COST AND PERFORMANCE REPORT

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

September 1998

Prepared by:

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

SITE INFORMATION

Identifying Information:

Des Moines TCE Superfund Site
Des Moines, Iowa
Operable Unit 1

CERCLIS #: IAD98060687933

ROD Date: July 21, 1986

Treatment Application:

Type of action: Remedial

Period of operation: 12/87 - Ongoing (Contaminant concentration data collected through 1996; mass removal data collected through February 1997)

Quantity of material treated during application: As of December 1996, 4.9 billion gallons of groundwater

Background

Historical Activity that Generated Contamination at the Site: Manufacturing of metal wheels and brakes, and chemical storage/ distribution.

Corresponding SIC Code: 3523 (Manufacturing of farm machinery and equipment)

Waste Management Practice That Contributed to Contamination: Use of waste sludges on road surfaces for dust control and land application of waste sludges

Location: Des Moines, Iowa

Facility Operations: [8]

- An iron foundry operated on the property from approximately 1910 until Dico Corporation purchased the property in the early 1940s.
- Dico manufactured metal wheels and brakes at the site from 1961 through 1993. Dico was purchased by Titan Wheel International, Inc. in 1993. Production at the facility ceased in 1995.
- In September 1976, testing by the DMWW and the EPA detected TCE in the City's north gallery groundwater infiltration system, which served as a source of drinking water for the city. TCE levels ranged from 200 to 450 µg/L in samples collected from the gallery.
- EPA studies conducted between April and September 1978 identified TCE contamination in the production well on the Dico property. Investigations by EPA suggested that solvent sludges used on road and parking lot surfaces could be the cause of subsurface contamination.
- In October 1978, Dico agreed to discontinue the surface application of solvent sludges. No other source control measures were undertaken.
- In 1981 and 1982, an EPA Field Investigation Team (FIT) performed an assessment and RCRA Interim Status Inspection of the Dico area. Monitoring wells were installed on site and samples collected. Quarterly sampling of these monitoring wells was initiated in 1982.
- The site was placed on the National Priorities List (NPL) in September 1983.
- In April 1984, DMWW closed the north gallery water infiltration system.
- Remedial investigation (RI) field work was conducted in 1984 and 1985.

Regulatory Context: [9]

- On July 21, 1986, EPA issued a ROD for OU1, which addresses contaminated groundwater at this site.
- A Unilateral Administrative Order was issued to Dico on July 21, 1986 designating it as the lead for remedial activities.
- 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.

SITE INFORMATION (CONT.)

Background (Cont.)

Remedy Selection [9]:
Groundwater extraction and treatment via air stripping was selected in the 1986 ROD as the remedy for this OU.

Site Logistics/Contacts

Site Management:
PRP Lead

Oversight:
U.S. EPA Region VII

Treatment System Vendor:
Tonka Equipment Company

Remedial Project Manager:
Mary Peterson*
U.S. EPA Region VII
726 Minnesota Avenue
Kansas City, Kansas 66101
913-551-7882

*Indicates primary contact

MATRIX DESCRIPTION

Matrix Identification

Type of Matrix Processed Through the Treatment System: Groundwater

Contaminant Characterization [1,2,3,4,5,6]

Primary Contaminant Groups: Halogenated volatile organic compounds (VOCs)

- Contaminants of greatest concern at the site are trichloroethylene (TCE), trans-1,2-dichloroethylene (trans-1,2-DCE), and vinyl chloride (VC).
- Maximum concentrations detected during the 1985 RI/FS include TCE (8,467 µg/L), 1,2-DCE (2,000 µg/L), and VC (95 µg/L).
- Figures 1 and 2 provide TCE concentration contour maps prepared in 1985 and 1995, respectively. The 1985 figure shows the 500 µg/L TCE contour line crossing the Raccoon River (from the Des Moines TCE site). The 1995 figure shows the 10 µg/L TCE contour line pulled back to the same side of the Raccoon River as the Des Moines TCE site.
- The contaminant plume was estimated in the 1988 Annual Performance Report to be up to 45 feet thick and cover a 130-acre area. Assuming a standard porosity of 30%, the volume of contaminated groundwater was calculated to be 512 million gallons.

MATRIX DESCRIPTION (CONT.)

