Remediation System Evaluation

Cleburn Street Well Superfund Site
Grand Island, Nebraska

Report of the Remediation System Evaluation,
Site Visit Conducted at the Cleburn Street Well Site
April 24, 2001

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United States Environmental Protection Agency

NOTICE

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EXECUTIVE SUMMARY

The Cleburn Street Well Superfund Site, encompasses 144 blocks of downtown Grand Island, Nebraska and addresses contamination resulting from three dry cleaners and a solvents facility. The site consists of five operable units (OUs):

- OU1 is a soil vapor extraction (SVE) system that addresses the subsurface soil contamination from the former One Hour Martinizing located on the corner of 4^{th} and Eddy Streets;
- OU2 is a pump-and-treat system that addresses the groundwater contamination associated with the same facility;
- OU3 and OU4 are monitored natural attenuation programs that address the groundwater contamination associated with Liberty Cleaners and Ideal Cleaners, respectively; and
- OU5 addresses the soil and groundwater contamination associated with the former Nebraska Solvents.

This RSE report pertains to OU2, as it is the only Fund-lead pump-and-treat system within the site, and also to OU1 as it relates to OU2. Both OU1 and OU2 began operation in 1998 to address contamination associated with the One Hour Martinizing facility, and OU1 has since been turned over to the State as it is considered a containment remedy. Tetrachlorethylene (PCE) is the primary contaminant of concern for OU2 although other volatile organic compounds VOCs must be addressed as stipulated by the ROD. High concentrations of PCE indicate the presence of freephase PCE in the form of a dense non-aqueous phase liquid (DNAPL) that serves as a continuing source of dissolved phase PCE.

The pump-and-treat system consists of three extraction wells that pump a total of approximately 80 gpm and an air stripper that removes PCE from the extracted water. Treated water from the air stripper is discharged to the local sanitary sewer. The operator checks on the system weekly and also during the quarterly sampling events. Project management accounts for approximately 58% of the operations and maintenance costs, which is high compared to operations and maintenance costs for similar systems.

The following recommendations are suggested to improve effectiveness:

- The extraction wells are operating below designed pumping rates, possibly due to biofouling. These wells should be rehabilitated to increase the extraction rates to their designed levels as these higher rates may be required for plume capture.
- The capture zone should be more thoroughly investigated and possibly improved. Vertical variations in the hydraulic conductivity and the PCE contamination may discount the capture zone analyses done to date. One shallow and one deep monitoring well should be installed immediately downgradient of the extraction system to determine if it is capturing PCE from the source area.

- The current sampling protocol involves disposing of well-purge water into the storm sewer. As this purged water has high PCE concentrations, this practice should be discontinued. The purged water could be fed through the air stripper to remove the PCE.

- The easy accessibility to groundwater suggests that unregistered private wells could be used for water supply of local residences. Public records and previous surveys of wells in the area should be reviewed for completeness to ensure no wells are operating in the vicinity of the site.

- The high concentrations of PCE in groundwater and soil could result in harmful levels of PCE in indoor air or standing water near the source area. Samples of air in nearby businesses and standing water in the underground traffic-light vault should be analyzed for PCE.

- Finally, the Pine Street well may still be used for water supply during periods of high demand. If this is the case, that well should be sampled for PCE and site-related contaminants as it lies approximately 1,500 feet downgradient of the source area.

Implementation of these recommendations would require approximately $21,000 in capital costs and an approximate increase of $7,500 in annual operations and maintenance costs.

The following recommendations are suggested to reduce operating costs:

- Because OU1 is managed by the State and OU2 is managed by the EPA, different contracts are in place for operation of the two systems. However, the proximity of the two systems and the use of a common contractor suggests that operation of the two systems could be accomplished under a single contract. This could potentially reduce operator labor costs by $18,000 per year. If a single contract is infeasible under current program guidelines, the separate contracts should be coordinated such that operation and maintenance costs reflect a single site visit to address both operable units.

- The blower used for the OU1 SVE system is larger than necessary and is therefore operating with the air intake valve opened. This blower could be replaced by a smaller, more efficient one for $15,000. Savings of approximately $12,000 per year would result.

The life-cycle cost savings associated with these recommendations could offset those costs incurred from implementing the recommendations to improve effectiveness.

In addition, to the above-mentioned recommendations and a number regarding technical improvement of the SVE and pump-and-treat systems, this RSE report also suggests investigation and possibly implementation of an air sparging system to address the freephase PCE in the form of dense non-aqueous phase liquid (DNAPL). Such a system would likely significantly decrease the operating lifetime of the two systems. Furthermore, an exit strategy based on precedents set by other operable units should be developed to ensure the system does not operate longer than necessary.

PREFACE

This report was prepared as part of a project conducted by the United States Environmental Protection Agency (USEPA) Technology Innovation Office (TIO) and Office of Emergency and Remedial Response (OERR). The objective of this project is to conduct Remediation System Evaluations (RSEs) of pump-and-treat systems at Superfund sites that are "Fund-lead" (i.e., financed by USEPA). RSEs are to be conducted for up to two systems in each EPA Region with the exception of Regions 4 and 5, which already had similar evaluations in a pilot project.

The following organizations are implementing this project.

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The project team is grateful for the help provided by the following EPA Project Liaisons.

Region 1	Darryl Luce and Larry Brill	**Region 6**	Vincent Malott
Region 2	Diana Cutt	**Region 7**	Mary Peterson
Region 3	Kathy Davies	**Region 8**	Armando Saenz and Richard Muza
Region 4	Kay Wischkaemper	**Region 9**	Herb Levine
Region 5	Dion Novak	**Region 10**	Bernie Zavala

They were vital in selecting the Fund-lead pump-and-treat systems to be evaluated and facilitating communication between the project team and the Remedial Project Managers (RPM's).

TABLE OF CONTENTS

List of Tables

List of Figures

1.0 INTRODUCTION

1.1 PURPOSE

In the *OSWER Directive No. 9200.0-33, Transmittal of Final FY00 - FY01 Superfund Reforms Strategy, dated July 7,2000*, the Office of Solid Waste and Emergency Response outlined a commitment to optimize Fund-lead pump-and-treat systems. To fulfill this commitment, the US Environmental Protection Agency (USEPA) Technology Innovation Office (TIO) and Office of Emergency and Remedial Response (OERR), through a nationwide project, is assisting the ten EPA Regions in evaluating their Fund-lead operating pump-and-treat systems. This nationwide project is a continuation of a demonstration project in which the Fund-lead pump-and-treat systems in Regions 4 and 5 were screened and two sites from each of the two Regions were evaluated. It is also part of a larger effort by TIO to provide USEPA Regions with various means for optimization, including screening tools for identifying sites likely to benefit from optimization and computer modeling optimization tools for pump and treat systems.

