COST AND PERFORMANCE REPORT

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

September 1998

Prepared by:

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

SITE INFORMATION

Identifying Information

SCRDI Dixiana Superfund Site
Cayce, South Carolina

CERCLIS #: SCD980711394

ROD Date: September 26, 1986

Treatment Application

Type of Action: Remedial

Period of operation: 8/92 - Ongoing
(Data collected through March 1997)

Quantity of material treated during application: 20.6 million gallons of groundwater through March 1997

Background [7]

Historical Activity that Generated Contamination at the Site: Industrial waste storage

Corresponding SIC Code: NA

Waste Management Practice That Contributed to Contamination: Spills from poor waste handling practices, leaking drums

Location: Cayce, SC

Facility Operations:

- South Carolina Recycling and Disposal, Inc. (SCRDI) operated this site as an industrial waste storage facility until 1978. The starting date of operations at the site is not known. Waste materials stored on site included solvents, phenols, specialty chemicals, hydrogen peroxide, and pyridine.
- In 1978, SCRDI applied for a waste management permit from the South Carolina Department of Health and Environmental Control (SCDHEC). After a site visit, the permit was denied because of poor waste management practices, such as materials stored in leaking containers, drums stored in exposed conditions, and improper waste handling procedures.
- A suit was filed by SCDHEC against SCRDI for its waste management practices. As a result of this suit, SCRDI removed over 70 drums of waste and visibly contaminated soils were removed by SCRDI between September 1978 and June 1980. No other source control actions were performed at the site.
- In June 1980, SCDHEC implemented a preliminary groundwater study to determine the extent of subsurface contamination. Analytical results from this study indicated a potentially serious health concern from halogenated organic and metal contamination found on site. SCDHEC advised owners of affected residential wells to seek alternative water sources, and recommended a more detailed groundwater investigation.
- Groundwater contamination was confirmed during a detailed site investigation completed by SCDHEC in August 1982.
- The site was placed on the National Priorities List (NPL) in September 1983.
- A remedial investigation (RI) was completed in October 1985. The RI provided detailed information about the organic and metal contaminants found on site. The feasibility study (FS) was completed in September 1986.
- A Record of Decision (ROD) was issued in September 1986 for groundwater remediation. An Explanation of Significant Differences (ESD) was issued in 1991. The ESD documents specific modifications to the discharge point and treatment system.
- S&ME Inc., a PRP contractor, conducted an additional hydrogeologic study in 1994. The report, entitled Supplemental Site Investigation (SSI) Report provided new information about the hydrogeology of the site.

SITE INFORMATION (CONT.)

Background (Cont.)

- The remedial action for this site was managed by SCDHEC and EPA through June 1994. Remedial activities ceased in June 1994 because the EPA ARCS contract was canceled. EPA identified and named responsible parties in a Unilateral Administrative Order (UAO) issued in February 1995. As a result, the site changed from a fund-lead to a PRP-lead site. A new PRP contractor was hired and remedial activities resumed in November 1995.

Regulatory Context:

- On September 26, 1986, a ROD was signed for groundwater remediation at this site.
- Site activities are conducted under provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986, §121, and the National Contingency Plan (NCP), 40 CFR 300.

Remedy Selection: Extraction and treatment of groundwater via air stripping was selected as the remedy for this site.

Site Logistics/Contacts

Site Lead: EPA-lead from August 1992 through June 1994; PRP-lead from November 1995 to present

Oversight: EPA

Remedial Project Manager:
Yvonne Jones*
U.S. EPA Region IV
345 Courtland Street, N.E.
Atlanta, Georgia 30365
404-562-8793

*Indicates primary contact

State Contact:
Yanqing Mo
South Carolina Department of Health and Environmental Control
Bureau of Hazardous and Solid Waste
2600 Bull Street
Columbia, S.C. 29201

Treatment System Vendor:
Ebasco Services, Inc. (EPA Contractor)
Waste Abatement Technology (WATEC)
de maximis, Inc. (PRP project coordinator)
S&ME, Inc. (PRP contractor)
O&M, Inc. (PRP operations contractor)

MATRIX DESCRIPTION

Matrix Identification

Type of Matrix Processed Through the Treatment System: Groundwater

Contaminant Characterization [4, 10]

Primary Contaminant Groups: Halogenated volatile organic compounds (VOC) and metals

- The primary contaminants of concern are perchloroethylene (PCE), trichloroethylene (TCE), 1,1-dichloroethylene (1,1-DCE), 1,1,1-trichloroethane (1,1,1-TCA) and 1,1,1,2-perchloroethane (1,1,1,2-PCA).
- The maximum concentrations detected during initial investigations were PCE (600 µg/L), TCE (130 µg/L), 1,1,1-TCA (560

MATRIX DESCRIPTION (CONT.)

Contaminant Characterization (Cont.)

µg/L), 1,1-DCE (470 µg/L), and 1,1,1,2-PCA (25 µg/L).

