Case Study Abstract

Pump and Treat of Contaminated Groundwater at U.S. Department of Energy, Kansas City Plant Kansas City, Missouri

Site Name:
U.S. Department of Energy (DOE)
Kansas City Plant

Location:
Kansas City, Missouri

Contaminants:
Chlorinated Aliphatics; includes Tetrachloroethene (PCE), Trichloroethene (TCE), 1,2-Dichloroethenes (1,2-DCEs), and Vinyl Chloride
PCBs, Petroleum Hydrocarbons, and Metals
- TCE concentrations of > 10,000 µg/L in groundwater
- Presence of DNAPLs suspected

Period of Operation:
Status: Ongoing
Report covers - 5/88 to 2/94

Cleanup Type:
Full-scale cleanup (interim results)

Vendor:
Allied Signal, Inc.

SIC Code:
9711 (National Security)
3724 (aircraft-engine manufacturing)

Technology:
Groundwater Extraction with Advanced Oxidation Processes (AOPs)
- 14 extraction wells and one trench; screened intervals of wells ranged from 27 feet to approximately 47 feet below ground surface; flow rates ranged from 0.9 to 5 gallons per minute (gpm) based on a design flow rate of 2 gpm
- Interceptor trench of 250 ft. in length; ranged in depth from about 22 ft. to 31 ft.
- Treatment system - acidification to solubilize inorganic metals, bag filtration, UV/peroxide oxidation, and neutralization
- Initial AOP - UV/Ozone/Peroxide system replaced in May 1993 with a high intensity UV/Peroxide system

Cleanup Authority:
RCRA Corrective Action and Other: Kansas City Water and Pollution Control Department

Point of Contact:
G.P. Keary
Environmental Restoration Program Manager
DOE Kansas City Plant
Kansas City, MO

Waste Source:
Manufacturing Process

Type/Quantity of Media Treated:
Groundwater
- 11.2 million gallons treated (1993)
- Horizontal/Vertical distribution of VOCs in groundwater - up to 4,000 ft. horizontal and over 40 ft. vertical
- Alluvial deposits underlain by bedrock consisting of sandstone and shale
- Shale is relatively impermeable
- Porosity of aquifer is 20%
- Horizontal Hydraulic Conductivity of aquifer is 1.1 to 2.3 ft/day; sandstone is 0.04 to 0.005 ft/day; underlying shale is impermeable in water

Purpose/Significance of Application:
Full scale remediation of groundwater contaminated with VOCs using advanced oxidation processes (UV/peroxide).

Regulatory Requirements/Cleanup Goals:
- Final cleanup goals for site have not been established at time of report; will be set subsequent to RFI/CMS activities
- Treated groundwater discharged to municipal sewer system must meet requirements of permit issued by the Kansas City Water and Pollution Control Department; for organics - total organic halogen 0.16 mg/L; metals - 0.69 to 100 mg/L

Case Study Abstract

Pump and Treat of Contaminated Groundwater at U.S. Department of Energy, Kansas City Plant Kansas City, Missouri (Continued)

Results:

As of February 1994:
- Influent VOC concentrations to UV/Peroxide treatment system were 10.6 mg/L with an average influent concentration of 25 mg/L; effluent concentrations were 0.01 mg/L
- The UV/peroxide system destroyed > 99.95% VOCs
- PCBs were detected at levels up to 0.3 µg/L in influent to UV/peroxide unit; not detected in effluent
- VOC contaminant plume appears to be contained
- No significant change in VOC groundwater concentrations at this time

Cost Factors:
- Total Capital Costs: $1,383,400 (including equipment, site preparation, construction/engineering, startup)
- Annual Operating Costs: $355,200 (including maintenance, project management, laboratory analysis, supplies)
- An estimated total cost for completing the cleanup is not available at this time.

Description:

The U.S. Department of Energy (DOE) Kansas City Plant, constructed in 1942, has been used for aircraft engine manufacturing, production of nuclear weapons components, and defense-related research and manufacturing operations. During the 1980s, hydrogeologic investigations identified soil and groundwater contamination at the site which had resulted from releases from the research and manufacturing operations. The primary contaminants detected included chlorinated VOCs, aromatic VOCs, PCBs, and metals. DNAPLs are suspected in the groundwater, but have not been detected at this time. Final cleanup goals have not been established at this time. Treated water from the system is discharged to the municipal sanitary sewer system under the provisions of a Kansas City Water and Pollution Control Department wastewater discharge permit (2/88).

Operation of a groundwater pump and treat system, which includes an Advanced Oxidation Process (AOP), began in May 1988 under RCRA corrective action. The initial system included 14 extraction wells followed by a low intensity Ultraviolet (UV)/Ozone/Peroxide treatment system. This system was replaced in May 1993 by a high intensity UV/Peroxide system to provide additional 30 GPM treatment capacity for groundwater and to correct operational problems with the initial unit (equipment malfunctions and downtime). While the cleanup is ongoing at this time and final performance data are not yet available, interim results indicate that the extraction system appears to be containing the VOC contaminant plume. However, the concentrations of VOC in the groundwater have not changed significantly.

The total capital costs for this application were $1,383,400 and the annual operating costs were $355,200. With respect to the AOP, the replacement of the low intensity UV/ozone/peroxide system with the high intensity UV/peroxide system resulted in both increased treatment capacity and cost savings while meeting the discharge limits for the treated water. The high intensity UV/peroxide system eliminated the need for GAC polishing and treatment of air emissions and reduced operation and maintenance costs. Although more expensive than alternatives such as air stripping, AOP was selected because it destroys the contaminants rather than transferring contaminants to other media.

TECHNOLOGY APPLICATION ANALYSIS

SITE

U.S. Department of Energy
Kansas City Plant (KCP)
A RCRA Corrective Action Site
Kansas City, Missouri

TECHNOLOGY APPLICATION

This analysis covers an effort to **pump and treat groundwater** contaminated with volatile organic compounds **(VOCs)** by above ground **advanced oxidation processes (AOPs)**. The treatment began in May 1988 and is currently ongoing. This analysis covers performance through February 1994.

SITE CHARACTERISTICS

Site History/Release Characteristics

- The KCP is located within the Bannister Federal Complex approximately 13 miles south of downtown Kansas City, Missouri. The complex is bordered on the east by the Blue River and on the south by Indian Creek.
- Constructed in 1942 as an aircraft engine manufacturing facility, the KCP is part of the U.S. Department of Energy's (DOE) Albuquerque Operations Office. The Atomic Energy Commission, predecessor to the DOE, began production of components for nuclear weapons at the KCP in 1949. Subsequent defense related research and manufacturing operations resulted in the release of contaminants to the subsurface.
- A series of hydrogeologic investigations initiated in the early/mid 1980s revealed elevated contaminant concentrations (primarily chlorinated VOCs) in soil and groundwater.
- A groundwater pump and treat system, the subject of this report, started operation in May 1988. That system was designed as an interim remedial measure to prevent further migration of VOC-contaminated groundwater while additional RCRA Facility Investigation (RFI) and Corrective Measures Study (CMS) efforts to define final site remedial measures were being performed. A low intensity Ultraviolet (UV)/Ozone (O_3)/Hydrogen Peroxide (H_2O_2) treatment system operated until May 1993 when it was replaced by a high intensity UV/H_2O_2 system. The initial system was a demonstration of first-generation AOP technology; the replacement system is considered second-generation technology.