This nationwide project identifies all Fund-lead pump-and-treat systems in EPA Regions 1 through 3 and 6 through 10, collects and reports baseline cost and performance data, and evaluates up to two sites per Region. The site evaluations are conducted by EPA-TIO contractors, GeoTrans, Inc. and the United States Army Corps of Engineers (USACE), using a process called a Remediation System Evaluation (RSE), which was developed by USACE. The RSE process is meant to evaluate performance and effectiveness (as required under the NCP, i.e., and “five-year" reviews), identify cost savings through changes in operation and technology, assure clear and realistic remediation goals and exit strategy, and verify adequate maintenance of Government-owned equipment.

The Cleburn Street Well Site was chosen because it is the only Fund-lead P&T system operating in Region 7 at the time of this project. This report provides a brief background on the site and current operations, a summary of the observations made during a site visit, and recommendations for changes and additional studies. The cost impacts of the recommendations are also discussed.

A report on the overall results from the RSEs conducted at the Cleburn Street Well Site and other Fund-lead pump-and-treat systems throughout the nation will also be prepared and will identify lessons learned and typical costs savings.

1.2 TEAM COMPOSITION

The team conducting the RSE consisted of the following individuals:

Ed Mead, Chemical Engineer, USACE HTRW CX
Dave Becker, Hydrogeologist, USACE, HTRW CX
Peter Rich, Civil and Environmental Engineer, GeoTrans, Inc.
Doug Sutton, Water Resources Engineer, GeoTrans, Inc.

1.3 DOCUMENTS REVIEWED

Author	Date	Title/Description
Sverdrup Corporation	5/1993	Remedial Investigation Report for the Remedial Investigation/Feasibility Study at the Cleburn Street Well Site, Grand Island, Nebraska, Vol. I
Sverdrup Corporation	12/1993	Remedial Investigation Study for the Remedial Investigation/Feasibility Study at the Cleburn Street Well Site, Grand Island, Nebraska, Phase III Addendum
US EPA	6/7/1996	Record of Decision, Cleburn Street Well Superfund Site, Grand Island, Nebraska
U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry	3/26/1997	Public Health Assessment, Cleburn Street Well Superfund Site, Grand Island, Hall County, Nebraska
Sverdrup Environmental, Inc.	9/22/1997	Final Remedial Design, Cleburn Street Site, Operable Unit No. 1 & 2, Grand Island, Nebraska, Vol. I, Design Report
Sverdrup Environmental, Inc.	9/22/1997	Final Remedial Design, Cleburn Street Site, Operable Unit No. 1 & 2, Grand Island, Nebraska, Vol. 2, Design Specifications
Sverdrup Environmental, Inc.	9/22/1997	Final Remedial Design, Cleburn Street Site, Operable Unit No. 1 & 2, Grand Island, Nebraska, Vol. 3, Design Drawings
Remediation Technologies	6/10/1998	Site Characterization Summary Report, Remedial Investigation, Former Nebraska Solvents Site - OU5, Cleburn Street Well Superfund Site, Grand Island, Nebraska
Sverdrup Environmental, Inc.	7/1999	Operation and Maintenance Plan, Cleburn Street Site, Operable Unit No. 1 & 2, Grand Island, Nebraska
Sverdrup Environmental, Inc.	7/1999	Operation and Maintenance Manual, Air Stripper System, Cleburn Street Site, Operable Units No. 1 & 2, Grand Island, Nebraska
Sverdrup Environmental, Inc.	9/29/1999	Second Semi-annual Performance Report, Cleburn Street Site, Operable Units 1 and 2
Black and Veatch	10/20/2000	Annual Performance Report, Cleburn Street Site, Operable Unit 2

Author	Date	Title/Description
Black and Veatch	12/12/2000	October 2000 Quarterly Performance Report, Cleburn Street Site, Operable Unit 2
Christopher Exstrom	2001	2000 Annual Report on Volatile Organic Compound Level Monitoring at the Groundwater Monitoring Wells, Operating Units No. 3 and 4, Cleburn Street Superfund Site, Grand Island, Nebraska
Christopher Exstrom	2001	2000 Annual Report on Volatile Organic Compound Level Monitoring at the Soil-Vapor Extraction System, Operating Unit No. 1, Cleburn Street Superfund Site, Grand Island, Nebraska
Black and Veatch	3/9/2001	January 2001 Quarterly Performance Report, Cleburn Street Site, Operable Unit 2

1.4 PERSONS CONTACTED

The following individuals were present for the site visit:

Rob Blake, Black and Veatch
Matt Irmer, Geotechnical Services, Inc.
Mike McKinley, TapanAm
Mary Peterson, EPA Region 7
David Sanders, Black and Veatch

1.5 SITE LOCATION, HISTORY, AND CHARACTERISTICS

1.5.1 LOCATION

The Cleburn Street Well Superfund Site, named after a contaminated former public water supply well in downtown Grand Island, Nebraska, encompasses 144 blocks of that metropolitan area. The site is divided into the following five operable units

- OU1 is a soil vapor extraction (SVE) system addresses the subsurface soil contamination from the former One Hour Martinizing located on the corner of 4th and Eddy Streets;
- OU2 is a pump-and-treat system that addresses the groundwater contamination associated with the same facility;
- OU3 and OU4 are monitored natural attenuation programs that address the groundwater contamination associated with Liberty Cleaners and Ideal Cleaners, respectively; and

- OU5 addresses the soil and groundwater contamination associated with the former Nebraska Solvents.

This RSE report pertains to OU2, as it is the only Fund-lead P&T system within the site, and also to OU1 as it relates to OU2. Contamination of the Cleburn Street well was first detected in April 1986, final listing of the site on the National Priorties List (NPL) occurred on October 14, 1992. The Remedial Investigation (RI) began in 1992 with an accompanying pumping system that extracted water with high concentrations of PCE and discharged it to the sanitary sewer at 50 gallons per minute. Construction completion of the current OU1 SVE and OU2 pump-and-treat systems occurred in March 1998.

The site layout with the identified contaminant sources and contaminant plume is depicted in Figure 1-1.

1.5.2 POTENTIAL SOURCES

The groundwater contamination at OU2 is predominantly tetrachlorethylene (PCE) and small quantities of degradation products that stem from disposal practices at the One Hour Martinizing dry cleaners. In addition, there are small concentrations of 1,1,1 Trichlorethane, that potentially stem from OU5 directly to the west. PCE concentrations in groundwater beneath the One Hour Martinizing facility measured during the Remedial Investigation were as high as 170,000 ug/L which exceeds the solubility of PCE. This suggests the presence of freephase PCE which exists in the subsurface as a dense non-aqueous phase liquid (DNAPL). As of January 2001, PCE concentrations in MW-2A were 140,000 ug/L. This concentration is still indicative of DNAPL which serves as a continuing source of dissolved phase PCE. Although the groundwater extraction wells screen from approximately 45 to 60 feet below land surface, the DNAPL appears to be limited to the area around MW-2A and a depth of approximately 20 to 30 feet.

Smaller concentrations of BTEX (benzene, toluene, ethylbenzene, and xylene) are also found at the site and are stipulated as contaminants of concern by the ROD. These contaminants were found during the remedial investigation at OU5, but likely exist at OU2 due to leaks or spills at a former service station once located directly across 4th Street to the north of the former One Hour Martinizing facility.

