance of this technology and the values measured for each.

**Table 1: Matrix Characteristics [2]**

Parameter	Value
Soil moisture content	8.9 percent
Soil classification and particle size distribution	Granular and sandy with moderate silt content and a very low clay content; classified in the A-2-4 group according to the American Society for Testing and Materials (ASTM) soil classification system
Oil & grease or total petroleum hydrocarbons (TPH)	Information not provided
Bulk density	Calculated as 1.2 tons/yd <sup>3</sup>
Lower explosive limit	Information not provided

## TREATMENT SYSTEM DESCRIPTION

### Primary Treatment Technology

Thermal desorption

### Supplemental Treatment Technology

Post-treatment (air): filtration and carbon adsorption

### System Description and Operation [1, 2, 4]

#### System Description

In the X\*TRAX™ system, soils containing organic contaminants were heated indirectly in an inert atmosphere, driving off the water and

organic contaminants as vapor and leaving the dry solids behind. The vaporized contaminants then were condensed and collected as liquids. Figure 1 shows a material flow diagram for the X\*TRAX™ process.

The mobile X\*TRAX™ Model 200 full-scale system used at the Re-Solve site consisted of three semitrailers, one control room trailer, eight equipment skids, and various pieces of movable equipment. All skids and trailers that contained liquids had containment curbs for spill control. An area of approximately 125 by 145 feet was required for the equipment. Mobilization time totaled 11 weeks because it was necessary to construct a concrete slab at the site.

The X\*TRAX™ Model 200 system had three main components: (1) the thermal separation system, (2) the gas treatment system, and (3) the 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. They included water, organic liquids, and dust collected by the eductor scrubber, and water and organic liquids collected by the primary and secondary condensers.

#### System Operation

Figure 2 shows the equipment layout for the X\*TRAX™ Model 200 and identifies the specific equipment associated with the thermal separation, gas treatment, and liquid storage and processing systems. The thermal separation system consisted of a vibratory screener, a feeder, a rotary dryer, product conveyors, and a product cooler.

Before treatment in the X\*TRAX™ unit, contaminated soil was passed through a vibratory screener to separate materials that were one inch or less in diameter from those having diameters greater than one inch. That



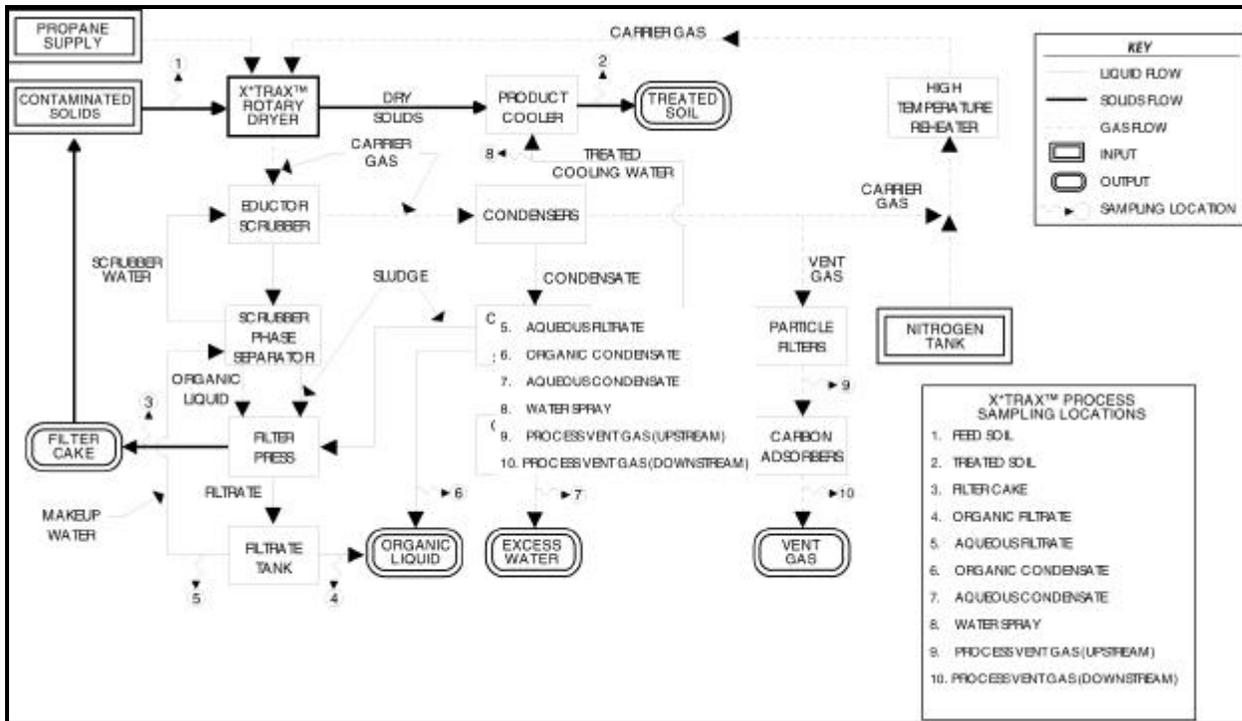


Figure 1. X\*Trax® Material Flow Diagram [2]