Contaminants of Concern

Contaminants identified as being of greatest concern in groundwater at the KCP are:

Tetrachloroethene	(PCE)
Trichloroethene	(TCE)
1,2-dichloroethenes	(1,2-DCEs)
Vinyl chloride	

Other contaminants detected in soil or groundwater include aromatic and halogenated VOCs, petroleum hydrocarbons, PCBs and selected metals.

Arsenic, present at concentrations higher than drinking water standards, was determined to be the result of natural geochemical processes.

Contaminant Properties

Properties of contaminants focused upon during remediation are:

Properties*	Units	PCE	TCE	1,2-DCEs**	Vinyl Chloride
Density	-	1.62	1.46	1.25/1.27	0.91
Vapor Pressure	mm Hg	95.2	28.1	7	245
Henry's Law Constant	atm-m^3/mole	0.0259	0.0091	0.0066/ 0.0076	0.0144
Water Solubility	mg/l	150	1,100	2,250/3,3500	2,670
Octanol -Water Partition Coefficient; K_{ow}	-	398	240	3/5	24
Organic Carbon Partition Coefficient; K_{oc}	-	364	126	49/59	57

* *Properties at 20 °C.* ** *Data presented for both cis and trans-isomers.*

Nature & Extent of Contamination

- Characterization of the nature and extent of contamination at the KCP evolved over a number of years of investigation and interim remediation. Thirty-seven solid waste management units were found to have contributed to three primary areas of groundwater contamination known as: the TCE Still Area, the Underground Tank Farm Area, and the Northeast Area/Outfall 001 Area.
- Groundwater contamination is largely confined within the KCP limits. However, chlorinated VOCs have migrated with groundwater along a backfilled stream channel to the Blue River northeast of the KCP.
- The vertical distribution and concentrations of VOCs in soil and groundwater suggest the potential presence of dense non-aqueous phase liquid (DNAPL) in several areas which contribute to groundwater contamination.
- The presence of numerous subsurface utilities/utility trenches, including building footing tile drains, have a significant impact on contaminant migration at the KCP site. These utilities act as sources of recharge water, preferential migration pathways, and collectors for contaminated groundwater.

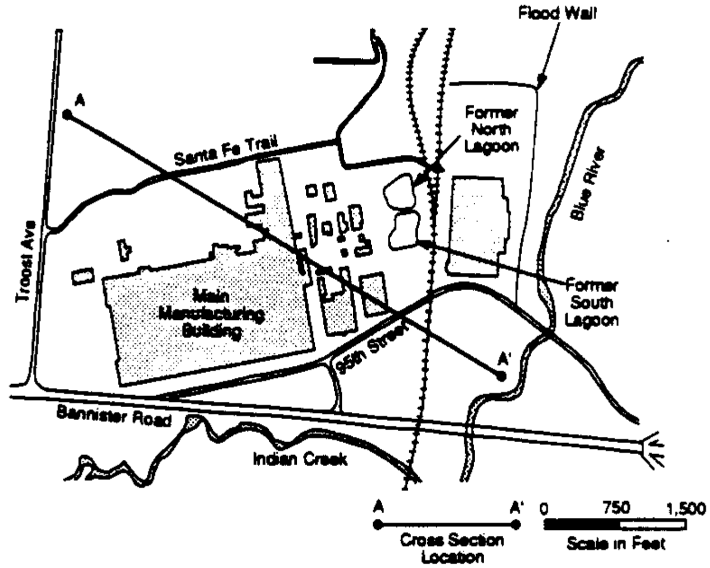
Contaminant Locations and Geologic Profiles

Remedial investigation field activities at the site have included:

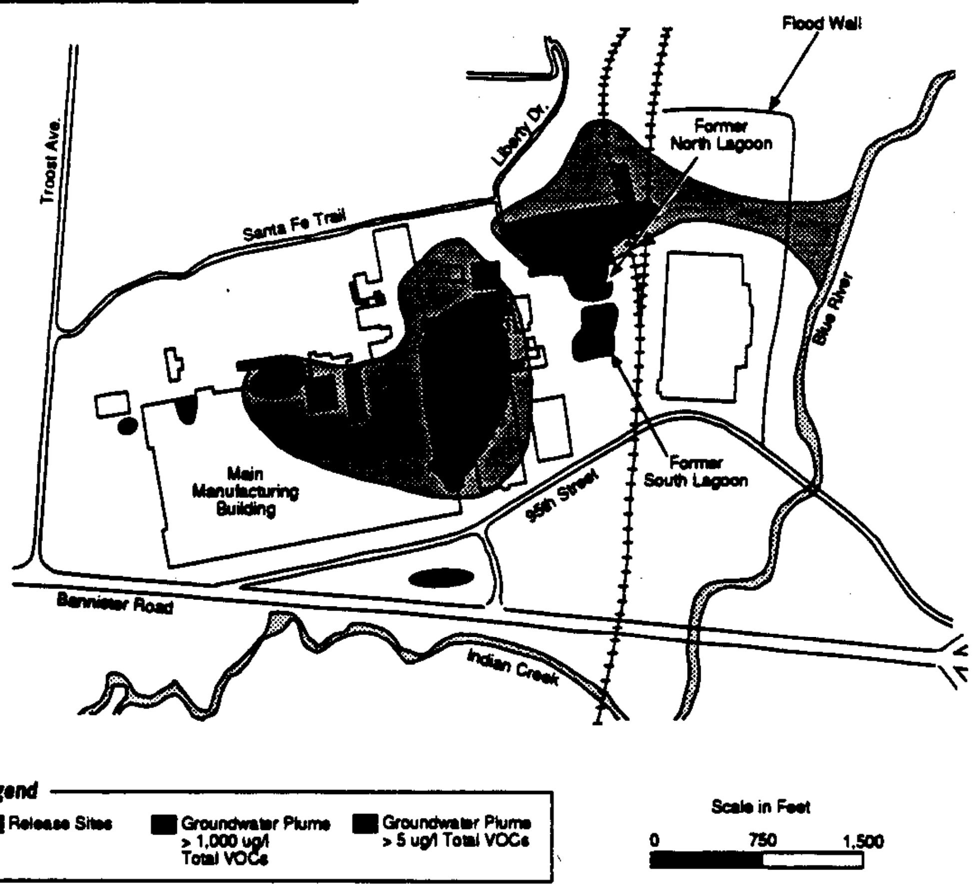
- Borings and subsurface soil sampling
- Monitoring well installation and groundwater sampling
- Groundwater elevation measurements
- Geophysical testing
- Water source/sink assessment
- Hydraulic tests
- Borehole packer testing
- Surface water sampling and elevation measurements
- Groundwater modeling

Data from ~200 soil borings and ~190 monitoring/extraction wells were used to develop an understanding of subsurface conditions, including contaminant migration. Selected data from site studies have been used in this report to depict site conditions.