1.5.3 HYDROGEOLOGIC SETTING

Silty sands, sands, and gravelly sands with occasional thin clay layers extend from the surface to 90 feet below the surface and are underlain by a clay aquitard that ranges from 144 to 153 feet thick. This formation above the aquitard serves as the source of the public water supply and is the portion affected by site-related contaminants. The groundwater underlying the site is, on average, 18 to 22 feet below the surface and according to the RI flows in a 75^{E} to the east of north at approximately 0.06 feet per day and almost directly east when the Cleburn Street Well was in operation. This follows from an average hydraulic conductivity of approximately 6 feet per day as determined by slug tests during the RI, a gradient of 0.003, and a porosity of 0.3. It should be noted that a pumping test conducted during the design stage with EW-1 and a few monitoring wells yielded a hydraulic conductivity of 0.24 feet per minute (345 feet per day) which translates to a linear groundwater velocity of 3.5 feet per day.

Interpretations in the RI of soil borings suggest that the upper portions of the aquifer (between land surface and a depth of 40 feet) consist of finer, less conductive materials than the medium to coarse material present at 40 to 60 feet.

1.5.4 DESCRIPTION OF GROUND WATER PLUME

The PCE groundwater plume originates at the location of the former One Hour Martinizing shop on the corners of 4^{th} and Eddy Streets and extends eastward toward and beyond the Cleburn Street well. As of January 2001, the PCE concentration at MW-2A, which screens 20 to 30 feet below land surface, was 140,000 ug/L; however, other monitoring points in the immediate vicinity had much lower PCE concentrations. The PCE concentration in EW-2, 20 feet to the side and screened from 45 to 60 feet below land surface, registered only as high as 1,100 ug/L. MW-2B, which is located adjacent to MW-2A but is 90 feet deep, had undetectable levels of PCE. The concentration in the Cleburn Street well, located approximately 250 feet to the east was 70 ug/L, and concentrations to the north, south, and east of the Cleburn Street well measured 10 ug/L or less. The portion of the plume beyond the Cleburn Street well is not well-defined.

2.0 SYSTEM DESCRIPTION

2.1 SYSTEM OVERVIEW

Remediation associated with the One Hour Martinizing facility consists of OU1, which is a State-lead SVE system, and OU2, which is a Fund-lead pump-and-treat system. The building housing the former shop has been divided into two sections. The section to the north along 4th Street is privately owned and leased out to private businesses. The southern section houses an air stripper for treating the extracted groundwater and the SVE system.

2.2 EXTRACTION SYSTEM

2.2.1 OU1 EXTRACTION SYSTEM

The OU1 extraction system consists of four SVE wells approximately 30 feet apart in a oriented in a line between the front of the treatment building and Eddy Street. Each well is approximately 17 feet deep with a 10-foot screening interval.

2.2.2 OU2 EXTRACTION SYSTEM

The OU2 extraction system consists of three groundwater extraction wells approximately 40 feet apart and interspersed between the SVE wells. The groundwater extraction wells are approximately 55 to 60 feet deep with screened intervals of 15 feet, which differs from the design plan of 50 feet deep with screened intervals of 25 feet.

2.3 TREATMENT SYSTEM

2.3.1 OU1 TREATMENT SYSTEM

The vapors from the SVE wells flow under negative ambient pressure through a moisture knockout container, through an air-to-air heat exchanger that raises the temperature of the vapors to 90 F, through two of six carbon units in a two series–three parallel carbon vessels system, and then into a Roots 50-horsepower positive displacement blower. The vapors leave the blower hot and under positive ambient pressure, flow through the above air-to-air heat exchanger where the heat is transferred to the incoming vapors and discharged to the ambient air outside of the treatment building. The water resulting from condensation in the system is sent through two liquid phase carbon units and is then discharged to the storm sewer. The system is checked every week and serviced every two months.

2.3.2 OU2 TREATMENT SYSTEM

The water from the ground water extraction wells are pumped with submersible well pumps to the surface and through flow measuring and recording meters to the inlet of the air stripper. The air stripper is a QED Model 16.4. with a fan and 7.5 HP motor. The treated water is discharged to the storm sewer. The off gas from the air stripper is discharged through a stack to the ambient air outside of the treatment building. The system is checked every week and during the quarterly sampling events.

2.4 MONITORING SYSTEM

Monitoring occurs quarterly in the extraction wells, the Cleburn Street well, and a select number of monitoring wells. In addition, annual sampling events include sampling for PCE, BTEX, TCE, and 1,1,1 TCA in all site-related wells (except MW-7 which has been buried and inaccessible since the RI). Table 2-1 provides the results from the August 2000 annual sampling event and those locations that are sampled quarterly.

Table 2-1: PCE concentrations from the August 2000 annual sampling event

Sampling Location	PCE concentration (ug/L)
air stripper influent*	460 and 600
air stripper effluent*	1
EW-1*	700
EW-2*	820
EW-3*	45
Cleburn Street Well*	110
MW-2A*	41,000
MW-2B*	undetected
MW-8A	undetected
MW-8B	undetected
MW-9A	11
MW-10A	undetected
MW-10B	undetected
MW-11A	29
MW-11B	undetected
MW-12A*	110 and 170
MW-13A*	undetected

* locations also sampled quarterly

Note: For locations with duplicate samples, both concentrations are presented.

3.0 SYSTEM OBJECTIVES, PERFORMANCE AND CLOSURE CRITERIA

3.1 CURRENT SYSTEM OBJECTIVES AND CLOSURE CRITERIA

The SVE system (OU1) is considered a containment remedy and was therefore transferred to State-lead after a year of operation. The pump-and-treat system (OU2) is both a containment and restoration remedy. The containment aspect of the remedy began during the Remedial Investigation with a single well extracting contaminated water and discharging it without treatment to the sanitary sewer. The restoration aspect of the remedy began with operation of the current pump-and-treat system for "extraction of groundwater containing contaminants about MCLs". According to the ROD the contaminants are all volatile organic carbons (VOCs) that were detected at least once. Included in the ROD, however, is a provision to waive the cleanup levels through a Technical Impracticability (TI) waiver if DNAPL is detected at the One Hour Martinizing source area.

In addition, a precedent has been sent by the remedies associated with the Liberty and Ideal Cleaners source areas (OU3 and OU4). For these sources, where PCE concentrations are as high as 95 ug/L, monitored natural attenuation is the current remedy as long as human health and the environment are effectively protected.

3.2 TREATMENT PLANT OPERATION GOALS

Air emissions from the SVE and pump-and-treat air stripper must comply with Nebraska air regulations, and the water effluent from the air stripper must comply with the permitting requirements under the National Pollutant Discharge Elimination System (NPDES) Program.

3.3 ACTION LEVELS

Action must be taken if air emission or water effluent levels for the contaminants of concern violate either Nebraska air regulations or the criteria of the NPDES Program.