- According to the RI report, the areal extent of the plume in 1982 was 80,000 square feet and it extended to a depth of 40 feet. The volume of the plume detected at the site was initially estimated to be 4.8 million gallons. A 1994 groundwater study found the plume to be 204,000 square feet in areal and approximately 12.2 million gallons. According to the study report, the plume increased in size partly because the plume was not contained during the first two years of operation. The increase in size also is attributed to a more accurate estimate of the plume location, since the 1994 estimate reflects a better understanding of the site hydrogeology [10].
- Figure 1 illustrates contaminant distribution detected during the 1994 site investigation.
- In 1982, contaminants were suspected to be located primarily within Units C and D beneath the site. Subsequent groundwater evaluations performed in 1994 revealed multiple sand zones (see Hydrogeology), all contaminated.

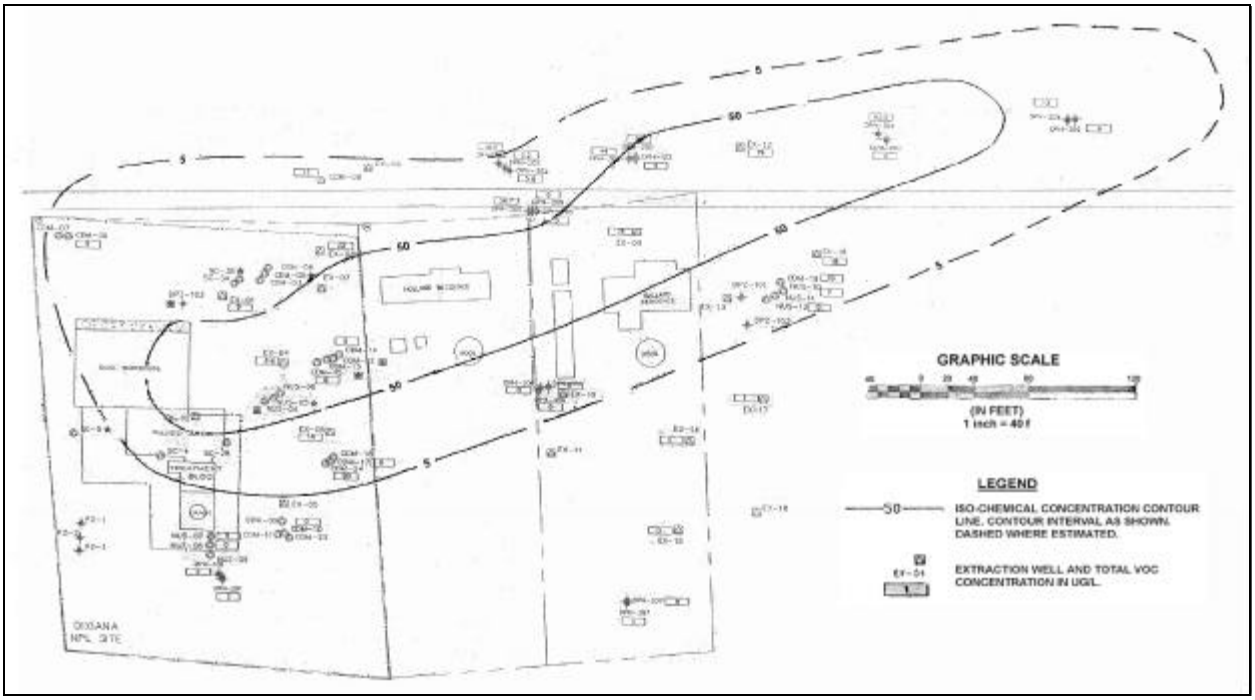

Figure 1. Initial Concentration Contour Map - Total VOCs (1994)

MATRIX DESCRIPTION (CONT.)

Matrix Characteristics Affecting Treatment Costs or Performance

Hydrogeology [4,10]:

Eight distinct soil layers have been identified within the upper 100 feet of soils beneath the SCRDI Dixiana site. These units are labeled A through H. Five water-bearing units (A,C,D,F, and H) have been identified; Units B, E, and G are semiconfining layers. The water table begins approximately 14 feet below ground surface. Groundwater flows in an easterly direction in the upper unconfined aquifer (Unit A). Groundwater flows in a southeasterly direction in Units C, D, F, and H.

The original site characterization data collected in 1984 and 1985 identified Unit C as the uppermost water-bearing region. Units C and D are hydraulically connected and were suspected of containing the majority of the groundwater contamination. In the 1994 investigation, Unit A was identified as the uppermost aquifer and samples revealed that most groundwater contaminants were present in this unit. The original remedial design was based on the early site characterization data. As a result, no extraction wells were placed in Unit A. Because the thickness of Unit D was overestimated in many areas in the early study, many of the extraction wells placed in Unit D were actually screened across both Units D and F. The wells with screened intervals across both units presented a pathway for contaminants to migrate from Unit D into Unit F, which was previously uncontaminated.

Unit A Undifferentiated sands, silts, clays
Unit B Kaolinitic clays
Unit C Undifferentiated sands, silts, clays
Unit D Sands, silty sands
Unit E Kaolinitic clays
Unit F Sands, clayey sands, discontinuous clay layers
Unit G Kaolinitic clays
Unit H Sands, silty sands, clayey sands

Tables 1 and 2 include technical aquifer information and extraction well data, respectively. The extraction wells are discussed in the following section.

