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EPA Superfund
Record of Decision:

FORT RILEY
EPA ID: KS6214020756
OU 05
JUNCTION CITY, KS
07/03/2006

Record of Decision

354 Area Solvent Detections (Operable Unit 005) at Main Post Fort Riley, Kansas

June 16, 2006

Prepared for

U.S. Army Corps of Engineers
Kansas City District

Prepared by

Burns & McDonnell
SINCE 1898

Contract Number: DACA41-96-D-8010
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List of Acronyms and Abbreviations

AR	Army Regulation
ARAR	Applicable or Relevant and Appropriate Requirement
BER	Bureau of Environmental Remediation
bgs	below ground surface
BMcD	Burns & McDonnell Engineering Company, Inc.
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene
CCl_4	Carbon Tetrachloride
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
chemox	Chemical Oxidation
CFR	Code of Federal Regulations
cm^2	square centimeters
COC	Chemical of Concern
COPC	Chemical of Potential Concern
COPEC	Chemical of Potential Ecological Concern
CSM	Conceptual Site Model
CY	Calendar Year
DA	Department of the Army
DCE	Dichloroethene
DCFA	Dry Cleaning Facilities Area
DES	Directorate of Environment and Safety
DO	Dissolved Oxygen
DPW	Directorate of Public Works
DSR	Data Summary Report
EAB	Enhanced Anaerobic Bioremediation
FFA	Federal Facility Agreement
FFTA	Former Fire Training Area
FS	Feasibility Study
ft	foot/feet
HEAST	USEPA Health Effects Assessment Summary Tables
HHBRA	Human Health Baseline Risk Assessment
HQ	Hazard Quotient
HRS	Hazard Ranking System
IC	Institutional Control
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
IWSA	Installation-Wide Site Assessment
KAR	Kansas Administrative Record
KDHE	Kansas Department of Health and Environment
kg	kilograms
$KMnO_4$	Potassium Permanganate
lb	pound
LBA	Louis Berger & Associates
m^3 of air/hr	cubic meters of air per hour
MAAF	Marshall Army Airfield
MCL	Maximum Contaminant Level
mg/day	milligrams per day
mg/L	milligrams per liter

List of Acronyms and Abbreviations

MNA	Monitored Natural Attenuation
MnO_4	Permanganate Ion
MPEO	Master Plan Environmental Overlay
msl	Mean Sea Level
NA	Natural Attenuation
NAP	National Academy Press
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NOD	Natural Oxidant Demand
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
O&M	Operation and Maintenance
ORP	Oxidation-Reduction Potential
OSHA	Occupation Health and Safety Administration
OU	Operable Unit
PAH	Polycyclic Aromatic Hydrocarbon
PCE	Tetrachloroethene
POL	Petroleum, Oil, and Lubricants
PP	Proposed Plan
PRG	Preliminary Remediation Goal
PWE	Directorate of Public Works - Environmental Division
RAB	Restoration Advisory Board
RACER	Remediation Action Cost Engineering and Requirements
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RD/RA	Remedial Design/Remedial Action
RME	Reasonable Maximum Exposure
ROD	Record of Decision
RPMP	Real Property Master Plan
RSK	Kansas Risk Based Standards
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
TBC	to-be-considered
TCA	Trichloroethane
TCE	Trichloroethene
TOC	Total Organic Carbon
UCL	Upper Confidence Limit
UPRR	Union Pacific Railroad
USACE	United States Army Corps of Engineers
USAEHA	United States Army Environmental Hygiene Agency
USC	United States Code
USDOE	United States Department of Energy
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UST	Underground Storage Tank
yd^3	cubic yards
VC	Vinyl Chloride
VOC	Volatile Organic Compound
µG/L	micrograms per Liter

1.0 DECLARATION

1.1 SITE NAME AND LOCATION

SITE NAME:	Fort Riley, Kansas, 354 Area Solvent Detections, Main Post
USEPA IDENTIFICATION NUMBER:	KS6214020756; Federal Facility Agreement Docket Number VII-90-F-0015
LOCATION:	Fort Riley, Kansas
SITE TYPE:	Federal Facility
LEAD AGENCY:	The United States Department of the Army (DA) (Fort Riley)
SUPPORTING AGENCIES:	The United States Environmental Protection Agency (USEPA), Region VII; the State of Kansas, Kansas Department of Health and Environment (KDHE), Bureau of Environmental Remediation (BER)
OPERABLE UNIT:	Operable Unit (OU) 005

1.2 STATEMENT OF BASIS AND PURPOSE

This document is published as a Record of Decision (ROD) for the Fort Riley, Kansas, KS6214020756, 354 Area Solvent Detections (354 Site) (OU 005) under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended (CERCLA) 42 United States Code (USC) § 9601 et seq. The remedy was chosen in accordance with CERCLA, as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and to the extent practical, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) 40 Code of Federal Regulations (CFR) Part 300. The remedy was selected based upon the Administrative Record file for the 354 Site (OU 005). This ROD is consistent with previous RODs for other OUs at Fort Riley discussed in Section 2.4 and is expected to be in agreement with the Final Comprehensive ROD for the entire Fort Riley Site (Figure 1-1). Documents supporting this ROD are identified in Section 4.0.

This remedy was selected by the DA (Fort Riley) in consultation with the USEPA, Region VII, and the KDHE. The State of Kansas and the USEPA concur with the selected remedy.

1.3 ASSESSMENT OF THE SITE

The response action selected in this ROD is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment. The principal threat pertains to potential future use of site-impacted groundwater. Groundwater is the primary source of drinking water and water used for non-domestic purposes (e.g., livestock and irrigation) for Fort Riley and many of the surrounding communities. However, groundwater from the 354 Site is not currently used as a source of drinking water. An existing well field west of the 354 Site currently provides virtually all of Fort Riley's water needs. Alluvial sand and gravel deposits in the Kansas and Republican River valley areas are excellent aquifers. In the upland areas, bedrock is also tapped as a source of water (Burns & McDonnell [BMcD], 2003a).

1.4 DESCRIPTION OF THE SELECTED REMEDY

The Fort Riley National Priorities List (NPL) site currently encompasses five OUs located at the post. The OUs have been designated by the DA (Fort Riley) based on the results of prior investigations. The five OUs include: the Southwest Funston Landfill site (OU 001); the Pesticides Storage Facility site (OU 002); the Dry Cleaning Facilities Area (DCFA) site (OU 003); the Former Fire Training Area (FFTA)-Marshall Army Airfield (MAAF) Site (OU 004); and the 354 Area Solvent Detections Site (OU 005).

The selected remedy for the 354 Site (OU 005) at Fort Riley is Monitored Natural Attenuation (MNA) with institutional controls (ICs). This alternative reflects the long-term site management plan for the 354 Site in that the remedy relies on natural degradation processes already occurring at the 354 Site (OU 005) to further reduce contaminant concentrations to levels below the maximum contaminant levels (MCLs) at the Kansas River and uses ICs to restrict groundwater usage at the 354 Site. MNA is currently conducted as part of post-performance monitoring of the source in-situ treatment and soil removal action completed at the 354 Site in December 2004. ICs currently in place at the 354 Site are controlled by the environmental overlay of the Fort Riley Real Property Master Plan (RPMP). The RPMP is the means through which the post authorities will control and limit development and other activities on the post. This includes overall controls on land use, the issuing of excavation permits that will define and limit potential exposure for utility and grounds workers, and tactical dig permits that control potential exposure for soldiers.

With this alternative, progress at the 354 Site (OU 005) will be monitored through groundwater sampling, and ICs will be implemented to restrict groundwater usage until remediation is complete. The Remedial Design/Remedial Action (RD/RA) Plan for the 354 Site (OU 005) will be completed upon ROD approval. The RD/RA Plan will include more details of the ICs and the monitoring to be conducted under the MNA approach. The primary form of ICs will be restricting the installation and use of groundwater supply wells at and down gradient of the 354 Site (OU 005). The primary control for the 354 Site (OU 005) will be to restrict use through the environmental overlay of the Fort Riley RPMP.

The source of contamination in soil was reduced to concentrations below the soil-to-ground water protection pathway Kansas Risk Based Standard (RSK) levels. RSK levels are levels determined by the KDHE that would prevent further leaching of contaminants to groundwater. The source reduction occurred through a source removal pilot study (using in-situ treatment and excavation) and was completed in 2004. Natural attenuation, combined with the source removal, has been responsible for the continuing decrease of contaminant levels in groundwater. In the final round of groundwater sampling for the Remedial Investigation (RI) in July of 2002, ten monitoring wells of the 37 monitoring wells sampled had volatile organic compound (VOC) contaminants at levels greater than MCLs (BMcD, 2003a). The number of monitoring wells with VOC contaminants at levels greater than MCLs has decreased steadily since that time, with only four wells having VOC contaminants at levels greater than MCLs in April 2005 as shown in Figure 1-2 (BMcD, 2005a). The decline in VOC contaminant concentrations are presented in Table 1-1 which lists the July 2002 and April 2005 data. The values presented in Table 1-1 are those wells that were in the groundwater monitoring program and remain there currently.

The following key elements of the selected remedy will be implemented:

- Monitoring the natural attenuation of the contamination within the Kansas River alluvial aquifer;
- Restricting the installation and use of on-site groundwater wells at and down gradient of the 354 Site (OU 005); and

- Conducting a review of the protectiveness and progress of the remediation in accordance with CERCLA § 121 and the NCP 40 CFR § 300.430(f)(4)(ii) at least every five years.

The remediation goal is to restore the groundwater to its beneficial use, which may include drinking water or non-domestic uses such as agricultural (livestock or irrigation). When groundwater cleanup levels (MCLs) have been achieved at all of the monitoring wells within the Kansas River alluvial aquifer and have not been exceeded for a period of three consecutive years post-ROD (Calendar Year [CY] 2006), the cleanup/remediation of the 354 Site (OU 005) will be considered complete, and the 354 Site (OU 005) will be recommended for close-out.