4.0 FINDINGS AND OBSERVATIONS FROM THE RSE SITE VISIT

4.1 FINDINGS

In general, the RSE team found the system to be well operated and maintained. The observations and recommendations given below are not intended to imply a deficiency in the work of either the designers or operators, but are offered as constructive suggestions in the best interest of the EPA and the public. These recommendations obviously have the benefit of the operational data unavailable to the original designers.

4.2 SUBSURFACE PERFORMANCE AND RESPONSE

4.2.1 WATER LEVELS AND CAPTURE ZONES

The current extraction system was designed based on a capture zone analysis using a modeling package called Quickflow, parameters from the RI, and the hydraulic conductivity estimated from the pumping test (0.24 feet/min). During operation the capture zone was reanalyzed with simple analytical techniques based on actual flows rather than designed flows. The results suggested that capture is likely but that a more conclusive analysis should be conducted. The capture zone of the groundwater extraction system was being evaluated by site contractors with aquifer testing at the time of the RSE visit. The results of this testing will presumably determine the capture zone of the three wells. The resulting capture zone will likely include the source of contamination at the location of the former One Hour Martinizing shop but will not include downgradient portions of the plume that have PCE concentrations as high as 100 ug/L.

The vertical variations in hydraulic conductivity may affect the capture zone. The documents reviewed by the RSE team did not contain boring logs for the extraction wells; however, the RI does contain a cross-section of the interpreted site geology from the boring logs (Figure 3-6 in the RI). This figure suggests that in the vicinity of MW-2B (and therefore the extraction wells) fine to medium sand and even silty and clayey fine sands are the predominant materials to a depth of 40 feet below land surface. From 40 feet to 60 feet, there appears to be a change to fine to coarse and medium to coarse sand. Based on discussion during the RSE visit, extraction wells are approximately 60 feet deep with screened intervals of 15 feet. If this is the case, the wells screen the coarser subsurface media therefore potentially extracting cleaner water from deeper portions of the aquifer and not capturing the plume in the shallower portions.

4.2.2 CONTAMINANT LEVELS

PCE concentrations in MW-2A strongly suggest, if not assure, the presence of DNAPL that acts as a continual source of dissolved phase PCE. The DNAPL appears to be limited to the upper portions of the aquifer based the discrepancy in groundwater concentrations between MW-2A (41,000 ug/L in August 2000) and MW-2B (undetected in August 2000). MW-2A and MW-2B are located adjacent to one another, but MW-2A has a depth of approximately 30 feet and MW-2B has a depth of approximately 90 feet. Because the extraction wells screen from 45 to 60 feet below the surface, they are likely extracting a significant amount of cleaner water from deeper portions of the formation rather than highly contaminated water from the shallower portion of the formation. This is supported by the lower concentrations in the extracted water. Table 2-1 shows that sampling of the extraction wells in August 2000 yielded concentrations ranging from 45 ug/L to 820 ug/L, a range which is substantially lower than the 41,000 ug/L from MW-2A during the same sampling event.

The horizontal extent of the DNAPL has not clearly been defined upgradient of MW-2A due to the presence of the building housing the treatment systems and the private wood-staining operation. The operations of the One Hour Martinizing facility could have resulted in PCE contamination of the soils directly beneath the building.

Concentrations of 1,1,1 TCA, BTEX, and other VOCs were detected in MW-2A and MW-12A as recently as January 2001. While the pump-and-treat system addresses this contamination as stipulated in the ROD, these constituents are not consistent with the operation of a dry cleaning facility. These contaminants were detected in both soil and groundwater beneath the west parcel of the Nebraska Solvents location during the Nebraska Solvents RI. While the 1,1,1 TCA at OU2 may have migrated from the Nebraska Solvents site, the majority of BTEX present in the groundwater beneath OU2 likely stems from leaks or spills at a former gasoline service station once located directly across 4^{th} Street to the north of the One Hour Martinizing facility.

4.3 COMPONENT PERFORMANCE

4.3.1 EXTRACTION-WELL PUMPS AND PIPING

The extraction wells are consistently running below design level of 40 gpm each. EW-1 is extracting approximately 27 gpm, EW-2 is extracting approximately 20 gpm, and EW-3 is extracting approximately 36 gpm. During the RSE visit, these wells were throttled to reduce flow and EW-2 was cycling. This suggests the possibility of well fouling. In addition, the well vaults need to be drained. Water in the vault for EW-1 has almost risen to the well cap.

4.3.2 AIR STRIPPER

The air stripper is well-maintained and has effectively removed PCE to concentrations below discharge standards. The stripper has a high-high sump level and low air pressure alarm and shutdown to prevent blower damage and discharge of untreated water. The air pressure in the stripper is monitored to determine tray fouling, and the trays have required cleaning on a yearly basis.; however, the air flow rate into the unit is not being measured. The air flow rate is not measured and therefore the air-to-water ratio is unknown. The system appears to be running at a air-to-water ratio that is higher than required but not at substantial cost.

4.3.3 ACID WASH SYSTEM

The acid wash system is not needed and has not been used. Acid and caustic, however, are stored onsite.

4.3.4 SVE Blower

The SVE blower is a Roots Model 418 J belt-drive rotary lobe positive displacement blower powered by a 50-horsepower designed to operate at 1,300 cubic feet per minute and a pressure drop equivalent to 9 inches of mercury. The blower is operating with the air intake valve open allowing the blower to take in a large quantity of ambient air. The vacuum established on the well-side of the air intake is 5.25 inches of mercury. No meter is installed to determine the current flow rate.

4.3.5 Liquid and Vapor Phase Carbon Units

Each of the six vapor phase carbon units contains 1,200 pounds of activated carbon, and each of the two liquid phase carbon units contains 200 pounds of activated carbon. Carbon replacement is handled and paid for by the State. Replacement of the lead vapor phase carbon units occurs approximately every 10 months based on weekly PID measurements. Replacement of the liquid phase carbon had not occurred between the time of system operation and the RSE visit. Condensate from the SVE system could be treated through the air stripper rather than the liquid phase carbon. This alteration should be made when the liquid GAC is spent.

4.4 Components or Processes that Account for Majority of Costs

Total operating cost for OU2 is approximately $110,000 per year with approximately 58% of that going to project management.

4.4.1 Labor

Operator labor, which totals $1,750 per month, involves a weekly check of the OU2 system and the labor associated with the quarterly and annual sampling events. In addition, project management from Black and Veatch totals on average $5,400 per month, which appears high compared to project management costs of approximately $3,500 per month for similar systems.

4.4.2 Chemical Analysis (On and Off Site)

Chemical analysis for OU2 is accomplished through the EPA Regional lab at no direct cost to the system.

4.4.3 Non-Utility Consumables and Disposal Costs

There are no costs assumed by EPA for non-utility consumables or disposal costs. The acid and caustic for the acid wash system are not used, and the carbon for the SVE system (OU1) is paid for by the State.

4.4.4 Utility Costs

The EPA pays for the electricity used by both OU1 and OU2. The average monthly electric bill is $1,400, and the average monthly gas bill is $600. The phones for OU1 and OU2 combined cost $125 per month.

