

## Case Study Abstract

### Composting at the Dubose Oil Products Co. Superfund Site, Cantonment, Florida

<b>Site Name:</b> Dubose Oil Products Co. Superfund Site	<b>Contaminants:</b> Organic compounds - volatiles, halogenated; volatiles, nonhalogenated (BTEX); semivolatiles, halogenated and semivolatiles, nonhalogenated (PAHs) - Total VOC concentrations ranged from 0.022-38.27 mg/kg - Total PAH concentrations ranged from 0.578-367 mg/kg - PCP concentration ranged from 0.058-51 mg/kg	<b>Period of Operation:</b> November 1993 - September 1994
<b>Location:</b> Cantonment, Florida		<b>Cleanup Type:</b> Full-scale cleanup
<b>Vendor:</b> David Price/Garland Long Waste Abatement Technology, L.P. (WATEC) 1300 Williams Drive Marietta, GA 30066 (770) 427-1947	<b>Technology:</b> Composting - Treatment structure was 33,000 ft <sup>2</sup> modular building - Included systems for leachate collection, aeration, inoculum growth and application, and wastewater treatment - Ambient air was drawn down through soil pile - Operating parameters included soil oxygen and moisture contents, pH, and nutrient levels - Each batch of soil was treated to less than the cleanup goals within 14-30 days	<b>Cleanup Authority:</b> CERCLA - ROD Date 3/29/90 - PRP Lead
<b>SIC Code:</b> 4953 W (Waste processing facility, miscellaneous)		<b>Point of Contact:</b> Mark Fite USEPA Region 4 Atlanta Federal Center 100 Alabama St., S.W. Atlanta, GA 30303 (404) 562-8927
<b>Waste Source:</b> Waste Treatment Plant	<b>Type/Quantity of Media Treated:</b> Soil - 19,705 tons of soil - Lakeland loamy sand - TPH 300-600 mg/kg - Moisture content 8%	
<b>Purpose/Significance of Application:</b> Full-scale application of composting to treat VOC- and PAH-contaminated soil		
<b>Regulatory Requirements/Cleanup Goals:</b> - Total PAHs (sum of 17 specific constituents) less than 50 mg/kg - Total xylenes less than 1.5 mg/kg; benzene less than 10 mg/kg; TCE less than 0.05 mg/kg; DCE less than 0.07 mg/kg; and PCP less than 50 mg/kg		
<b>Results:</b> - Cleanup goal met for all constituents, with total PAHs in treated soil ranging from 3.3-49.9 mg/kg - Of the 58,559 tons of soil excavated, only 19,705 tons exceeded cleanup goal and thus required treatment		

## Case Study Abstract

### Composting at the Dubose Oil Products Co. Superfund Site, Cantonment, Florida (Continued)

**Cost Factors:**

- Actual costs of \$7,736,700 were reported by the PRP Steering Committee
- The cost for activities directly attributed to treatment was not provided separately from the total project cost, and therefore a unit cost for treatment was not calculated

**Description:**

The Dubose Oil Product Co. Superfund site is a former waste treatment, recycling, and disposal facility that operated from 1979 to 1981. Operations performed at Dubose included thermal treatment of waste oil, petroleum refining wastes, oil-based solvents, and wood treatment wastes; steam heating of spent iron and pickle liquors; and rock salt filtration of waste diesel fuel. During a remedial investigation (RI), soil at the site was found to be contaminated with PAHs at concentrations ranging from 0.578 to 367 mg/kg total PAH, PCP ranging from 0.058 to 51 mg/kg, and VOCs ranging from 0.022 to 38.27 mg/kg.

A Record of Decision (ROD) was signed for this site in March 1990. Composting was selected in the ROD instead of in situ biological treatment because it was identified as easier to control and more reliable, and because it was believed that monitoring would be easier to perform. The composting system used at Dubose consisted of a treatment structure, a leachate collection system, an aeration system, an inoculum growth and application system, and an on-site wastewater treatment system. Contaminated soil was treated in batches, with each batch containing from 660 to 2,310 tons of soil. For most of the batches, soil depth ranged from 4.0 to 4.25 feet. Composting activities were performed from May to November 1993, and site restoration activities were completed by August 1996.

All 359 soil grids in the compost system met the soil cleanup goals established for Dubose. For total PAHs, before-treatment concentrations ranged from 50.8 to 576.2 mg/kg, while after-treatment concentrations ranged from 3.3 to 49.9 mg/kg (average - 19 mg/kg). For PCP, before-treatment concentrations ranged from 7.67 to 160 mg/kg, while after-treatment concentrations ranged from 16.5 to 36.3 mg/kg. The primary removal mechanism identified for VOCs in this application was volatilization, while for PAHs it was bioremediation. Several lessons were learned about operation of the composting system during this application. For example, the vendor indicated that applying an inoculum mixture with a fire hose provided for adequate diffusion of soil moisture.

## **COST AND PERFORMANCE REPORT**

### **EXECUTIVE SUMMARY**

This report presents cost and performance data for a composting application at the Dubose Oil Products Co. Superfund site, in Cantonment, Florida. Composting was used at the Dubose site to treat soil contaminated with polynuclear aromatic hydrocarbons (PAHs), pentachlorophenol (PCP), and volatile organic compounds (VOCs), including benzene, xylene, trichloroethene (TCE), and 1,2-dichloroethene (DCE). The specific PAHs of interest at Dubose were acenaphthylene, acenaphthene, anthracene, benzo(a)anthracene, benzo(b and k)fluoranthenes, benzo(a)pyrene, benzo(ghi)perylene, chrysene, dibenz(a,h)anthracene, fluorene, fluoranthene, indeno(1,2,3)pyrene, naphthalene, phenanthrene, pyrene, and 2-methylnaphthalene.

The Dubose site is a former waste treatment, recycling, and disposal facility that operated from 1979 to 1981. Operations performed at Dubose included thermal treatment of waste oil, petroleum refining wastes, oil-based solvents, and wood treatment wastes; steam heating of spent iron and pickle liquors; and rock salt filtration of waste diesel fuel. During a remedial investigation (RI), soil at the site was found to be contaminated with PAHs (total) at concentrations ranging from 0.578 to 367 mg/kg, PCP ranging from 0.058 to 51 mg/kg, and VOCs ranging from 0.022 to 38.27 mg/kg.

A Record of Decision (ROD) was signed for this site in March 1990. The ROD specified treatment of contaminated soil using composting and identified numerical soil cleanup goals and leachate discharge standards for the site. Composting was selected instead of in situ biological treatment because it was identified as easier to control and more reliable, and because it was believed that monitoring would be easier to perform and samples would be more representative. Composting was also believed to be approximately equal in cost to in situ biological treatment. Soil cleanup goals included PAHs (total) - 50 mg/kg, PCP - 50 mg/kg, benzene - 10 mg/kg, xylenes (total) - 1.5 mg/kg, TCE - 0.05 mg/kg, and DCE - 0.07 mg/kg. Leachate discharge standards ranged from 1 to 50 µg/L for the target constituents/parameters.

The composting system used at Dubose consisted of a treatment structure, a leachate collection system, an aeration system, an inoculum growth and application system, and an on-site wastewater treatment system. Contaminated soil was treated in batches, with each batch containing from 660 to 2,310 tons of soil. For most of the batches, soil depth ranged from 4.0 to 4.25 feet. Soil was aerated to maintain a pore space oxygen content of approximately 20 percent, and inoculum was added over a period of two days (typically), until the entire surface area of the soil was moistened. A moisture content of approximately 15% and a carbon:nitrogen:phosphorus ratio of 120:10:2 was maintained during the application. Off-gasses collected by the aeration equipment were treated using granular activated carbon (GAC) adsorbers prior to discharge to the atmosphere. Composting activities were performed from May to November 1993, and site restoration activities were completed by August 1996.