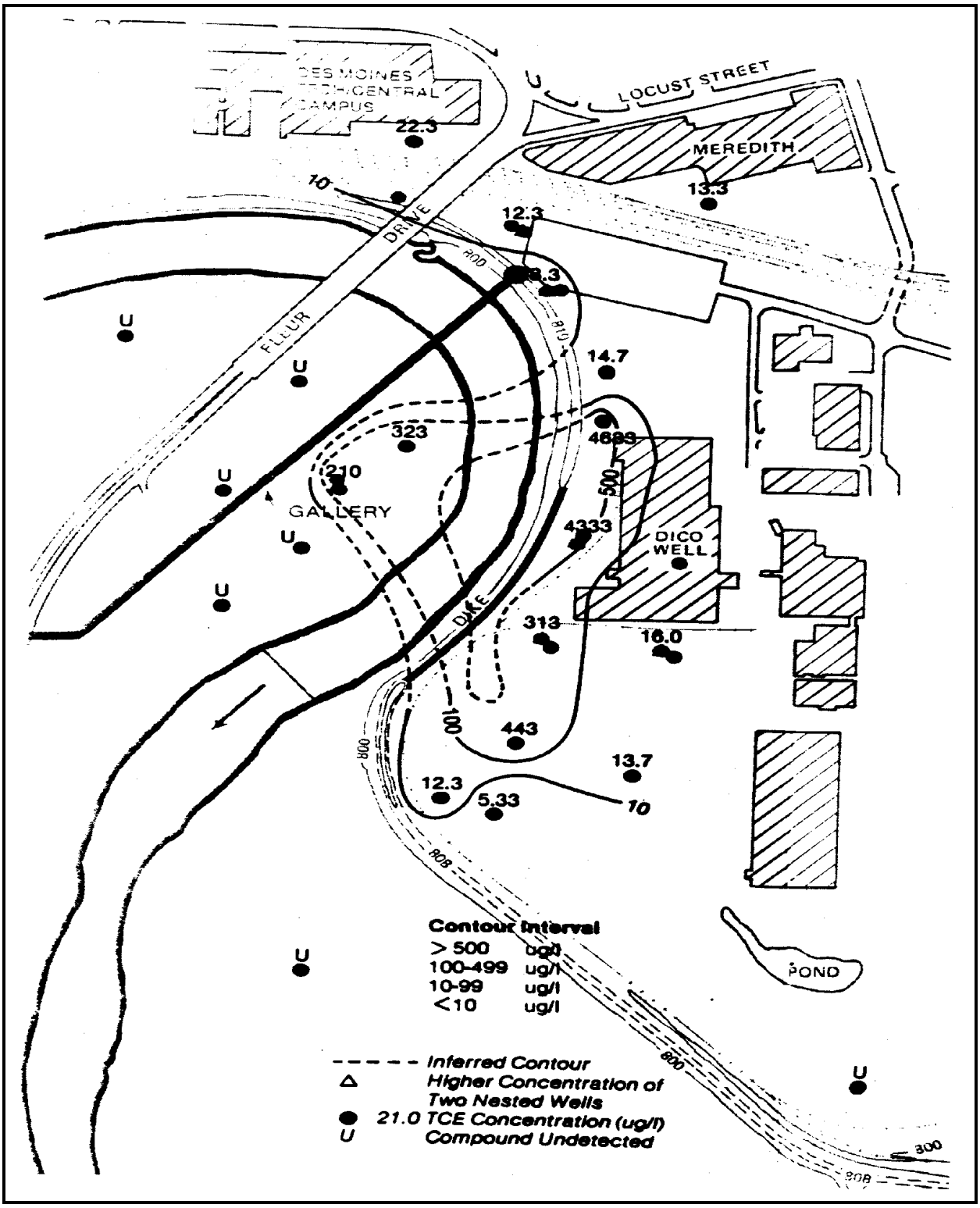

Figure 1. TCE Concentration Contours (1985) [10]

MATRIX DESCRIPTION (CONT.)