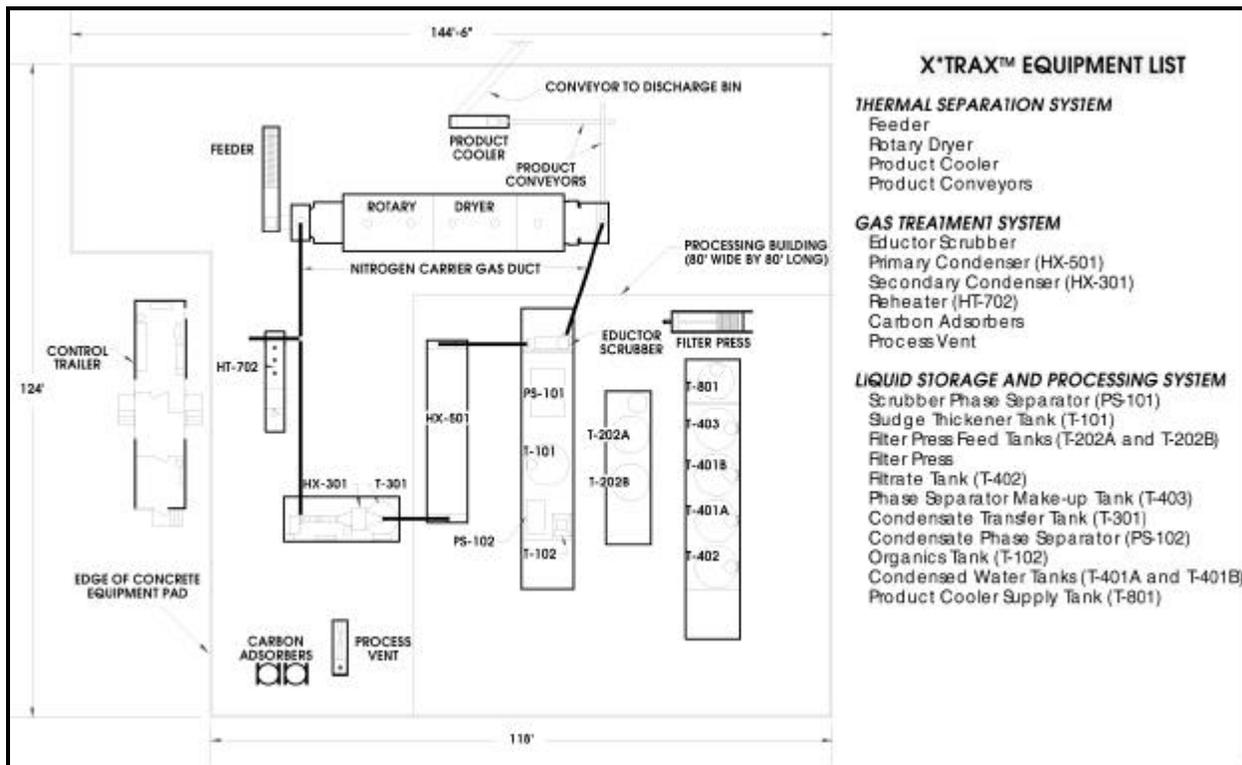


Figure 2. X\*Trax® Model 200 Equipment Layout [2]

## TREATMENT SYSTEM DESCRIPTION (CONTINUED)

operation was required to ensure that soil passing through the X\*TRAX™ unit was small enough to be treated without causing a malfunction of the unit. Feed material typically was delivered to the vibratory screener by a front-end loader or similar equipment. The inclined and horizontal conveyors then moved the feed material from the screener to the rotary dryer (thermal separator) at a regulated rate. The X\*TRAX™ system was equipped with an automatic waste feed cutoff feature. When certain operating parameters exceed specified control limits, the inclined conveyor automatically shut down, effectively stopping the flow of contaminated solids to the dryer. Table 2 presents the conditions that would cause the automatic waste feed cutoff feature to operate.

**Table 2:  
List of Conditions for Operations of  
Automatic Waste Feed Cutoff [4]**

ITEM	CONDITION
Carrier gas stream	High oxygen concentration (greater than 7 percent)
Dryer internal gas pressure	High pressure (greater than 2" water column (WC) for 60 seconds)
Primary heat exchanger, HX-501	High differential pressure across exchanger*
Secondary heat exchanger, HX-302	High outlet temperature*
Recirculation blower	Low outlet pressure*
Dryer cylinder	Loss of rotation
Product handling equipment (for example, cooler mixer, double flap valve, or product conveyors)	Stoppage

\* Value will depend on selected operating conditions.