Table 1. Technical Aquifer Information

Unit Name	Thickness (ft)	Conductivity (ft/day)	Average Velocity (ft/day)	Flow Direction
A	10-15	10	0.6	East
C	7-10	10	0.8	Southeast
D	7-9	10	0.8	Southeast
F	10-15	45	NC	Southeast
H	50-70	5	NC	NC

NC - Not Characterized
Source: [10]

TREATMENT SYSTEM DESCRIPTION

Primary Treatment Technology

Pump and treat with air stripping

Supplemental Treatment Technology

Pyrolox metal media filtration

System Description and Operation [6, 11, 12]

Table 2. Technical Well Data

Well Name	Unit Name	Depth (ft)	Design Yield (gal/min)
7 Extraction Wells	C/D	18-35	3-10
1 Extraction Well	C	13-26	3-10
7 Extraction Wells	D	24-35	3-10
Recovery Trench	A	10-12	NA

Note: Table represents current conditions. Average system rate for Phases I and II was 4 gpm. Average system rate since November 1995 has been 40 gpm. NA = Not Available

Source: [11]

System Description:

- Two distinct remedial systems have operated at this site; one operated from August 1992 to June 1994, and the second from November 1995 to present. A supplemental site investigation (SSI) was performed in 1994, and a remedial system optimization study was performed in 1995. As a result, the remedial system operated by PRPs (November 1995 to present) was modified from the EPA system (August 1992 to June 1994) to optimize performance.

- From August 1992 to June 1994, 20 extraction wells were pumped to remove groundwater from Units C and D and Unit F (through the hydraulic connection with Unit D). Eight of the extraction wells were located in areas of higher contaminant concentrations; the remaining wells were located on the periphery of the plume.

- The treatment system that operated from August 1992 until June 1994 consisted of an 18,000-gallon equalization tank, a pyrolox metal media filter unit, and a packed-column air stripper.

- Under the PRP-lead, the pump and treat (P&T) system was modified to consist of 15 extraction wells (five taken off line), a 300-foot shallow collection trench, and a shallow stacked tray air stripper. The revised extraction system was designed to collect groundwater from contaminated Units A,C, and D. Total extraction rate for this system has averaged 40 gpm.

- The pre-1995 treatment system was replaced in October 1995; the modified system became operational in November 1995. The equalization tank is no longer used in the modified system.

- Effluent from both systems has been discharged to the City of Cayce municipal treatment plant under a wastewater discharge permit.

System Operation:

- Quantity of groundwater pumped from the aquifer in gallons:

Year	Volume Pumped (gallons)	Unit Name
1992-1994	3.1 million	C,D,F
1995-1997	17.5 million	A,C,D

TREATMENT SYSTEM DESCRIPTION (CONT.)

System Description and Operation (Cont.)

- From August 1992 to June 1994, the site was operational approximately 80% of the time. Downtime was due to power failures from lightning strikes and scaling within process piping.
- From November 1995 through March 1997, the remedial system has been operational nearly 98% of the time. The modified system was designed to operate continuously without full-time staff on site. A remote sensing and control system was installed, which allows personnel to check and modify system operations from off-site locations.
- The EPA groundwater remediation program (1992-1994) was designed to be performed in two phases lasting 270 days (Phase I) and 321 days (Phase II), respectively. During Phase I, eight on-site wells within the more contaminated part of the plume were to be pumped at 1.5 gpm each, and 12 off-site wells were to be pumped at 0.17 gpm each. During Phase II, after on-site groundwater was remediated, the on-site wells would not be pumped, and the off-site wells would be pumped at either 0.5 or 0.9 gpm each.
- Based on a site modeling evaluation completed with Phase I data, the pumping rates for Phase II were revised. On-site wells would continue to be pumped at 1.5 gpm and eight off-site wells would be shut off. The remaining four off-site wells would continue pumping at 0.17 gpm each.
- The modified extraction well system designed by the PRPs consists of 15 extraction wells including eight existing wells, four replacement wells, and three new wells.
- The four wells that were replaced were hydraulically connecting Units D and F. The old wells were properly closed and replaced with new wells at the same location, but screened in Units C and D only.
- Three new well locations were picked to optimize hydraulic containment and mass recovery. The locations were chosen based on information from the 1994 SSI.
- Six of the 15 extraction wells are located in the central part of the plume. These wells are pumped at approximately 4 to 6 gpm. The remaining wells are pumped at 1 to 2 gpm.
- A shallow recovery system (SRS) was also installed to collect groundwater from Unit A. This system has reportedly contributed approximately 6 gpm. The SRS consists of 300 feet of trenches that intercept the shallow groundwater plume to a depth of 12 feet.
- The new extraction system was designed to optimize recovery from Units C and D, while eliminating the cross-contamination of Unit F. The extraction rate has been increased by a factor of 10, and the groundwater plume is being contained.
- A shallow stacked tray air stripper was chosen to replace the tall packed column air stripper because the newer models of stacked tray air strippers are more economical to operate and maintain [12].
- The QuickFlow™ Analytical Ground-Water Flow Model developed by Geraghty & Miller was used during optimization of the modified extraction well systems [12].
- From 1992 to 1994, air stripping media was changed on one occasion when it became clogged and ineffective.
- Since 1995, no air stripping media has been utilized in the on-site treatment system; therefore, downtime from changeouts has not occurred.