Soil sampling and analysis were performed for each of 359 grids of soil treated, including analysis for PAHs (total), PCP, and specific VOCs. Additional sampling and analysis were performed for leachate contaminants, and for monitoring of contaminants in the ambient air. All soil grids met the soil cleanup

**EXECUTIVE SUMMARY (CONT.)**

goals established for Dubose. For total PAHs, before-treatment concentrations ranged from 50.8 to 576.2 mg/kg, while after-treatment concentrations ranged from 3.3 to 49.9 mg/kg (average - 19 mg/kg). For PCP, before-treatment concentrations ranged from 7.67 to 160 mg/kg, while after-treatment concentrations ranged from 16.5 to 36.3 mg/kg. The primary removal mechanism identified for PAHs in this application was bioremediation; however, volatilization was identified as the primary mechanism for removal of VOCs, either in handling or through the aeration system. In addition, PAHs and VOCs were not measured in ambient air monitors at levels greater than their levels of concern for the application.

Actual costs of \$7,736,700 were reported by the PRP Steering Committee's oversight contractor for this application, including approximately \$2.5 million for before-treatment activities and \$5.25 million for activities directly attributed to treatment. The \$5.25 million expended for activities directly attributed to treatment corresponds to \$266 per ton of soil treated (19,705 tons). This cost is relatively high because of the relatively large quantity of soil excavated (58,559 tons) but not further treated compared with the amount of soil treated. Unit costs based on the amount of soil excavated would be approximately one-third of \$266, or \$90 per ton of soil excavated. The application at Dubose was PRP-lead, and no information is provided in the available references on the portion of the \$5.25 million cost that represents activities for excavation of less-contaminated soil that did not require further treatment in this application.

## SITE INFORMATION

### Identifying Information:

Dubose Oil Products Co. Superfund Site  
Cantonment, Florida  
CERCLIS # FLD000833368  
Action Memorandum Date: March 29, 1990

### Treatment Application:

Type of Action: Remedial  
Treatability Study Associated with Application? Yes (See discussion under remedy selection)  
EPA SITE Program Test Associated with Application? No  
Period of Operation: November 1993 - September 1994  
Quantity of Material Treated During Application: 19,705 tons of soil [31]

### Background

**Historical Activity that Contributed to Contamination at the Site:** Waste storage, treatment, recycling and disposal

**Corresponding SIC Code:** 4953 W (Waste processing facility, miscellaneous)

**Waste Management Practice that Contributed to Contamination:** Waste Treatment Plant

**Site History:** [1, 31]

The 20-acre Dubose Oil Products Company Superfund site (Dubose, or DOPC) is a former waste storage, treatment, recycling, and disposal facility located approximately two miles west of Cantonment, Florida, as shown in Figure 1. Site operations began in 1979, and included thermal treatment of waste oil, petroleum refining wastes, oil-based solvents, and wood treatment wastes; steam heating of spent iron and steel pickle liquors; and rock salt filtration of waste diesel fuel.

Site operations ceased in 1981, and the site owner began closure of the site at that time. Closure activities included excavation of buried drums, operation of an aeration system to remediate on-site drainage ponds, and movement of contaminated material with heavy equipment. In March 1982, the Florida Department of Environmental Regulation (now called the Florida Department of Environmental Protection - FDEP) conducted an Interim Status Standards Compliance Inspection at the site. In April and May 1982, EPA and FDEP sampled the site and found buried metal objects, contaminated springs and leachate seeps, and an oil sheen on the North Pond.

In November 1984, FDEP directed an outside contractor (OH Materials Company) to excavate an on-site pond and fill it with contaminated soils and sediments. Between November 1984 and

## SITE INFORMATION (CONT.)

### Background (cont.)

May 1985, the contractor excavated an area of the site and lined it with a 36 millimeter (mm) PVC liner. The depression was filled with site soils to approximately 20 feet above surrounding grade and covered with a 30 mil PVC cover. An estimated 38,000 cubic yards of soil was placed in the former pond area, referred to as the soil "vault". The vault was approximately 170 feet long by 170 feet wide by 35 feet deep.

In October 1987, a consent agreement was signed by FDEP and the DOPC potentially responsible party (PRP) steering committee (DOPCSC). Following the consent agreement, the PRP Steering Committee tasked a consultant (Engineering-Science) to conduct a remedial investigation/feasibility study (RI/FS) for the site.



Figure 1. Site Location

The RI was conducted in 1988, and revealed contamination above health-based levels in the vault soils, shallow aquifer beneath the site, on-site surface water, and sediment. The RI identified the primary contaminants of concern in the soil, groundwater, surface water, and sediment as volatile organic compounds (VOCs) including trichloroethene, benzene, toluene, and xylenes and semivolatile organic compounds including polynuclear aromatic hydrocarbons (PAHs) and phenols (e.g., pentachlorophenol, or PCP).

**Regulatory Context:** [1] A Record of Decision (ROD) was signed for this site in March 1990. The ROD identified remedial actions for this site, including:

- Excavation of the top 20 feet of vault soils, shown in the RI to be uncontaminated, and placement of those soils into a ravine area at the site;
- Transformation of a hog barn area into a process area, and installation of a batch bioremediation (composting) system at that location;

**SITE INFORMATION (CONT.)****Background (cont.)**

- Excavation of the remainder of the vault soils in separate batches, treatment of the batches using bioremediation, followed by disposal in the ravine area;
- Drainage and filling of the on-site ponds;
- Placement of a 2-foot topsoil layer over the ravine and former pond area, grading and vegetation;
- Installation of surface water runoff controls to accommodate seasonal precipitation;
- Groundwater monitoring;
- Additional soil sampling during remedial design to confirm location of "hot spots" of contaminated soil outside of the vault; and
- Deed restrictions to preclude inappropriate future use.

The ROD identified numerical soil cleanup goals and leachate discharge standards for this site (see discussion under treatment system performance).

**Remedy Selection:** [1, 30, 31] Composting was selected as the remedy for the Dubose site from 10 alternatives. The ROD indicated that composting would be easier to control and more reliable than in situ biological treatment. In addition, the ROD indicated that monitoring the effectiveness of composting would be easier than for in situ treatment, because the mixing and turning of soil piles will make the soil more homogeneous and soil grab samples more representative. The ROD also indicated that composting would be approximately equal in cost to in situ biological treatment.

As part of the RI, Engineering Science was tasked to conduct bench-scale treatability studies on the effectiveness of biological remediation for on-site soils. Engineering Science conducted the following four types of treatability studies using contaminated soil from the containment vault: in-situ column, serum bottle, biometer, and mesocosm experiments. The mesocosm experiments showed that composting could be used to reduce the concentrations of all contaminants of concern at Dubose. [33]

Pilot-scale treatability testing was attempted six times during this project. However, soil excavated for pilot-scale tests was found to contain too low a concentration of target compounds, and no pilot-scale testing was completed.

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**SITE INFORMATION (CONT.)**

**Site Logistics/Contacts**

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**Site Management:** PRP Lead  
**Oversight:** EPA

**Remedial Project Manager:**

Mark Fite  
U.S. EPA, Region 4  
Atlanta Federal Center  
100 Alabama St., S.W.  
Atlanta, GA 30303  
(404) 562-8927

**PRP Steering Committee Oversight Contractor:**

Kenneth Stockwell  
Parsons Engineering Science, Inc.  
57 Executive Park South, N.E., Suite 500  
Atlanta, GA 30329-2265  
(404) 235-2351

**Treatment Vendor:**

David Price/Garland Long  
Waste Abatement Technology, L.P. (WATEC)  
1300 Williams Drive  
Marietta, GA 30066  
(770) 427-1947