The rotary dryer was a 42-foot-long steel cylinder with a diameter of 90 inches that rotated inside a furnace heated by burning either propane or natural gas fuel. The dryer was divided into five separate heating zones to enhance temperature control, and was positioned at an incline, slightly higher at the inlet. As the dryer rotated, the feed material tumbled slowly and gradually moved to the lower end of the dryer.

The furnace supplied heat through the dryer wall to vaporize water and organic contaminants from the feed material as it moved through the dryer. Because the heating was indirect, contaminated solids in the dryer were isolated completely from combustion gases in the furnace.

The dryer operated under a slightly negative pressure to prevent any waste or waste by-products from leaking out of the system. Moisture and organic vapors released from the contaminated solids were swept continuously out of the dryer by the nitrogen carrier gas. The carrier gas had a flow rate ranging from 700 to 900 cubic feet per minutes (cfm) during the pilot test. With experience, this was reduced to about 400 cfm during full-scale operations. About 5 to 10 percent of the carrier gas was replaced continuously with fresh nitrogen gas to maintain a low oxygen concentration (less than 4 percent) and prevent combustion from occurring in the dryer. The X\*TRAX™ system was equipped with a high-level alarm that sounded if the oxygen concentration of the carrier gas exceeded 4 percent. If the oxygen concentration increased to 7 percent, a second high-level alarm would sound, the automatic waste feed would cut off, and additional nitrogen would be introduced directly into the rotary dryer.

The primary process control parameter that RUST used to determine the degree of contaminant removal in the dryer was the temperature of the treated soil. This parameter was controlled by adjusting the feed rate, furnace temperature, and residence time of materials in the dryer (which is a function of cylinder rotation speed and angle of inclination).

Two enclosed screw conveyors moved the treated solids from the discharge end of the dryer to the product cooler. The product cooler



## TREATMENT SYSTEM DESCRIPTION (CONT.)

was a horizontal, continuous mixer with a spray tower mounted above the solids inlet. As dry, treated solids entered the product cooler, they were sprayed with water to lower the temperature and reduce dust emissions. The solids then were mixed as they passed through the product cooler. The wet, cool solids exiting the product cooler dropped onto an inclined belt conveyor that carried the material to a soil discharge bin. A full discharge bin constituted a treatment batch and contained approximately 180 tons (150 yd<sup>3</sup>) of soil. A total of 250 batches were treated during the remedial action.

The rotary dryer produced decontaminated soil and off-gases. Each batch of treated soil from the X\*TRAX™ unit was monitored for PCBs to ensure that the treatment criterion of 25 mg/kg had been achieved before the soil was returned to the site for backfilling. Materials that were shown to have concentrations of PCB higher than 25 mg/kg were retreated in the X\*TRAX™ system; one treatment batch (approximately 0.5 percent of soil treated) required reprocessing. Treated soil and sediments were backfilled on site and covered with 18 inches of gravel.

The carrier gas was passed through two condensers in series. The primary condenser typically cooled the carrier gas to near-room temperature. Most of the water vapor, as well as organic compounds of low and intermediate volatility, was condensed. The resulting liquid then flowed under gravity to the condensate transfer tank. The carrier gas then passed through the secondary condenser, where its temperature was reduced to 40° F, condensing the remaining water vapor and organic constituents. A mist eliminator located immediately downstream of the secondary condenser was used to remove remaining moisture entrained in the carrier-gas stream. Liquids from both the secondary condenser and the mist eliminator, if any, flowed under gravity to the condensate transfer tank. After the organic contaminants and water vapor were removed, most of the carrier gas was recycled to the rotary dryer. However, 5 to 10 percent of

the carrier gas was discharged continuously to the atmosphere as process vent gas. This process vent gas was treated with an air pollution control (APC) system that consisted of a 10-micron particle filter, a high-efficiency particulate air (HEPA) filter, three carbon adsorption units, and a power vent blower. The carbon unit included, in series, a 150-pound (lb) guard bed, a 1,000-lb main adsorber, and a 150-lb backup bed. The remedial design/remedial action (RD/RA) statement of work called for the carbon adsorber to be replaced before the daily emission rate exceeded 0.38 pounds per hour (lb/hr) of total hydrocarbons (THC); however, according to the final remedial action report, emissions never exceeded 0.296 lb/hr.

A phase separator was used to separate liquid condensate into aqueous (water) and organic phases. The recovered organic condensate was shipped to an incinerator permitted under TSCA. The recovered water initially was used to cool the treated soils and sediments (product). Later, because some high concentrations of organic substances and particulates were detected in the water, it was discharged to the on-site water treatment system (WTS), and the treated water from the WTS was used to cool the product.

The WTS was constructed on site to treat groundwater extracted at the site, groundwater removed during the dewatering operations associated with excavation, surface water from storm events, decontamination water, and excess water condensate generated by the X\*TRAX™ system. The WTS consisted of the following treatment units: oxidation using potassium permanganate, flocculation and sedimentation, green-sand filtration, sludge filter pressing, air stripping, liquid-phase carbon adsorption, and vapor-phase carbon adsorption.