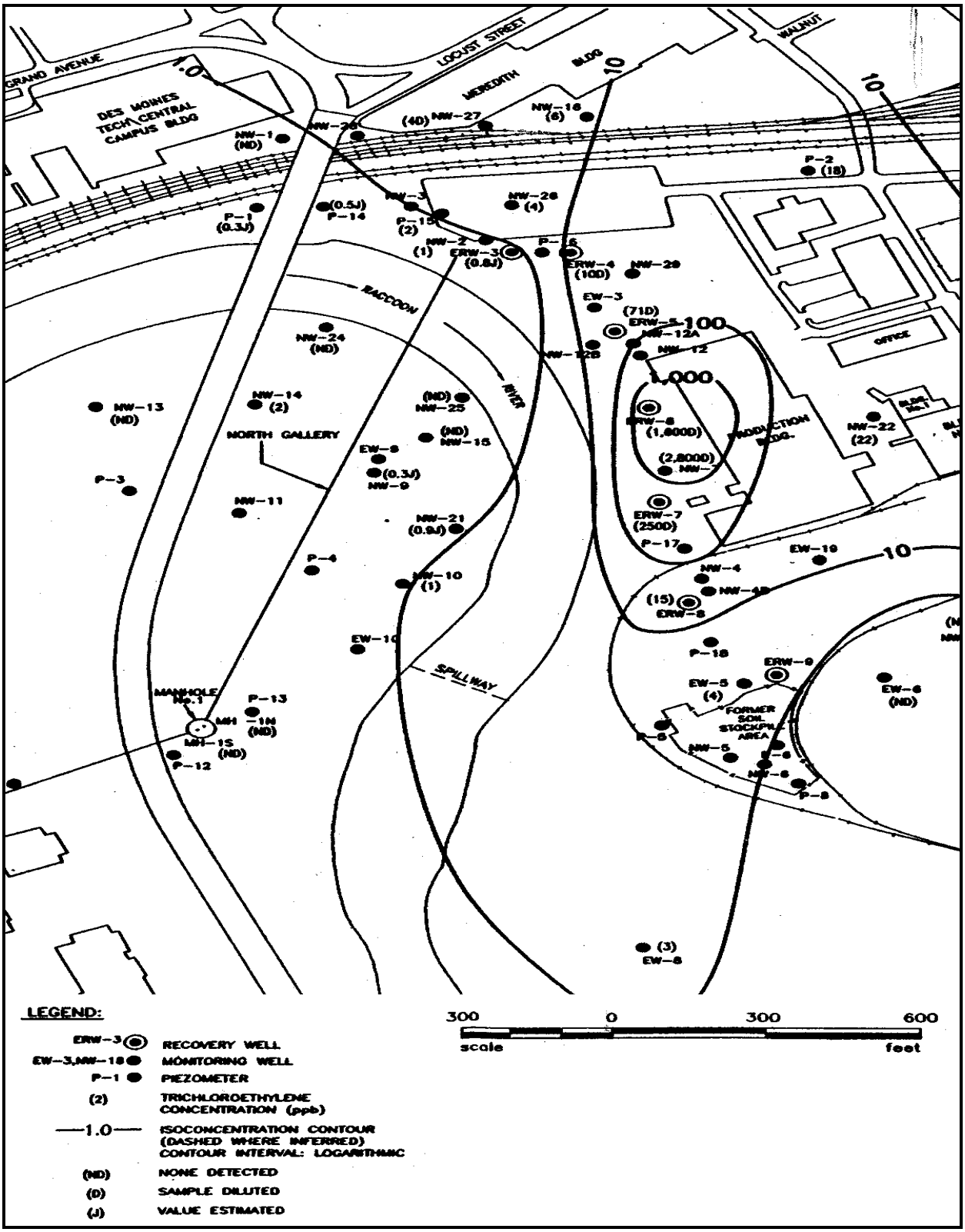

Figure 2. TCE Concentration Contours (1995) [5]

MATRIX DESCRIPTION (CONT.)

Matrix Characteristics Affecting Treatment Costs or Performance

Hydrogeology [8]:

Two distinct hydrogeologic units have been identified beneath this site.

Upper Unit	The geology of this unit consists of 40 to 60 feet of unconsolidated alluvial silt, clay, sand, and gravel overlying consolidated shale bedrock. The top 10 feet of the alluvial materials consist of silt and clay overbank deposits. The bottom 30 to 50 feet of aquifer consist of sand and gravel, which extend to the top of the shale bedrock.
Lower Unit	The shale bedrock extends over 100 feet in depth. This unit is not contaminated.

Water levels range from 10 to 25 feet below ground surface. Groundwater flow is to the southeast; however, high-volume pumping from the DMWW infiltration galleries may affect the flow direction in some areas. The Raccoon River, which flows between the site to the east and the DMWW facility to the west, can gain from or lose to the aquifer depending on water levels.

Tables 1 and 2 include technical aquifer information and technical well data. A discussion of extraction wells is included in the following section.

Table 1: Technical Aquifer Information

Unit Name	Thickness (ft)	Conductivity (ft/day)	Average Velocity (ft/day)	Flow Direction
Upper Aquifer	40-60	535	0.1-0.8	South and Southeast

Source: [9]

TREATMENT SYSTEM DESCRIPTION

Primary Treatment Technology

Pump and treat with air stripping

Supplemental Treatment Technology

None

TREATMENT SYSTEM DESCRIPTION (CONT.)

System Description and Operation

Table 2: Technical Well Data [7]

Well Name	Unit Name	Depth (ft)	Design Yield (gal/day)
ERW-3	Upper Aquifer	40	230,400
ERW-4	Upper Aquifer	40	201,600
ERW-5	Upper Aquifer	40	187,200
ERW-6	Upper Aquifer	40	230,400
ERW-7	Upper Aquifer	40	302,400
ERW-8	Upper Aquifer	40	302,400
ERW-9	Upper Aquifer	40	252,000

Note: Overall the average total extraction rate is approximately 1.5 million gpd, based on the volume of water pumped since operations began.

System Description [7,10]

- The groundwater extraction system consists of seven wells installed in the plume east of the Raccoon River on the Dico property. Extraction wells are constructed of 12-inch diameter galvanized steel pipe with seven feet of screen placed near the bottom of the sand and gravel aquifer. The purpose of the design was to achieve off-site groundwater goals and to capture the on-site plume to eliminate further off-site contamination. The two-dimensional Modflow model was used in the design process.

- The extraction system was designed for full containment and partial aquifer restoration. Extraction wells were located within the heart of the plume, and hydraulic manipulation of the groundwater gradient was used to contain the contaminant plume.

- Groundwater is withdrawn from the aquifer, treated through an air stripper, and discharged to the Raccoon River under a National Pollution Discharge Elimination System (NPDES) permit. During the nine years of operation, the system has achieved an average extraction rate of 1,000 gpm.

- The treatment system consists of a 39-foot tall stainless steel tower with an internal diameter of 7½ feet. Countercurrent flows of air and groundwater are sent through the tower at a ratio of 60 to 1, respectively. The tower is designed for a maximum flow of 1,850 gpm for a minimum 96% removal efficiency. Treated groundwater is discharged to the Raccoon River through an 18-inch sewer outfall.

System Operation [1,2,3,4,5,6]

- A system of 29 on- and off-site monitoring wells is used to measure changes in groundwater concentrations on a quarterly basis and water levels on a monthly basis.

- The average system extraction rate was 1,270 gpm from start-up until February 1990, 1,000 gpm from February 1990 through January 1995, and 800 gpm since January 1995. The reduction in extraction rates has been due to wells clogging from iron corrosion. Hydraulic containment was still achieved at the reduced extraction rates. The overall pumping history is listed below:

Year	Average Gallons/Year Pumped
1988-1989	667,512,000
1990-1994	525,600,000
1995-1996	420,480,000

TREATMENT SYSTEM DESCRIPTION (CONT.)

System Description and Operation (Cont.)