TREATMENT SYSTEM DESCRIPTION (CONT.)

Operating Parameters Affecting Cost or Performance

The major operating parameter affecting cost or performance for this technology is the extraction rate. Table 3 presents the value measured for this and other performance parameters.

Table 3: Performance Parameters

Parameter	Value	
Extraction Rate	4 gpm (92-94); 40 gpm (95-97)	
Maximum Daily Flow	86,000 gallons	
Performance Standard (Effluent)	Temp.	140 °F
	pH	6-9 units
	Dichloromethane	1.58 mg/L
	Carbon tetrachloride	5.07 mg/L
	1,1-Dichloroethane	29.13 mg/L
	1,1,1-TCA	2.60 mg/L
	TCE	6.48 mg/L
	PCE	1.21 mg/L
	Chloroform	1.78 mg/L
	1,1,2-TCA	13.54 mg/L
	1,1,2,2-TCA	3.46 mg/L
	1,1-DCE	1.67 mg/L
Remedial Goals (aquifer)	1,1,1-TCA	200 µg/L
	TCE	5 µg/L
	1,1,2-TCA	5 µg/L
	PCE	5 µg/L
	1,1,2,2-TCA	5 µg/L
	1,1-DCE	7 µg/L
	Chloroform	100 µg/L
	Carbon tetrachloride	5 µg/L
	Benzene	5 µg/L
	Dichloromethane	5 µg/L

Source: [5, 6, 7, 12]

Timeline

Table 4 presents a timeline for this remedial project.

Table 4: Project Timeline

Start Date	End Date	Activity
9/86	---	Record of Decision signed
---	9/88	Remedial design completed
10/90	7/91	P&T system constructed
7/91	---	ESD issued
	6/92	Sewer line completed to City of Cayce POTW
8/92	7/93	Phase I performed
7/93	6/94	Phase II performed
6/94	---	Remedial activities stopped; EPA and PRPs enter into negotiations; UAO issued, changing site to PRP-lead
10/94	---	Supplemental Site Investigation performed
6/95	10/95	P&T system modified by PRPs
11/95	ongoing	Modified P&T system restarted

Source: [6, 8, 10]

TREATMENT SYSTEM PERFORMANCE

Cleanup Goals/Standards [5, 6, 7, 12]

- The goal of this remedy is to reduce the concentration of contaminants in the groundwater to primary drinking water standards or maximum contaminant levels (MCL). These standards are applied throughout the aquifer as measured in all wells installed on and off site. Table 3 contains specific clean-up criteria.

Additional Information on Goals

- A secondary goal of this remedy is to hydraulically control the migration of contaminants in the groundwater to eliminate further spreading of contaminants downgradient of the site.

Treatment Performance Goals [5, 6, 7, 12]

- The treatment system must reduce contaminant levels in the treated water to meet discharge requirements imposed by the local POTW. These requirements are stipulated in the discharge permit with the City of Cayce POTW and are also included in Table 3.

Performance Data Assessment [7, 8, 9, 10]

For this report, total contaminants includes PCE, 1,1-DCE, and 1,1,1-TCA.

- From 1992 to 1997, groundwater monitoring results indicate that contaminant concentrations have not been reduced to below cleanup goals. To illustrate how total contaminant concentrations have changed from 1992 to 1997, Figure 2 presents data from wells NUS-04 and CDM-13 in the central part of the plume. Well NUS-04 and CDM-13 are the only wells that were sampled consistently from 1992 to 1997. Total contaminant concentrations in well NUS-04 have been reduced by approximately 81% since 1992.

- From 1992 until November 1995, the plume was not contained, as was determined during a SSI performed in October 1994. Sampling revealed that groundwater contaminants in Units C and D had migrated more than 300 feet downgradient of the most downgradient extraction well. The total plume size at that time was estimated to be 204,000 square feet. The initial plume size was estimated to be 80,000 square feet. According to the SSI, the increase was attributed to both the loss of plume containment and increased accuracy in the estimate of the plume size.

- Water level data collected in quarterly reports indicate that hydrodynamic control of the plume has been maintained since November 1995. Only one off-site well, DMW 202, shows contaminant concentrations above detection limits.

- A total of 20.6 million gallons of groundwater was treated from 1992 to 1997. Taking into account the hours of system operation, the calculated daily average treatment rate was 4 gpm during EPA-lead operation and 40 gpm during PRP-lead operation. The remedial system was shut down from June 1994 through November 1995.

- As shown in Figure 3, the P&T system has removed approximately seven pounds of contaminant mass from 1992 to 1996. Figures 4, 5, and 6 show PCE, TCE, and 1,1-DCE concentrations, respectively, for NUS-04 and CDM-13.

- PCE concentrations in Figure 4 begin at 2,500 µg/L and 1,100 µg/L for wells NUS-04 and CDM-13, respectively. PCE concentrations in NUS-04 decline to 500 µg/L, but spike above 3,000 µg/L on two occasions. PCE concentrations in CDM-13 decline to 64 µg/L, but then rebound to 500 in the December 1993 sampling.