4.5 RECURRING PROBLEMS OR ISSUES

The system operates continuously with little or no problems.

4.6 REGULATORY COMPLIANCE

The water discharge criteria is regularly met. The air emissions are not regularly measured but are likely well below those specified in air regulations.

4.7 TREATMENT PROCESS EXCURSIONS AND UPSETS, ACCIDENTAL CONTAMINANT/REAGENT RELEASES

There are no recorded excursions of discharge or air emission standards. However, water obtained during quarterly sampling is discharged into the storm sewer. Some of this water, especially that from MW-2A, has high concentrations of PCE.

Prior to the treatment system construction, impacted groundwater was discharged to the sanitary sewer without treatment. Discharges to the sanitary sewer could have resulted in spreading PCE contamination if the sewer has leaks, which is typical of these systems.

4.8 SAFETY RECORD

The plant has an excellent safety record.

5.0 EFFECTIVENESS OF THE SYSTEM TO PROTECT HUMAN HEALTH AND THE ENVIRONMENT

5.1 GROUND WATER

The ROD stipulates institutional controls to prohibit the use of contaminated water for drinking and the installation of private drinking wells in the vicinity of the site. In addition, the ROD mentions that due to the shallow nature groundwater elevation, a number of unregistered private wells could exist within the site. A city ordinance currently prohibits the installation of new wells in vicinity of the site. Also, in the early stages of the remedy, EPA coordinated with the city to identify private wells in the area, and none were found.

The Pine Street well, located approximately 1,500 feet downgradient, had not been contaminated at the time of the RSE and provides public water during periods of heavy demand according to a public health assessment by the U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry (ATSDR) in March 26, 1997. The same ATSDR assessment reports that a private well is located upgradient of the One Hour Martinizing source area and appears to be unaffected by site-related contamination. The assessment also states that

> Sampling data for other private wells in the site area were not available to ATSDR during the development of this health assessment. ATSDR considers this a significant data gap because area private wells, especially those located near the One Hour Martinizing location or the Cleburn Street well, may be affected by site-related groundwater contaminants.

5.2 SURFACE WATER

Surface water is not threatened by site-related contamination. The Cleburn Street well is occasionally operated to prevent high water levels. All treated water from OU2 is sent to the storm sewer which in turn discharges to the Wood River 2.5 miles to the south. Site-related contamination of the Wood River from OU2 discharge is unlikely as VOCs would tend to volatilize before reaching it.

Standing water in a subsurface traffic-light vault near the One Hour Martinizing facility, had high concentrations of PCE in 1988. These concentrations have likely decreased with the operation of the SVE system.

5.3 AIR

The mass of PCE released from OU2 is approximately 0.3 pounds per day as determined by data from the January 2001 quarterly report and the following calculation:

$$\frac{330\text{ ug PCE}}{\text{liter}} \times \frac{80\text{ gallons}}{\text{minute}} \times \frac{1440\text{ minutes}}{\text{day}} \times \frac{10^{-9}\text{ kg}}{\text{ug}} \times \frac{2.2\text{ lbs}}{\text{kg}} \times \frac{3.785\text{ liters}}{\text{gallon}} = \frac{0.32\text{ pounds PCE}}{\text{day}}$$

Therefore, the air emissions from these two operable units do not cause a threat to human health or the environment. The shallow groundwater PCE concentrations in the immediate vicinity of OU2 are relatively high, however, and could result in PCE vapors in the unsaturated zone beyond the reach of the SVE system. These vapors could affect the air quality in basements or enclosed spaces located above the groundwater plume. The ATSDR assessment reports, "No sampling data for VOCs in ambient air (indoor or outdoor) at the site were available during the development of this public health assessment. For indoor air, this is considered to be a significant data gap since VOCs in soil gas may accumulate inside buildings (e.g., residences, businesses) at areas with significant groundwater and soil contamination (e.g., near One Hour Martinizing location)."

5.4 SOILS

There are no accessible contaminated soils associated with OU1 or OU2 as pavement and asphalt cover the area. OU1 currently addresses subsurface soil contamination.

5.5 WETLANDS

There are no wetlands in the vicinity of OU1 and OU2.

6.0 RECOMMENDATIONS

6.1 RECOMMENDATIONS TO ENSURE EFFECTIVENESS

6.1.1 IMPROVE WELL-MAINTENANCE PROGRAM

The extraction wells are operating between 80 and 90 gpm, which is significantly lower than the 120 gpm specified in the design. This lower operating rate is likely due to throttling of the pumps in each well and also to well fouling, especially for EW-2. The operators should use Hach BART tests to determine the nature of the fouling problem and the correct rehabilitation technique. When the proper technique is identified, well rehabilitation should commence for those extraction wells that require it, and a quarterly well-maintenance program may be necessary to prevent further fouling. In addition, during quarterly sampling events, the specific capacity of each well could be measured to determine if the performance is decreasing over time. BART tests and well rehabilitation for each fouled well could be accomplished for approximately $2,000 including operator labor. Also, the quarterly well-maintenance program to prevent future fouling could increase annual costs by approximately $2,000 per well per year. More information about well maintenance can be found in USACE Engineering Pamphlet EP 1110-1-27 at http://www.usace.army.mil/inet/usace-docs.

6.1.2 DETERMINE CAPTURE-ZONE EFFECTIVENESS

The capture zone of the extraction system was analyzed during design with the Quickflow modeling package and during operation with simplistic analytic methods outlined in hydrogeological literature. While the analysis done during design showed that current pumping rates would not provide adequate capture for extraction wells placed 50 feet apart, the extraction wells are actually closer to 40 feet apart, and simple analytical methods suggest this spacing and pumping rate are sufficient. To more thoroughly analyze capture, the operators conducted further aquifer testing at the time of the RSE visit, and the results from this test will be used to reevaluate the capture zone.

This testing and the subsequent analysis will likely show that the extraction wells are sufficiently spaced horizontally to capture pollutants, but it will not provide sufficient information regarding vertical variations in contamination and hydraulic conductivity. As demonstrated by the high PCE concentrations in MW-2A, the "hot spot" of contamination occurs near MW-2A at a depth of approximately 20 to 30 feet. However, the extraction wells reportedly screen from 45 to 60 feet, well below the contamination. Furthermore, the RI interpretations of the boring logs suggested this deeper portion of the aquifer may be more conductive than the upper portion near the "hot spot". It is this vertical variation in hydraulic conductivity and the possible presence of a relatively impermeable layer that has prevented the DNAPL from settling deeper into the aquifer. Thus, it is likely that despite potentially positive results from the recent capture zone analysis by the operators, adequate capture may not be provided.