1.5 STATUTORY DETERMINATIONS

The DA, USEPA, and KDHE have determined that the selected remedy meets the requirements of CERCLA § 121, and, to the extent practical, the NCP. The selected remedy was chosen over the other alternatives because it provides risk reduction through degradation of contaminants in the groundwater and provides measures to prevent future exposure to currently contaminated groundwater. Based on the information available at this time, the DA, USEPA, and KDHE believe the selected remedy will be protective of human health and the environment, will comply with applicable or relevant and appropriate requirements (ARARs), will be cost-effective, and will utilize permanent solutions to the maximum extent practicable (BMcD, 2005b). Although the selected remedy does not involve engineered treatment, it does rely on natural degradation processes already occurring at the 354 Site (OU 005) to further reduce contaminant concentrations to levels below the MCLs. Evidence of natural degradation processes at the Site, as per the USEPA MNA guidance document (USEPA, 1999a), includes 1) decreasing contaminant concentration trend, and 2) supporting geochemical data measurements. The source of contamination in the soil was successfully treated by in-situ permanganate mixing and excavation in 2004. This treatment reduced concentrations of VOCs in soil to below levels that would continually leach to groundwater. As a result, the known contamination source was effectively removed. In addition, natural attenuation/ degradation of the VOCs plume(s) is effectively reducing the contamination based on available data. The selection of MNA as the selected remedy is based upon current and reasonably projected land use and exposures. However, hazardous substances, pollutants, or contaminants may remain at the 354 Site (OU 005) above levels that would allow for unlimited use and unrestricted exposure. The rationale for choosing this remedy is based on the fact that no source materials (such as liquids, areas contaminated with high concentrations of toxic compounds, or highly mobile materials) constituting principal threat wastes likely exist at the 354 Site (OU 005) that require further treatment or removal.

Because this remedy will result in hazardous substances, pollutants, or contaminants remaining at the 354 Site (OU 005) above levels that allow for unlimited use and unrestricted exposure, a review in accordance with CERCLA and the NCP will be conducted no less often than every five years after initiation of the selected remedial action to ensure that the remedy is, or will be, protective of human health and the environment. The first five-year review of the selected remedy will include consideration of the following factors:

- the performance of MNA in achieving cleanup levels (MCLs);
- the use of property above the groundwater plume to ensure that groundwater with contamination above cleanup levels (MCLs) is not used for incompatible uses; and
- if no wells exceed groundwater cleanup levels (MCLs) for three consecutive years, a recommendation for discontinuing sampling and site close out will be made.

1.6 ROD DATA CERTIFICATION CHECKLIST

In accordance with A Guide to Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Decision Documents (USEPA, 1999b), the following information is included in the Decision Summary section of this ROD. Additional information can be found in the Administrative Record file for the 354 Site (OU 005).

- Chemicals of concern (COCs) and their respective concentrations (Section 2.7.1)
- Baseline risk represented by the COCs (Section 2.7.1)
- Cleanup levels established for COCs and the basis for these levels (Section 2.8)
- How source materials constituting principal threats are addressed (Section 2.11)
- Current and reasonably-anticipated, future, land-use assumptions and current and potential, future, beneficial uses of groundwater as defined in the baseline risk assessment and ROD (Section 2.6)
- Potential land (Section 2.6.1) and groundwater (Section 2.6.2) use that will be available at the 354 Site (OU 005) as a result of the selected remedy
- Estimated capital, annual operation and maintenance (O&M), and total present worth costs, discount rate, and the number of years over which the remedy cost estimates are projected (Section 2.12.3 and Tables 2-35 and 2-36)
- Key factors that led to selecting the remedy (i.e., describe how the selected remedy provides the best balance of tradeoffs with respect to the balancing and modifying criteria, highlighting criteria key to the decision) (Section 2.12.1)

1.7 AUTHORIZING SIGNATURES

On the basis of the RI/Feasibility Study (FS) performed at the 354 Site (OU 005), the selected remedy, MNA with ICs, meets the requirements for remedial action set forth in CERCLA, as confirmed by the following signature pages.

Lead and Support Agency Acceptance of the ROD
Fort Riley Army Installation
354 Area Solvent Detections, OU 005

Signature sheet to the ROD for the 354 Site (OU 005) final action at the Fort Riley Installation between the United States Army, Fort Riley and the USEPA, Region VII, with concurrence by the State of Kansas acting through KDHE, BER.

Gene Reuna 7/3/06

for Cecilia Tapia — Date

Superfund Division Director, USEPA

Lead and Support Agency Acceptance of the ROD
Fort Riley Army Installation
354 Area Solvent Detections, OU 005

Signature sheet to the ROD for the 354 Site (OU 005) final action at the Fort Riley Installation between the United States Army, Fort Riley and the USEPA, Region VII, with concurrence by the State of Kansas acting through KDHE, BER.

Thomas T Smith 22 June 06

Thomas T. Smith — Date

COL, Infantry

Garrison Commander

2.0 DECISION SUMMARY

This Decision Summary provides an overview of the groundwater conditions at the 354 Site (OU 005), the remedial alternatives, and the analysis of those options. In addition, this section explains the rationale for the remedy selection and describes how the selected remedy satisfies statutory requirements.

2.1 SITE NAME, LOCATION, AND DESCRIPTION

The Fort Riley, Kansas, 354 Area Solvent Detections, Main Post, (OU 005), is located at the Main Post cantonment area of the Fort Riley Military Installation, which is located in Geary County and Riley County, near Junction City. Main Post is in the southern region of Fort Riley, north of the Kansas River (Figures 1-1 and 2-1). The term "354 Site" is used in this report to refer to the entire 354 Area Solvent Detections Site within the Main Post area.

Fort Riley is identified by the USEPA as Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) site KS6214020756. This document is issued by the DA, the lead agency for the activities at Fort Riley, with consultation with the USEPA and KDHE, the support agencies. Cleanup work at the 354 Site (OU 005) has been funded by the DA (Fort Riley) through the Installation Restoration Program (IRP).

The 354 Site currently encompasses portions of the Main Post as far north as Godfrey Avenue, and virtually the entire point bar south of the Union Pacific Railroad (UPRR) grade and east of the Henry Drive Bridge. This point bar and an ancient alluvial terrace dominate the topography across this area. The point bar is part of the active floodplain and consists of approximately 60 feet (ft) of alluvial sediments overlying shale or limestone bedrock. The terrace, located to the north of the railroad grade, also consists of alluvial sediments deposited on shale and limestone bedrock; however, this area is topographically higher than the floodplain and the unconsolidated terrace deposits vary in thickness from nine to 64 ft.

The Fort Riley NPL site currently encompasses five OUs located at the post. The OUs have been designated by the DA (Fort Riley) based on the results of prior investigations. The five OUs include: the Southwest Funston Landfill Site (OU 001); the Pesticides Storage Facility Site (OU 002); the DCFA Site (OU 003); the MAAF Site (OU 004); and the 354 Area Solvent Detections Site (OU 005).

2.2 SITE HISTORY AND ENFORCEMENT ACTIVITIES

The former Building 354 was constructed in 1935 as a gasoline service station. In addition to gasoline and diesel fuel, it may have been subsequently used as a storage site for solvents and road oil. Two 10,000-gallon steel underground storage tanks (USTs), one 12,800-gallon steel UST, and one 8,500-gallon steel UST were installed at the Site circa 1935 (United States Army Corps of Engineers [USACE], 1995), and were used for gasoline and diesel storage. Two 10,000-gallon steel USTs were installed at the Site in 1980 and were used for diesel storage (Dames & Moore, 1995). The USACE indicated that the USTs at this She were also used to store road oil, and may have been used to store solvents (USACE, 1996). The former USTs (including the solvent tank) were 20 ft south of the former Building 354 and approximately 60 ft northwest of the Site (Figure 2-2). A drawing dated June 1982, obtained from the Fort Riley Directorate of Public Works (DPW), indicated plans to replace the pump on a solvent tank located approximately 15 ft southeast of former Building 354. The drawing does not indicate if the tank was an UST or an above-ground tank.

Five of the six USTs, shown on historical drawings of the Site, were removed in 1990 and 1991. The sixth tank, a 8,500-gallon steel UST, reportedly used for diesel storage, was not found (Dames & Moore, 1995). Fort Riley Real Property records of the DPW Compound indicate that five USTs were located at this Site, which corresponds to the number removed in 1990 and 1991.

Building 367 is located on Carr Avenue and was constructed in 1903. The building originally served as an artillery gun shed and presently serves as a vehicle maintenance shop. Building 430 is located on Godfrey Avenue and was constructed in 1932. The building was originally built and is still maintained as a fire station. Both of these structures are on the National Register of Historic Places within the Main Post Historic District.

The RI study area encompasses a large amount of area that historically has had a wide variety of land uses. The nature of industrial activities on the post can be directly related to periods of development. Main Post was the first part of the installation developed in the mid-nineteenth century. The post, prior to World War I, evolved from a frontier outpost to a military training post. Limited industrial facilities included a few simple shops, such as blacksmith operations and storehouses for supplies. Military practice ranges were located near the barracks area in the lowlands along the Kansas River valley bluffs. During World War I, Fort Riley underwent significant expansion in support of the war effort. Much of this expansion took place at locations in the Kansas River alluvial valley, both upstream and downstream from Main Post. More industrial infrastructure was put in place as motor pools and auto repair facilities replaced stables and blacksmith shops. Landfill areas were established on the floodplain to the south of Main Post. The Army airfield became operational in 1921.

Greatly-expanded, industrial infrastructure was put in place to support Army forces training for World War II. Motor pool activities greatly expanded at Main Post. Additional rail capacity was built along the UPRR, including a petroleum off-loading facility and pipeline, and an asphalt batch plant. Following World War II, shops for maintaining tactical equipment were moved to Custer Hill.

Today, that portion of the study area located within Main Post, to the north and west of the UPRR right-of-way, is used for vehicle maintenance and storage, office blocks, warehouses, barracks, and some residential housing units. Much of this area is covered with either concrete or asphalt, and has a high density of buried utilities, including water, sewer, electricity, gas, telephone, and fiber-optic cable. Much of the area to the south and east of the UPRR grade, which is located on the Kansas River floodplain, is in a natural or semi-natural state, with large tracts of deciduous forest. Much of the forest area along the Kansas River is conserved as critical habitat for a transient population of bald eagles. There are some structures in this area, mainly along the UPRR grade, which are used for warehouses and as administrative offices. Underground utilities are present, but not as dense as in the Main Post area.