TREATMENT SYSTEM PERFORMANCE (CONT.)

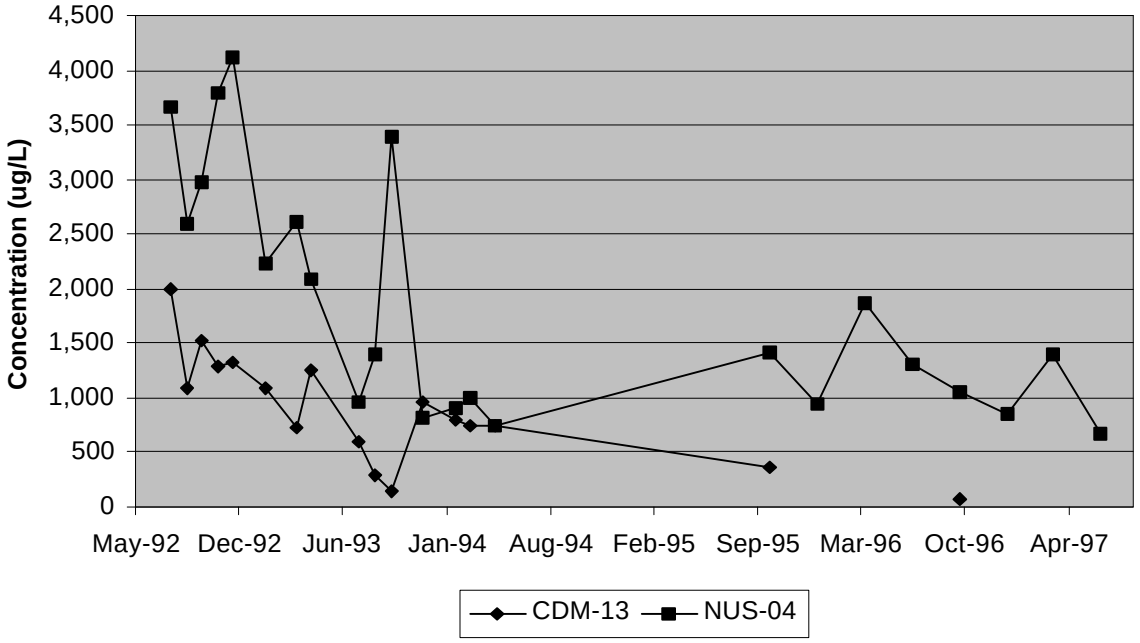

Figure 2. Total Contaminant Concentrations in Groundwater (August 1992 - July 1997) [2,7,8,12]

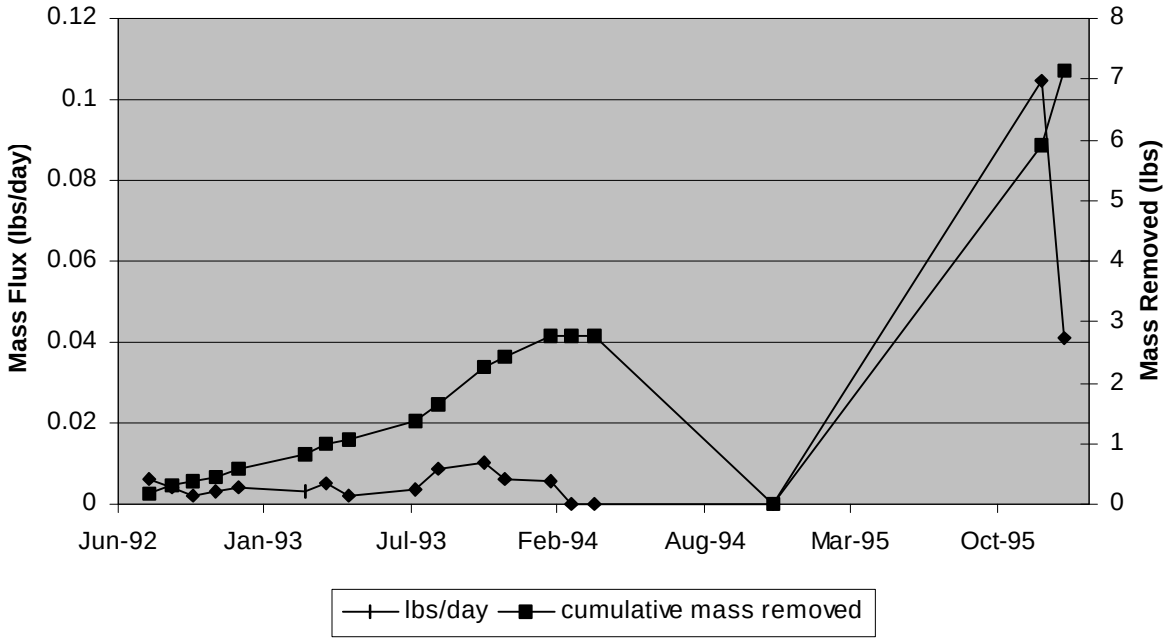

Figure 3. Total Contaminant Mass Flux and Cumulative Mass Removal (August 1992 - January 1996) [2,7,8]

TREATMENT SYSTEM PERFORMANCE (CONT.)