- From December 1987 through December 1996, the system has been operational approximately 95% of the time. Downtime has been due to routine maintenance activities.
- Iron corrosion resulted in severe plugging of the air stripping media in September 1988. Spherical shaped media were replaced with chandelier type media in January 1991.
- An in-line pump was installed in June 1991 to provide a continuous injection of organophosphanic acid and biological growth inhibitor (chlorine) into the system. This reduced iron corrosion and bio-fouling problems.
- By 1993, iron encrustation and corrosion caused various problems with the extraction system. Wells ERW-5 and ERW-7 were redeveloped, and ERW-9 was completely taken out of service. Redevelopment of wells ERW-5 and ERW-7 flushed corrosion and iron build-up from the wells and re-opened screened intervals to improve water flow.

Operating Parameters Affecting Treatment Cost or Performance

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

Table 3: Performance Parameters

Parameter	Value
Average Pump Rate	1,041 gpm
Performance Standard (effluent)	1. 96% removal efficiency 2. NPDES effluent limitations: TCE 80.7 µg/L PCE 8.85 µg/L *trans*-1,2-DCE 135,000 µg/L VC 43.5 µg/L
Remedial Goal (aquifer)	5 µg/L TCE (off-site only)

Source: [1, 2, 3, 4, 5, 6, 9]

Timeline

Table 4 presents a timeline for this remedial project.

Table 4: Project Timeline

Start Date	End Date	Activity
7/86	---	ROD and UAO issued
10/86	3/87	Remedial design performed
9/87	12/87	Remedial construction performed
12/87	ongoing	Operation of remedial system and quarterly remedial monitoring
6/91	---	Installation of organophosphanic acid and chlorine pumps
5/92	---	Final inspection of groundwater extraction and treatment system by EPA
6/93	10/93	Redevelopment of wells ERW-5, 7, and 9

Source: [7]

TREATMENT SYSTEM PERFORMANCE

Cleanup Goals/Standards

The cleanup goal for this site is to reduce the TCE concentration in groundwater on the west side of Raccoon River (opposite the facility) to 5 µg/L or less for four consecutive months. This goal must be met in all monitoring wells located on the west side of Raccoon River. At this time, on-site goals have not been specified [9].

Treatment Performance Goals

- The groundwater treatment system is required to remove, at a minimum, 96% of the influent TCE concentration [7].
- Effluent discharged from the treatment system must meet surface water criteria for the Raccoon River. The NPDES permit limits are included in Table 3 [7].
- As a secondary goal, the remedial system is designed to create an inward gradient toward the site to contain and treat the on-site plume [9].

Performance Data Assessment

For this report, total contaminant concentration includes TCE, trans-1,2-DCE, and VC concentrations.

- The first goal of the remedial system is aquifer restoration on the west side of Raccoon River. Based on 1989 sampling data from all off-site monitoring wells, the system appears to have achieved this goal within the first two years [3].
- The secondary goal of the treatment system is to capture and treat the on-site plume to prevent future off-site contamination. Figure 3 depicts groundwater elevation contours measured in October 1996. The figure shows that groundwater elevations closest to the source areas are approximately 1 foot lower than at the outer edges of the plume [6]. Groundwater levels have been measured monthly during the remedial action. Based on data provided in the 1988 Annual Performance Report, an inward hydraulic gradient appears to have been achieved within the first month of operation. The area affected by the inward hydraulic gradient encompasses the entire contaminant plume [1].
- Figure 4 depicts the TCE concentrations detected in off-site wells NW-15 and NW-21 from 1987 to 1996. These are the off-site wells closest to the source area and have historically had the highest off-site TCE concentrations. TCE concentration in wells NW-15 and NW-21 dropped from levels as high as 12 µg/L and 25 µg/L, respectively, to below the goal of 5 µg/L by the December 1989 sampling event.
- Figure 5 illustrates changes in average contaminant concentrations in the groundwater over time. This figure depicts total concentrations of TCE, trans-1,2-DCE and VC, as well as TCE concentrations alone. All monitoring wells, on-site and off-site, were used for this figure. Average total contaminant concentrations declined steadily from 1987 through October 1996. Average TCE concentrations have declined from 45 µg/L to less than 5 µg/L.
- Figure 6 depicts the concentration of TCE detected in on-site wells ERW-6, ERW-7, and NW-7. These wells are located in the most contaminated part of the plume. The maximum concentrations of contaminants in the groundwater during the October 1996 sampling event were 2,400 µg/L (TCE), 150 µg/L (1,2-DCE), and 100 µg/L (VC). These concentrations were found in well ERW-6, which is in the center of the plume.
- By December 1996, a total of 4.9 billion gallons of groundwater were treated [6]. Taking into account the life of the system and a 95% operational rate, the average treatment rate was 1,000 gpm.

TREATMENT SYSTEM PERFORMANCE (CONT.)

Performance Data Assessment (Cont.)

- Figure 7 presents data on contaminant removal from 1988 to 1997. By February 1997, the P&T system had removed nearly 30,000 pounds of contaminant mass from the groundwater. The mass flux rate declined from 62 lbs/day to 16 lbs/day within the first 6 months of operation. During the last 8 years of operation, the mass flux rate declined from 16 lbs/day to less than 2 lbs/day. The decrease in mass flux can be attributed to a decrease in contaminant concentrations in the influent to the treatment system as well as a reduction in the volume of groundwater treated.
- At the 6-month sampling event, the influent concentration to the treatment system was 1,100 µg/L and the average groundwater concentration was 70 µg/L.