Environmental investigations and sampling events were performed at Fort Riley during the 1970s and 1980s. These investigations identified activities and facilities where hazardous substances had been released or had the potential to be released to the environment. Potential sources of contamination included landfills; printing, dry cleaning, and furniture shops; and pesticide storage facilities (BMcD, 2003a).

Hazard Ranking System (HRS) ranking was performed in 1988 by the USEPA based on the aggregation of two individual areas of the Fort Riley Superfund site, the Southwest Funston Landfill and the Pesticide Storage Facility. It was noted that other potentially contaminated areas exist at Fort Riley (e.g., burn pits, fire training areas, and dry cleaner operations). These sites received a comprehensive score of 33.79. As a

result, on July 14, 1989, the USEPA proposed inclusion of Fort Riley on the NPL pursuant to CERCLA. Effective June 1991, the DA entered into a Federal Facility Agreement (FFA), Docket No. VII-90-F-0015, with the State of Kansas KDHE and USEPA Region VII to address environmental pollution subject to CERCLA, the NCP, and/or the Resource Conservation and Recovery Act (RCRA) (USEPA, 1991).

Pursuant to the FFA, Fort Riley conducted an Installation-Wide Site Assessment (IWSA) in 1992 (Louis Berger & Associates [LBA], 1992) to identify sites having the potential to release hazardous substances to the environment. The IWSA did not specifically identify the 354 Site as a potential area of concern requiring further evaluation. It did address petroleum, oil, and lubricant (POL) facilities (including the 354 Site) as sites which might be evaluated under the UST programs and would normally be excluded from CERCLA since it was not intended to cover sites impacted exclusively by petroleum contamination. However, following the removal of the USTs at the 354 Site, investigation of soil and groundwater revealed the presence of chlorinated solvent contamination. As a result, during January 1997, the 354 Area Solvent Detections was formally designated an OU.

In 1998, the Army began a RI/FS to identify the types, quantities, and locations of the contaminants at the 354 Site (OU 005) and to develop a plan to address the contamination problem. The RI report provided the basis for the FS report, which presents the alternatives available to address potential risks identified in the RI report. The USEPA and KDHE approved of the RI and FS reports in 2003 and 2005, respectively (BMcD, 2003a and 2004a).

A pilot study for soil remediation was performed at the Building 367 location during 2004. This remediation effort was successful in treating and removing approximately 1,000 cubic yards (yd^3) of soil that were contaminated with chlorinated solvents. This effectively eliminated the source of groundwater contamination, which should result in continuing decreases in future groundwater concentrations. Pilot study results are reported in the Pilot Study Report, *Pilot Study for Soil Remediation, 354 Area Solvent Detections (Operable Unit 005) at Main Post, Fort Riley, Kansas* (BMcD, 2005c).

The monitoring wells associated with the 354 Site (OU 005) have been sampled as part of the groundwater monitoring program at Fort Riley. The results of these sampling events are provided in the Data Summary Reports (DSRs) for each event (Dames & Moore, 1995 and BMcD, 1999, 2000a, 2000b, 2000c, 200la, 200Ib, 2002a, 2002b, 2002c, 2003b, 2004b, 2004c, 2005a, and 2005d).

The *Proposed Plan, 354 Area Solvent Detections (Operable Unit 005) at Main Post, Fort Riley, Kansas* (BMcD, 2005b), was issued to inform the public of Fort Riley's, USEPA's, and KDHE's preferred remedy based on information included in the Administrative Record. The intention was to solicit public comments pertaining to the remedial alternatives evaluated, including the preferred alternative. Submitted on May 18, 2005, the Draft Final Proposed Plan (PP) was accepted by the KDHE and USEPA with no comments, as presented in the Responsiveness Summary (Section 3.0 of this document).

2.3 HIGHLIGHTS OF COMMUNITY PARTICIPATION

The RI/FS process was conducted in accordance with CERCLA requirements to document the comprehensive remedial activities and proposed remedial plan for the 354 Site (OU 005). Primary documents developed during the RI/FS process included the RI report (with the human health baseline risk assessment [HHBRA]), FS report, and PP for the 354 Site (OU 005) (BMcD, 2003a, 2004a, and 2005b, respectively). These reports were released to the public between November 2003 and June 2005, and have been made available for public review as part of the Administrative Record file at the Fort Riley DPW -

Environmental Division (PWE), formerly known as the Directorate of Environment and Safety (DES). The Administrative Record is the set of supporting information used to determine the preferred alternative. These reports were also made available to potentially affected persons and the public in the Dorothy Bramlage Public Library (Junction City) and Manhattan Public Library. The PP can be viewed electronically by conducting a search at the following website: http://www.riley.army.mil/services.

Notices of availability of these documents and the notice for the public meeting to discuss the PP were published in the *Manhattan Mercury* and the *Junction City Daily Union* on June 12, 2005. A public comment period for the PP was declared from June 12, 2005 through July 12, 2005 to provide a reasonable opportunity for comment and to disseminate information regarding the document. No comments were received from the public.

A public meeting was held at the PWE, Building 407 Pershing Court, Fort Riley, Kansas at 7:00 pm local time on July 12, 2005 in conjunction with the Restoration Advisory Board (RAB) meeting to discuss the PP. At this meeting, representatives for the DA, KDHE, and USEPA were available to inform the public about the 354 Site (OU 005) and remedial options under consideration. The official transcript for the public meeting was recorded and transcribed verbatim by Ms. Jennifer L. Gibson, court reporter. There were no comments made by the public during the meeting.

2.4 SCOPE AND ROLE OF OPERABLE UNIT

The problems at Fort Riley are complex and site specific in nature. Therefore, the CERCLA work on the installation is organized into separate operable units. There are currently five OUs located on Fort Riley. The OUs have been designated by the DA (Fort Riley) based on the results of prior investigations. The five OUs include: the Southwest Funston Landfill Site (OU 001), the Pesticide Storage Facility Site (OU 002); the DCFA Site (OU 003); the FFTA-MAAF Site (OU 004); and the 354 Area Solvent Detections Site (OU 005). The remedy selected for each site includes landfill capping for the Southwest Funston Landfill Site (OU 001); capping, soil excavation, and removal for the Pesticide Storage Facility Site (OU 002); MNA and ICs for the DCFA Site (OU 003); and MNA and ICs for the FFTA-MAAF Site (OU 004).

The 354 Site, the subject of this ROD, addresses groundwater contamination. The 354 Site is a discrete area of contamination that does not affect or is not affected by the other OUs at the Fort Riley NPL site. Ingestion of water, if extracted from the terrace aquifer, poses a current and potential risk to human health because the concentrations of contaminants are greater than the MCL for drinking water (as specified in the Safe Drinking Water Act). This should be the final response action for the 354 Site (OU 005) because the principal threat at the site has been removed based on the post-performance monitoring results for the ex-situ excavation and removal and treatment of soil by in-situ chemical oxidation (potassium permanganate) during the removal action/pilot study conducted in 2004. The selected response action addresses the remedial action objectives (RAOs) established for the 354 Site. Refer to Section 2.8 for more information on RAOs and preliminary remediation goals (PRGs).

2.5 SITE CHARACTERISTICS

The conceptual site model (CSM); site overview; summary of surface and subsurface features; sampling strategy; known or suspected sources, types, and location of contamination; and nature and extent of contamination are discussed below. Additional details regarding the 354 Site (OU 005) characteristics are provided in the RI report (BMcD, 2003a).

2.5.1 Conceptual Site Model

Figure 2-3 presents the human health CSM. Reasonable exposure scenarios were developed based on how the 354 Site (OU 005) is currently used and assumptions about its future use and physical site features.

2.5.2 Site Overview

The 354 Site is located at the Main Post cantonment area, in the southern region of Fort Riley (Figures 1-1 and 2-1). Most of the probable source of contamination in soil, which was located just east of Building 367, was eliminated by the pilot study, which involved in-situ treatment and excavation of the impacted soil. Remaining soil has concentrations below the levels determined by KDHE that would prevent further leaching of contaminants to groundwater. For further information on the treatment, refer to the Pilot Study Report (BMcD, 2005c). The groundwater plume originated from the Building 367 area, but has migrated south towards the Kansas River floodplain (Figures 2-1 and 2-2).

2.5.3 Surface and Subsurface Features

A point bar of the Kansas River and an ancient alluvial terrace area dominate the topography across the 354 Site (OU 005). The. point bar lies between the UPRR grade and the Kansas River (Figure 2-1). It is an area of low relief, with ground elevations generally between 1,048 and 1,063 ft above mean sea level (msl). The area to the north of the UPRR grade is an ancient alluvial terrace. The topography on the terrace generally rises to the north. Elevations vary from about 1,065 ft above msl south along the railroad grade, to approximately 1,125 ft above msl at the north portion of the study area in the vicinity of Godfrey Avenue. With the exception of the Kansas River, no perennial creeks or streams are found in the study area.

Unconfined groundwater is present within both the terrace deposits (terrace aquifer) and the Kansas River alluvium (Kansas River alluvial aquifer). Groundwater within the terrace aquifer is present directly above the bedrock surface, with a saturated thickness ranging from zero (dry) to about 16 ft. Groundwater flow is controlled by the topography of the bedrock surface, which imparts a southerly direction of groundwater flow. The thickness of saturated material within the Kansas River alluvial aquifer is greater, up to 35 ft in some areas. Groundwater flow here is controlled in large part by the Kansas River and is to the east/southeast, across the point bar. Permeability of the terrace and alluvial sediments is probably very similar; however, transmissivity is greater in the Kansas River alluvium since the saturated thickness is greater. Groundwater gradients are an order of magnitude greater within the terrace aquifer than within the Kansas River alluvial aquifer.

A more detailed description of the geology and hydrogeology of the 354 Site (OU 005) is presented in Section 2.5 of the RI report (BMcD, 2003a).

2.5.4 Sampling Strategy

Over the years, a variety of activities have been conducted at the 354 Site, and could have resulted in chlorinated solvent and petroleum hydrocarbon contamination. These include facilities for the storage and maintenance of motorized equipment, facilities for storing and dispensing fuel and oil for vehicles, and at least one area where fire fighting equipment may have been serviced or used for training. Specific areas identified as possible source areas include the following:

- Building 367 and adjacent paved areas.