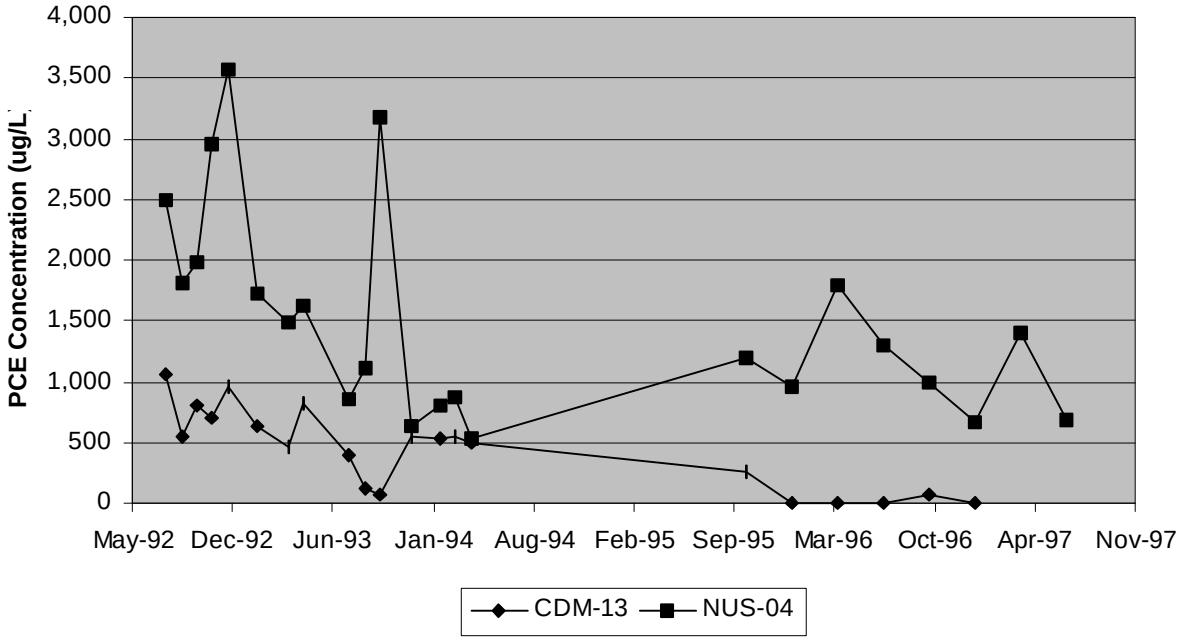

Figure 4. PCE Concentrations (1992 - 1997) [2,7,8,12]

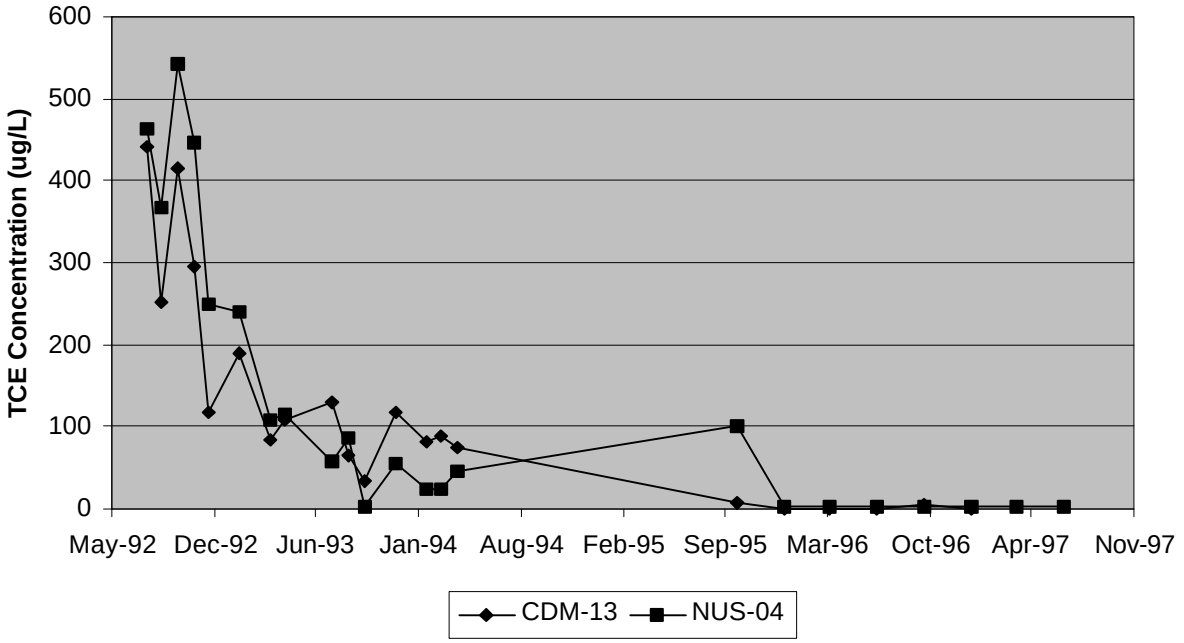

Figure 5. TCE Concentrations (1992 - 1997) [2,7,8,12]

TREATMENT SYSTEM PERFORMANCE (CONT.)