Site Layout (Plan View)



Horizontal Distribution of VOCs in Groundwater - Generalized Representation (Plan View)



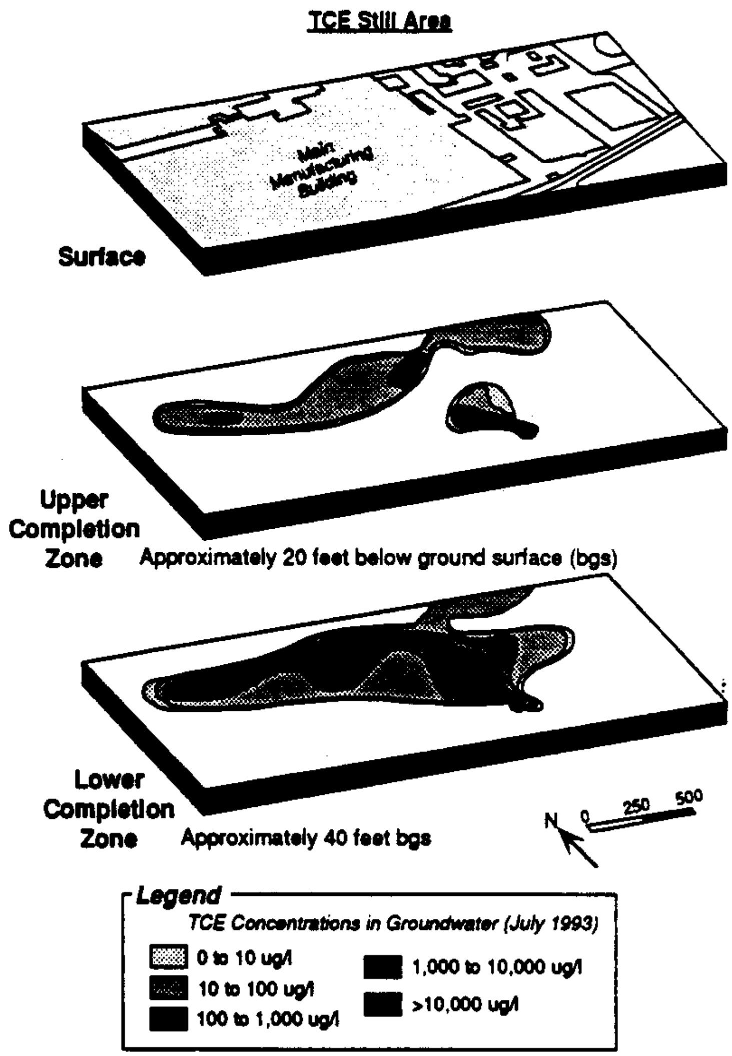
Contaminant Locations and Geologic Profiles (Continued)

Vertical Distribution of VOCs in Groundwater

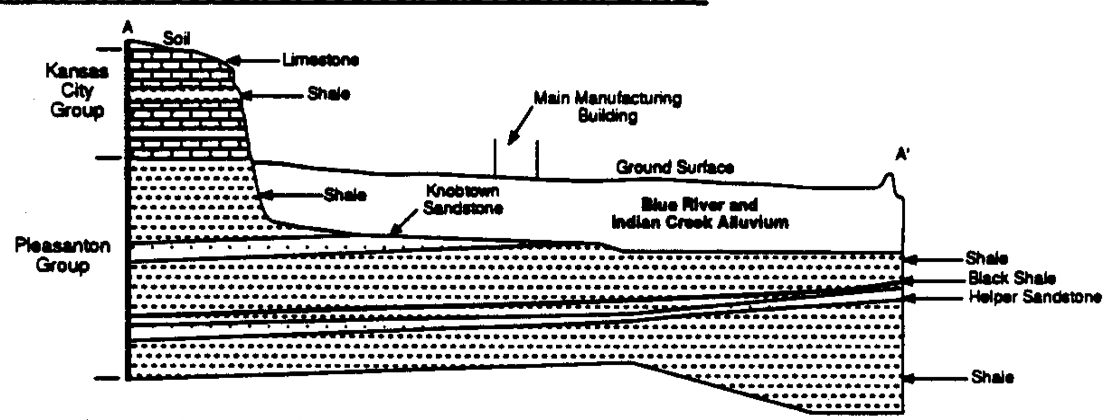
• In general, concentrations of prime contaminants of concern in groundwater increase with depth in overburden soils at the KCP site. Dense non-aqueous -phase liquid(s) (DNAPL) may be present in some areas. The figure below, illustrating TCE concentrations in groundwater at one of the 3 primary contamination areas (the TCE Still Area), is representative of the vertical distribution of chlorinated VOCs at the KCP site.

• Alluvial deposits at the KCP site are under lain by bedrock consisting of alternating layers of sandstone and shale. A thin layer of sandstone (< 10 feet thick) immediately beneath the alluvium pinches out beneath the site. Packer testing performed on the shale indicated it was relatively impermeable. No bedrock migration of VOCs has been observed.

• Because the bedrock surface dips in the opposite direction as alluvial groundwater flow, additional monitoring wells were completed within the shallow sandstone at the request of EPA to monitor for the potential migration of VOCs. No VOCs or dissolved-phase contamination have been detected in these wells. Additionally, contaminant transport modeling predicted that VOCs (if present) would migrate at an average rate of < 1 foot per year under worst-case conditions in the sandstone.



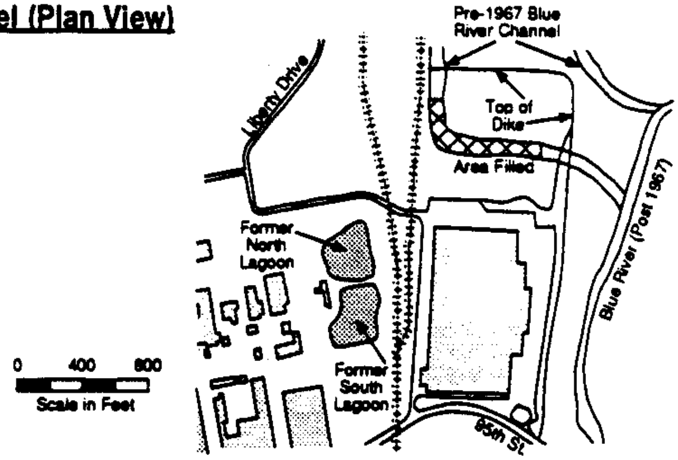
Schematic Cross-Section of Bedrock and Alluvium at KCP



Notes: Cross section is not to scale.
Cross section location shown on site map (page 2).