## MATRIX DESCRIPTION

### Matrix Identification

**Type of Matrix Processed Through the Treatment System:** soil (ex situ)

### Contaminant Characterization

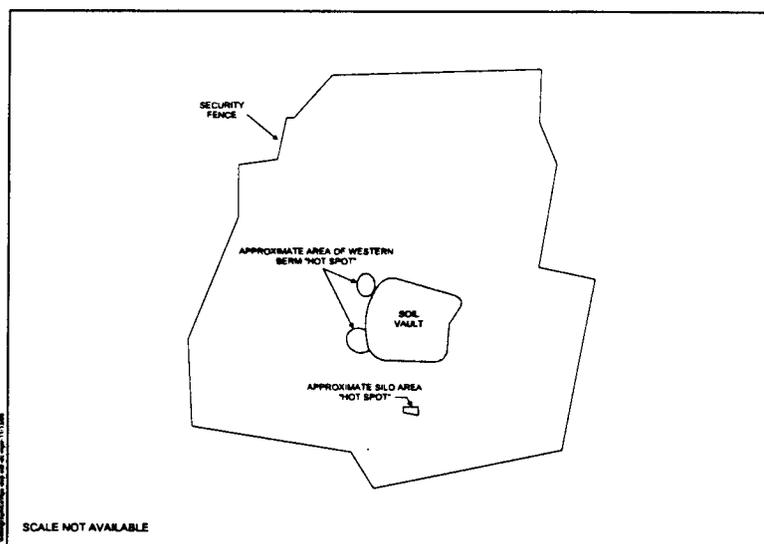
**Primary Contaminant Groups:** organic compounds - volatiles, halogenated; volatiles, nonhalogenated (BTEX); semivolatiles, halogenated and semivolatiles, nonhalogenated (PAHs)

During the RI, analyses of 278 soil and sediment samples were made to determine the nature and extent of contamination in the DOPC vault. Analysis of materials in the vault indicated a general stratification of contaminants, with the highest concentration of volatile and semivolatile organic compounds present at 25-30 feet below the top of the vault. Table 1 shows the range of contaminants measured in the soil vault during the RI. In this application, total PAHs were defined as the sum of the following 17 constituents: acenaphthene, acenaphthylene, anthracene, benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, Benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, pyrene, and 2-methylnaphthalene. [31]

**Table 1. Range of Contaminants Measured in Soil Vault During RI [31]**

Contaminant/Parameter	Range of Concentrations (mg/kg)
VOCs	0.022 - 38.27
Total PAHs	0.578 - 122.4
PCP	0.058 - 51

In addition, analyses of soils outside the vault were performed, and several small areas of contaminated soil were characterized, including areas in the western berm of the vault and an on-site silo. The maximum total PAH concentration measured in the soils outside the vault was 367 mg/kg. [6, 31] Figure 2 shows the location of the soil vault, western berm and silo area "hot spots" at the DOPC site.



**Figure 2. Location of Soil Vault and Hot Spots at DOPC Site [6]**

**MATRIX DESCRIPTION (CONT.)****Matrix Characteristics Affecting Treatment Cost or Performance**

The major matrix characteristics affecting cost or performance for this technology and the values measured for each are shown in Table 2.

**Table 2. Matrix Characteristics [17]**

<b>Parameter</b>	<b>Value</b>	<b>Measurement Method</b>
Soil Classification	Not provided	-
Clay Content and/or Particle Size Distribution	Not provided	-
pH	6.9 to 7.9	N/A
Total Petroleum Hydrocarbons	300 - 600 mg/kg	N/A
Moisture Content	8%	N/A

N/A - Measurement method not reported for this parameter because resulting value not expected to vary among measurement methods.

Although detailed soil classifications and particle size distribution information is not provided in the available references, the RPM indicated the soil was a Lakeland loamy sand. [32]

## TREATMENT SYSTEM DESCRIPTION

**Primary Treatment Technology Type:** Composting

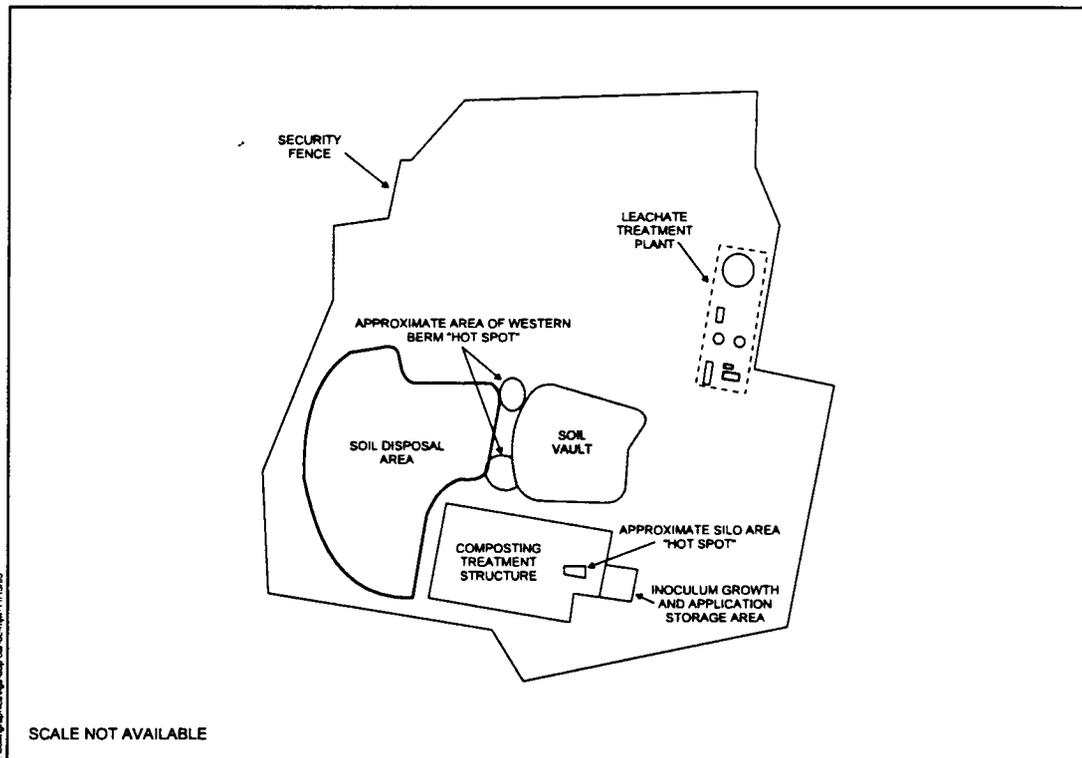
**Supplemental Treatment Technology Type:**

Post-treatment (air) - carbon adsorption; post-treatment (water) - chemical, filtration

### Compost System Description and Operation

The composting system used at DOPC consisted of a treatment structure, a leachate collection system, an aeration system, an inoculum growth and application system, and an on-site wastewater treatment system. Soil was piled approximately 4.0 to 4.25 feet deep in the treatment structure, and ambient air was drawn downward through the soil pile. A soil oxygen content of approximately 20% was maintained for this application. The inoculum solution was prepared using native soil microbes, and sprayed over the soil pile using a fire hose. Soil moisture was maintained at approximately 15%.

Figure 3 shows the layout of the major equipment at the site, including the location of the soil disposal area.



**Figure 3. Layout of Major Equipment at DOPC [6]**

**TREATMENT SYSTEM DESCRIPTION (CONT.)**

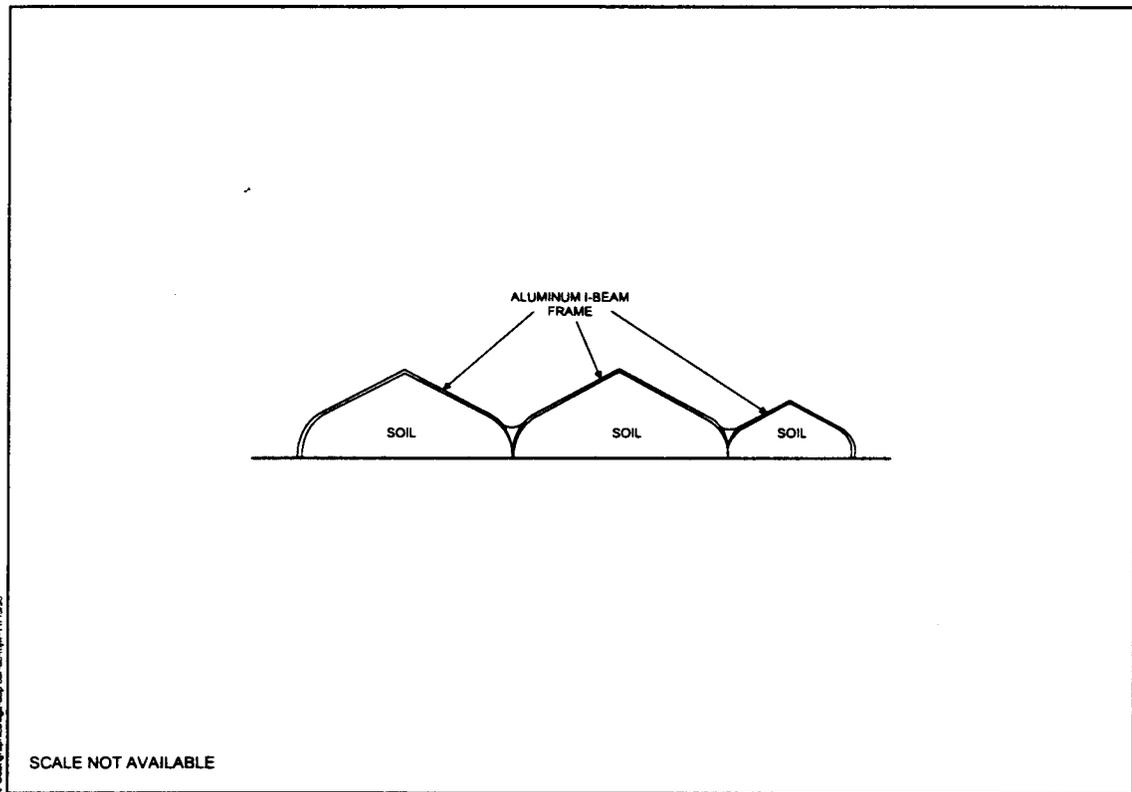
**Compost System Description and Operation (cont.)**