- Building 332, former Building 354, its associated USTs, and adjacent areas of the DPW Compound.
- Building 430.
- Former service station to northwest of UPRR depot.
- Petroleum unloading facility and pipeline along the UPRR grade.

A number of field investigations have been conducted at the 354 Site. These investigations, beginning in 1992, included collection and chemical analysis of soil-gas samples, groundwater-screening samples, soil samples, and groundwater samples. Monitoring wells were also installed and sampled at the 354 Site. The data substantiate that petroleum hydrocarbons and chlorinated solvents, including tetrachloroethene (PCE), trichloroethene (TCE), and cis-l, 2-dichloroethene (DCE), were present in the soil and groundwater at the 354 Site. Benzene, toluene, ethylbenzene, and xylenes (BTEX) have been detected in the study area, specifically at and down gradient of the former Building 354 location. Details regarding the historical sampling events are provided in the RI report (BMcD, 2003a) and DSRs (Dames & Moore, 1995 and BMcD, 1999, 2000a, 200Gb, 2000c, 2001a, 2001b, 2002a, 2002b, 2002c, 2003b, 2004b, 2004c, 2005a, and 2005d).

The United States Geological Survey (USGS) has conducted surface-water sampling of the Kansas River at Fort Riley in order to determine whether contamination from sites adjacent to the river has impacted the river. The USGS conducted surface-water sampling events in March 2000, July 2000, and July 2001. These samples were collected both upstream and downstream of the point where the groundwater plume enters the river. The samples were analyzed for VOCs. VOCs were not detected in any samples (BMcD, 2003a).

2.5.5 Known or Suspected Sources, Types, and Location of Contamination/Nature and Extent of Contamination

The known or suspected sources, types, and location of contamination/nature and extent of contamination are fully presented in the RI report (BMcD, 2003a). The major findings of the RI and FS (BMcD, 2004a) are as follows:

- Soil is not a medium of concern at the 354 Site. The area of shallow soil contaminated with PCE, located just east of Building 367, was remediated during the source removal pilot study.

- Groundwater is a medium of concern at the 354 Site. PCE, TCE, cis-1,2-DCE, and benzene are the chemicals of potential concern (COPCs). TCE and cis-1,2-DCE are degradation products of the primary PCE contamination at this Site.

- Aquifer contamination is present as a relatively narrow plume within the terrace aquifer, flowing to the south from the vicinity of Building 367. Within the Kansas River alluvial aquifer, this plume increases in size, although concentrations of PCE and its degradation products decrease below regulatory levels of concern. Analytical samples from the Kansas River are non-detect for the COPCs.

- Natural attenuation of contaminants is the dominant mechanism for the decrease in contaminant levels in groundwater at this Site. Natural attenuation was determined to be occurring at the 354 Site based on the presence of degradation products of PCE and favorable natural attenuation parameters. Natural attenuation appears to be active mainly within the Kansas River alluvial aquifer.

Note that Table 2-1 (Positive Detections in Groundwater, November 1998 through April 2005) clearly presents data emphasizing declining contaminant trends. For example, for PCE the highest result is shown as 4,630 micrograms per liter (µg/L), with the most recent result (April 2005) shown as 98.5 µg/L. Also, the highest result for TCE is shown as 160 µg/L, with the April 2005 result shown as 3.8 µg/L.

The primary chlorinated solvent source was located immediately east of Building 367. This source was principally PCE, based on both soil and groundwater data. TCE and cis-1,2-DCE were present as well, but at much lower levels. Table 2-2 presents the VOC detections in the pre-pilot study soil borings at the Building 367 site that exceeded the RSK for the soil-to-groundwater protection pathway. Secondary chlorinated solvent sources may exist in the vicinities of Building 332, the DPW Compound, and Building 430. There are sources of BTEX contamination in the vicinity of Building 332, the former Building 354, and along the UPRR grade (petroleum unloading facility), based on both soil and groundwater evidence. Polycyclic aromatic hydrocarbons (PAHs), at low concentrations, were detected in soil collected from the vicinities of Building 367, Building 430, and former Building 354/Building 332/DPW Compound areas.

Chlorinated solvents, including PCE, TCE, cis-l, 2-DCE, and carbon tetrachloride ($CC1_4$), have been detected in groundwater from both the terrace and Kansas River alluvial aquifers. The highest concentrations of these compounds have been detected in groundwater samples collected from the terrace aquifer immediately east and down gradient of Building 367. These compounds are also present in the Kansas River alluvial aquifer, but at much lower concentrations. Petroleum compounds are present locally, mainly in samples collected from monitoring wells at and immediately south of the DPW Compound. Although very low concentrations of cis-1,2-DCE have been detected at monitoring wells immediately adjacent to the Kansas River, contaminants have not been detected in surface-water samples collected from the Kansas River. Table 2-1 presents the positive VOC, SVOC, TPH, metal, natural attenuation parameter, and general, water-quality parameter detections at the 354 Site (OU 005) from November 1997 through April 2005. Table 2-1 also presents the associated MCLs, the highest and lowest concentrations reported, and the most recent concentrations reported (April 2005).

Arsenic, barium, chromium, lead, and mercury were detected in the groundwater at the 354 Site. Only arsenic was detected at a concentration in excess of the MCL or lead in excess of the action level. These detections were all located within or immediately adjacent to the Kansas River alluvial aquifer. The lack of detections in terrace monitoring wells suggested that these were not site-related contaminants.

Chlorinated solvent contamination is transported south within the terrace aquifer to the Kansas River alluvial aquifer. Advection appears to be the dominant transport process. Adsorption is probably also contributing to the reduction of PCE mass in groundwater, with volatilization possibly playing a minor role. Based on an evaluation of natural attenuation (NA) parameters and the contaminant chemistry, it appears that little or no biotransformation of chlorinated solvents is occurring within the terrace aquifer. Dissolved oxygen (DO), oxidation-reduction potential (ORP), and nitrate levels are high, while ferrous iron levels remain low, all suggesting an environment unsuitable for reductive dechlorination. This is confirmed by high levels of PCE within the groundwater, and modest amounts of the daughter products (TCE and cis-1,2-DCE) present.

Once the contaminant plume intersects the Kansas River alluvial aquifer, environmental conditions change. The direction of transport becomes easterly, moving with the general direction of flow of the Kansas River. Dispersion becomes more significant, relative to advection, as groundwater flow velocities tend to be only one-tenth of those within the terrace aquifer. Within the Kansas River alluvial aquifer, conditions improve for the performance of reductive dechlorination. DO, ORP, and nitrate levels drop significantly, as ferrous

iron levels increase, suggesting that environmental conditions improve greatly for reductive dechlorination. In addition, PCE disappears shortly after entering the Kansas River alluvial aquifer, to be replaced with TCE, and finally cis-l, 2-DCE.

cis-l, 2-DCE is less amenable to dechlorination in an anaerobic reducing environment, compared to PCE and TCE. In this system, it appears that once the degradation pathway reaches cis-l, 2-DCE, the dechlorination process slows, leaving cis-l, 2-DCE to be further attenuated by advection and dispersion. The absence of vinyl chloride (VC) and ethane/ethene throughout the plume also suggests a stalling of the reductive dechlorination process at cis-l, 2-DCE. Another factor influencing reductive dechlorination is the availability of primary carbon sources to act as electron donors. BTEX is present in groundwater in the area where the plume enters the Kansas River alluvial aquifer, but is not present down gradient. These organics can serve as a primary substrate for microorganisms facilitating reductive dechlorination. As BTEX is degraded, the reduction of chlorinated substances stalls, leaving cis-l, 2-DCE. Total organic carbon (TOC) levels are below the 20 milligrams per liter (mg/L) threshold considered optimal for reductive dechlorination, which may inhibit the continued dechlorination of cis-l, 2-DCE.

The human health and ecological risk assessments concluded that COPCs in groundwater and soils did not pose significant risks to human health or the environment. However, some COPCs in groundwater occur at levels above MCLs/action level. These are: PCE, TCE, cis-l, 2-DCE, benzene, arsenic, and lead. Since lead and arsenic appear unrelated to the 354 Site based on the locations of detections exceeding MCLs/action level, they were excluded from further consideration in the FS. Based on the results of the risk assessments, the ARAR analysis, and the COPCs currently present at concentrations above MCLs, the following are considered COCs in groundwater for the 354 Site (OU 005): PCE, cis-1,2-DCE, TCE, and benzene.

2.6 CURRENT AND POTENTIAL FUTURE SITE AND RESOURCE USES

2.6.1 Land Uses

The 354 Site (OU 005) is part of the Fort Riley reservation and is not zoned by Geary County. North and west of the UPRR grade is a built-up area (Main Post), with building and road development. Buildings include offices, barracks, family housing units, warehouses, and maintenance facilities. South and east of the UPRR grade is the point bar of the Kansas River. This area is mainly covered with forest and vegetation; although, there is one built-up area between the UPRR grade and Marshall Avenue. The built-up area consists of warehouses, several of which have been converted to office buildings.

Land use at the 354 Site (OU 005) is classified under the RPMP. It is anticipated that land use activities will remain unchanged into the foreseeable future. The Main Post area to the north of the UPRR grade is classified as a National Register Historic District. The area to the south of the UPRR grade is classified as open space under the RPMP and should not see change from current land classification because it is within the active flood plain of the Kansas River where land uses must be in compliance with Executive Order 11988 - Floodplain Management. This Order restricts and places requirements on actions that occur within a flood plain. Additionally, the area within 100 meters of the current Kansas River bank is critical wildlife habitat for bald eagles that winter over at Fort Riley.

2.6.2 Water Uses

Groundwater is the primary source of drinking water for Fort Riley and many of the surrounding communities. Alluvial sand and gravel deposits in the Kansas and Republican River valleys are excellent

aquifers. Potential users of the Kansas River are identified in this section. Fort Riley, Morris County Rural Water District, and the communities of Junction City and Ogden rely on groundwater withdrawn from alluvial materials for their drinking water supplies. Fort Riley has eight active wells, Junction City has nine active wells, Ogden has three active wells (United States Army Environmental Hygiene Agency [USAEHA], 1992), and Morris County Rural Water District has three active wells. The Fort Riley well field is not currently operating at full capacity. Ogden also provides water to a rural water district in Riley County. The wells for Ogden and Junction City are more than four miles from the Site and the Morris County Rural Water District wells withdraw water from the Clarks Creek alluvium, which is hydraulically separated from the Kansas River alluvium.