Location of Old Blue River Channel (Plan View)

The former Blue River channel, now filled, has a hydraulic conductivity an order of magnitude greater than the surrounding soil. This former river channel is serving as a preferential pathway for migration of contaminated groundwater from the Northeast Area/001 Outfall to the current location of the Blue River.



Groundwater Sinks and Sources

Several site structures (in addition to the extraction wells and interceptor trench) serve as sinks/collectors for groundwater on the KCP site and impact contaminant migration. Groundwater drains include: the 001 Outfall Interceptor system [~6,000 gallons per day (GPD)], which is a collection system to prevent groundwater infiltration into an NPDES storm sewer, a sump for the building southwest of the former South Lagoon, building footer drains, and possibly the plant sewer lines. Building drains control the surface of the water table in the vicinity of the Main Manufacturing Building.

In addition to recharge due to infiltrating precipitation, it is believed that leaking underground water and steam lines could be serving as a source of water to the subsurface. The KCP has initiated a study to quantify artificial sinks and sources of water in the subsurface at the KCP site.

Site Conditions

- The KCP is situated in the Blue River Valley about 800 feet above Mean Sea Level (MSL) and is in the 100-year flood plain of the both the Blue River and Indian Creek. However, a 500 year event floodwall protects the site.
- Approximately 46% of the site is covered by grass or gravel and is available for recharge. The site receives ~ 34 inches of precipitation per year.
- The topography of the complex is flat-lying except where it drops ~ 30 feet along the Blue River and Indian Creek and where it rises ~ 50 feet north of the KCP site.
- The Pennsylvanian bedrock (shales) in the vicinity of the KCP is noted for its uniformity. There are no structural features such as faults, that affect the KCP site. No fractures were observed in bedrock (shale) cores performed at the KCP site.
- The surface of the bedrock at the KCP site slopes to the east, reflecting surface topography. However, the slope or dip of individual layers (sandstones and shales) is to the west. Site lithologic logs indicate the presence of ~1 to 3 feet variation in the elevation of the bedrock surface.
- Groundwater flow at the KCP site is primarily to the east and discharges to the Blue River and Indian Creek. A portion of the KCP site groundwater flow is to the south.

Key Aquifer Properties

Aquifer parameters for the alluvial deposits at the KCP site have been estimated as:

Property	Units	Tank Farm	South Lagoon	Northeast Area
Porosity	%	20	20	20
Hydraulic Gradient	ft/ft	0.002	0.008	0.007 to 0.02
Horizontal Hydraulic Conductivity*	ft/day	2.3	1.1	1.5
Groundwater Velocity	ft/yr	8.4	16	19 to 55
Storage Coefficient**	-	0.002	0.0005	0.002

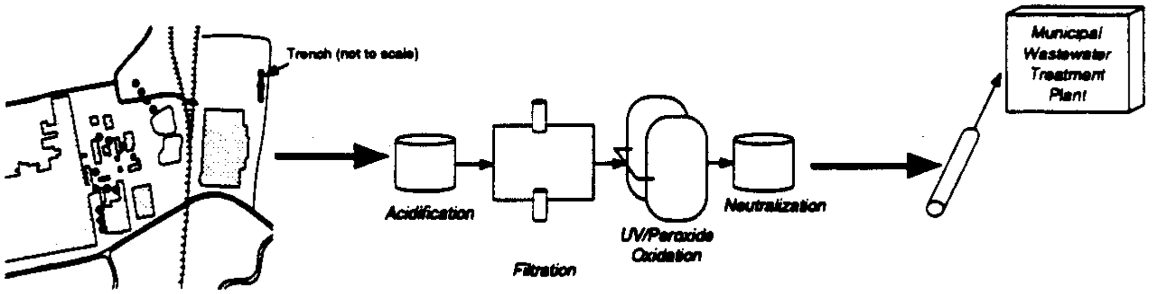
* Based on pumping test data. Conductivities calculated from bail and slug test data were ~ one order of magnitude lower.
** Low values are reflective of the fine-grained nature of the aquifer materials.

The horizontal hydraulic conductivity of the shallow (knobtown) sandstone is 0.04 to 0.005 ft/day. The underlying shale is impermeable to water.

REMEDIATION SYSTEM

Overall Process Schematic

Extraction Well Network and Trench | **Replacement Treatment System** | **Discharge to Sanitary Sewer**