PCE concentrations downgradient of the extraction system as sampled from the Cleburn Street well, MW-8A, MW-8B, MW-9A, MW-10A, and MW-10B have decreased or remained low possibly indicating capture of the PCE source. However, these wells are more than 250 feet downgradient of the extraction system. Therefore, to determine if the extraction system is continuing to effectively contain the source area, a monitoring-well couplet could be installed approximately 50 to 100 feet downgradient of the extraction well array. One monitoring well in this couplet would screen from 20 to 30 feet deep (the approximate depth of the contamination "hot spot") and the other would screen from 40 to 60 feet deep (the approximate depth of the screening intervals for the extraction wells). The concentration trend in each of these two wells over time would show whether or not contamination is captured by the extraction well array. As it may take considerable time to evaluate the concentration trend it is beneficial to measure water levels from these and all other site-related wells and to compare the results to those expected based on known aquifer parameters, the locations of the extraction wells, and the pumping rates. Drilling the two monitoring wells would cost approximately $10,000 and adding them to the quarterly sampling program would cost approximately $1,000 per year. In addition, simple numerical modeling of groundwater flow could be used to evaluate the measured water levels from the current and recommended wells; however, such modeling would likely cost about $15,000.

It should be noted that buildings, roads, and other aspects of an urban environment may complicate drilling of these wells, making this recommendation infeasible. In this case, MW-8A and MW-8B, which are located approximately 250 feet downgradient of the extraction system, could be used as less favorable, but feasible, sentinel wells. If a breach in the capture zone occurred, concentrations trends in these two wells may reflect it after an appreciable amount of time. If additional analysis of the capture zone is preferred, the simple numerical modeling suggested above could be conducted to evaluate water levels measured from the current wells. Although this would provide some indication of capture, it would not be as reliable as an evaluation including the two new recommended monitoring wells.

6.1.3 MODIFY WELL-SAMPLING PROTOCOL

The current well-sampling protocol, observed by the RSE team during the site visit, includes disposing of purged water to the storm sewer and sanitary sewer. As a result of this protocol, water with high concentrations of PCE, potentially over 100,000 ug/L, is released into the storm and/or sanitary sewer. Because these sewers often have leaks, and this contamination could reenter the aquifer at another location, purged water should be fed through the air stripper. Current bailing techniques result in water with high turbidity, and this turbidity is detrimental to the air stripper. This turbidity could be eliminated in one of two ways. First, the sampling could be accomplished with low-flow pumping. Purge water from low-flow pumps have less turbidity, and this water could be directly fed into the air stripper influent. In addition, using a low-flow pump should facilitate the sampling and should provide more representative samples. Alternatively, the purged water from bailing could be dumped into the acid wash tank allowing particles to settle. Once sufficient settling has occurred, the contents of the acid wash tank (i.e., the purged water with no acid), could be fed through the air stripper.

6.1.4 REVIEW PREVIOUS SURVEYS OF PRIVATE WELLS IN AREA

The ROD specified "extraction of groundwater containing contaminants above MCLs". The current system, however, does not address PCE contamination more than twenty feet downgradient of the extraction well array. Assuming the PCE upgradient of the extraction wells is contained, the PCE downgradient will eventually disperse and fall below MCLs. However, until that time, water near and downgradient of the site should not be used for drinking. A city ordinance currently prohibits the installation of new wells. Public records should be reviewed to ensure that wells installed prior to the ordinance are not still operational, and previous surveys of wells in the area should be reviewed for completeness. If these initial reviews reveal the potential for operating wells in the area, further investigation may be necessary.

6.1.5 CONDUCT SAMPLING OF INDOOR AIR AND STANDING WATER

The high PCE concentrations near the heart of the plume could result in PCE vapors entering nearby buildings. Indoor air sampling should be conducted in the former building that housed One Hour Martinizing shop and perhaps buildings directly across Eddy Street from the extraction system. In addition, sampling for VOCs should be conducted in standing water found in the traffic box light just east of the former One Hour Martinizing facility. Quarterly sampling for one year should cost approximately $5,000 including labor. If contamination is found during this first year, this sampling could be added to the quarterly sampling events in the future, potentially raising sampling costs (including labor) by approximately $5,000 per year.

6.1.6 SAMPLE PINE STREET WELL FOR PCE

A public health assessment by the U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry (ATSDR) in March 26, 1997 reported that the Pine Street well continues to operate during periods of peak demand. It is possible that PCE at concentrations above MCLs may, at some point, impact this well, and sampling for PCE at this location should occur quarterly as it is downgradient of current PCE contamination. If PCE contamination of the well is found, well-operation should be adjusted accordingly. Analytical costs for quarterly sampling of PCE and other VOCs from this one location should cost under $500.

6.2 RECOMMENDATIONS TO REDUCE COSTS

6.2.1 COMBINE OPERATION OF OU1 AND OU2 AND REDUCE FREQUENCY OF PID MEASUREMENTS

Geotechnical Services, Inc. (GSI) is contracted by Black and Veatch to maintain OU2 and by the University of Nebraska at Kearney to maintain OU1. Labor costs could be reduced by having the operators maintain both systems under the same contract and reducing the frequency of PID measurements (done for carbon replacement) from weekly to monthly. With the reduction in PID sampling, maintenance of both sites could be easily accomplished in a single visit. Thus, if GSI is currently billing for two visits, this recommendation could yield savings of approximately $1,500 per month. If a single contract is infeasible under current program guidelines, the separate contracts should be coordinated such that operation and maintenance costs reflect a single site visit to address both operable units.

6.2.2 REPLACE SVE BLOWER WITH A SMALLER, MORE EFFICIENT UNIT

The SVE blower is rated at 50 horsepower and has a capacity to move 1,300 cubic feet per minute with a pressure drop of 9 inches of mercury. However, the blower is operating with the air intake valve open and a vacuum at the well heads of 5.25 inches of mercury. The air flow rate should be measured, and based on those results, a 25 horsepower blower could be installed so that the energy used to run the blower is used to move only air from the subsurface and not clean air from the air intake valve. A 25 horsepower blower cost approximately $15,000 but would use half of the electricity of the 50 horsepower blower which would save approximately $1,000 per month in electricity costs.

6.2.3 CONSIDER REDUCTIONS IN PROJECT MANAGEMENT COSTS

The project management costs associated with this site are on average $5,400 per month, which translates to approximately $65,000 per year or 58% of the system O&M costs. This appears high given the project management responsibilities associated with this system and also appears high compared to project management costs at similar systems. The project management cost therefore should be compared with the associated responsibilities to see if the cost can be reduced. The RSE team did not attempt to quantify potential savings.

6.3 TECHNICAL IMPROVEMENT

6.3.1 MEASURE SVE WELL PARAMETERS

The air flow rate and PCE concentrations from each of the SVE wells should be measured to inform the site managers of the mass removed from each well. This information could be used to optimize the SVE system if it is found that the majority of mass is coming from one or two of the four SVE wells. PCE concentrations are measured with PID weekly; however, the contracted team from the University of Nebraska at Kearney report that the PID measurements show broad uncertainties. Thus, the concentrations should be measured and reported with more exact techniques such as gas chromatography. While gas chromatography may already be used, the results were not available in the 2000 OU1 annual report reviewed by the RSE team.

In addition, the vacuum induced by the SVE system should be measured in neighboring wells that at least partially screen the vadose zone. This information would indicate the SVE capture zone. This is especially important if an air sparging system is implemented (See Section 4.1).