The vapor-phase carbon units of the WTS were changed once in the summer of 1993 and once in the summer of 1994. An aerobic biological fixed-film aqueous treatment system was installed in the WTS to remove acetone from the condensate because acetone was not removed efficiently by air stripping or carbon adsorption. The flocculation/sedimentation, ultrafiltration, and biological treatment systems were added during full-scale operation to treat organic constituents and particulates in the water condensate.

## TREATMENT SYSTEM DESCRIPTION (CONT.)

In this application, the X\*TRAX™ unit treated 36,200 yd<sup>3</sup> of soils and sediments contaminated with PCBs, consisting of 36,000 yd<sup>3</sup> soils and 200 yd<sup>3</sup> of sediments.

The full-scale WTS was designed for a maximum flow rate of 150 gallons per minute (gpm). However, during this application, it operated at continuous flow rates that ranged from 100 to 120 gpm.

### Operating Parameters Affecting Treatment Cost or Performance [2]

Table 3 presents the major operating parameters that affected cost or performance of this technology and the values measured for each.

**Table 3: Operating Parameters [2]**

Parameter	Value
Dryer feed rate	120 tons per day for entire project, including downtime (154 tons per day was the maximum daily feed rate)
Dryer cylinder shell temperature	500 to 1100° F
Temperature of treated soil	700 to 750° F; with an average of 732° F
Residence time of solids	2 hours for soil temperature of 732° F
Recirculation rate of carrier gas	700 to 900 cfm during pilot test, reduced to 400 cfm during full-scale operations
System throughput	Calculated as 80 tons per day average reflects intermittent operation due mainly to excess moisture in untreated soils from inclement weather

### Timeline

**Table 4: Timeline [1]**

Start Date	End Date	Activity
12/30/82	-	Site was placed on NPL
07/01/83	-	First ROD was signed by EPA Regional Administrator, requiring the removal of PCB-contaminated soil from four on-site lagoons, a cooling pond, and an oil spreading area
09/08/83	-	Site was placed on NPL
09/83	06/87	Supplemental RI/FS was performed to assess the extent of contamination that had migrated beyond the remediated areas and the boundaries of the site
-	9/85	USACE completed removal of approximately 15,000 yd <sup>3</sup> of highly contaminated PCB soils for disposal off site.
09/24/87	-	Second ROD was signed by EPA Regional Administrator, requiring source control (soil-sediment treatment) and MOM (groundwater treatment) remedies
05/31/89	-	Consent decree was signed by EPA Regional Administrator



## TREATMENT SYSTEM DESCRIPTION (CONT.)

**Table 4 (continued): Timeline [1]**

Start Date	End Date	Activity
09/91	-	Source control pilot activities began
05/12/92	06/10/92	X*TRAX™/DECHLOR pilot test was conducted
06/11/93	-	EPA issued an ESD to eliminate the DECHLOR process from the remedy
06/18/93	-	EPA approved the Re-Solve group's submittals to begin full-scale remediation
06/21/93	06/19/94	Full-scale X*TRAX™ treatment of PCB-contaminated soils and sediments was conducted
12/14/94	06/21/95	Source control closeout walkthrough began and ended (three walkthroughs were conducted)
-	12/21/94	Demobilization ended after approximately four to six weeks

## TREATMENT SYSTEM PERFORMANCE

### Cleanup Goals/Standards [1, 3]

The 1987 ROD identified a cleanup level for PCBs in soil and sediment of 25 mg/kg. That cleanup level was based on a  $1 \times 10^{-5}$  health-based risk level. In addition, the ROD required that sediment contaminated with PCBs at concentrations greater than 1.0 mg/kg be excavated. Although it was required that sediment containing PCBs at concentrations greater than 25 mg/kg be treated, it is not clear from the available references whether sediment containing PCBs at concentrations between 1.0 and 25 mg/kg was treated or simply backfilled with treated soil. The ROD did not specify cleanup goals for VOCs for soil and sediments.

Additional requirements were established for the following aspects of this application:

- Perimeter air monitoring
- Process vent emission rate
- Limits on concentrations of contaminants in the effluent from the WTS

Table 5 summarizes the perimeter air monitoring action levels for VOCs and dust, and

required response activities should the action levels be exceeded.

The process vent emission rate was limited to 0.38 lb/hr of THC, calculated on the basis of 150 mg/kg of THC in untreated soil, a processing rate of 150 tons of soil per day, and 80 percent reduction of THC across the carbon vessel.