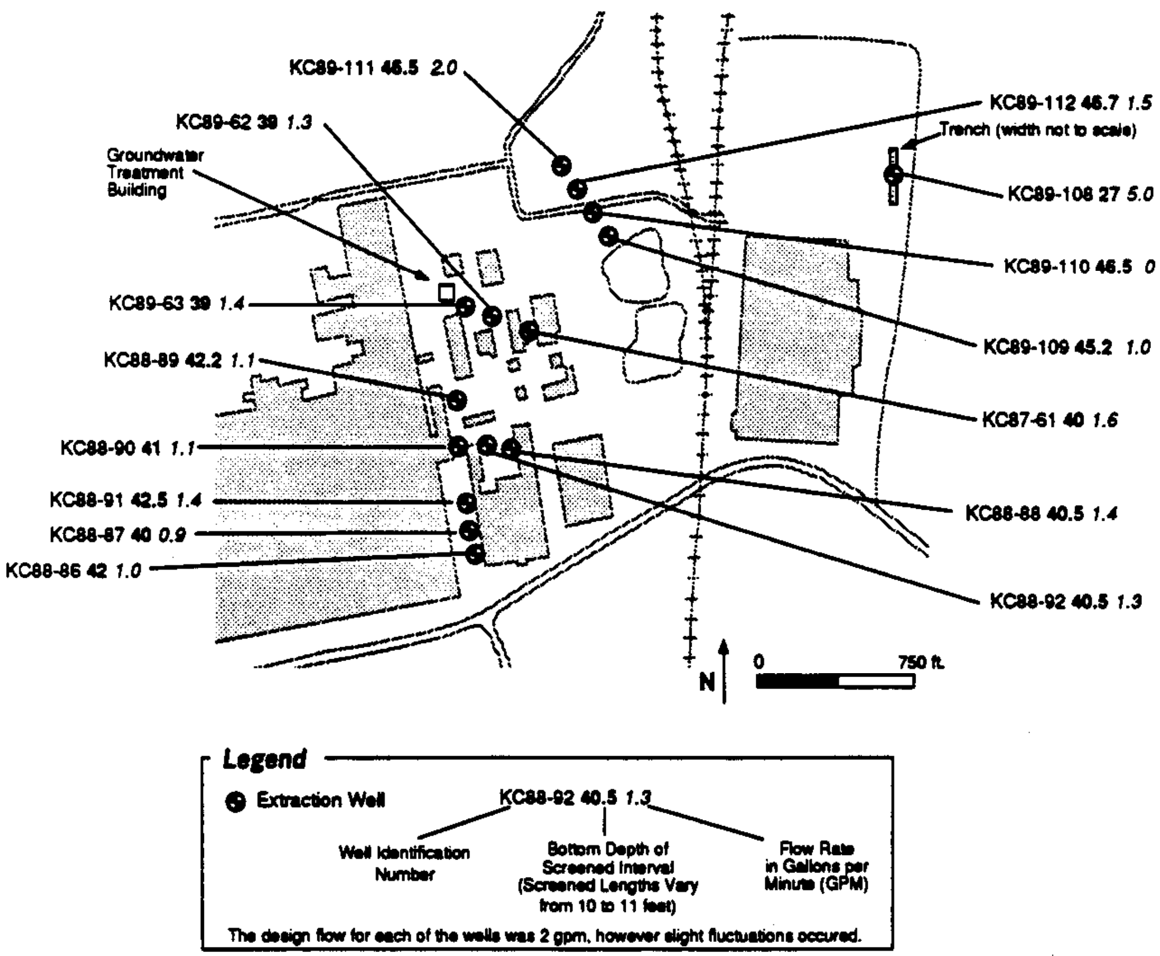


Fourteen extraction wells and one trench installed in three phases (1987, 1988, and 1989).

Acidification to solubilize inorganic metals, bag filtration, (UV/peroxide) oxidation of organic contaminants in one of two reactors, and subsequent neutralization.

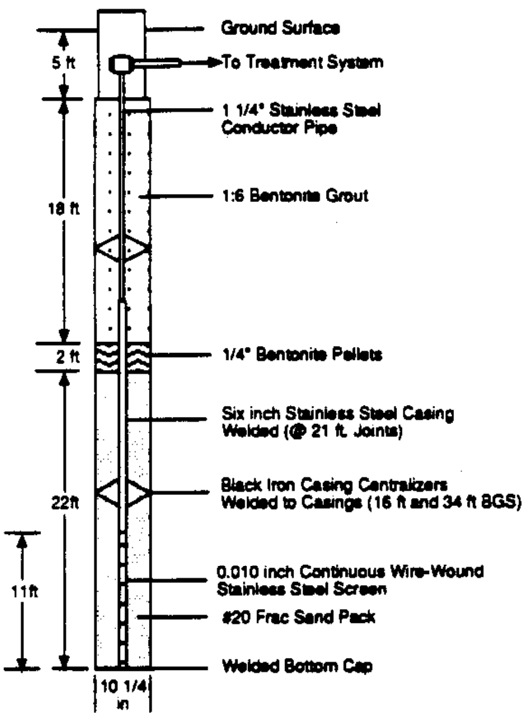
Discharge treated water to municipal wastewater treatment plant.

Extraction Well Network



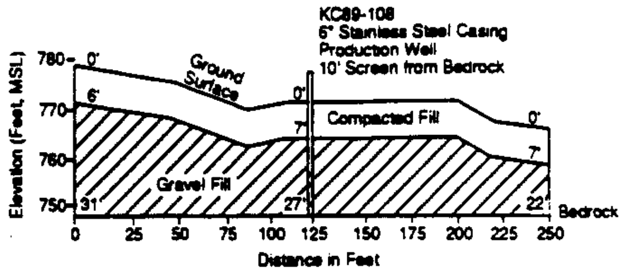
Extraction Well Detail

Typical extraction well (KC89-112)



NOTES: 1.) Some extraction wells completed with subsurface vaults
2.) Submersible pumps with stainless steel impellers in each well

Interceptor Trench Schematic



Key Design Criteria

- Hydraulic containment of VOC-contaminated groundwater
- Handle range of flow rates to allow for operational flexibility
- Destruction of organic contaminants in extracted groundwater rather than transfer to another media
- Redundant treatment capability to maintain hydraulic containment in the event of unanticipated breakdown, and to provide for treating increased flow rates during future-final site remediation

Key Monitored Operating Parameters

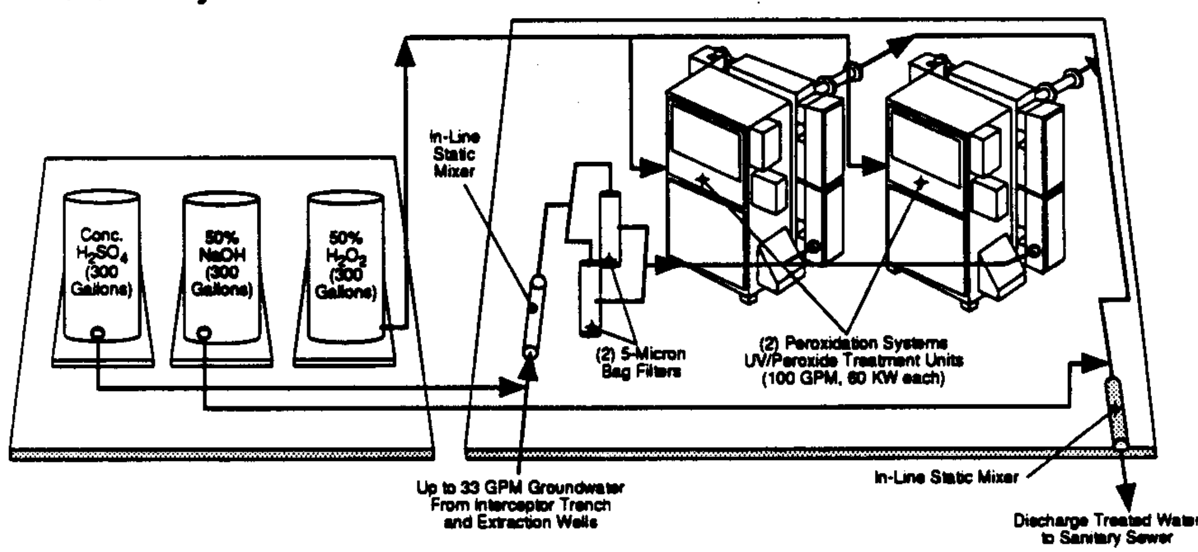
- Groundwater elevations
- Groundwater VOC concentrations

(to assess containment system performance)

- Water flow rates
- Temperature, pressure, and pH
- UV and H_2O_2 dosage
- Filter pressures
- Influent/effluent contaminant concentrations

(to assess treatment system operation and effectiveness)

Treatment System Schematic



PERFORMANCE

Performance Objectives

- Prevent further migration of VOC-contaminated groundwater from 3 areas of identified contamination
- Design and operate treatment system to decrease VOC concentrations in extracted groundwater to below sewer discharge limits