The Fort Riley water supply wells are located approximately four miles upgradient (west) of the 354 Site (OU 005) near Camp Forsyth. The nearest water supply well (used as a backup well) is located at MAAF, one mile south of the 354 Site (OU 005). The purpose for this well is to service the airfield in the event of an emergency affecting the Fort Riley water distribution system.

At the 354 Site (OU 005), there are no known water supply wells completed in the terrace aquifer. The transmissivity of the terrace aquifer is quite low. This is due to the limited saturated thickness, which is generally no greater than ten ft, and usually less than this depth. Because of the prolific supply available from the Kansas River alluvial aquifer, there is no reason for water supply wells to be completed in the terrace aquifer. There are no reasonably anticipated changes in water use at the 354 Site (OU 005) currently or in the near future. Implementation of ICs will ensure water supply wells are not completed in the terrace aquifer until remediation is complete.

For more information regarding water uses and hydrogeology at the 354 Site (OU 005), refer to the RI report (BMcD, 2003a).

2.7 SUMMARY OF SITE RISKS

The baseline risk assessment (human health and ecological) that was completed for the 354 Site (OU 005) in 2003 found that the estimated risks to human health and the environment were within or below the USEPA acceptable levels. The DA's (Fort Riley) remedy decision is based on the presence of site-related contaminants at the Site in the Kansas River alluvial aquifer at levels exceeding drinking water standards (MCLs), which are identified as an ARAR. Since no specific groundwater use restrictions are in place, concern remains that future development and groundwater use may occur, although the likelihood is remote. Therefore, while contaminant concentrations are decreasing due to NA, and despite the absence of human health or ecological risks, the exceedance of MCLs provides the basis for remedial action at the 354 Site (OU 005).

Although additional sampling of groundwater has occurred since 2003 and the principal threat waste (soil source) was removed in 2004, the HHBRA presented in the RI was not updated for this ROD. The HHBRA may be found in the Administrative Record file for the 354 Site (OU 005). Although the results of the HHBRA are not the basis for remedial action at the 354 Site (OU 005), a brief discussion of the contaminants and exposures that were evaluated is appropriate. The following subsections of the ROD summarize the human health and ecological risk assessments that were conducted as part of the RI at the 354 Site (OU 005).

2.7.1 Summary of Human Health Risk Assessment

This subsection provides a brief summary of the four primary components of the human health risk assessment: identification of COPCs, the exposure assessment, the toxicity assessment, and the risk characterization. Details regarding each of these components can be found in Section 7 of the RI report (BMcD, 2003a).

The 354 Site (OU 005) is located in an active portion of Main Post. Land use around the Building 367 and Building 354/332/DPW Compound Areas is industrial in nature, while Building 430, a fire station, is adjacent to a residential area. Because there are three distinct source areas at the Site, risk was evaluated separately for the Building 367 Area, the Building 354/332/DPW Compound Area, and the Building 430 Area. The Building 430 Area is the only area where residents are a potentially exposed population; however, each of the three areas likely has similar worker populations either currently present or reasonably anticipated to be present in the future. Rather than conducting a duplicative evaluation wherein each worker population was evaluated in each source area, the scope of the human health risk assessment was simplified such that each relevant worker population was evaluated only in the source area with the highest chemical concentrations. The following describes the selection of exposure scenarios for quantitative evaluation (BMcD, 2003a):

- Indoor workers represent a potentially exposed population in each source area; however, the levels of chlorinated solvent and PAH contamination were significantly higher in the Building 367 Area than in the Building 430 Area; therefore, a separate indoor worker population was not evaluated in the Building 430 Area. Since the Building 354/332/DPW Compound Area had different contaminants than the Building 367 Area, a separate indoor worker population was evaluated. Thus, two indoor worker populations were evaluated, one each in the Building 367 and Building 354/332/DPW Compound Areas.

- Groundskeepers are likely present in all three areas. The source area near Building 367 is entirely paved, thus limiting the likelihood of direct contact with contaminated soil by a groundskeeper. Therefore, a groundskeeper was not evaluated in the Building 367 Area. Chemical concentrations in soil and groundwater were higher in the Building 354/332/DPW Compound Area than in the Building 430 Area; therefore, groundskeepers were only evaluated in the Building 354/332/PW Compound Area.

- Utility excavation workers are likely present in all three source areas; however, chemical concentrations were significantly higher in shallow soil samples from the Building 367 Area than in either of the other areas. Therefore, utility excavation workers were only evaluated in the Building 367 Area.

- Residents are only expected to be present in the Building 430 Area; therefore, residents were not evaluated in either of the other source areas.

Identification of Chemicals of Potential Concern

COPCs include those site-related chemicals detected at the 354 Site that have the potential to impact human health. For this risk assessment, COPCs were generally identified as those organic constituents that were detected in one or more samples from a given data set. Metals in soil were eliminated from further consideration in the Data Evaluation Technical Memorandum and Work Plan (BMcD, 2001c) and are not

considered site-related COPCs in this risk assessment. However, given recent changes in USEPA guidance and USACE policy regarding evaluation of background levels of metals in risk assessments, potential human health risks associated with exposure to background levels of metals in soil are provided in the HHBRA uncertainties section (BMcD, 2003a). Arsenic and lead were detected in groundwater samples from the Kansas River alluvial aquifer at concentrations above the MCL (for arsenic) or the action level (for lead), and also the area-wide background. Although not considered site-related, arsenic and lead would be considered as COPCs in the HHBRA in accordance with recent USEPA and USACE guidance. However, groundwater is not likely to be used as a drinking water source (see Section 2.6.2) and is generally too deep to be directly contacted. Given the absence of potentially completed exposure pathways, metals were not included in the quantitative risk assessment. Similarly, non-volatile organics were not retained as COPCs in groundwater due to the lack of completed exposure pathways. It should be noted that the non-volatile organics detected in groundwater are phthalates, which are common laboratory contaminants. Therefore, COPCs consisted of all organic constituents detected in soil and all VOCs detected in groundwater.

The following chemicals were selected as COPCs in shallow subsurface soil in the Building 367 Area:

- PAHs:

Acenaphthylene	Benzo(k) fluoranthene	Naphthalene
Benzo(a) anthracene	Chrysene	Phenanthrene
Benzo(a) pyrene	Dibenz(a, h) anthracene	Pyrene
Benzo(b) fluoranthene	Fluoranthene	
Benzo(g, h, i) perylene	Indeno(l, 2,3-cd) pyrene	

- Volatiles:

Acetone	PCE	m, p-Xylene
Carbon disulfide	trans-1,2-DCE	cis-1,2-DCE
TCE		

The following chemicals were selected as COPCs in groundwater in the Building 367 Area:

- Volatiles:

1,1,2-Trichloroethane (TCA)	cis-1,2-DCE	TCE
$CC1_4$	PCE	VC
Chloroform	trans-l, 2-DCE	

The following chemicals were selected as COPCs in surface and subsurface soil in the Building 354/332/DPW Compound Area:

- PAHs:

Benzo(a) anthracene	Benzo(k) fluoranthene	Phenanthrene
Indeno(l ,2,3-cd) pyrene	Benzo(a) pyrene	Chrysene
Benzo(b) fluoranthene	Dibenz(a, h) anthracene	Pyrene
Benzo(g, h, i) perylene	Fluoranthene	

The following chemicals were selected as COPCs in deep subsurface soil in the Building 354/332/DPW Compound Area:

- Volatiles:

  BTEX

The following chemicals were selected as COPCs in groundwater in the Building 354/332/DPW Compound Area:

- Volatiles:

BTEX	cis-1,2-DCE	TCE
$CC1_4$	PCE	
Chloroform	trans-1,2-DCE	

The following chemicals were selected as COPCs in surface soil in the Building 430 Area:

- PAHs:

Benzo(a) anthracene	Benzo(k) fluoranthene	Phenanthrene
Indeno(l, 2,3-cd) pyrene	Benzo(a) pyrene	Chrysene
Benzo(b) fluoranthene	Dibenz(a, h) anthracene	Pyrene
Benzo(g, h, i) perylene	Fluoranthene	

The following chemicals were identified as COPCs in soil gas in the Building 430 Area:

- Volatiles:

$CC1_4$	TCE

The following chemical was selected as a COPC in groundwater in the Building 430 Area:

- Volatiles:

  Chloroform

A summary of the soil COPCs, including the range and frequency of detections in soil, is presented in Tables 2-3, 2-4, 2-5, and 2-6. A summary of the groundwater COPCs, including the range and frequency of detections in groundwater, is presented in Tables 2-7, 2-8, 2-9, and 2-10, respectively. A summary of the soil-gas COPCs, including the range and frequency of detections is presented in Table 2-11.

Exposure Assessment

The exposure assessment identified potentially exposed populations and potentially completed pathways, as shown in the human health CSM, presented as Figure 2-3.

The risk assessment evaluated potential exposures to current and future indoor workers, future utility excavation workers, current groundskeepers, and current child residents. Based on the human health CSM, the potentially completed exposure pathways evaluated for each population are as follows:

- Current and Future Indoor Workers - Ingestion of chemicals in soil as indoor dust (Building 354/332/DPW Compound Area only), inhalation of vapor phase chemicals from soil and inhalation of vapor phase chemicals from groundwater.

- Future Utility Excavation Workers - Ingestion of chemicals in soil, dermal contact with chemicals in soil, inhalation of chemicals in dust, inhalation of vapor phase chemicals from soil; and inhalation of vapor phase chemicals from groundwater.

- Current Groundskeeper - Ingestion of chemicals in soil, dermal contact with chemicals in soil, inhalation of chemicals in dust, inhalation of vapor phase chemicals from soil; and inhalation of vapor phase chemicals from groundwater.

- Current Child Residents - Ingestion of chemicals in soil, dermal contact with chemicals in soil, inhalation of chemicals in dust, inhalation of vapor phase chemicals from soil gas; inhalation of vapor phase chemicals from groundwater.