System Design

Treatment Structure [17]

The treatment structure used at DOPC was a 33,000 square foot modular pre-engineered building (approximately 220 by 150 feet) that included three separate units (bays) positioned side by side. The structure was an aluminum I-beam frame structure with reinforced PVC fabric tensioned between the beams. Figure 4 shows a side view of the treatment structure. This structure was leased from Sprung Instant Structures of Fontana, California.

The floor of the structure was covered with a continuous 40 mm low density polyethylene (LDPE) liner which was anchored on top of a continuous 4 foot high wall around the facility. The wall inside of the structure was made of pressure treated lumber reinforced with welded wire mesh.



**Figure 4. Side View of Treatment Structure [17]**

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## TREATMENT SYSTEM DESCRIPTION (CONT.)

### Compost System Description and Operation (cont.)

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#### Leachate Collection System [17]

A leachate collection system was used to collect leachate generated from rainwater which blew in from the sides of the open end structure, from excess inoculum mixture which leached out of the soil, and from excess water draining from wet soil placed in the treatment structure.

The treatment structure was designed to incline east at a slope of 1%, and north at a slope of 1%, such that leachate would collect at the northeast corner of the structure. To assist in leachate collection, a composite drainage material was installed on top of the LDPE liner, consisting of a high density polyethylene (HDPE) capillary grid with a continuous 6 ounce non-woven geotextile attached to both sides. The geotextile acted as a fabric filter to keep solids out of the capillary grid. Eighteen (18) inches of filter sand were placed on top of the composite drainage materials to protect the liner and help leachate to drain to the collection system.

At the north end of the facility, a 2 foot deep by 2 foot wide leachate collection trench was installed. This trench was filled with number 68 stone, and transported leachate by gravity along the slope to the east end of the facility. Leachate was discharged from the trench to a concrete sump, located outside of the structure, and from there pumped to an on-site wastewater treatment system.

#### Aeration System [17, 32]

The aeration system used at DOPC, shown in Figure 5, pulled air through the soil placed inside the treatment structure, and consisted of pipes and valves, a moisture separator, a blower unit, and two vapor phase carbon vessels. This system also extracted VOCs from the soil.

Approximately 3,000 feet of aeration piping were installed throughout the treatment structure on top of the composite drainage mat, and below the 18 inches of filter sand, as shown in Figure 6. The pipes were 4-inch diameter perforated 3034 PVC wrapped in polyester pipe sock, and spaced approximately 10 inches apart.

The blower unit used at DOPC was a 15 horsepower Rotron EN12 explosion proof regenerative blower, which pulled approximately 300 cubic feet per minute (cfm) of air at a vacuum at 80 to 90 inches of water.

## TREATMENT SYSTEM DESCRIPTION (CONT.)

### Compost System Description and Operation (cont.)

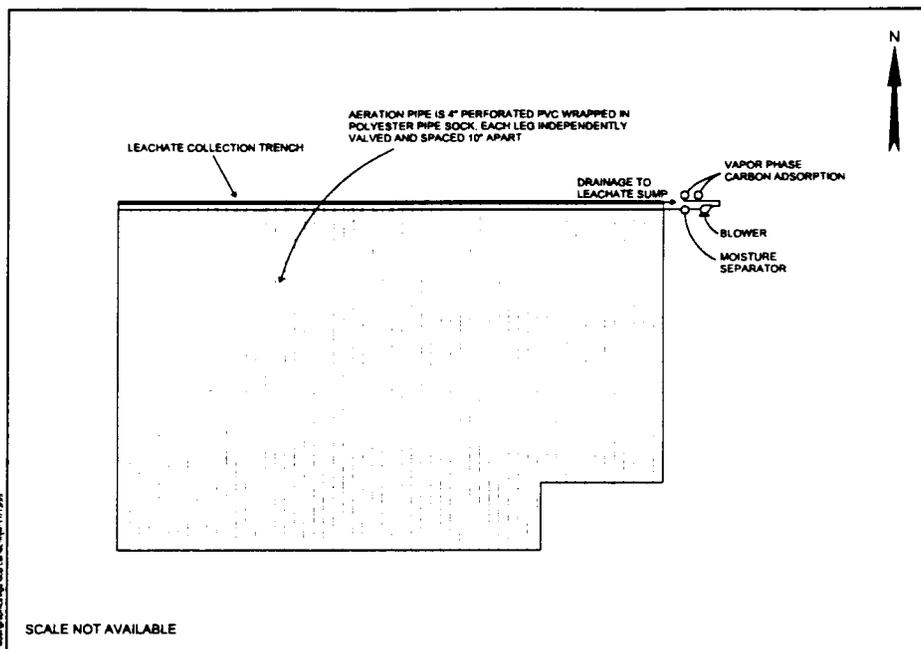


Figure 5. Layout of Aeration System Used at DOPC (top view) [17]

Figure 5. Layout of Aeration System Used at DOPC [17]

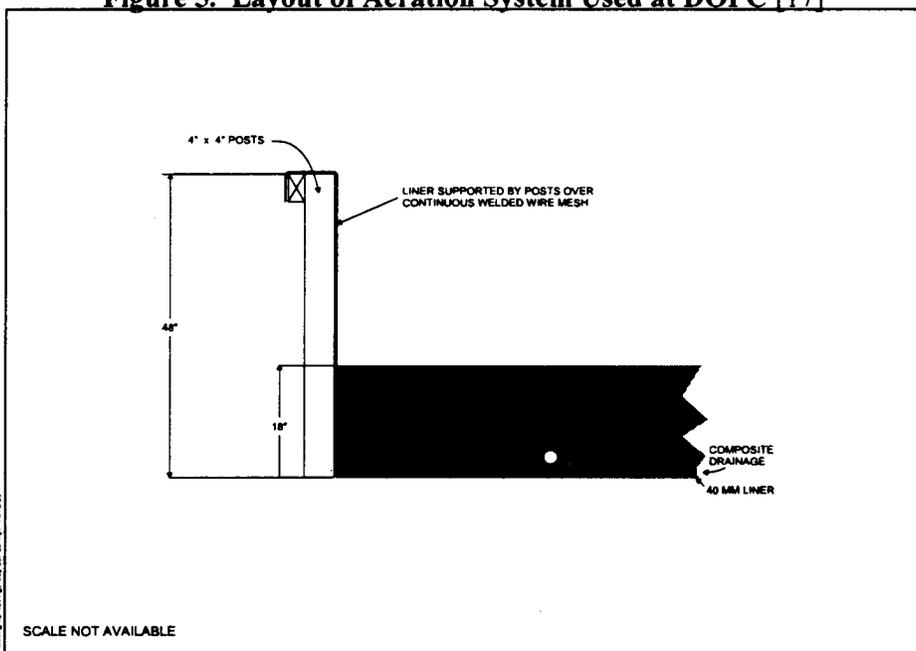


Figure 6. Location of Aeration Piping at DOPC [17]

## TREATMENT SYSTEM DESCRIPTION (CONT.)

### Compost System Description and Operation (cont.)

The VOC-containing air discharged from the blower passed through two Carbtrol W-2 vapor phase carbon adsorbers plumbed in parallel. Each of these units contained 300 pounds of granular activated carbon (GAC) and were designed to treat a maximum air flow of 250 cfm. According to WATEC, a total of 1,800 pounds of GAC were used in this application. VOCs in the carbon exhaust were monitored daily, and carbon switchouts were made as appropriate to avoid VOC breakthrough. WATEC reported that they had given consideration to recirculating air from the carbon exhaust to the soil stockpile, but decided that the system was performing adequately without doing so and therefore they chose to not perform recirculation.