Remedial Action History/Plan

Remediation at the KCP site is being implemented in a phased manner. The following groundwater-related interim remedial actions have been performed to date:

1988 Initiated pumping of groundwater (6 GPM) from Underground Tank Farm Area and treatment with $UV/O_3/H_2O_2$ system as interim measure and to demonstrate treatment technology

↓

1990 Treatment of additional 14 GPM from TCE Still Area and 13 GPM from Northeast Area/001 Outfall using the same treatment system with additional Aqueous-Phase Granular Activated Carbon (GAC) polishing

↓

1993/1994 Second-generation UV/H_2O_2 treatment system installed to provide capacity for treating an additional 30 GPM (approximate) of groundwater from the 001 Outfall Area, and to provide additional operational and environmental benefits

Overall Performance Summary

Conclusions drawn after 5 (plus) years of operating the interim pump and treat system are summarized below:

- The extraction system appears to have been effective in substantially containing VOC-contaminated groundwater emanating from the KCP site. The KCP expects to begin extracting up to an additional 30 GPM of VOC-contaminated groundwater to prevent its infiltration into the 001 Outfall storm sewer line during 1994.
- The concentrations of VOCs in groundwater and the extent of contamination has not changed considerably in the TCE Still Area, Underground Tank Farm Area or the Northeast Area/001 Outfall since initiating the Interim Remedial Action.
- While the initial AOP treatment system met discharge limits, ozone leaks, the need to treat air emissions and significant downtime required for maintenance contributed to the decision to change to the high-intensity UV/H_2O_2 AOP. The new AOP system has also operated within discharge limits.

Operational Performance

Volume and Rate of Water Pumped/Treated

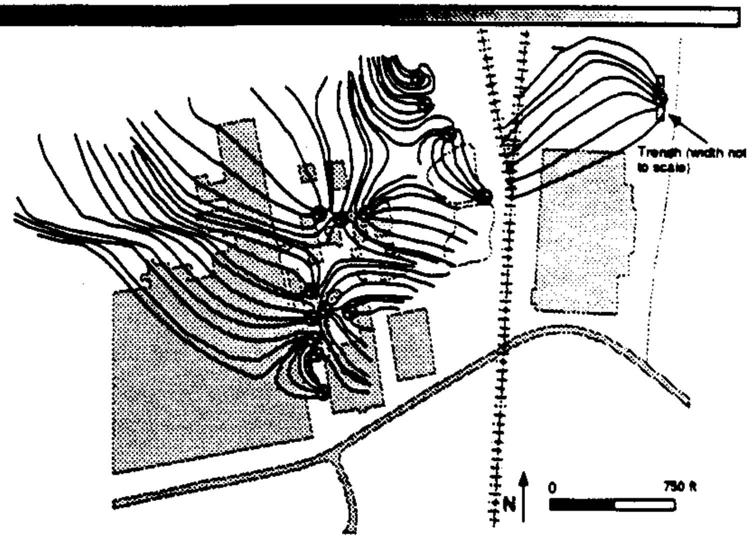
- During 1993, a total of approximately 11.2 million gallons of groundwater water was extracted and treated by the interim system. Of this total, ~2.2 million gallons was extracted from the Underground Tank Farm Area ~4.5 million gallons from the TCE Still Area and ~4.5 million gallons from the Northeast Area/001 Outfall.
- The average daily flow rate for the entire interim system in 1993 varied from a high of 32 GPM in January to < 2 GPM in July, during treatment unit replacement.

System Downtime

- Numerous equipment malfunctions and a significant amount of downtime occurred during the first 15 months (May 1988 - July 1989) of continuous operation of th $UV/O_3/H_2O_2$ system. The system operated > 65%of the time in 1988 except during September when it was shut down for equipment modifications. The interim system operated 61% of the time in 1989 except during June when it was down for servicing modifications by the manufacturer. Except during downtime periods for construction, equipment, modifications and frozen pipes, and the $UV/O_3/H_2O_2$ system operated > 90% of the time from 1990 until May 1993 when it was replaced by the high intensity UV/H_2O_2 system.
- The replacement UV/H_2O_2 system commenced continuous operation in August/September 1993. This treatment system has operated > 95% of the time. Much of the maintenance that required the prior treatment system to be shut down can now be performed while the replacement system remains operational.

Hydrodynamic Performance

• A modeling evaluation performed in May 1992 concluded that the extraction system was substantially containing the three primary groundwater VOC plumes at the KCP site. The planned addition of supplemental extraction wells near Outfall 001 is intended to decrease infiltration of contaminated groundwater into storm sewer lines to comply with NPDES permit effluent standards.



Effect on In Situ Contaminant Concentrations

While the pump and treat system has removed a substantial mass of VOCs from the subsurface, statistically significant changes of in situ groundwater VOC concentrations have not occurred.

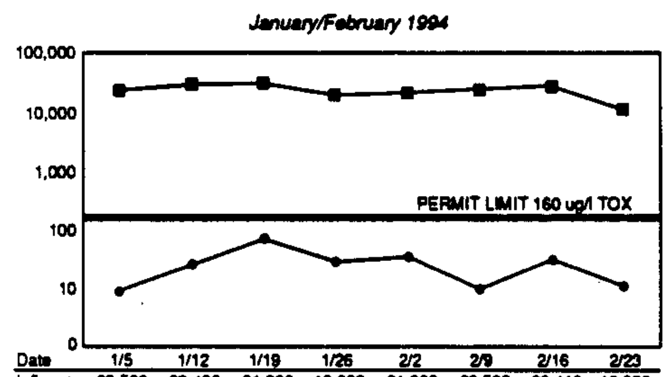
Treatment System Performance

• The original UV/O_3/H_2O_2 treatment system was replaced with the high intensity UV/H_2O_2 in May 1993 to provide capacity to treat an additional 30 GPM from the 001 Outfall Area. Despite the on-going maintenance problems, the UV/O_3/H_2O_2 treatment system routinely met permit discharge limits at a flow rate ~ 6 GPM from 1988 until 1990. The sewer discharge limit for total organic halogens was exceeded on 2 occasions in 1990 as a result of the adding of ~ 27 GPM of groundwater extracted from the TCE Still Area and the Outfall 001/Northeast Area. The original system was designed to handle only 25 GPM of water containing VOCs at concentrations higher than predicted by an Interim Corrective Measure Study. Aqueous-phase granular activated carbon (GAC) polishing of the UV/O_3/H_2O Unit effluent was added in the late 1990 to remove residual organics prior to discharge. An in-line filter was installed and backwashing instituted to extend the life of the GAC by removing iron and manganese that precipitated following oxidation in the AOP reactor.