**Table 5: Perimeter Air Monitoring Action Levels [1]**

Parameter	Action Level	Response
VOCs	5 ppm above background for 15 minutes or 0.5 ppm average above background for 8 hours (0900-1700 hours)	Stop excavation, initiate vapor control measures, implement contingency plan, if needed
Dust	5 milligrams per cubic meter ( $\text{mg}/\text{m}^3$ ) above background for 15 minutes or $0.15 \text{ mg}/\text{m}^3$ average above background for 24 hours	Stop excavation, initiate dust control measures, implement contingency plan, if needed

## TREATMENT SYSTEM PERFORMANCE (CONT.)

Effluent from the WTS had daily and monthly limits for VOCs (acetone, methyl ethyl ketone, and methylene chloride), PCBs, and metals (arsenic, lead, and manganese); these limits are shown under treatment performance data.

### Treatment Performance Data

Treatment performance data for the application of this technology include results of analysis from the pilot-scale SITE demonstration and from the full-scale remedial activity. SITE demonstration results are provided in Appendix A to this report.

### **Remedial Action Performance Data [1]**

Post-treatment confirmatory analysis was performed by collecting a grab sample every six hours from the product conveyor while the bin was being filled. Once the 150 yd<sup>3</sup> bin was filled, (approximately 30 to 36 hours of operation), grab samples were composited into one sample for analysis for PCBs. More than 250 samples of treated soil were collected. Only one of these samples had a concentration of PCB higher than 25 mg/kg, and approximately 200 tons of soil were retreated.

Table 6 summarizes the results of analysis of treated soil for PCBs from full-scale operations.

The data show that the concentration of PCBs in treated soil ranged from 0.59 to 21 mg/kg, with an average concentration of PCBs of 2.8 mg/kg.

No additional data were provided on the concentrations of PCBs in specific samples of treated soil.

Table 7 summarizes the results of testing of process vent emissions from the full-scale operation. The process vent emissions were monitored continuously for THC with an FID, both before and after they passed through a 1,000-lb carbon adsorption vessel. Table 7 shows the process vent emissions of VOCs which ranged from 0.002 to 0.296 lb/hr, with an average emission rate of 0.138 lb/hr.

Perimeter air monitoring was performed with real-time instruments such as a MicroTIP photoionization detector for VOCs and dust monitor and filter/media. The results of filter media samples were used for comparison with real-time monitoring, primarily to identify contaminants. The perimeter air monitoring system was connected to a computer that recorded continuous readings. The monitoring static alarms were triggered when a VOC level of 5 ppm above background or a dust level of 5 mg/m<sup>3</sup> above background was detected.

Table 8 summarizes the results for daily and monthly average concentrations for selected constituents in the WTS effluent. This table only shows those constituents detected in at least one of the effluent samples analyzed. As shown in Table 8, the following constituents were measured at concentrations that exceeded their respective toxicity limits: acetone (chronic), PCBs (acute and chronic), arsenic (chronic), and manganese (acute and chronic).

**Table 6: Concentrations of PCBs in Treated Soil During Full-scale Operations [1]**

Samples	Cleanup Level for PCBs (mg/kg)	Range of Concentrations (mg/kg)	Average Concentration (mg/kg)
Treated soil	25	0.59 to 21	2.8

**Table 7: VOC Rates in Process Vent Emissions [1]**

Location	Performance Standard (lb/hr)	Range of Emission Rates (lb/hr)	Average Emission Rate (lb/hr)
Process Vent	0.38	0.002 to 0.296	0.138



## TREATMENT SYSTEM PERFORMANCE (CONT.)

To evaluate the effect of those episodic exceedances on the quality of water in the river to which the effluent was discharged, the treatment system vendor estimated the concentration of those contaminants in the river using data on the discharge concentrations, and the actual water discharge and river flow rates (as compared with the high discharge and low river flow assumptions used for establishing the discharge limits for the remedial action).

According to the vendor, the results from this estimation indicated that the concentration of acetone, PCBs, arsenic, and manganese would not be higher than the concentrations of those contaminants used in developing an effluent discharge permit.

### Performance Data Quality [1]

The quality assurance and quality control (QA/QC) program used throughout the remedial action met the requirements of the EPA and the Commonwealth of Massachusetts. QC was

established and assured during the remedy. Except for the ENSYS test kits, no problems or exceptions were noted.

All monitoring was performed according to the requirements set forth in the following documents:

- Field Operations Support Plan (FOSP), including a quality assurance project plan
- Implementation plan
- Remedial action work plan
- Source control remedy final (100 percent) design report

ENSYS immunoassay test kits were used to estimate concentrations of PCBs in soils. A comparison of results from the test kits with results from the off-site laboratory indicated that the data from the test kits correlated with the laboratory data in 90 percent of cases; in the other 10 percent, the results from the test kits showed higher concentrations than the laboratory data. Therefore, the test kits were shown to have a false positive bias.