#### Inoculum Growth and Application System [17, 18]

The inoculum growth and application system consisted of two inoculum growth tanks, an inoculum mixing tank, and a pump and fire hose for dispensing the mixture. A schematic of this system is shown in Figure 7. Two 2,000-gallon polyethylene tanks were used to grow the inoculum, using indigenous site soil, water, nutrients, and air. Indigenous site soil was found to contain sufficient microbial activity to support the composting process. Inoculum was allowed to grow for at least 7 days before use in the treatment structure.

The inoculum mixing tank was a 5,000-gallon polyethylene tank equipped with a Lightnin Vector 1-1/2 horsepower high speed mixer operated at 750 rpm. A portion of the inoculum from the growth tank was mixed with additional nutrients and water in this tank. The inoculum mixture was pumped from the mixing tank using a Pulsafeeder centrifugal pump and a firehose and nozzle at 20 gallons per minute.

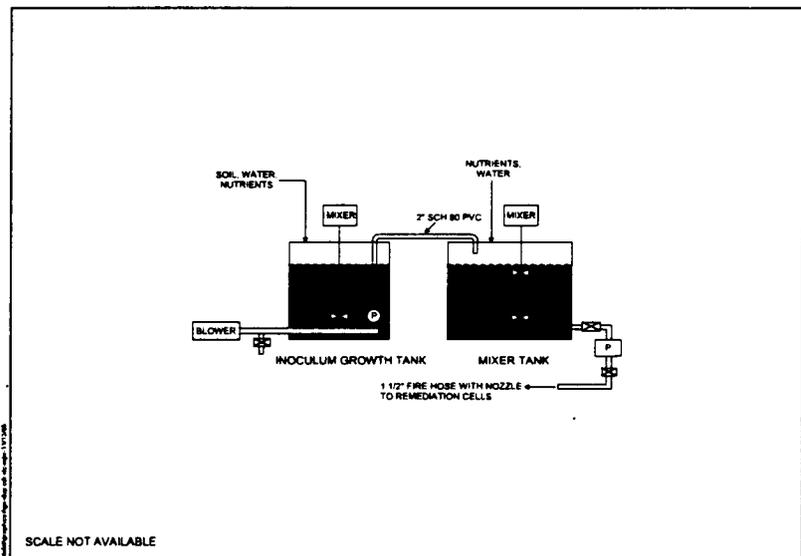


Figure 7. Inoculum Growth and Application System Schematic [17]

## TREATMENT SYSTEM DESCRIPTION (CONT.)

### Compost System Description and Operation (cont.)

It was anticipated that a cometabolite (molasses) would need to be added to the mixture in this tank to support the microbial population, however, this proved unnecessary. The treatment vendor identified several possible reasons for this, including higher than expected soil TPH concentrations, and smaller than expected concentrations of high ring contaminants and PCP.

#### On-Site Wastewater Treatment System [31]

The on-site wastewater treatment system consisted of the following components:

- A 250,000-gallon influent storage tank;
- A 6,000-gallon iron oxidation reactor tank and clarifier;
- Two multimedia (gravel, garnet, sand, and anthracite) filters each rated at 50 gpm;
- Two granular activated carbon (GAC) filters rated at 200 gpm and operated at 50 gpm to provide an empty bed contact time of 25 minutes through each filter; and
- A 10,000-gallon effluent storage tank.

#### System Operation [31]

Each of the three bays in the treatment structure was used as a treatment cell, and soil was treated in each cell on a batch basis. A batch of soil contained between 660 and 2,310 tons of soil, depending upon the size of the bay and the depth of the soil being treated. For most of the batches, soil depth ranged from 4.0 to 4.25 feet.

Soil from the vault or other hot spots was transported to the treatment cells and spread in the cell. The soil in the cell was then marked into 165 cubic yard grids. Each grid was sampled and analyzed for VOCs, PCP, and PAHs. Grids that contained VOCs, PCP, or PAHs at concentrations greater than the soil cleanup goals (see discussion under cleanup goals and standards) were left in the treatment cell. Soil in grids that did not exceed any of the cleanup goals was removed from the cell and transported to the soil disposal area, as shown in Figure 3. Soil was moved in and out of the facility with a 2-1/2 or 4-1/2 yard rubber tire front end loader.

Of the 58,559 tons of soil excavated at the DOPC site, 19,705 tons were treated using the composting system. The other 38,854 tons of soil excavated met the soil cleanup standards and did not require treatment.

Aeration of the soil was accomplished using an aeration system sized to introduce a soil pore volume once every 90 minutes, and to maintain a pore space oxygen content of approximately 20 percent. Air flow rate was maintained at between 250 and 300 cfm for the application.

**TREATMENT SYSTEM DESCRIPTION (CONT.)**

**Compost System Description and Operation (cont.)**

Inoculation of the soil was performed by adding the inoculum mixture to the soil relatively slowly, at about 20 gallons per minute and continued until the entire surface area of the cell was moistened. Generally, a batch was inoculated over a period of two days to provide time for the water to soak into the soil, while minimizing surface puddling or runoff. A soil moisture content of approximately 15% and a carbon:nitrogen:phosphorus ratio of 120:10:2 was maintained during this application.

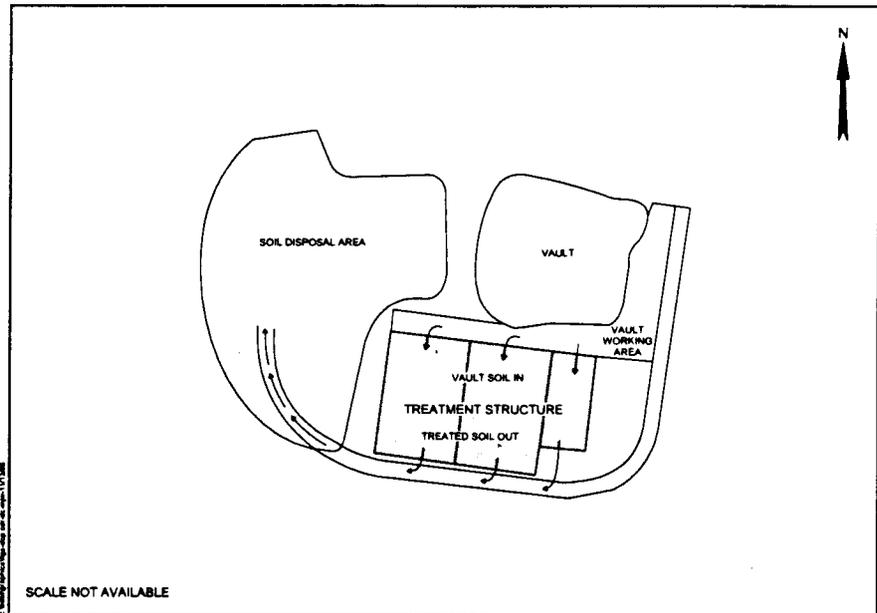
Leachate collected from the soil was treated in the on-site wastewater treatment system to remove excess nutrients and other contaminants.

Early in the project, the treatment vendor was concerned that simply applying the inoculum mixture to the top of the soil mass with a fire hose may not allow for adequate diffusion of soil moisture to the bottom of the soil mass. To address this concern, they conducted a field pilot test of the soil moisture in a batch at various depths before and after application. The test showed that after 24 hours, soil moisture was relatively homogenous (plus or minus 2 percent) throughout the soil mass, and that there was adequate diffusion of moisture throughout the soil mass.