• Following successful completion of a rigorous acceptance testing program of the replacement UV/H_2O_2 system during late 1992, the system was placed into operation during May 1993. As illustrated in the following graph, total VOC concentrations in the replacement system effluent have been well below the sewer discharge limit. The on-going maintenance problems experienced with the initial system have been eliminated.

UV/Peroxide Treatment System Performance

January/February 1994



Date	1/5	1/12	1/19	1/26	2/2	2/9	2/16	2/23
Influent	23,500	30,400	31,000	19,600	21,000	23,500	26,410	10,600
Effluent	9	25	67	27	32	9	28	10

Method Detection Limit = 5 ug/l   All results ug/l total VOCs

• The initial UV/O_3/H_2O_2 system destroyed ~ 94.6% VOCs; ~3.7% were emitted to ambient air and ~ 1.7% were discharged to the sanitary sewer system. The replacement UV/H_2O_2 system destroyed > 99.95% VOCs; ~< 0.05% are discharged to the sanitary sewer system and there are no emissions.

• The system is designed to treat up to 30,000 ug/l. Influent averaged approximately 25,000 ug/l.

• Up to 0.3 ug/l PCBs have been detected in the UV/H_2O_2 treatment system influent. PCBs have not been detected in the treated groundwater discharged to the sanitary sewer.

Legend
■ Influent VOC Concentration —●— Effluent VOC Concentration

COST

• Although advanced oxidation was more expensive then other alternatives such as air stripping/GAC, it was selected because of its waste minimization benefits. With advanced oxidation the contaminants are destroyed, and not transferred to another media.

• The selection of the high intensity UV/H_2O_2 treatment to replace the UV/H_2O_2 was due in part to cost savings associated with: eliminating GAC polishing, eliminating the need to treat air emissions, and reduced operation and maintenance labor and expenses.

• Capital and operating costs for the replacement UV/H_2O_2 system is presented below. Operating costs for treatment (including replacement parts, laboratory analysis, utilities, labor, and raw materials) calculated by Oak Ridge National Laboratory were $15.51/1,000 gallons for the first-generation UV/O_3/H_2O_2 demonstration unit and are projected to be $13.80/1,000 gallons for the second-generation UV/H_2O_2 replacement units once the additional 001 Outfall extraction system commences operation. The costs presented below are based on actual costs spent from fiscal years 1987 to 1994; the cost figures are not in constant dollars.

Capital Costs

Extraction Wells, Vaults, Pumps, Piping, Trenching, Electrical Conduit, & Utilities	$1,213,900
Bag Filter Units (2)	4,500
Tanks (3)	1,700
Treatment Buildings (site preparation, construction, and engineering), 3 original extraction wells	126,000
Control Systems	2,300
Equipment Installation	20,000
Startup (including acceptance testing)	15,000
Total Capital Cost	**$ 1,383,400**

Operating Costs

Electrical Power	$ 25,300
Maintenance	
Labor	52,200
Equipment Repair and Replacements[a]	3,300
Engineering Support and Project Management	44,200
Laboratory Analysis (Influent/Effluent)	78,000
Monitoring Well Analysis	110,000
Consumables	
Hydrogen Peroxide 3,600 gallons/year @ $4.00/gallon	14,400
Sulfuric Acid 3,600 gallons/year @ $1.09/gallon	3,900
Caustic 7,200 gallons/year @ $1.91/gallon	13,800
Bag Filters	700
Extraction Pump and Motor Assembly Replacement (2/year)	1,200
Transport and Disposal of Spent Filters and Personal Protective Equipment	500
Extraction Well Rehabilitations	
Chemical Treatment	5,300
Redevelopment	2,400
Total Annual Operating Cost	**$ 355,200**

[a] Average annual cost of equipment repair and replacement costs from 1983 to 1994, including costs associated with system start-up and the purchase of spare parts.

REGULATORY/INSTITUTIONAL ISSUES

• The KCP Site investigation is being performed in accordance with a U.S. Environmental Protection Agency RCRA 3008 (h) Administrative Consent Order in 1989. Initial investigation efforts, and the extraction and treatment of groundwater from the Underground Tank Farm Area were performed as voluntary actions in 1988 with EPA cognizance

• Treatment of extracted groundwater using $UV/O_3/H_2O_2$ was initiated in 1988 as a demonstration of one of the first full-scale operating AOP systems. A rigorous program of pilot testing and long term performance monitoring was implemented to assure regulators of the effectiveness of this treatment technique and to develop data on long-term reliability and operation and maintenance costs. The second generation UV/H_2O_2 that replace the $UV/O_3/H_2O_2$ system in 1992 also underwent rigorous prove-in testing in accordance with a Startup Plan approved by EPA and the City of Kansas City, MO.

• Treated water is discharged to the municipal sanitary sewer system under the provisions of a wastewater discharge permit issued by the Kansas City Water and Pollution Control Department in February 1988. Discharge limits are summarized below:

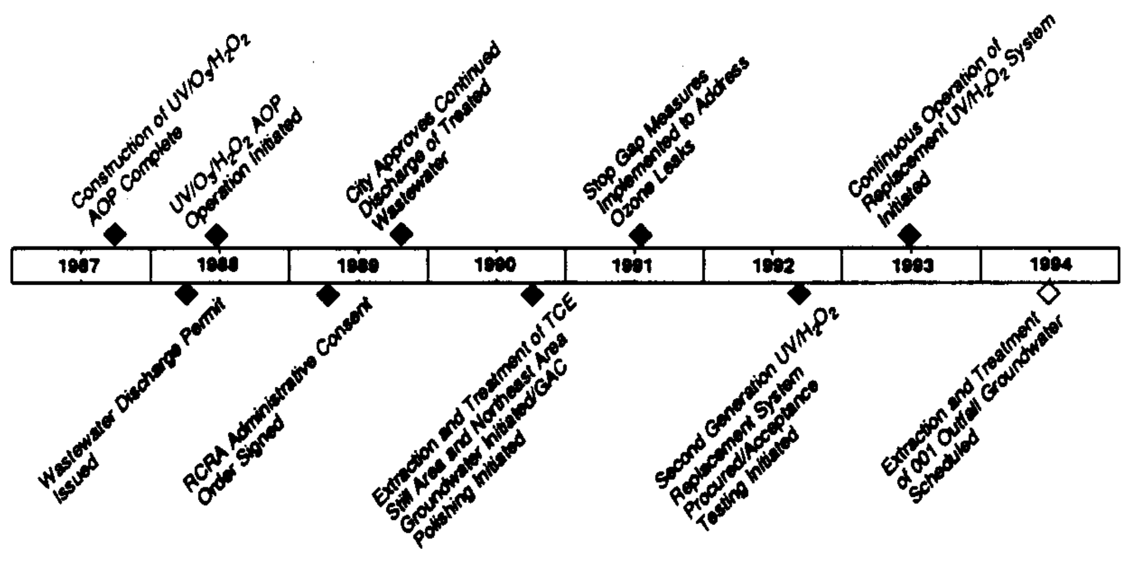
Parameter	Concentration (mg/L)	Parameter	Concentration (mg/L)
Cadmium	0.69	Arsenic	0.250
Chromium	2.77	Total Organic Halogen	0.16
Copper	3.38	Sulfides	10.0
Lead	0.69	Oil and Grease	100
Nickel	3.98	Total Cyanide	2.0
Zinc	2.61		
Iron	100.00		
Manganese	20.00		
Boron	1.00		

• Final cleanup goals have not yet been established for the site. Cleanup goals will be set subsequent to completing RFI/CMS activities.