**Table 8: Summary of Daily and Monthly Average Concentrations for Selected Constituents in WTS Effluent [1]**

	Acute Exposure		Chronic Exposure	
	Daily Limit (mg/L)	Range of Daily Averages (mg/L)	Monthly Limit (mg/L)	Range of Monthly Averages (mg/L)
Acetone	15.0	ND-15	3.0	ND-4.3
Methyl Ethyl Ketone	1.75	ND-0.052	0.35	ND-0.027
Methylene Chloride	0.35	ND-0.2	0.072	ND-0.036
PCBs	0.0005	ND-0.12	0.0001	ND-0.0123
Arsenic	0.05	ND-0.05	0.01	ND-0.05
Lead	0.075	ND-0.007	0.015	ND-0.006
Manganese	5.7	ND-14	5.7	0.12-10

## COST OF THE TREATMENT SYSTEM

### Procurement Process [1]

For this application, the Re-Solve Site Group procured ENSR Consulting and Engineering Inc. as its project coordinator, and RUST as the prime soil/sediment (source control) contractor.

In addition, EPA procured Halliburton NUS Corporation and Raytheon Engineers and Constructors Inc. to serve as EPA oversight contractor.

Region 1 determined that preparation of a nonbinding preliminary allocation of responsibility (NBAR) would promote expedited settlement with the RPs. Region 1 therefore prepared an NBAR that allocated 15 percent total liability to generators of PCBs and apportioned the remainder of the liability to non-generators of PCBs, proportionate to their volumetric contributions.

### Costs [1, 2]

RUST was paid \$19,190,000 to implement the source control remedy at this site. That cost included the cost of treatment of 44,400 tons, or 36,200 yd<sup>3</sup>, of soils and sediments with the patented X\*TRAX™ thermal desorption process.

The actual cost of the source control remedy included the costs of the following ancillary activities: design and implementation of a full-scale pilot study, preparation of remedial design documents, mobilization, on-site dewatering, installation and operation of an on-site WTS, excavation of soils and sediments, post-excavation sampling, sampling of treated soil, backfilling with treated soils, grading of the site, monitoring of the X\*TRAX™ process, perimeter air monitoring, restoration of wetlands, and final grading, installation of an 18-inch gravel cap, demobilization, and installation of site fencing.

According to RUST, the actual cost to treat the contaminated soil and sediment at this site was approximately \$6,800,000. This cost represents a unit cost of \$155 per ton of soil treated (44,000 tons treated), and includes the following cost directly associated with the X\*TRAX™ technology: site preparation and mobilization of the unit, capital equipment, startup, labor, consumable materials, utilities, handling of residues and waste associated with the unit, transportation and disposal, maintenance and modification, and demobilization of the unit.

Under the terms of a 1989 consent decree, EPA was required to reimburse the RPs approximately 30 percent of the reasonable remedial action costs, not to exceed a cap of \$6,900,000. This condition would have required EPA to reimburse the RPs approximately \$5,800,000 of the \$19,190,000 expended on the action. (It is not known under what timetable such a reimbursement took or would take place.)

## OBSERVATIONS AND LESSONS LEARNED

### Cost Observations and Lessons Learned [1, 2]

The total cost for the remedial action at Re-Solve OU 2 was \$19,190,000, which included approximately \$6,800,000 to treat the contaminated soil and sediment at the site. This cost for treatment represented a unit cost of \$155 per ton of soil treated (44,000 tons treated).

The remedy identified in the 1987 ROD required use of thermal desorption followed by dechlorination of the residual oil contaminated with PCBs. However, based on the results from the pilot-scale demonstration of the dechlorination technology, it was determined that dechlorination would not be cost-effective or economically feasible on a full-scale basis, and it was replaced in this application with off-site incineration of residual oils contaminated with PCBs. The final remedial action report



## OBSERVATIONS AND LESSONS LEARNED (CONT.)

indicated that this modification saved money in the implementation of the remedy; however the amount of savings was not quantified.

### Performance Observations and Lessons Learned [1, 2]

The soil and sediment treated in the remedial action met the cleanup goal of 25 mg/kg for PCBs, with only approximately 0.5 percent of the soil quantity required to be re-treated because it did not meet the cleanup goal on the first pass through the desorber. During the full-scale application, the concentration of PCBs in the treated soil, as analyzed using Method 8080, ranged from 0.59 to 21 mg/kg, with an average of 2.8 mg/kg.

As illustrated by the SITE demonstration results, the analytical results for total PCBs achieved by Method 8080 are relatively similar to the results achieved by Method 680, with both methods showing PCB removal efficiencies of greater than 99.7 percent for the pilot-scale testing.

The process vent emission rate during the full-scale application ranged from 0.002 to 0.296 lb/hr, with an average emission rate of 0.138 lb/hr, thus meeting the performance standard for an emission rate of 0.38 lb/hr.

The condensate water generated by the X\*TRAX™ unit was treated on site using a

multi-stage WTS. All treated water met acute and chronic limits identified for effluent water, except for the following constituents in some episodic samples: acetone (chronic), PCBs (acute and chronic), arsenic (chronic), and manganese (acute and chronic). To evaluate the impact of those exceedances on the quality of water in the river to which the effluent is discharged, the treatment system vendor estimated the concentration of these contaminants in the river using data on the measured discharge concentrations, and the actual water discharge and river flow rates. Information was not provided on whether those exceedances resulted in any action by the state. According to the vendor, the results from this estimation indicated that the concentration of acetone, PCBs, arsenic, and manganese would not be higher than the concentrations of those contaminants used in developing an effluent discharge permit.