Performance Data Completeness

- Data are available for concentrations of contaminants in the groundwater on a quarterly basis. Data for influent and effluent concentrations from the treatment system are available on a weekly basis.
- Contaminant concentrations detected during annual sampling events were used for analyses performed in this report. As of the date of this report, data are available for the 1987, 1988, 1989, 1990, 1991, 1992, 1993, 1995, and 1996 annual sampling events. References 1-6 contain annual sampling data.
- In Figure 5, a geometric mean was used for average groundwater concentrations detected in 13 monitoring wells and 6 extraction wells located within the original plume area. It should be noted that for the October 1996 sampling event, data from 4 of the 13 monitoring wells was not available.
- Contaminant mass removal was determined using analytical results from influent samples, along with flow rate data. Quarterly data were used for the first year to better depict the rapidly changing mass flux rate.
- Data from all monitoring and extraction wells within the original plume were used to calculate the mean concentration. When concentrations below detection limits were encountered, half of the detection limit was used in the calculation of the mean.

Performance Data Quality

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

TREATMENT SYSTEM PERFORMANCE (CONT.)

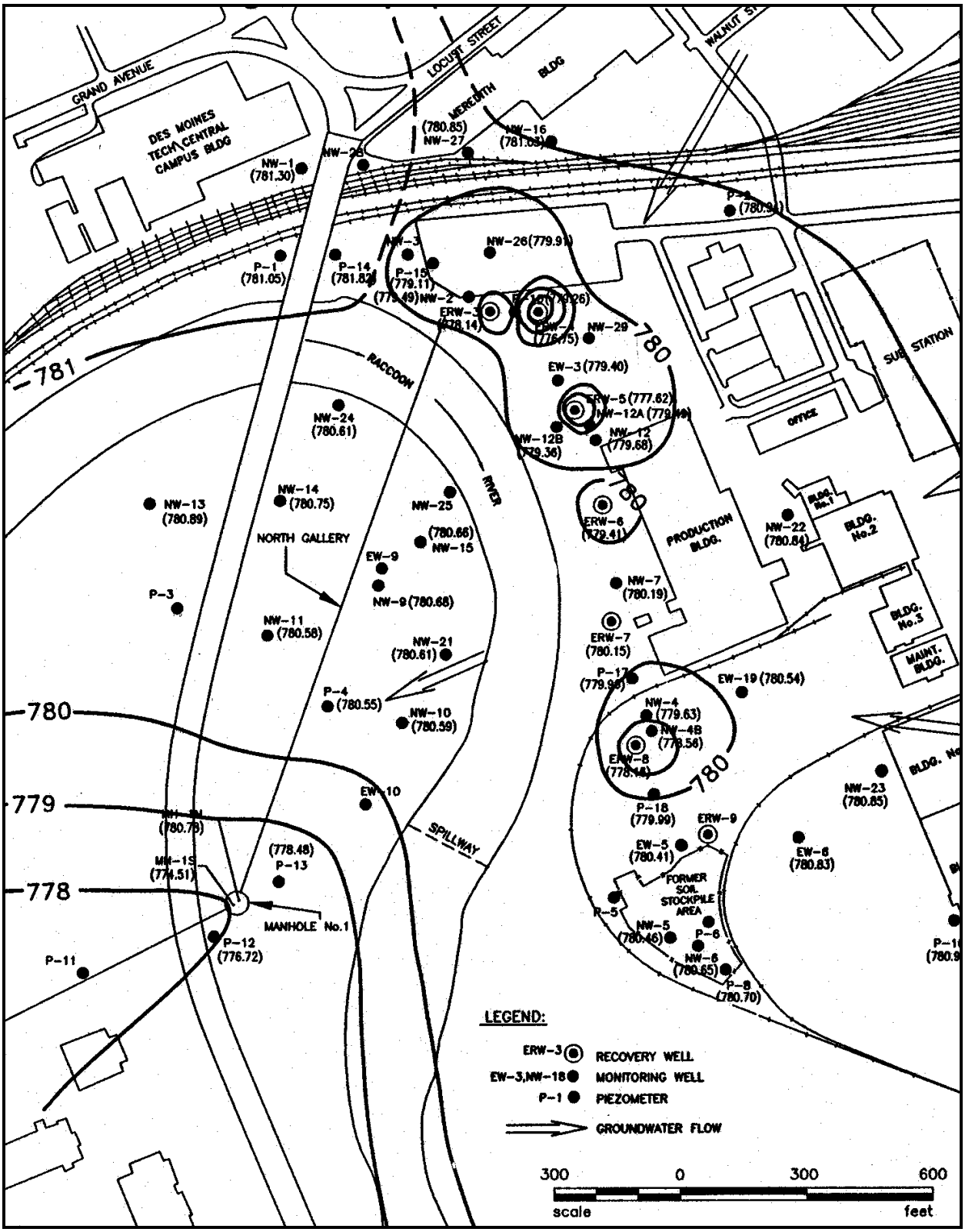

Figure 3. Groundwater Elevation Contours (1996) [6]

TREATMENT SYSTEM PERFORMANCE (CONT.)