The potential for human health risk due to exposure to chemicals at the Site was considered for soil, groundwater, and air media. Ingestion of groundwater is an incomplete pathway; therefore, risk was not calculated for this exposure pathway.

USEPA's *Supplemental Guidance to RAGS, Calculating the Concentration Term* (USEPA, 1992) specifies that the reasonable maximum exposure (RME) concentration for a receptor population be calculated using the 95 percent upper confidence limit (UCL) of the arithmetic mean of chemical concentrations. These values were calculated assuming a log-normal distribution of the data. However, there are instances where the 95 percent UCL can be greater that the maximum detected value, such as when there are elevated detection limits or small sample sizes with great variability. In these situations, USEPA recommends that the maximum detected concentration be used.

The maximum detected concentrations and the 95 percent UCLs are shown in Tables 2-12 through 2-19, with the values used in calculations specified. Exposure concentrations were based on actual data from the 354 Site (OU 005). Intake assumptions were based on USEPA guidance and are described in detail in the RI report (BMcD, 2003a). Major assumptions used to calculate intake are presented below:

- Current and Future Indoor Workers - Ingestion of chemicals in soil as indoor dust (Building 354/332/DPW Compound Area only), inhalation of vapor phase chemicals from soil and inhalation of vapor phase chemicals from groundwater.
  - Weight - 70 kilograms (kg)
  - Inhalation Intake - 0.633 cubic meters of air per hour (m^3 of air/hr)
  - Soil Ingestion Intake - 50 milligrams per day (mg/day)
  - Variable Fraction of Soil Ingested from Contaminated Source - 1
  - Exposure Time, Frequency, and Duration - Considered a regular full-time worker who is in the Building 367 or Building 354/332/DPW Compound Areas for 8 hours a day, 250 days per year, for 25 years Variable
  - Fraction of Time Spent Indoors - 1

- Future Utility Excavation Workers - Ingestion of chemicals in soil, dermal contact with chemicals in soil, inhalation of chemicals in dust, inhalation of vapor phase chemicals from soil; and inhalation of vapor phase chemicals from groundwater.
  - Weight - 70 kg
  - Exposed Skin Area - 3,600 square centimeters (cm^2)
  - Soil to Skin Adherence Factor - 0.20 mg/cm^2
  - Inhalation Intake - 2.5m^3 of air/hr
  - Soil Ingestion Intake - 330 mg/day
  - Variable Fraction of Soil Ingested from Contaminated Source - 1
  - Exposure Time, Frequency, and Duration - Workers conduct excavation work in the Fort Riley area for 8 hours a day, 6 days per year, for 25 years

- Current Groundskeeper - Ingestion of chemicals in soil, dermal contact with chemicals in soil, inhalation of chemicals in dust, inhalation of vapor phase chemicals from soil; and inhalation of vapor phase chemicals from groundwater.
  - Weight- 70 kg
  - Exposed Skin Area - 3,600 cm^2
  - Soil to Skin Adherence Factor - 0.02 mg/cm^2
  - Inhalation Intake - 1.5 m^3 of air/hr
  - Soil Ingestion Intake - 100 mg/day
  - Variable Fraction of Soil Ingested from Contaminated Source - 1
  - Exposure Time, Frequency, and Duration - Groundskeeper mows a given area for 4 hours a day, 26 days per year, for 25 years

- Current Child Residents - Ingestion of chemicals in soil, dermal contact with chemicals in soil, inhalation of chemicals in dust, inhalation of vapor phase chemicals from soil gas; inhalation of vapor phase chemicals from groundwater.
  - Weight (0-6 years old) - 15 kg
  - Exposed Skin Area - 2,800 cm^2
  - Soil to Skin Adherence Factor - 0.20 mg/cm^2
  - Inhalation Intake - 0.272 m^3 of air/hr
  - Variable Fraction of Time Spent Indoors - 1
  - Soil Ingestion Intake - 200 mg/day
  - Variable Fraction of Soil Ingested from Contaminated Source - 1
  - Exposure Time, Frequency, and Duration - Child spends 24 hours a day, 350 days per year, for 3 years

Toxicity Assessment

In a risk assessment, toxicity of COPCs is evaluated for both carcinogenic potential and noncarcinogenic adverse health effects. Data regarding health effects are then used to derive numerical toxicity values. Toxicity values used in the risk assessment were obtained from the following sources:

- Integrated Risk Information System (IRIS) (USEPA, 2003),
- Health Effects Assessment Summary Tables (HEAST) (USEPA, 1997a), and
- The USEPA National Center for Environmental Assessment Superfund Technical Support Center (USEPA, 1999c).

Risk Characterization

The non-carcinogenic risk value, the hazard quotient (HQ), represents the ratio of the chemical-specific intake rate to the toxicity value for that chemical. HQs are summed within each pathway and then for all pathways for a total hazard index. If the total hazard index is one or less, it is unlikely for even sensitive populations to experience adverse health effects within the described scenario. Tables 2-20, 2-21, 2-22, 2-23, and 2-24 show the intakes, reference values, and HQs for the future indoor worker at the Building 367 Area, future utility excavation worker at the Building 367 Area, current indoor worker scenario at the Building 354/332/DPW Compound Area, current groundskeeper at the Building 354/332/DPW Compound Area, and the current child resident at the Building 430 Area, respectively. Please note that the values presented in Tables 2-20, 2-21, 2-22, 2-23, and 2-24 are in scientific notation (i.e., 2E-03 instead of 0.002). Also note that the tables show that the non-carcinogenic hazard indices did not exceed the USEPA acceptable level for the exposure scenarios evaluated.

Carcinogenic risk represents the probability of developing cancer as a result of exposure to a given chemical. The chemical-specific risks are summed within each pathway and then for all pathways to yield total excess cancer risk posed by a site. This represents the probability of developing cancer that is solely attributable to exposure from the site and is in excess of the general background risk. USEPA has established the risk range of one in 10,000 to one in a million (1E-04 to 1E-06 in scientific notation) as a commonly-accepted, remediation goal. An excess, lifetime, cancer risk greater than one in 10,000 would generally be considered unacceptably high, while risks within the range would be acceptable depending upon site use. Risks of one in a million or less are generally considered insignificant. Tables 2-25, 2-26, 2-27, 2-28, and 2-29 show the intakes, slope factors, and the excess, lifetime, cancer risk associated with chemical exposure for the future indoor worker at the Building 367 Area, future utility excavation worker at the Building 367 Area, current indoor worker scenario at the Building 354/332/DPW Compound Area, current groundskeeper at the Building 354/332/DPW Compound Area, and the current child resident at the Building 430 Area, respectively. Please note that the values presented in Tables 2-25, 2-26, 2-27, 2-28, and 2-29 are in scientific notation (i.e., 2E-03 instead of 0.002). Also note that the tables show that the carcinogenic risk values did not exceed the USEPA acceptable range for the scenarios evaluated.

Uncertainties

Conducting a risk assessment requires making a number of assumptions that serve to introduce degrees of uncertainty in the final result. Uncertainties are inherent in the chemical identification, toxicity assessment, and exposure assessment processes. However, the cumulative effect is generally that risk has been overestimated, not underestimated. Section 7.6 of the RI report (BMcD, 2003a) provides a detailed discussion of the uncertainties and their potential effect on the risk assessment.

2.7.2 Summary of Ecological Risk Assessment

The purpose of the ecological evaluation was to assess possible adverse effects to ecological receptors that may come in contact with contaminated media. Qualitative observations, calculated exposure estimates, and best professional judgement were used to determine whether further evaluation of ecological risk is necessary (BMcD, 2003a).

Chemicals that may elicit adverse effects to ecological receptors are considered chemicals of potential ecological concern (COPECs).

The following chemicals were detected in soil samples and selected as preliminary COPECs for soils:

Benzo(a) anthracene	Benzo(a) pyrene	Benzo(b) fluoranthene
Benzo(g, h, i) perylene	Benzo(k) fluoranthene	Chrysene
Dibenz(a, h) anthracene	Fluoranthene	Indeno(l,2,3-cd) pyrene
Phenanthrene	Pyrene	

The following chemicals were detected in groundwater samples and selected as preliminary COPECs for groundwater:

Benzene	Bromodichloromethane	$CC1_4$
Chloroform	cis-l,2-DCE	Dibromochloromethane
TCE	PCE	trans-1,2-DCE
VC		

Preliminary COPECs were further evaluated and compared to toxicological benchmarks in the preliminary semi-quantitative screening.

The 354 Site (OU 005) was evaluated for the presence of ecological receptors (plants, animals, and soil organisms) and completed, ecological-exposure pathways. Ecological receptors and/or completed exposure pathways were identified within the terrace area (main operational portion) of the 354 Site (OU 005). Completed exposure pathways for terrestrial ecological receptors were not identified in the point bar area of the 354 Site because the contaminant sources at the 354 Site (OU 005) include spills and USTs associated with Buildings 430, 367, 332, and 354 in the terrace area. None of the spills and USTs associated with these buildings are in the point bar area. Since habitat is limited and human activity makes the area unattractive for the establishment of natural communities, soil and groundwater in the terrace area of the 354 Site (OU 005) were not evaluated due to a lack of completed exposure pathways. Therefore, COPECs at this location present no ecological risk. Groundwater was evaluated in the point bar area of the Site due to the aquatic communities observed in the Kansas River.

Potentially completed exposure pathways were identified at the 354 Site (OU 005), and these pathways were evaluated. Based on the available habitat at the 354 Site, wildlife receptors potentially present were identified and compared to a list of species for which benchmarks have been established. Natural history characteristics (See Tables 2-30 and 2-31) used to calculate exposure were obtained from the *Wildlife Exposure Factors Handbook Vol. I & II* (USEPA, 1993a), *Preliminary Remediation Goals for Ecological Endpoints* (Efroymson et.al., 1997), *Toxicological Benchmarks for Wildlife: 1996 Revision* (ORNL, 1996), and *The Wild Mammals of Missouri* (Schwartz and Schwartz, 1981). If benchmarks were not available for a selected species, benchmarks for species representative of the various taxa and life histories expected to occur within the 354 Site were selected as surrogate benchmark values. Representative terrestrial receptors (short-tailed shrew, white-footed mouse, meadow vole, cottontail rabbit, red fox, and white-tailed deer) were assessed semi-quantitatively. The preliminary screening did not provide any indications of adverse ecological effect from exposure to soil contamination. All other terrestrial receptors, including plants and soil organisms, were qualitatively assessed and determined to exhibit no adverse effects. The qualitative risk characterization was based on the lack of any visible adverse effects within the plant and animal communities of the 354 Site (OU 005). Based on the results of the semi-quantitative and qualitative evaluations of soil contaminants, ecological risk to terrestrial flora and fauna inhabiting the 354 Site (OU 005) is expected to be insignificant. Additionally, protected species (See Table 2-32) are unlikely to experience adverse effects due to incidental contact with contaminated soil. The future presence of any protected species in the contaminated areas at the 354 Site (OU 005) is likely to be transitory.