### Other Observations and Lessons Learned [1]

According to the vendor, the optimum moisture content for the X\*TRAX™ system is 20 percent. At significantly higher moisture content, the system requires more heat and produces excess water that requires treatment or disposal, thereby increasing costs. At a moisture content below 20 percent, supplemental water is needed; during both the pilot-scale demonstration and the remedial action, supplemental water was provided from an on-site groundwater treatment system.

Table 9 shows observations and lessons learned as provided by EPA in its Remedial Action Closeout Report.

**Table 9: Other Observations and Lessons Learned [1]**

Treatment Process
<ul style="list-style-type: none"> <li>The original design for the transportation of treated soils to the product cooler by vibrating V-trough conveyors was modified to increase its effectiveness. Modifications included removal of the vibrating conveyer, repositioning of the product cooler immediately after the rotary dryer, and transportation of the wetted soils from the product cooler to a radial stacker by a standard conveyor belt system.</li> <li>The original design of the product cooler, consisting of a spray tower, a demister, and a blower, was inefficient in removing dust particles from the steam. The efficiency of the process was increased by the addition of a series of sprays, chevron packings, mesh pads, and a power cyclone (called a powerclone) to the vent stack. Installation of a high-pressure pump at the powerclone also enhanced the removal efficiency of the system.</li> </ul>



## TREATMENT SYSTEM DESCRIPTION (CONT.)

**Table 9 (continued): Other Observations and Lessons Learned [1]**

<b>Treatment Process (continued)</b>
<ul style="list-style-type: none"> <li>• The effectiveness of the phase separator used to separate the organic contaminants and water from the organic condensate wastewater stream was increased by the installation of a biological treatment process following the Calgon Klensorb 100™ (Klensorb) System (which involved a combination of granular activated carbon and clay filters). It turned out to be more cost-effective to incur increased costs for maintenance of the Klensorb System than to purchase new membranes for the ultrafiltration membrane system (if used as a separator) every time a membrane became clogged.</li> <li>• The biological treatment system used to treat the separated aqueous stream required an extended startup period. The contractor recommended a self-adjusting pH monitoring and control system for the biological treatment system for future use of the X*TRAX™ application.</li> <li>• Real-time air monitoring instruments were sensitive to changes in temperature and climate; that sensitivity caused false positive readings at perimeter monitoring stations. The perimeter air monitoring system, therefore was modified. The calibration frequency of the continuous monitoring instruments was increased to two times per day, and the instruments were checked an additional four times per day to ensure that instrument drift was not occurring.</li> <li>• Much of the gas and liquid processing equipment was erected and operated under open air roofs. It was recommended that the structure used to house that equipment be oversized by 25 percent to accommodate unanticipated additions to the treatment facility.</li> </ul>
<b>Construction Process</b>
<ul style="list-style-type: none"> <li>• ENSYS immunoassay test kits were used to estimate concentrations of PCBs in soil. The testing provided an estimate of the concentration of PCBs within 30 minutes, allowing the contractor to determine whether to continue excavating or to move heavy equipment to another area.</li> <li>• Covering large piles of soil with geotextiles to control fugitive dust proved to be ineffective. Wind consistently disturbed the geotextile fabric or blew it off the pile; resecuring the geotextile fabric was a labor-intensive task.</li> <li>• As the excavation location changes, the surface-water runoff controls must be changed to prevent the migration of contaminants to previously excavated areas. Surface-water runoff controls should be implemented, monitored, and maintained continuously throughout the application.</li> <li>• It would be more cost-effective to excavate to depths at which the concentration of PCBs is known to be below the clean-up level as compared with collecting large numbers of post-excavation samples. At Re-Solve, a kreiging model was used to predict the depth of the boundary layer. Samples were collected from the predicted boundary layer to confirm the results of the model. It would have been more cost-effective to excavate well beyond that layer. Results of analysis indicated that 75 percent of samples from the predicted boundary layer showed concentrations that required treatment. Excavating beyond the boundary layer would eliminate the use of intermediate bins, saving time and money by eliminating the need to collect samples for analysis and the need to construct and move the bins.</li> <li>• The lowest production rates occurred in winter because snow and ice increased the moisture content of contaminated soils. If the pile of contaminated soil had been under roof to protect it from winter weather, the time schedule could have been reduced by 11 to 17 percent, saving as much as 16 to 21 percent of the total cost of remediation (less the cost of the structure).</li> </ul>



## TREATMENT SYSTEM DESCRIPTION (CONT.)

**Table 9 (continued): Other Observations and Lessons Learned [1]**

### Remedial Action Management Structures

- The steering committee of Re-Solve Site Group hired an executive coordinator and an independent environmental consultant to report on the process of remedial design and remedial action (RD/RA) and to coordinate technical aspects of the RD/RA process. That organizational structure proved to be extremely successful at the Re-Solve Superfund site and was highly recommended by the contractor [that coordinated the organization].