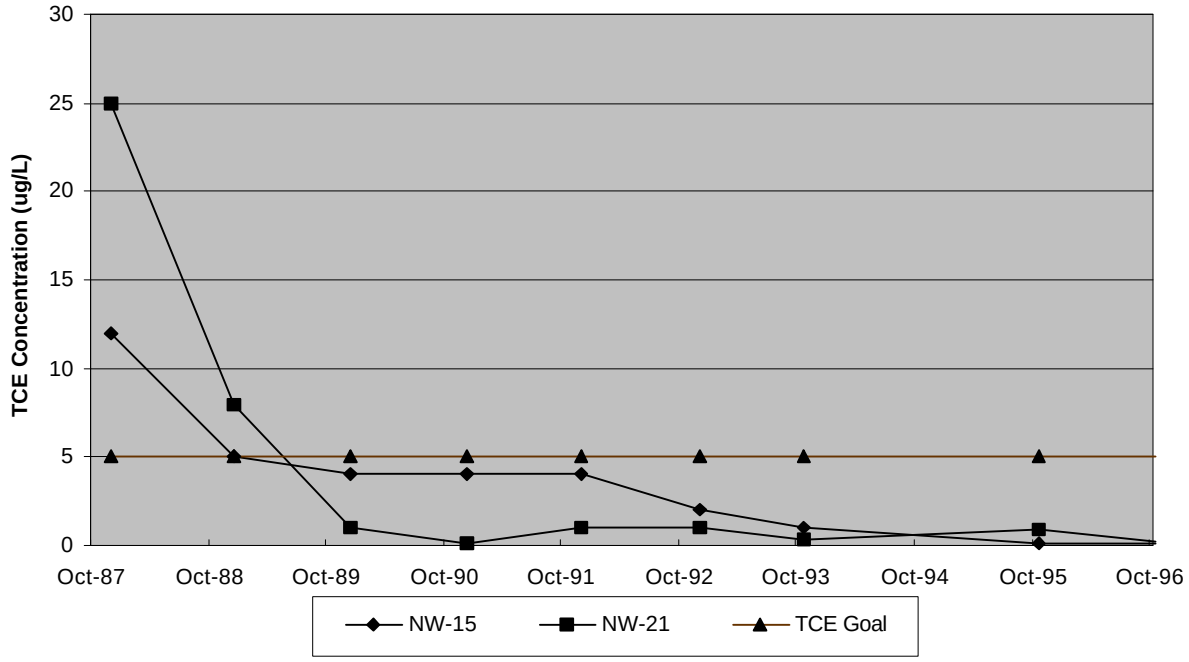

Figure 4. TCE Concentration for Two Off-Site Monitoring Wells [1-6]

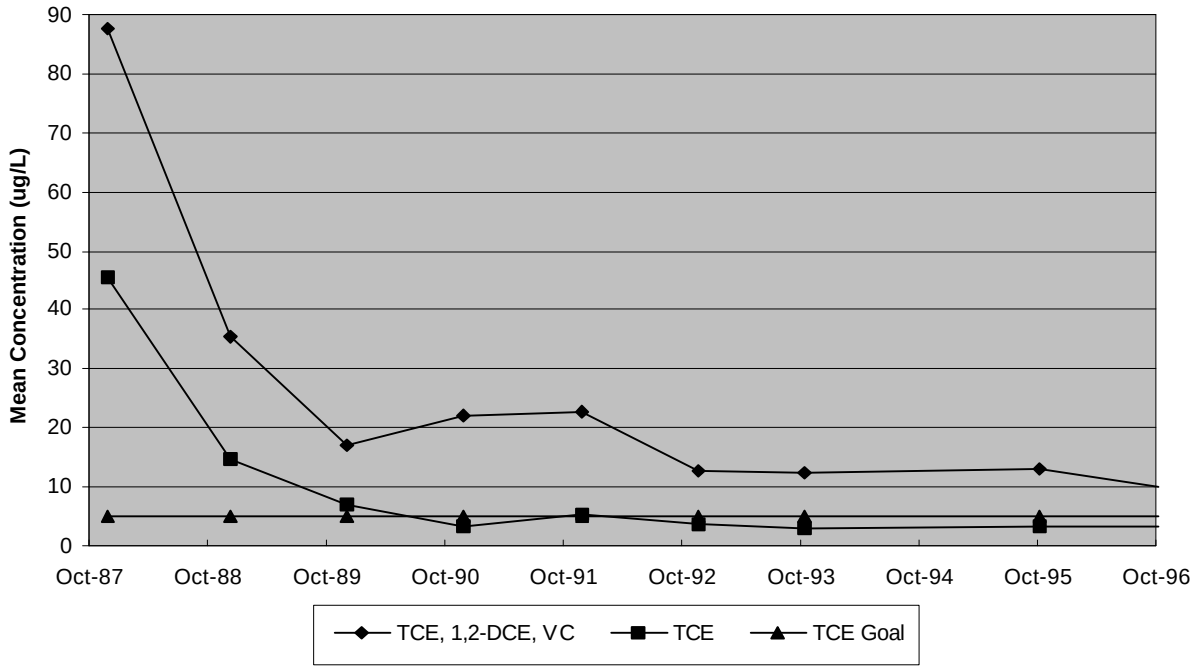

Figure 5. Geometric Mean of Total Contaminants and TCE [1-6]

TREATMENT SYSTEM PERFORMANCE (CONT.)