Potential for risk to benthic organisms inhabiting the Kansas River was assessed quantitatively. Existing chemical concentrations in groundwater near the Kansas River (as measured in samples collected from monitoring wells within the point bar area of the 354 Site [OU 005]) were compared to benchmark values for benthic organisms as shown in Table 2-33. The maximum detected concentrations of VOCs in groundwater near the Kansas River were below the benchmarks used for this evaluation. Therefore, current VOC concentration conditions within the point bar area of the 354 Site (OU 005) are unlikely to pose appreciable risk to benthic organisms in the Kansas River.

As stated in Section 8.2.1 of the RI (BMcD, 2003a), critical habitat for the bald eagle, piping plover, and interior least tern occurs along the Kansas River at the southern edge of the 354 Site (OU 005). Bald eagles are migratory and known to winter along the Kansas River. Both the piping plover and the interior least tem are seasonal inhabitants along the Kansas River. Although the food gathered along the Kansas River may make up a significant dietary component of wintering bald eagles, piping plovers and interior least terns, the approximate one-mile stretch of the Kansas River in the 354 Site (OU 005) would only account for approximately one-quarter to one-half of each species' foraging range. Only minimal exposure to arsenic would be expected due to the short amount of time these species spend along the Kansas River at the 354 Site (OU 005) and the relatively low concentrations detected in the point bar north of the Kansas River. The assessment found that the risk to bald eagles, piping plovers, and interior least terns in the vicinity of the 354 Site (OU 005) are most likely to be insignificant.

Risks to other state and federally listed species known to occur in Riley County are also likely to be insignificant.

2.7.3 Basis for Action

The baseline risk assessment (human health and ecological) that was completed for 354 Site (OU 005) found that the estimated risks to human health and the environment were within or below the USEPA acceptable levels. The presence of site-related contaminants in the Kansas River alluvial aquifer at levels exceeding drinking water standards (MCLs, identified as an ARAR) provides the basis for remedial action.

2.8 REMEDIAL ACTION OBJECTIVES

As identified in the USEPA guidance *Rules of Thumb for Superfund Remedy Selection* (USEPA, 1997b), a remedial action is generally warranted if one or more of the following conditions apply:

- Cumulative excess carcinogenic risk to an individual exceeds 10^{-4}.
- Non-carcinogenic hazard index is greater than one.
- Site contaminants cause adverse environmental impacts.
- Chemical-specific standards (i.e., ARARs) or other measures that define acceptable levels are exceeded and exposure to contaminants above these levels is predicted for the RME identified in the risk assessment.

Originally at the time of the FS for the 354 Site (OU 005), only the last listed item above applied, in that chemical-specific ARARs were being exceeded. The drinking water standard (i.e., MCL) has not been exceeded in the groundwater, which is entering the Kansas River alluvial aquifer on the north margin of the point bar, since April 2004. Note that Table 2-1 (Positive Detections in Groundwater, November 1998 through April 2005) clearly presents data emphasizing declining contaminant trends. For example, for PCE, the highest result is shown as 4,630 µg/L, with the most recent result (April 2005) as 98.5 µg/L, both within

the terrace aquifer. Also, the highest result for TCE is shown as 160 µg/L, with the April 2005 result as 3.8 µg/L.

RAOs provide a general description of what remedial action is anticipated to accomplish. RAOs are developed based on protection of human health and the environment including consideration of the goals of the CERCLA program. The current goal for long-term groundwater cleanup is summarized in the NCP:

> "USEPA expects to return usable groundwaters to their beneficial uses wherever practicable, within a time frame that is reasonable given the particular circumstances of the site. When restoration of groundwater to beneficial uses is not technically practicable, USEPA expects to prevent further migration of the plume, prevent exposure to the contaminated groundwater, and evaluate further risk reduction."

RAOs are developed in this section considering the 1) current and future use at the 354 Site (OU 005); 2) beneficial use of groundwater at the 354 Site (OU 005); 3) results of risk assessment; and 4) anticipated fate and transport of contaminants beneath the 354 Site (OU 005). Current land use, risk assessment (including media of interest, COPCs, and exposure pathways), and anticipated fate and transport are summarized in previous sections of this report with details provided in the RI Report (BMcD, 2003a). RAOs and PRGs should reflect current and potential groundwater uses and exposure scenarios that are consistent with those uses. As identified in the risk assessment, groundwater at the 354 Site (OU 005) is not currently used as a drinking water source, nor is such use anticipated in the foreseeable future. Fort Riley possesses sufficient excess capacity from the existing supply wells to provide potable water for any foreseeable expansion on the post. Additionally, the evaluation of environmental risk concluded that there is no detrimental exposure to environmental receptors at the Site.

The Kansas River reach flowing through Fort Riley is a major classified river under the Kansas State Water Plan. This reach of the river has multiple designated uses, one of which is domestic supply (KDHE, 2002). Because of this designated use, the Kansas River and its associated alluvial aquifer fall under the Kansas Antidegradation Policy. This policy applies in those situations where either an intentional or unintentional release of pollutants from a point source results in contamination or potential contamination of an alluvial aquifer that threatens to preclude attainment of the designated use of the alluvial aquifer or its associated surface water.

Although there is virtually no prospect for additional water supply wells to be installed within the Kansas River alluvial aquifer on the point bar, groundwater does discharge from the alluvial aquifer to the Kansas River along this reach. Therefore, the beneficial use of the groundwater would be as a potential source of domestic supply once it discharges to and enters the surface-water system. RAO and PRG development should reflect this.

Based on the human health and ecological risk assessments, the preliminary ARARs, the media of interest, the COPCs in groundwater at this Site, and the anticipated land and beneficial groundwater use, the RAOs for the 354 Site (OU 005) are to:

- Prevent the potential of degradation of the surface waters of the Kansas River by reducing levels or eliminating contaminants from the margin of the Kansas River alluvial aquifer.
- Reduce contamination levels to below MCLs within the Kansas River alluvial aquifer through the use of natural and/or active remedial processes.
- Reduce contaminant levels, to the extent practicable and appropriate, within the terrace aquifer, through natural and/or active remedial processes.

The RAOs are listed in the general sequence in which they should be addressed (USEPA, 1997b). These RAOs were used in the development and evaluation of remedial alternatives.

Generally, drinking water standards are relevant and appropriate as PRGs for groundwater that is determined to be a current or potential future source of drinking water. As indicated above, groundwater at the 354 Site (OU 005) is considered to have a potential beneficial use as a drinking water source due to its hydraulic connection to the Kansas River. The ultimate goal for the groundwater at the 354 Site (OU 005) is to meet unrestricted use requirements. The PRGs for groundwater are levels determined safe for drinking water (MCLs). The MCLs for the COCs at the 354 Site (OU 005) are as follows:

- PCE 5 µg/L
- TCE 5 µg/L
- cis-l, 2-DCE 70 µg/L
- Benzene 5 µg/L

Table 2-1 (Positive Detections in Groundwater, November 1998 through April 2005) clearly presents data emphasizing declining contaminant trends. For example, for PCE, the highest result is shown as 4,630 µg/L, with the most recent result (April 2005) as 98.5 µg/L. Also, the highest result for TCE is shown as 160 µg/L, with the April 2005 result as 3.8 µg/L.

2.9 DESCRIPTION OF REMEDIATION ALTERNATIVES

Following the initial screening of alternatives, the DA (Fort Riley) evaluated and selected a range of alternatives to consider for the 354 Site (OU 005). The alternatives follow:

- Alternative 1 - No Action
- Alternative 2 - MNA and ICS
- Alternative 3 - In-Situ Chemical Oxidation, MNA, and ICs
- Alternative 4 - Enhanced Anaerobic Bioremediation (EAB), MNA, and ICs
- Alternative 5 - Groundwater Extraction and Ex-Situ Treatment, MNA, and ICS

The discussion below was excerpted from the FS report, so only data that were available at the time of the preparation of the FS were used.

2.9.1 Description of Remedy Components

Following the initial screening of potential alternatives, the DA (Fort Riley) evaluated and determined a range of alternatives to consider for the 354 Site (OU 005). The alternatives are discussed below.

2.9.1.1 Alternative 1 - No Action

This alternative is the "no action" alternative which is a requirement of the NCP and provides a baseline for comparison of active remedial alternatives developed for the 354 Site (OU 005). Under the no action alternative, ICS are not implemented and remediation and monitoring of the groundwater contamination are not conducted.

By definition, this alternative requires that the current monitoring program be discontinued. At a minimum, CERCLA requires administrative re-assessments every five years, if the site is not open for unrestricted use,

whenever contaminants are left in place. Therefore, with no ICS in place with this alternative, the possibility for the public's use of the affected aquifer for a drinking water source remains.

Groundwater sampling results, up to and including the April 2005 sampling round, indicate that preliminary chemical-specific ARARs (i.e., MCLs) were exceeded for two of the COPCs at the 354 Site (PCE and benzene) (BMcD, 2004a and 2005a). Based on the October 2004 sampling results, it appears that ARARs are being met within the Kansas River alluvial aquifer. Concentrations of PCE and benzene that exceed the ARARs were primarily within the plume in the terrace aquifer and, therefore, localized with little effect on the Kansas River alluvial aquifer.