Installing pitot tubes at each of the SVE well heads would cost less than $500 and measuring the induced vacuum in a few neighboring wells could be added to the quarterly sampling events for a nominal cost.

6.3.2 TREAT SVE CONDENSATE WITH AIR STRIPPER RATHER THAN CARBON

The condensate from the SVE system is currently treated with activated carbon. This water could be collected and sent through the air stripper thereby eliminating the need for the liquid phase carbon units. This should be done when the liquid phase carbon is spent. It will cost approximately $500 for the associated changes, but eliminating replacement of the liquid phase carbon units will offset this cost.

6.3.3 REFORMAT QUARTERLY PERFORMANCE REPORTS

The quarterly performance reports provide sample information in tables and in concentration vs. time plots. While the data is also summarized in the text, this text does not provide additional analysis beyond these tables and figures. The text should be used to highlight changes or note trends so that site managers can identify them more easily. For example, the 1999 annual report has four instances in which influent PCE concentrations to the vapor-phase carbon units of the SVE system were higher than the concentrations from the SVE wells. The concentrations were reported in the text, but the anomaly was not explained. The quarterly performance reports should also include updated plume maps rather than reprinting the same plume map from 1999.

6.3.4 DRAIN WATER FROM EXTRACTION-WELL VAULTS

All three of the extraction well vaults had significant amounts of water in them. In EW-1, the water was almost to the level of the well cap. The vaults should be drained and retrofitted so that rainwater does not accumulate in them. Draining the vaults and retrofitting them would cost approximately $1,500.

6.3.5 SAMPLE MONITORING WELLS FOR ADDITIONAL PARAMETERS

PCE is known to undergo reductive dechlorination in reduced environments. Measurements of oxidation-reduction potential (ORP), dissolved oxygen (DO), dissolved organic carbon (DOC), sulfate (SO_4^-), nitrate (NO_3^-), and dissolved iron will help determine the potential for reductive dechlorination. These measurements could easily be made with field test kits and reported during the quarterly sampling events for additional analytical costs of $1,000 per year.

6.4. RECOMMENDATIONS TO GAIN SITE CLOSEOUT

6.4.1 INVESTIGATE USE OF AIR SPARGING

The primary issue of concern at the site is the presence of DNAPL as indicated by the high dissolved concentrations of PCE in MW-2A. The DNAPL could be limited to the area immediately surrounding MW-2A, but as no soil probes were done under the One Hour Martinizing building, the extent of the DNAPL under the building is not known. Whatever the extent, the current pump-and-treat and SVE system will not eliminate this continuing source of dissolved phase PCE. As a result, a more aggressive approach is required. A cost-effective approach is to install and operate an air sparging system with sparging wells at approximately 20 to 30 feet deep. The sparged air would help volatilize the DNAPL and transport it to the vadose zone where the SVE system can remove it. The extent and design of this system would depend on the extent of DNAPL.

A small geoprobe should be used to determine the extent of DNAPL in the area near MW-2A and under the building. For approximately $5,000 the geoprobe could be used for one or two days to sample approximately 10 locations. In the process, the geoprobes would also provide pertinent information regarding site stratigraphy, which is important as it helps identify the preferential flow paths of the sparged air. Care must be taken to ensure that PCE laden air is not transported beyond the reach of the current SVE system. Implementing this system would require drilling one or more air sparging wells, installing an air compressor and the associated piping, and running tests. Operation requirements would be similar to that of the air stripping or SVE system. A sparging system with proper testing, controls, and one well should cost approximately $50,000 to install with each additional well costing approximately $5,000. Operation of the air sparging system, including reporting and additional project management, would increase the annual costs of the system, perhaps by $10,000, but it would also shorten the operating lifetime of the pump-and-treat system.

6.4.2 DEVELOP AN EXIT STRATEGY

An exit strategy should be developed for the site. This strategy would begin with aggressive removal of the DNAPL. Once this continuing source of dissolved phase PCE has been removed, the site managers should be begin to consider monitored natural attenuation (MNA). OU3 and OU4 with PCE concentrations as high as 95 ug/L, currently have MNA as the remedy. With this precedent, it is reasonable to assume that MNA could be used at OU2 once PCE concentrations are consistently below 95 ug/L.

In addition, the contaminants other than PCE and its degradation products should not affect the operation and closure of OU2 as they are most likely not associated with the OU2 source. Rather, the RI from OU5 (Nebraska Solvents) indicates that the west parcel of the Nebraska Solvents property is the most likely source of these contaminants. Operation of the pump-and-treat system at OU2 may, however, be required as part of the remedy for OU5.

6.5 UNUSED GOVERNMENT-OWNED EQUIPMENT

The acid wash system, and the associated chemicals on site, are not used for the current system. If the acid wash tank is not used in the disposal of sampling water (see Section 6.1.3), it and the other parts of the acid wash system could be used at another site. USACE currently has a program designed to help the transfer of unused government-owned equipment from Fund-lead sites to other Fund-lead sites where that equipment can be used. The contact for this program is

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7.0 SUMMARY

The observations and recommendations given below are not intended to imply a deficiency in the work of either the designers or operators, but are offered as constructive suggestions in the best interest of the EPA and the public. These recommendations obviously have the benefit of the operational data unavailable to the original designers.

The RSE process is designed to help site operators and managers improve effectiveness, reduce operation costs, improve technical operation, and gain site closeout. Recommendations to improve effectiveness include rehabilitating fouled wells, analyzing and possibly improving the capture zone, modifying the current well-sampling program, surveying for local private wells, and conducting indoor sampling. Recommendations to reduce costs include combining the labor contract for OU1 and OU2 and replacing the existing SVE blower with a smaller, more efficient one. Recommendations for technical improvement include measuring additional operating parameters of the SVE system, treating condensate water from the SVE system with the air stripper, reformatting the quarterly reports, and draining water from the extraction-well vaults. Regarding site close out, the report recommends investigating and possibly implementing the use of air sparging to address the DNAPL on site and developing an exit strategy based on precedents set in other operating units.

Tables 7-1 summarizes the costs and cost savings associated with each recommendation. Both capital and annual costs are presented. Also presented are the expected change in life-cycle costs are over a 30-year period for each recommendation both with discounting (i.e., net present value) and without it.

Table 7-2 summarizes the estimated life-cycle costs of

- the current system,
- the current system with implementation of the recommendations excluding air sparging, and
- the current system with implementation of all recommendations including air sparging.

For the purposes of demonstrating potential cost savings associated with the air sparging system, it is assumed that the air sparging system decreases the lifetime of the system by half, which may be an optimistic. Therefore, a 30-year period is used for the life-cycle of the systems without air sparging and a 15-year period is assumed for the life-cycle of the system with air sparging.