SCHEDULE

Major Milestones

◆ *Completed Activities* ◇ *Future Activities*



• Extraction and treatment of groundwater from near the 001 Outfall will be initiated following NEPA review and obtaining approval from a railroad to a pipe groundwater beneath an active rail line that crosses the KCP site.

LESSONS LEARNED

Implementation Considerations

• An understanding of the extent of contamination at this site has evolved over a decade of investigation, monitoring, and remediation. Defining the extent of contamination has focused on determining the need for remediation in specific areas of the site, selecting and designing remedies, and evaluating the effectiveness of implemented remedial actions.

• Monitoring data and modeling results suggest that predicting the rate of aquifer restoration my be complicated due to hydrogeologic variability caused by leaking underground utilities, building footing tile drains and other anthropogenic factors and the likely presence of DNAPL(s) in a a number of areas of the site.

• Initiating an interim remedial action provided for hydraulic containment of VOCs dissolved in groundwater while the full extent of contamination and supplemental remedial actions are defined.

• Extraction flow rates must be manually adjusted at the individual well heads. The ability to control flows from the central treatment system building would eliminate difficulty in performing this task.

• Substantial and frequent fouling of the extraction system wells with bacterial slime and oxides of naturally-occurring iron and manganese have resulted in the need for frequent chemical treatment and redevelopment of wells, and repair/replacement pumps, pump motors and water level probes.

• Vaults and pipe conduits allow oxygenated rainwater to drain into extraction wells through vent tubes, contributing to the growth of bacterial slime and need for more frequent well treatment/redevelopment. Modifications made to minimize this concern have included installation of berms and drainage systems around selected well vaults. Measures to epoxy seal openings in the piping conduit are being investigated.

• The initial $UV/O_3/H_2O_2$ treatment system was not designed to adequately handle the flow rate and VOC concentrations realized with the interim containment system. The replacement UV/H_2O_2 treatment system was designed to handle a wider range of flow rates and concentrations to provide operational flexibility.

• The initial $UV/O_3/H_2O_2$ treatment system experienced significant downtime for acid cleaning of filters, ozone sparger tubes and UV lamp sheathes, and GAC backwashing/changeout. The replacement system provides for pH adjustment prior to UV/H_2O_2 treatment to minimize fouling caused in part by oxidation of inorganics.

Technology Limitations

• The initial $UV/O_3/H_2O_2$ treatment system was a first-generation AOP technology installed and operated at the KCP for demonstration purposes. The second-generation (replacement) AOP treatment system, operational since May 1993, has performed well at a lower cost and without the on-going maintenance problems experienced with the initial demonstration system.

• The saturated hydrocarbons present at the KCP site were readily treated by both the initial $UV/O_3/H_2O_2$ and the second-generation/replacement UV/H_2O_2 systems. AOP manufacturers' literature indicates that treatment efficiencies for unsaturated hydrocarbons are much lower.

• UV/H_2O_2 was selected instead of a second-generation $UV/O_3/H_2O_2$ AOP to replace the initial treatment system because systems that employ ozone: require more maintenance (e.g., the ozone generator and delivery system), residual ozone in the headspace of the reaction chamber is corrosive to the chamber, and catalytic oxidation is required to destroy ozone in the air discharge.

Future Technology Selection Considerations

• Greater attention should be paid to the design of extraction well systems that minimize operation and maintenance problems.

• AOP systems can destroy saturated hydrocarbons in extracted groundwater. However, designs must consider the potential for fouling with oxidized inorganics and the implementation of pretreatment measures when appropriate to ensure satisfactory performance and manageable maintenance.

ANALYSIS PREPARATION

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HAZWRAP

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CERTIFICATION

This analysis accurately reflects the performance and costs of the remediation:

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SOURCES

Major Sources For Each Section

Site Characteristics:	Source #s (from list below) 3, 4, 6, 7, 8, 9, and 10
Remediation System:	Source #s 1, 2, 3, 4, 5, 7, 8, 9, and 10
Performance:	Source #s 1, 2, 3, 4, 6, 7, 8, 9, 10, and 11
Cost:	Source #s 1, 2, 8, and 11
Regulatory/Institutional Issues:	Source #s 1, 3, 4, 5, 6, 9, and 11
Schedule:	Source #s 1, 2, 4, 5, 6, 7, and 10
Lessons Learned:	Source #s 1, 2, 4, 6, 7, 10, and 11

Chronological List of Sources and Additional References

1. *Kansas City Plant Groundwater Treatment System Overview*, prepared by AlliedSignal, Inc., Undated.

2. Kansas *City Plant Ultraviolet/Ozone/Hydrogen Peroxide Groundwater Treatment System Overview*, prepared by M.E. Stites, Environment, Safety and Health Department AlliedSignal, Inc., and R.F. Hughes, Energy and Environmental Systems Division, Oak Ridge Associated Universities, Undated.

3. *Tank Farm Interceptor System Evaluation and Treatment Unit Corrective Action Plan - Rev 1*, April 1991.

4. *Groundwater Interceptor System Evaluation, Kansas City Plant*, prepared by Department of Energy, Albuquerque Operations Office, Environmental and Health Division, Environmental Programs Branch, May 1992.

5. *Groundwater Treatment System Interim Measures Plan, U.S. DOE Kansas City Plant*, revised August 1993.

6. *TCE Still Area RCRA Facility Investigation Report - Draft, Kansas City Plant*, prepared by Department of Energy, Albuquerque Operations Office, Environmental and Health Division, Environmental Programs Branch, Environmental Restoration Program, September 1993.

7. *Kansas City Plant Groundwater Remediation*, prepared by AlliedSignal, Inc., October 15, 1993.

8. *Northeast Area/001 Outfall Corrective Measure Study - Draft, Kansas City Plant*, prepared by Department of Energy, January 1994.

9. *Annual Groundwater Monitoring Report for Calender Year 1993, Kansas City Plant*, prepared by Department of Energy, Albuquerque Operations Office, Environmental Programs Branch, Environmental Restoration Program, March 1994.

10. *Data Package Supplied by Mr. Michael E.* Stites, AlliedSignal, Inc., April 25, 1994.

11. *Personal Communications with Michael E. Stites and Joseph L. Baker*, AlliedSignal, Inc. May and June 1994.