**Disposition of Treated Soil [31]**

According to the PRP steering committee oversight contractor, the composting system treated all soil batches to the cleanup levels within 14 to 30 days. In addition, the contractor stated that

88% of the soil was treated to meet the cleanup goals within 14 days; however, no data supporting this percentage are provided in the available references. As shown in Figure 8, contaminated soil was transported from the soil vault or other hot spot to the treatment structure. Treated soil was then transported to an on-site soil disposal area.



**Figure 8. Schematic Showing Movement of Soil [18]**

## TREATMENT SYSTEM DESCRIPTION (CONT.)

### Compost System Description and Operation (cont.)

#### System Shutdown

After all soil piles were treated to meet the cleanup standards, the treated soil was sampled and excavated, piping and liner materials were removed, and the soil beneath the liner was sampled to verify that contaminants had not migrated beneath the liner. The excavation was then backfilled with treated soils (which had been stored in the ravine area at the site) to above grade, and a limited quantity of topsoil was placed on top of the excavation. The site was graded, erosion control measures were installed, and vegetation was applied. The ROD had required Dubose to apply two feet of topsoil over all the excavation, however, the actual quantity of topsoil applied was less than two feet. It is not known if this difference in topsoil quantity had any affect on vegetation growth. No information was provided in the available references on why the actual quantity used differed from the ROD specification.

#### Health and Safety [32]

All work at the site was performed using Level B personal protective equipment (e.g., supplied air respiration). The vendor monitored work zone and breathing zone ambient air contaminants throughout the remediation, and reportedly never identified any elevated concentrations that would have required them to implement their contingency plan.

### Operating Parameters Affecting Treatment Cost or Performance

The major operating parameters affecting cost or performance for this technology and the values measured for each are shown in Table 3.

**Table 3. Operating Parameters [3, 17, 18, 31]**

Parameter	Value	Measurement Method
Air Flow Rate	250 to 300 cfm	N/A
Mixing Rate/Frequency	No mixing in compost pile	N/A
Moisture Content	15%	N/A
pH	6.9 to 7.9	N/A
Residence Time	14 to 30 days/batch	N/A
Temperature	ambient	N/A
Oxygen Uptake Rate	not measured	-
Hydrocarbon Degradation	not measured	-
Nutrients and Other Soil Amendments	C:N:P:120:10:2	not available
Soil Loading Rate	660 to 2,310 tons/batch soil depth 4.0 to 4.25 feet	N/A
Soil Oxygen Content	approximately 20% (one soil volume every 90 minutes)	N/A

N/A - Measurement method not reported for this parameter because resulting value not expected to vary among measurement methods.

**TREATMENT SYSTEM DESCRIPTION (CONT.)****Timeline**

A timeline for this application is shown in Table 4.

**Table 4. Timeline [1, 31, 32]**

<b>Start Date</b>	<b>End Date</b>	<b>Activity</b>
January 1979	November 1981	Waste storage, treatment, recycling, and disposal facility operated by DOPC
March 1982	May 1982	EPA and FDEP inspect and sample site
November 1984	May 1985	Contaminated soil excavated and placed in on-site vault
June 1986	-	DOPC listed on NPL
October 1987	-	Consent agreement reached by FDEP and DOPCSC
February 1988	October 1988	Remedial investigation performed
March 1990	-	ROD signed
May 1993	November 1993	Site preparation activities performed
November 1993	September 1994	Soil vault excavation and treatment activities performed
September 1994	August 1, 1996	Site restoration and remediation facilities demolition performed
August 19, 1996	-	Final site inspection performed.
September 1996	-	Final Remedial Action Report issued (approved February 1997)

## TREATMENT SYSTEM PERFORMANCE

### Cleanup Goals/Standards

The ROD identified soil cleanup goals and leachate discharge cleanup standards for total PAHs, PCP, total xylenes, benzene, TCE, and DCE, as shown in Table 5. [1]

**Table 5. Cleanup Goals and Standards [1]**

Constituent/Parameter	Soil Cleanup Goal (mg/kg)	Leachate Discharge Standard (µg/L)
Total Polynuclear Aromatic Hydrocarbons (PAHs)	50	10
Pentachlorophenol (PCP)	50	30
Total Xylenes	1.5	50
Benzene	10	1
Trichloroethene (TCE)	0.050	3
1,1-Dichloroethene (DCE)	0.070	7

### Additional Information on Goals

Cleanup goals for constituents/parameters in the soil were based on either leaching potential or health-based criteria, as follows [1]:

- Leaching potential: Total PAHs, total xylenes, TCE, and DCE.
- Health-based criteria: PCP and benzene.

### Treatment Performance Data

As discussed under treatment system description, soil placed in the treatment cells was divided into grids, then analyzed to determine if the grid contained levels of constituents of concern above the cleanup goals. Only soil in grids where the contaminants exceeded the cleanup goals was treated. Treatment performance data consist of soil samples for 286 grids of soil from the soil vault, 68 grids of soil from the west berm, and 5 grids of soil from the silo (359 grids total), and air emission samples at and near the perimeter of the site.

### Soil Samples [31, 32]

A total of 359 grid samples were analyzed for benzene, DCE, TCE, total xylenes, PCP, and total PAHs. Of the 359 grids, 56 (16%) contained total PAHs at concentrations greater than the cleanup goal (50 mg/kg) and 102 contained VOCs, primarily xylenes, in excess of the VOC cleanup goals. The 56 grids exceeding the total PAH cleanup goal contained 8,783 tons of soil. Table 6 shows the grid number and contaminant concentrations before- and after-treatment for the 56 grids that exceeded the total PAH cleanup goal. The 102 grids exceeding the cleanup goal for VOCs contained 10,922 tons of soil. Thus, 19,705 tons of soil (8,783 tons for PAHs and 10,922 tons for VOCs) required treatment.

Table 6. Before- and After-Treatment Concentrations for 56 of 359 Grids [31]\*

Grid No.	Before-Treatment Concentrations (mg/kg)							After-Treatment Concentrations (mg/kg)						
	UVS	LVS	Total PAHs	PCP	Total Xylenes	Benzene	TCE	DCE	Total PAHs	PCP	Total Xylenes	Benzene	TCE	DCE
		Cleanup Goal	50	50	1.5	10	0.05	0.07	50	50	1.5	10	0.05	0.07
118	013	59.02	7.67	21.6	0.05		0.03			0.40				
133	024	63.2		1.4						0.2				
137	036	67.7		1.4						0.04	0.03			
138	025	51.7		0.47										
148	026	54.3		0.19						0.08				
151	035	63.9		0.45										
163	029	55.6		6.36										
164	030	61.4		10.9						0.08				
165	031	53.3		4.0						0.13				
167	032	122.2		0.15			0.02			0.4				
168	037	73.2		0.41			0.02			0.01				
169	038	123.4	43.3	0.29			0.02			0.26				
171	034	58.0	26	58.6	0.3		1.0							
175	040	59.7		5.8						0.05				
188	042	57.0		0.07						0.04				
192	044	51.7		0.68						0.09				
198	048	53.0	17.9	11.1	0.02		0.05							
202	052	109.2		17.4	0.08		0.47			0.13				
219	066	52.5		4.00	0.01									
221	067	59.7		5.31	0.02					1.05				
224	068	84.3	31.1	5.43	0.04		0.07			0.36				0.04
226	069	53.6		11.9	0.09		0.14			0.53				
233	072	106.3		0.97						0.09				
235	074	96.0		48.9						0.65				
236	075	60.8		5.70										
237	076	132.1		15.5						0.11				
238	077	222.6	29.7	69.5	0.50					0.65				
239	078	78.0		0.18						0.04				
240	079	232.50	92.7	22.5										
241	080	73.6		17.1						0.03				
242	081	111.1		23.5										
243	082	62.0		24.5						0.14				
244	083	246.2	104.6	13.9										
WB14	102	105.7								0.10				

Table 6 (Continued)