Table 7-1. Cost summary table for individual recommendations

Recommendation	Reason	Estimated Change in			
		Capital Costs	Annual Costs	Life-cycle Costs*	Life-cycle Costs **
6.1.1 Rehabilitate fouled extraction wells	Effectiveness	$6,000	$6,000	$186,000	$102,700
6.1.2 Determine capture-zone effectiveness with sampling	Effectiveness	$10,000	$1,000	$40,000	$26,100
6.1.3 Modify well-sampling program	Effectiveness	$0	$0	$0	$0
6.1.4 Survey local private wells	Effectiveness	$0	$0	$0	$0
6.1.5 Conduct indoor air sampling	Effectiveness	$5,000	$0	$5,000	$5,000
6.1.6 Sample Pine Street well for PCE	Effectiveness	$0	$500	$15,000	$8,100
6.2.1Combine operator labor for OU1 and OU2	Cost reduction	$0	($18,000)	($540,000)	($290,500)
6.2.2 Replace blower for OU1	Cost reduction	$15,000	($12,000)	($345,000)	($178,700)
6.2.3 Consider reducing project management costs	Cost reduction	not quantified	not quantified	not quantified	not quantified
6.3.1 Measure SVE well parameters	Technical improvement	$500	$0	$500	$500
6.3.2 Treat SVE condensate with air stripper	Technical improvement	$500	($100)	($2,500)	($1,100)
6.3.3 Reformat Quarterly Performance Reports	Technical improvement	$0	$0	$0	$0
6.3.4 Drain water from extraction-well vaults	Technical improvement	$1,500	$0	$1,500	$1,500
6.3.5 Sample wells for additional parameters	Technical improvement	$0	$1,000	$30,000	$16,100
6.4.1 Investigate and implement air sparging	Gain site close out	$55,000	$10,000	see Table 7-2	see Table 7-2
6.4.2 Develop an exit strategy	Gain site close out	$0	$0	$0	$0

Costs in parentheses imply cost reductions.
* assumes 30 years of operation with a discount rate of 0% (i.e., no discount).
** assumes 30 years with a discount rate of 5% and no discounting in the first year.

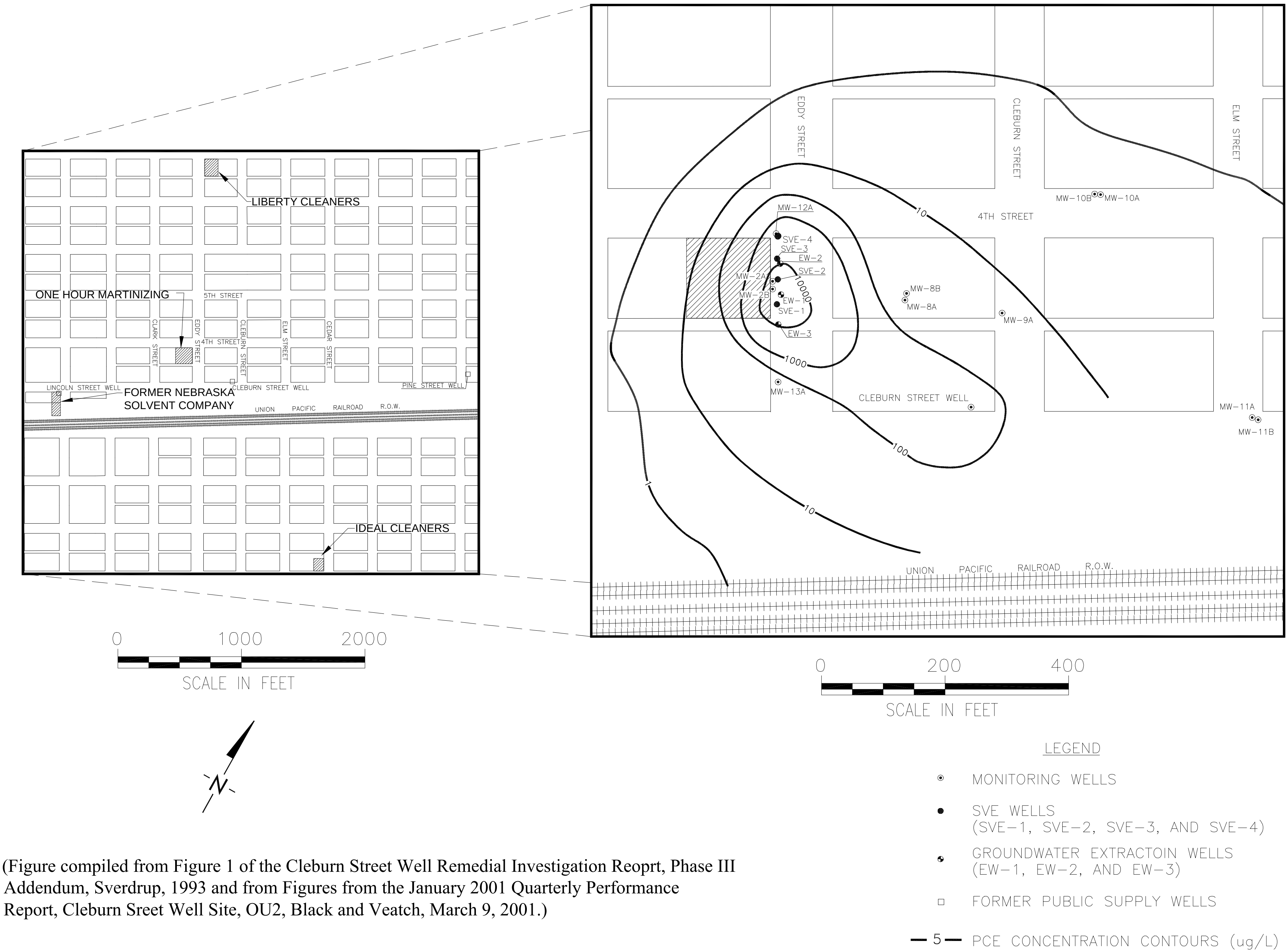
Table 7-2. Cost estimates for systems with and without implemented recommendations

	Description	Capital Costs	Annual O&M Costs	Estimated Life-cycle Costs*	Estimated Life-cycle Costs**
Current P&T system	Current	$0	$110,000	$3,300,000	$1,775,500
P&T system with recommendations (no air sparging)	Moderate	$38,500	$88,400	$2,690,500	$1,463,000
P&T system with all recommendations including air sparging	Aggressive	$93,500	$98,400	$1,569,500	$1,165,900

Note: 30 years of operation is assumed for systems without air sparging, and 15 years of operation is assumed for the system with air sparging
* assumes a discount rate of 0% (i.e., no discount).
** assumes a discount rate of 5% and no discounting in the first year.

FIGURES

FIGURE 1-1. SITE LAYOUT SHOWING THE CONTAMINANT SOURCES, GROUNDWATER EXTRACTION WELLS, SVE WELLS, AND THE 1999 PCE PLUME.



(Figure compiled from Figure 1 of the Cleburn Street Well Remedial Investigation Reoprt, Phase III Addendum, Sverdrup, 1993 and from Figures from the January 2001 Quarterly Performance Report, Cleburn Sreet Well Site, OU2, Black and Veatch, March 9, 2001.)

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