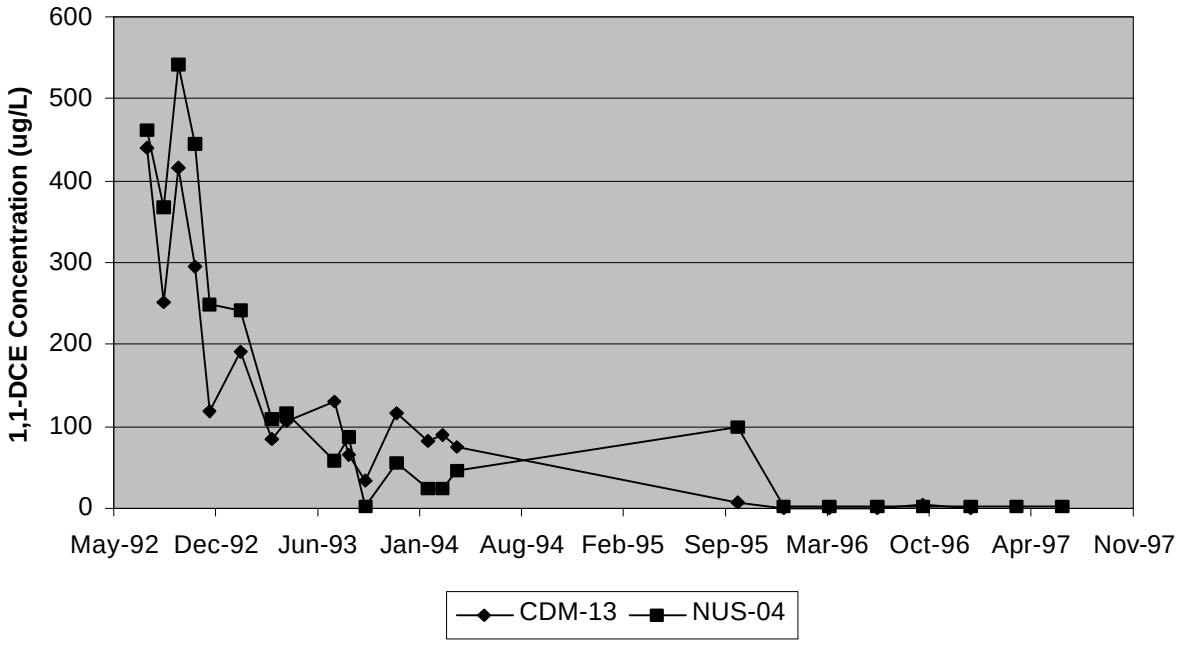

Figure 6. 1,1-DCE Concentrations (1992 - 1997) [2,7,8,12]

Performance Data Assessment (Cont.)

- In Figure 5, TCE concentrations in wells NUS-04 and CDM-13 follow similar patterns, beginning near 450 µg/L and declining to approximately 75 µg/L. In October 1996, TCE concentrations were 2 and 6 µg/L, respectively.

- As shown in Figure 6, 1,1-DCE concentrations in NUS-04 and CDM-13 begin at 675 µg/L and 425 µg/L, respectively. Concentrations in NUS-04 are reduced to 30 µg/L and in CDM-13 to 74 µg/L before the system is shut down. In October 1995, concentrations in NUS-04 increased to 150 µg/L, but declined below detection limits by July 1997.

- During Phase I and II operations, all effluent limitations were met with one exception. PCE and 1,1,1-TCA were detected at 5.9 and 7.7 µg/L, respectively, in effluent samples collected during December 1992. The treatment system was shut down and the air stripper packing was replaced after it was determined that the original material had become clogged and ineffective. The system was restarted and all effluent limitations were met during the remainder of Phases I and II.

- Review of the treatment system influent and effluent data from November 1995 through March 1997 indicate that the treatment system is compliant with SCDHEC air discharge requirements and wastewater discharge permit for the City of Cayce POTW.

TREATMENT SYSTEM PERFORMANCE (CONT.)

Performance Data Completeness

- During Phases I and II, monitoring wells were sampled monthly according to the Performance Standards Verification Monitoring (PSVM) plan. During PRP management, a set of seven sampling points were monitored quarterly. Two of the seven wells were the same during both PRP and EPA operation periods.
- Influent and effluent samples are collected on a monthly basis. Data are reported to the City of Cayce to comply with the wastewater discharge permit. Data from 1992 to 1994, December 1995, and January 1996 were available for mass removal calculations in this report.
- Contaminant mass removal was determined from system influent measurements, along with treatment data from 1992 through January 1996. The PRPs have not collected influent data; therefore, mass removal can be calculated only through January 1996.
- Sample collection procedures are documented in the PSVM plan.

Performance Data Quality

The QA/QC program used throughout the remedial action met the EPA and the State of South Carolina requirements. All monitoring was performed using EPA-approved methods, and the vendor did not note any exceptions to the QA/QC protocols.