## REFERENCES

- Halliburton NUS Corporation and Raytheon Engineers and Constructors, Inc. 1996. Final Remedial Action Report, Source Control Remedial Action, Re-Solve, Inc. Superfund Site, North Dartmouth, Massachusetts, Project 0211. February.
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### Preparation of Analysis

This case study was prepared for the U.S. Environmental Protection Agency's (EPA) Office of Solid Waste and Emergency Response, Technology Innovation Office. Assistance was provided by Tetra Tech EM Inc. under EPA Contract No. 68-W4-0004.

**APPENDIX A**

**Results From EPA SITE Demonstration [2]**

During the SITE demonstration, samples of untreated (feed) and treated soil were analyzed for PCBs by EPA Method 8080 and by EPA Method 680-SIM (specific ion monitoring). The results obtained by Method 8080 were used to determine compliance with the cleanup standard specified in the ROD. Results obtained by Method 680 were used to determine whether there were differences between the feed and treated soils in the specific patterns of Aroclors. It was believed that heating soil in the X\*TRAX™ rotary dryer had the potential to affect Aroclor patterns.

Table A-1 summarizes the results of the SITE demonstration by both analytical methods for samples of feed and treated soil. As Table A-1 shows, the average total concentration of Aroclors as obtained by Method 680 was reduced from 247 mg/kg to 0.13 mg/kg, a removal efficiency of 99.95 percent. (For the 12 samples of feed soil analyzed by Method 680, total concentrations of PCBs ranged from 181 to 425 mg/kg. Concentrations of PCBs in treated soil were relatively consistent, ranging from not detected to 0.22 mg/kg in the 12 samples.) The average concentration of PCBs as obtained by Method 8080 was reduced from 318 mg/kg to 0.863 mg/kg, a removal efficiency of 99.73 percent. (Total concentrations of Aroclors ranged from 211 to 518 mg/kg in the three samples of feed soil and from 0.68 to 1.01 mg/kg in the samples of treated soil analyzed by Method 8080.)

**Table A-1: Average PCB Concentrations in Feed and Treated Soil Samples as Measured During SITE Demonstration [2]**

Compound	Feed Soil (mg/kg)	Treated Soil (mg/kg)	PCB Removal Efficiency (%)
<b>Method 680<sup>a</sup></b>			
Monochlorobiphenyls	ND (0.55) <sup>b</sup>	ND (0.11)	-
Dichlorobiphenyls	16	ND (0.11)	-
Trichlorobiphenyls	74	0.13 <sup>c</sup>	-
Tetrachlorobiphenyls	91	ND (0.21)	-
Pentachlorobiphenyls	49	ND (0.21)	-
Heptachlorobiphenyls	1.0 <sup>c,d</sup>	ND (0.32)	-
<b>Total<sup>e</sup></b>	<b>247</b>	<b>0.13</b>	<b>99.95</b>
<b>Method 8080<sup>f</sup></b>			
Aroclor 1242	213	0.756	-
Aroclor 1254	105	0.107	-
<b>Total</b>	<b>318</b>	<b>0.863</b>	<b>99.73</b>

- a No octachlorobiphenyls, nonachlorobiphenyls, or decachlorobiphenyls were detected in any of the 12 samples analyzed by Method 680.
- b ND indicates not detected, with the average laboratory target reporting limit (TRL) shown in parentheses.
- c Compound was detected in some but not all soil samples; a value of one-half the TRL was used to represent ND samples in calculating an average concentration.
- d Numerical result listed is less than the average TRL and should be considered approximate.
- e ND values are assigned a value of zero in calculating total concentrations of PCBs.
- f Three samples (one from each test) were analyzed by Method 8080.

**APPENDIX A  
(CONT.)**

Throughout the SITE demonstration program, the vendor measured concentrations of THCs in the process vent continuously at intervals of one hour. Measurements were made ahead of the first 150-lb guard bed and after the 1,000-lb main adsorber. The average upstream concentration of THCs was 7,123 ppm, with a maximum value of 8,762 ppm. The average downstream concentration was 795 ppm, with a maximum value of 1,349 ppm. The average removal efficiency was 89 percent. After the downstream monitoring location, the process vent gas passed through a second 150-lb carbon bed, where additional THC was removed before discharge to the atmosphere.

To measure VOCs, three samples of gas were collected during the SITE demonstration test. The average total concentration of VOCs in the process vent gas was 397 micrograms per cubic meter ( $\mu\text{g}/\text{m}^3$ ). Two compounds, chloromethane and methylene chloride, accounted for almost 98 percent of VOC emissions. Monitoring and sampling results indicated that, during the SITE demonstration, air emissions from the X\*TRAX™ process vent met the performance standard for process vent emissions.

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