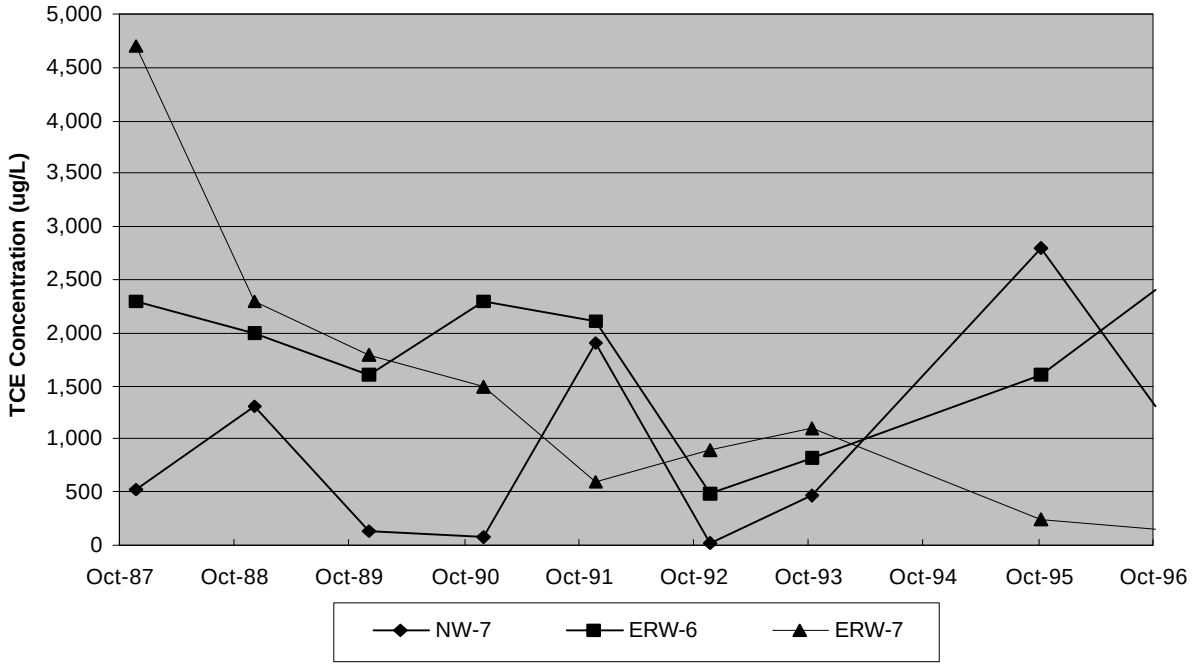

Figure 6. On-Site Wells with Highest TCE Concentrations [1-6]

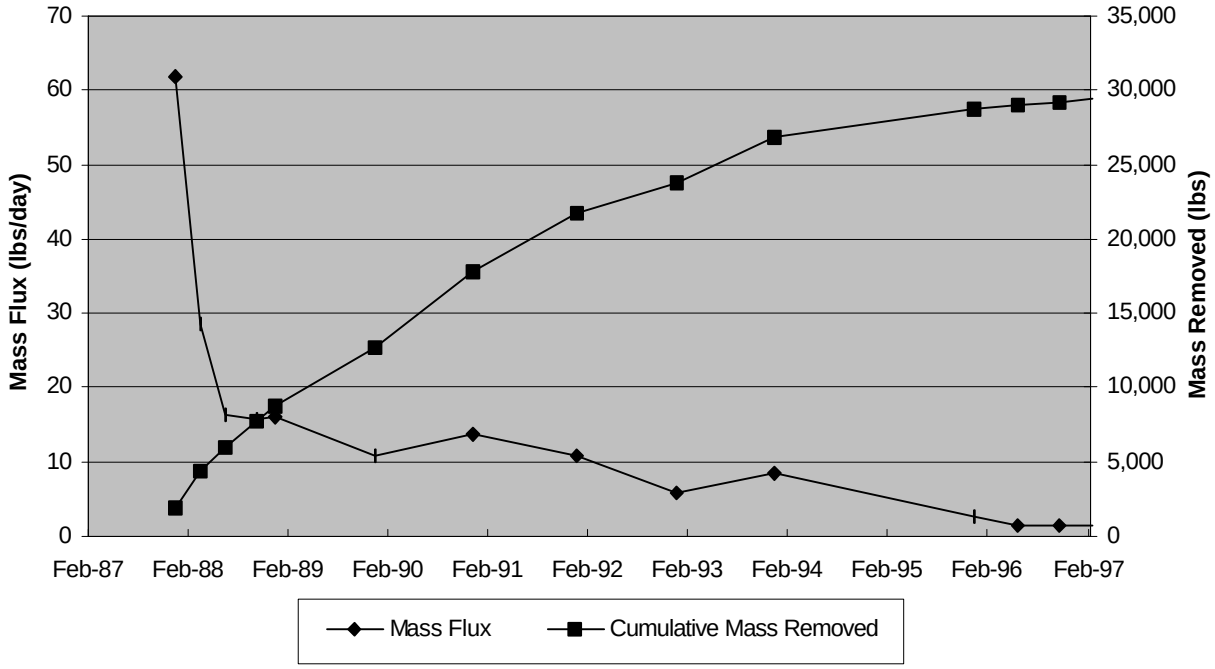

Figure 7. Mass Flux and Total Contaminants Removed [1-6]

TREATMENT SYSTEM COST

Procurement Process

Dico Corporation contracted with Eckenfelder, Inc. to construct and operate the treatment system. Dico maintains responsibility for operations and maintenance of the treatment system.