TREATMENT SYSTEM COST

Procurement Process

Until the 1995 UAO, the U.S. EPA was the lead agency for this site and SCDHEC was the support agency. Ebasco was the EPA ARCS contractor responsible for remedial action activities until 1994. Currently, the site is a PRP-lead site with Solutia, Lucent Technologies, and Therm-O-Disc named as primary responsible parties. de maximis, Inc. is currently the primary contractor for the PRP group.

Cost Analysis

All costs for investigation, design, construction and operation of the treatment system at this site were borne by the PRPs.

TREATMENT SYSTEM COST (CONT.)

Capital Costs for EPA-Lead Operation [5]

Remedial Construction	
Mobilization and Preparatory Work	$103,000
Groundwater Extraction Wells	$267,000
Groundwater Treatment System Installation	$474,000
Facilities Construction	$214,000
Analytical	$7,100
Mobilization/Demobilization of Lab Services	$3,800
Demobilization	$120,800
Total Remedial Construction	**$1,189,700**

Costs for PRP-Lead Operation

Upgrade from Stripping Tower, New Extraction Wells, and Collection Trench	$294,000
PRP O&M Costs (total through March 1997)*	$180,000

Operating Costs for EPA-Lead Operation [5]

Significant Operations	$35,000
Influent/Effluent Analysis	$70,000
Periodic Maintenance	$125,000
POTW	$20,000
Total Annual Operating Expense	**$250,000**

Other Costs for EPA-Lead Operation [5]

Project Planning	$334,668
Intermediate Design	$58,600
Final Design	$88,013
Closeout	$4,978
Technical Assistance	$27,823
Corps Oversight	$17,080
Total Design	$531,161
EPA Oversight	$9,627
State Oversight	$123,377

*Estimated O&M cost for PRP activities is less than $100,000/year.

Cost Data Quality

Actual cost data are available from the EPA Region IV Remedial Project Manager (RPM).

OBSERVATIONS AND LESSONS LEARNED

- Actual costs incurred during the EPA-lead operation of the P&T system were approximately $1,439,700 ($1,189,700 in capital costs and $250,000 in operating and maintenance costs), which corresponds to $200,000 per pound of contaminants removed and $464 per 1,000 gallons of groundwater. Mass removed and the volume of groundwater treated under PRP management were not included in unit calculations.
- After 35 months of operation, the contaminant concentrations in the well with the highest concentrations (NUS-04), have been reduced by 81%. However, containment concentrations remain above the cleanup goals.
- The treatment system has met the SCDHEC air discharge requirements and, with one exception in December 1992, has operated in compliance with effluent limitations. The exceedance was attributed to air stripper packing becoming clogged; after the packing was replaced, there were no additional exceedances.
- According to the RPM, the pumping schedule set for this site during the original EPA design anticipated total site restoration within less than two years [5].
- As a result of the initial RI, which did not accurately characterize the site, initial extraction wells were screened across Units D and F, which allowed contaminants from the upper contaminated Unit (D) to flow into the lower, previously uncontaminated Unit (F). These wells were subsequently closed to eliminate the source of contaminants for the lower zone. New

TREATMENT SYSTEM COST (CONT.)

wells were completed with screened intervals entirely within Units C and D [10].

- In the 1994 supplemental site investigation, the upper sandy Unit A, was determined to be the most highly contaminated unit beneath this site. Initial characterization data failed to identify this, and initial design parameters did not include groundwater recovery from this unit. Until November 1995, the contaminant plume in this unit migrated off site unimpeded. The modified extraction system was designed to prevent further migration of the plume in this unit as well as all groundwater contamination [10].

- When the ARCS contract that Ebasco operated under was terminated, no groundwater was extracted from June 1994 until November 1995. The stop in operations led to plume loss during this period [5].

- In 1994 and 1995, after a supplemental site investigation was completed by the PRPs, the extraction well configuration was redesigned and a collection trench was added to the recovery system. This effort was required to contain the groundwater plume that was escaping the groundwater recovery system up until that time.

- The air stripping tower was leased to EPA by Ebasco for use at this site. When Ebasco was replaced by the PRP contractor, de maximis, a new stacked tray air stripper was purchased. The cost of upgrading to the stacked tray air stripper, as well as reconfiguring the extraction wells and adding the collection trench, was approximately $294,000.

REFERENCES

1. Ebasco Environmental. Operational Status Report for March 1994.
2. Ebasco Environmental. Phase II Operations Evaluation, May 1994.
3. Ebasco Environmental. Phase I Operations Evaluation, July 1993.
4. NUS. Remedial Investigation Report for SCRDI Dixiana, 1986.
5. Correspondence with Remedial Project Manager. U.S. Environmental Protection Agency/Region 4, January 16, 1998.
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8. Site Monitoring Report, August 1 through October 31, 1996. O&M, Inc., November 1996.
9. O&M, Inc. Site Monitoring Report, November 1 through March 31, 1997, April 1997.
10. S&ME, Inc. Supplemental Site Investigation Report, November 1994.
11. U.S. Environmental Protection Agency. Five Year Report for the SCRDI Dixiana Superfund Site, September 1995.
12. Comments on draft Cost and Performance Report, May 1998. U.S. EPA Region 4 and de maximis, Inc., May 31, 1998.

Analysis Preparation

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

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