Grid No.	LVS	Before-Treatment Concentrations (mg/kg)						After-Treatment Concentrations (mg/kg)					
		Total PAHs	PCP	Total Xylenes	Benzene	TCE	DCE	Total PAHs	PCP	Total Xylenes	Benzene	TCE	DCE
	Cleanup Goal	50	50	1.5	10	0.05	0.07	50	50	1.5	10	0.05	0.07
WB16	103	55.1		0.30						0.16			
251	086	175.3		4.12	0.02			3.8					
255	089	60.1		0.420				4.5		0.13			
256	090	78.7	20.1	2.50		0.25		26.9		0.57			
258	091	61.2		22.5				36.3	16.5	0.05			
259	092	576.2		16.6				23.1		0.95			
260	093	66		10.9				49.9	36.3				
261	094	119.2	27.0	28.5				25.4		0.56			
263	096	66.5		9.0				21.9		0.76			
266	099	117.2		0.44									
267	100	68.0		0.64				15.5					
268	101	297.7		44				13.4		0.455			
273	106	50.8		1.05		0.80		18.6		0.49			
274	107	51.9	17.3	8.0		0.01		44.5		0.56			
275	108	139.1	97.4	24.2									
281	111	186.8	100	29.4									
282	112	101.3	44.6	16.8									
286	116	76.4	16.8	21.1									
WB29	118	69.9		0.33									
WB40	120	166.6		0.49				4.2					
WB41	121	200.3											
WB43	122	191.6	160	2.03									

\*This table shows analytical results only for the 56 of 359 grids that contained total PAHs at concentrations exceeding the cleanup goal (50 mg/kg). LVS means upper vault samples and I.V.S means lower vault samples. Where no data are shown (blanks in table), analytical result was below detection limit.

## TREATMENT SYSTEM PERFORMANCE (CONT.)

### Treatment Performance Data (cont.)

The treatment vendor calculated the average concentrations for 17 PAHs measured in grids 101 through 221 before-treatment and after 14 days of treatment. The average concentrations for these constituents in grids that required treatment are shown in Table 7. In addition, for grids 101 through 221, which consisted of approximately 20,000 cubic yards of soil, the treatment vendor estimated that 9,900 cubic yards (50%) required treatment, including 2,970 cubic yards (15%) for total PAHs and 6,930 cubic yards (35%) for VOCs.

The treatment vendor indicated that, while the primary removal mechanism for PAHs was bioremediation, the primary removal mechanism for VOCs was volatilization, either in handling or through the aeration system. Before- and after-treatment data for the 102 grids exceeding the cleanup goal for VOCs are not presented in this report because the vendor believes these constituents were removed through volatilization rather than bioremediation.

According to the RPM, the soil was handled at least twice before undergoing composting, and there may have been some limited amount of fugitive losses during such handling. However, no data were collected to evaluate potential fugitive losses. In addition, work zone and breathing zone ambient air monitoring data for VOCs was collected throughout the remediation. These data never triggered the requirement to implement a contingency plan which would have had to be implemented if elevated concentrations were identified. The only contaminants measured in the ambient monitoring system were phenanthrene and naphthalene, and these contaminants were measured at concentrations less than their contingency levels. During aeration, all VOCs extracted from the soil were treated using the GAC system prior to release to the atmosphere.

### Air Emission Samples [31]

Air emission samples were collected at four air monitoring stations, each consisting of a volatile organic sampler (Xontech sampler) and a semi-volatile sampler (PS-1). Air monitoring was planned as a contingency measure in the event of a release or suspected release of airborne contaminants, and for monthly documentation during soil excavation/ transport activities.

No contingency monitoring was required by events occurring during the project. Monthly monitoring was performed over nine 24-hour periods when contaminated soil excavation/transport activities were underway.

According to the DOPCSC oversight contractor, analytical results of the air emission samples indicated all contaminants of concern were present at levels below levels of concern. These data are not provided in the available references, but are available in the detailed files for the project. [34]

**TREATMENT SYSTEM PERFORMANCE (CONT.)****Treatment Performance Data (cont.)****Table 7. Soil Treatment Results for Individual PAHs [18]<sup>1</sup>**

Constituent	Average Concentration in Soil Before Treatment (mg/kg)	Average Concentration in Soil After 14 Days of Treatment (mg/kg)
<b>Two-Ring PAHs</b>		
Naphthalene	1.48	BDL
2-Methyl Naphthalene	1.11	0.26
Acenaphthylene	BDL	BDL
Acenaphthene	4.15	0.74
<b>Three-Ring PAHs</b>		
Fluorene	5.2	0.89
Phenanthrene	16.5	3.6
Anthracene	26.4	7.94
<b>Four- and Five-Ring PAHs</b>		
Fluoranthene	9.56	5.28
Pyrene	5.52	4.35
Benzo(a)anthracene	BDL	BDL
Chrysene	BDL	BDL
Benzo(b)fluoranthene	BDL	BDL
Benzo(k)fluoranthene	BDL	BDL
Benzo(a)pyrene	BDL	BDL
Indeno(1,2,3-cd)pyrene	BDL	BDL
Dibenz(a,h)anthracene	BDL	BDL
Benzo(g,h,i)perylene	BDL	BDL

<sup>1</sup>This table shows average concentrations for only those grids within grid numbers 101 through 221 that required treatment for PAHs.

BDL - Below Detection Limit.

**Performance Data Assessment**

As discussed under treatment performance data, 56 of the 359 soil grids excavated at the DOPC site (corresponding to 8,763 of 58,559 tons of soil) required treatment for total PAHs. The analytical data for these soil grids summarized in Table 6 show that before-treatment concentrations of total PAHs ranged from 50.8 mg/kg to 576.2 mg/kg, with 21 of the 56 grids containing total PAHs at concentrations more than twice the soil cleanup goal for total PAHs (50 mg/kg). The after-treatment concentration data shown in Table 6 indicate that all 56 grids met the soil cleanup goals for total PAHs, PCP, total xylenes, benzene, TCE, and DCE. Total PAHs in the 56 treated soil grids ranged from 3.3 mg/kg to 49.9 mg/kg, and the average concentration of total PAHs in the treated soil was 19 mg/kg.

## TREATMENT SYSTEM PERFORMANCE (CONT.)

### Performance Data Assessment (cont.)

In addition, for these 56 soil grid samples, PCP before-treatment concentrations ranged from 7.67 mg/kg to 160 mg/kg, and after-treatment concentrations ranged from 16.5 mg/kg to 36.3 mg/kg; total xylenes before-treatment concentrations ranged from 0.07 mg/kg to 69.5 mg/kg, and after treatment concentrations from 0.03 mg/kg to 1.05 mg/kg; and TCE before-treatment concentrations ranged from 0.01 mg/kg to 1.0 mg/kg, and after treatment concentrations from 0.01 mg/kg to 0.04 mg/kg. Benzene and DCE were not measured at concentrations greater than their soil cleanup goals in these 56 grids.

Analytical data for individual PAHs shown in Table 7 indicate that the majority of PAHs measured at detectable concentrations in the soil in grid numbers 101 through 221 before treatment were two- and three-ring constituents. Six of the seven two- and three-ring PAHs shown in Table 7 had detectable concentrations before treatment, averaging up to 26.4 mg/kg for anthracene (a three-ring PAH), while only two of the ten four- and five-ring PAHs had detectable concentrations. Also as shown in Table 7, two- and three-ring PAHs showed approximately 80% reduction in average concentration after 14 days of treatment for these grids, while four- and five-ring PAHs showed less than 50% reduction in average concentration over the same time period.

Before- and after-treatment data for the 102 grids exceeding the cleanup goal for VOCs are not presented in this report because the vendor believes these constituents were removed through volatilization rather than bioremediation.

### Performance Data Completeness

Treatment performance data are available to characterize the before- and after-treatment concentrations for total PAHs, PCP, total xylenes, benzene, TCE, and DCE in the soil excavated at the DOPC site; and the range of operating parameters monitored in this application. In addition, the PRP steering committee oversight contractor reported that air emission monthly monitoring samples are available for nine 24-hour periods during excavation/transport activities. No data are available to link specific operating parameters with treatment performance data for individual batches (e.g., residence time, application of inoculum).