Cost Analysis

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

Capital Costs [14]

Remedial Construction	
Site Management	$639,962
Site Work	$10,934
Supplies	$28,118
Piping	$463,399
Monitoring Wells	$63,189
Extraction Wells	$231,541
Air Monitoring	$2,046
Air Stripper	$103,807
Analyses	$44,287
Total Remedial Construction	**$1,587,283**

Operating Costs [14,15]

Operation and Maintenance	
Labor	$48,438
Utilities	$435,946
Analyses	$141,279
Maintenance	$383,471
Cumulative Operating Expenses through 1996	**$1,009,134**

Other Costs

Remedial Design	
Air Stripper and Manhole	$271,717
Engineering Work	$87,137
Analyses	$128,570
Remedial Design	**$487,424**
EPA Personnel	$247,398

Cost Data Quality

Capital and operations and maintenance costs are provided in an unpublished EPA document entitled "Groundwater Remedial Cost Estimates." Estimates of operating costs for 1995 and 1996 were provided by the former Remedial Project Manager, Mr. Glenn Curtis.

OBSERVATIONS AND LESSONS LEARNED

- Total costs for the P&T system at this site were approximately $2,596,000 ($1,587,000 in capital costs and $1,009,000 in operating costs), which corresponds to $80 per pound of contaminants removed and $0.53 per 1,000 gallons of groundwater treated.
- Reports from as early as 1984 identify a separate plume of groundwater contamination that is moving southward from points north of the Dico property.
- The costs for this project were approximately $833,000 more than the projected costs in the ROD. This cost figure exceeds the ROD estimate by 47%, which falls within the confidence interval of no greater than 50% and no less than 30% as stated in the ROD.
- As of October 1996, the mean concentration of contaminants in the groundwater was 18 µg/L. The mean concentration is computed from 19 sampling points and provides an average measurement across all points. The maximum concentration detected was 2,650 µg/L at extraction well ERW-6 [6]. Although the average groundwater concentration has declined significantly, areas of high contamination still remain on site.

OBSERVATIONS AND LESSONS LEARNED (CONT.)

- Within several wells placed near the center of the plume, TCE concentration levels have fluctuated dramatically. In Figure 7, concentrations in well NW-7 can be seen to vary between 22 µg/L and 2,800 µg/L. This variation in contaminant concentrations typically indicates DNAPL presence.
- The most rapid reductions in contaminant concentrations occurred during the first two years of operation when mean concentration levels in groundwater fell by 81%. The mean groundwater concentrations only declined an additional 9% over the next eight years.
- Nearly 30,000 pounds of contaminants were removed from the groundwater over 108 months [6]. The P&T system was able to meet the cleanup goal on the west side of Racoon River, and contain and treat the on-site plume. However, TCE concentrations in on-site extraction wells remain above the remedial goal of 5 µg/L, with concentrations in well ERW-6 remaining in excess of 2,600 µg/L.
- Because groundwater concentrations of TCE have remained at elevated levels after nine years of groundwater extraction, the presence of a subsurface source zone, potentially a residual or sorbed DNAPL within the saturated zone, is suggested.
- Initial estimates of contaminant mass released predicted that less than 10 gallons of pure TCE would be removed from the aquifer [7]. In contrast, more than 2,800 gallons of contaminants have been removed as of December 1996, 80% of which is TCE.
- Dico has submitted a "Petition for Reimbursement of Costs" to the U.S. EPA for remedial costs incurred in addressing a northern plume of contamination. Dico claims that an off-site source has contributed to groundwater contamination that is flowing onto the Des Moines TCE site. Dico estimates that 29% of all costs incurred are attributed to the northern plume. This argument is made based on the fact that 2 of the 7 wells used in the remedial design for this site are placed in an area deemed the northern plume area. Dico claims that the northern plume was created by other parties to the north of their property [12]. The petition is in court at this time and no ruling has been made.

REFERENCES

1. Performance Evaluation Report No. 1 (December 1987 through March 1988), Aware, Inc. April 1988.
2. Performance Evaluation Report No. 3 (June 1988 through January 1989), Eckenfelder, Inc. May 1989.
3. Performance Evaluation Report No. 4 (January through December 1989), Eckenfelder, Inc. February 1990.
4. Performance Evaluation Report No. 8 (January through December 1993), Eckenfelder, Inc. July 1994.
5. Performance Evaluation Report No. 10 (January through December 1995), Eckenfelder, Inc. June 1996.
6. Progress Report for October 1996, Des Moines TCE Site, Eckenfelder, Inc. December 1996.
7. Remedial Action Report for Ground Water Treatment at the Des Moines TCE Site, U.S. EPA Region VII. July 21, 1992.

REFERENCES (CONT.)

8. Case Studies and Updates, U.S. EPA, "Case Study 3, Des Moines TCE." March 25, 1992.

9. Record of Decision, U.S. EPA, Des Moines TCE. July 1986.

10. Correspondence with U.S. EPA Remedial Project Manager, Mary Peterson, Region VII, March 4, 1997.

11. Groundwater Regions of the United States. Heath, Ralph. U.S. Geological Survey Water Supply Paper 2242. 1984.

12. Petition for Reimbursement of Costs, July 8, 1988. Dico, Inc.

13. Dense Nonaqueous Phase Liquids, Huling, Scott G. and J. W. Weaver. U.S. EPA. March 1991.

14. Groundwater Remedial Cost Estimates, prepared for Des Moines TCE Superfund Site, U.S. EPA, Unpublished.

15. Correspondence with Mr. Glen Curtis, former Remedial Project Manager, 3-4-97.

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.