### Performance Data Quality

The treatment vendor performed extensive quality assurance/quality control (QA/QC) procedures as part of this remedial activity. QA/QC procedures included development of a Quality Assurance Project Plan (QAPP - Ref. 12), use of standard EPA analytical procedures, such as SW-846 Method 8270 for PAHs and PCP and 8010/8020 for VOCs, and use of trip blanks, field duplicates, matrix spikes, and matrix spike duplicates. No exceptions to the QA/QC procedures were noted by the vendor for this treatment application. [31]

## TREATMENT SYSTEM COST

### Procurement Process

The PRP Steering Committee selected WATEC as the remedial action treatment vendor and Parsons Engineering Science, Inc. as the oversight contractor. WATEC designed, constructed, and operated the composting process at the DOPC site, and Parsons performed oversight activities, including sample collection and analysis, and preparation of a remedial action report.

No information is provided in the available references on the competitive nature of the two procurements; how many bids were provided for each function; or what was the basis for contractor selection.

### Treatment System Cost

Actual costs of \$7,736,700 were reported by the PRP steering committee's oversight contractor for this application, as shown in Table 8. Table 8 shows the specific activity and corresponding cost as reported by the oversight contractor.

**Table 8. Costs Reported by PRP Steering Committee [31]**

Activity	Actual Cost (\$)
Oversight by PRP Group	17,500
Remedial design	820,000
RI/FS	940,000
North pond effluent	18,500
Vault and north pond dike	5,000
Air monitoring	57,200
Groundwater and surface water monitoring	450,000
Site security fencing	9,300
Vault cover replacement	35,500
Repair of north pond dike	18,600
Miscellaneous (accounting, hog barn demolition, entrance road construction, tire disposal)	46,600
O&M of leachate treatment	42,500
Drums/Tanks/Structures/Miscellaneous Demolition and Removal	26,000
Remedial action/construction	4,780,000
DOPCSC remedial action oversight	470,000
<b>TOTAL</b>	<b>7,736,700</b>

## **TREATMENT SYSTEM COST (CONT.)**

### **Cost Data Quality**

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The costs for specific activities shown in Table 8 represent actual costs for those activities as reported by the PRP steering committee oversight contractor. No information was contained in the available references on the components of these specific activities, or the costs for those components (e.g., for the \$4.78 million expended on remedial action/construction).

### **Vendor Input**

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WATEC reported that a performance-based specification would be better suited for these types of projects. They reported that the design package on which they bid was not subsequently implemented, and that such changes would be accommodated more easily with a performance-based specification. [32]

## **OBSERVATIONS AND LESSONS LEARNED**

### **Cost Observations and Lessons Learned**

- Actual costs of \$7,736,700 were reported by the PRP Steering Committee's oversight contractor for this application including \$4,780,000 for remedial action/construction activities.
- Costs included the following WBS cost elements: mobilization and preparatory work, monitoring, sampling, testing, and analysis, site work, surface water collection and control, drums/tanks/structures/miscellaneous demolition and removal, and operation (short-term, up to 3 years).
- Based on the cost information provided by the PRP, costs for activities directly attributed to treatment could not be separated from before- and after-treatment costs, and therefore unit costs for activities directly attributed to treatment were not calculated or available for this application. The cost of \$4,780,000 provided by the PRP includes costs for excavation, storage, sampling, and analysis, which are considered before-treatment cost elements, costs for disposal, which is considered an after-treatment cost element, as well as costs directly attributed to treatment. No information was provided to disaggregate the remedial action/construction cost into discernible costs and activities.
- The RPM for this application expressed a preference for contracts which allow for flexibility in remedial design, stating that the use of a flexible design including temporary treatment structures in this application resulted in significant cost savings.

### **Performance Observations and Lessons Learned**

- Soil cleanup goals for all 19,705 tons of soil treated at the DOPC site were met in this application. Of the 58,559 tons excavated, 19,705 tons required treatment because one or more constituents were measured at concentrations greater than the cleanup goals, including 8,783 tons containing total PAHs at concentrations greater than the cleanup goals, and 10,922 tons containing VOCs (primarily xylenes).
- The analytical data for the 8,763 tons of soil that required treatment for total PAHs (corresponding to 56 sampling grids) indicate that before-treatment concentrations of total PAHs ranged from 50.8 mg/kg to 576.2 mg/kg, with 21 of the 56 grids containing total PAHs at concentrations more than twice the soil cleanup goal for total PAHs (50 mg/kg). Total PAHs in the 56 grids after treatment ranged from 3.3 mg/kg to 49.9 mg/kg, and the average concentration of total PAHs in the treated soil was 19 mg/kg.

## **OBSERVATIONS AND LESSONS LEARNED (CONT.)**

### **Performance Observations and Lessons Learned (cont.)**

- For these 56 soil grid samples, PCP before-treatment concentrations ranged from 7.67 mg/kg to 160 mg/kg, and after-treatment concentrations ranged from 16.5 mg/kg to 36.3 mg/kg; total xylenes before-treatment concentrations ranged from 0.07 mg/kg to 69.5 mg/kg, and after treatment concentrations from 0.03 mg/kg to 1.05 mg/kg; and TCE before-treatment concentrations ranged from 0.01 mg/kg to 1.0 mg/kg, and after treatment concentrations from 0.01 mg/kg to 0.04 mg/kg. Benzene and DCE were not measured at concentrations greater than their soil cleanup goals in these 56 grids.
- Analytical data for individual PAHs indicate that the majority of PAHs measured at detectable concentrations in approximately one-third of the grid samples before treatment were two- and three-ring constituents. Six of the seven two- and three-ring PAHs had detectable concentrations before treatment, averaging up to 26.4 mg/kg for anthracene (a three-ring PAH), while only two of the ten four- and five-ring PAHs had detectable concentrations.
- Analytical data indicated that two- and three-ring PAHs showed approximately 80% reduction in average concentration after 14 days of treatment, while four- and five-ring PAHs showed less than 50% reduction in average concentration over the same time period.

### **Other Observations and Lessons Learned**

- The primary removal mechanism for VOCs was volatilization, either in handling or through the induced draft aeration system, and the primary removal mechanism for PAHs was bioremediation. In addition, according to the treatment vendor, no VOCs or PAHs were detected in the leachate at the influent to the wastewater treatment facility, indicating that contaminants were not "washed" from the soil in this application.
- According to the RPM, the soil was handled at least twice before undergoing composting, and there may have been some limited amount of fugitive losses during such handling. However, no data were collected to evaluate potential fugitive losses, and work zone and breathing zone ambient air monitoring data for VOCs collected throughout the remediation never triggered Dubose to implement their contingency plan. The only contaminants identified in the ambient monitoring system were phenanthrene and naphthalene, and these contaminants were measured at concentrations less than their contingency levels.
- The composting system treated soil to the cleanup levels within 14 to 30 days on a batch basis. The overall process of excavating and treating soil at the DOPC site was completed within a 10 month period.

## **OBSERVATIONS AND LESSONS LEARNED (CONT.)**

### **Other Observations and Lessons Learned (cont.)**

- A co-metabolite was not required to be used for inoculum growth in this application, contrary to the original plan. The treatment vendor identified several possible reasons for this, including higher than expected soil TPH concentrations, and smaller than expected concentrations of high-ring contaminants and PCP.
- The treatment vendor found that applying the inoculum mixture to the top of the soil mass with a fire hose was adequate for maintaining the moisture content of the soil mass. A field pilot test showed that soil moisture was relatively homogeneous throughout the soil mass (plus or minus 2 percent) within 24 hours after inoculum application.
- The treatment vendor identified several items that required unexpected maintenance during system operation, including the moisture separator and the aeration piping. The quantity of rain experienced during this application exceeded original predictions, and the moisture separator capacity was frequently exceeded. The vendor modified the operation of the moisture separator during the application by installing a control panel and automatic drain so the unit would drain and re-start automatically. Also, some of the aeration piping occasionally was crushed, because of the relatively thin layer of sand protecting the piping and the use of heavy equipment in the treatment structure.
- The RPM noted a problem with planting grass as the final cover over this site, saying that the treated soil was not supporting the growth of Bahia grass, and that there was a need to place topsoil over the treated soil before planting grass.

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**Analysis Preparation**

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