Under the "no action" alternative there is no groundwater monitoring to determine concentration trends in the plume. Therefore, under the " no action" alternative the evaluation assumes that contaminant concentrations remain essentially unchanged. However, NA processes active within the aquifer are reducing contaminant concentrations. Without monitoring, the evolution of concentrations remains an unknown and, for the purposes of this evaluation, the assumption will be made that under the "no action" alternative that MCLs will continue to be slightly exceeded. No credit is given for the in-situ treatment and excavation of the shallow soil hot spot completed east of Building 367 and the current indications of stable to declining trends. Even under these very conservative constraints, the MCL exceedances are localized, are not exceeded at the Kansas River, and do not impact an existing drinking water supply.

2.9.1.2 Alternative 2 - MNA with ICS

This alternative includes MNA and ICS. The term MNA refers to the reliance on natural attenuation processes (within the context of a controlled and monitored site-cleanup approach) to achieve site-specific, remediation objectives within a time frame that is reasonable compared to those time frames offered by other more active methods (KDHE, 2001). MNA relies on natural subsurface processes to reduce contaminant concentrations. Some of these natural processes that appear to be occurring at the 354 Site (OU 005) are dilution, dispersion, volatilization, biodegradation, and sorption (BMcD, 2004a).

Natural attenuation is sometimes perceived as equivalent to "no action." However, MNA differs from the "no action" alternative in that the site is actively monitored and evaluated to reduce the risk of exposure and to evaluate potential further degradation of the aquifer. Typical performance parameters monitored for natural attenuation can include: temperature, pH, methane, ethane, ethene, alkalinity, nitrate, sulfate, sulfide, chloride, TOC, DO, ORP, ferrous iron, and contaminant concentrations. However, these parameters can be significantly reduced at those sites where the efficacy of reductive dechlorination has been demonstrated by an extended record of sampling results. System components of MNA are usually groundwater wells, soil borings, and/or soil vapor probes (BMcD, 2004a). Contaminant concentrations will be monitored periodically to evaluate if the natural attenuation processes are reducing contaminant concentrations to below chemical-specific ARARs (MCLs). Details regarding the system components of MNA at the 354 Site (OU 005) will be included in the Remedial Design/Remedial Action Plan for the 354 Site (OU 005).

Selection of this option as a sole remedy required the collection of groundwater quality information and evaluation of contaminant degradation rates and pathways. The evidence supporting natural degradation processes at the 354 Site (OU 005), as per the USEPA MNA guidance document (USEPA, 1999a), include 1) decreasing contaminant concentration trend, and 2) supporting geochemical data measurements. A risk assessment was used to evaluate whether MNA was likely to be protective of human health and the environment (BMcD, 2004a).

For MNA to be considered a stand-alone, remedial alternative for the 354 Site (OU 005), the criteria outlined in the following guidance documents must be met: *Monitored Natural Attenuation, Bureau of Environmental Remediation/Remedial Section Policy*, BER Policy # BER RS 042 (KDHE, 2001); and *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites* (USEPA, 1999a).

Site geochemical and contaminant concentrations and results from USEPA reductive dechlorination screening protocol (USEPA, 1998) indicated that there is strong evidence for reductive dechlorination (and thus natural attenuation) of chlorinated solvents at the 354 Site (OU 005) (BMcD, 2004a). Samples are collected, analyzed, and evaluated on a periodic basis. If the groundwater MCLs are not exceeded for three consecutive years, the 354 Site (OU 005) will be recommended for the discontinuance of sampling and for site closeout during the next periodic review. At a minimum, CERCLA requires administrative re-assessments every five years, if the Site is not open for unrestricted use, whenever contaminants are left in place.

The pilot study virtually eliminated the shallow soil contamination east of Building 367. This in-situ treatment and soil removal action was completed in December 2004. This will ensure that there is no re-mobilization of chlorinated solvent contamination from the shallow soils in this vicinity. The result should be decreasing concentrations of contaminants in groundwater both within the terrace aquifer and the Kansas River alluvial aquifer; therefore, credit was given for the pilot study when evaluating Alternative 2.

ICS

The primary control for the on-post portion of the 354 Site (OU 005) will be to restrict use through the environmental overlay of the RPMP. Master planning for Army installations is required by Army Regulation (AR) 210-20 which establishes a relationship between environmental planning and real property master planning in order to ensure that the environmental factors are included in planning decisions and land use. The long-range component of the RPMP consists of narratives and supporting graphics that include a Master Plan Environmental Overlay (MPEO) to reflect operational and environmental constraints. The 354 Site (OU 005) will be designated as restricted land use in the RPMP. The category directs the RPMP user to the MPEO that subsequently identifies the restrictions. Restrictions will limit exposure at the 354 Site (OU 005) by:

- Restricting use to non-residential
- Limiting public access
- Prohibiting installation of drinking water wells and groundwater use in the area
- Involving PWE personnel in proposed future plans for the 354 Site (OU 005)

The federal ownership of an active military base limits the layering of other proprietary or government controls. The only additional controls that will be implemented at the 354 Site (OU 005) are informational controls (KDHE Identified Site List and community awareness through the RAB).

As with Alternative 1, a review will be conducted no less often than every five years after initiation. This alternative is anticipated to meet preliminary chemical-specific ARARs (i.e., MCLs). Groundwater monitoring will provide data for the continuing evaluation of progress. It is anticipated that ICS could also be relaxed at the time RAOs are achieved across the 354 Site. The elimination of the soil hot spot at Building 367 under the pilot test program should also assist in meeting chemical-specific ARARs.

Preliminary location-specific ARARs for Alternative 2 mainly concern endangered species. Location-specific ARARs will be met by coordinating remedial activities with the Fort Riley DPW - Environmental Division personnel to minimize or eliminate adverse impact to wildlife. Preliminary action-specific ARARs include CERCLA, Occupational Safety and Health Administration (OSHA) regulations, and water-well construction and abandonment regulations. It is anticipated that there would be no difficulties complying with all of these.

In addition to ARARs, this alternative is anticipated to comply with the to-be-considereds (TBCs) discussed in *Monitored Natural Attenuation, Bureau of Environmental Remediation/Remedial Section Policy* (KDHE, 2001), and *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites* (USEPA, 1999a). MNA is not anticipated to pose an unacceptable risk to human health because the risk estimates for current and future RME scenarios do not exceed the USEPA accepted risk levels (BMcD, 2003a). MNA is not anticipated to allow continued degradation of groundwater quality, because the contaminant levels at the 354 Site are continuing to decrease. Samples collected from the Kansas River indicate that the plume is not impacting the river.

2.9.1.3 Alternative 3 - In-Situ Chemical Oxidation, MNA, and ICS

Chemical oxidation (chemox) converts hazardous contaminants to non-hazardous or less toxic compounds that are more stable, less mobile, and/or inert. The oxidizing agents most commonly used are ozone, peroxide, and permanganate (MnO_4). For the purposes of conceptual design, cost estimation, and applicability evaluation, the potassium permanganate ($KMnO_4$) technology and vertical injection points were used as a representative option. MnO_4 is a selective oxidant in that it has the potential to be less reactive with some of the natural organics and can persist longer in the subsurface than Fenton's reagent or ozone. MnO_4 is generally effective in treating chlorinated ethenes (i.e., PCE, TCE, and cis-l, 2-DCE). A system of vertical or horizontal wells could deliver these oxidants to selected aquifer zones. If monitoring results indicate that this groundwater contamination contributes to the plume such that natural processes are not attenuating the plume within a reasonable time frame, then this alternative is an option.

Alternative 3 consists of in-situ treatment of contaminated groundwater within the terrace aquifer located directly below the shallow soil hot spot just east of Building 367. This will include sampling of groundwater and matrix to evaluate the natural oxidant demand (NOD) (i.e., approximately 50 to 60 ft below ground surface [bgs]). For cost estimating purposes, it is assumed up to nine deep borings (i.e., similar to shallow, pilot-test scope) could be installed. Four of the borings could be converted to monitoring wells screened from the top of bedrock to the top of groundwater (approximately ten ft thick). The monitoring wells would be used to evaluate if the dissolved groundwater concentrations are sufficiently high to justify treatment and to monitor the effectiveness of treatment once implemented. Alternative 3 is designed to treat groundwater within the terrace aquifer that exhibits concentrations of COPCs in excess of MCLs. Although groundwater monitoring indicates that the plume poses no adverse risk to human health and the environment, by treating groundwater with contaminant levels above MCLs, it may be possible to reach site closure in a shorter time and possibly reduce the cost of long-term monitoring. This alternative focuses on treating the saturated zone, which has a thickness of approximately 6 ft and is at a depth of approximately 52 to 58 ft bgs.

The injection of concentrated MnO_4 solution or slurry is assumed to avoid longer-term O&M associated with solution injection, circulation, and recovery system. The injection can be implemented using direct-push technology with an injection pump and mixing equipment at the ground surface. A small pilot test will be conducted to evaluate the application mechanics including direct-push ease, injectability, and estimate effective injection radius, prior to full-scale implementation. For full-scale design, it is assumed

that injection is effective over an approximate ten ft radius and that eight direct-push injections (40 ft x 70 ft area) can be performed within five days. A total oxidant demand based on proposed, bench-scale testing and contingency for excess oxidant added to the subsurface is assumed to be slightly higher than the shallow, soil, bench-test results or 6.0 g $KMnO_4$/kg (0.006 pounds [lbs] $KMnO_4$/lb of soil). This would require an estimated injection of approximately 7,000 lbs of $KMnO_4$, assuming a 40 ft by 70 ft treatment area approximately ten ft thick with an aquifer matrix density of 1.5 tons per yd^3.

The inclusion of ICS and MNA with this alternative reduces the potential for human ingestion, inhalation, or direct contact with contaminated groundwater at the 354 Site (OU 005). These ICS are the same as described for Alternative 2. As with Alternative 1, a review will be conducted no less often than every five years after initiation.

The pilot study soil remediation treatment virtually eliminated the shallow, soil, contamination east of Building 367. This in-situ treatment and soil removal action was completed in December 2004. This will ensure that there is no re-mobilization of chlorinated solvent contamination from the shallow soils in this vicinity. The result should be decreasing concentrations of contaminants in groundwater both within the terrace aquifer and the Kansas River alluvial aquifer.

Groundwater monitoring will provide data for the continuing evaluation of progress. It is anticipated that ICS could also be relaxed at the time RAOs are achieved across the 354 Site (OU 005).

This alternative is anticipated to control exposure to the contaminated groundwater through governmental controls and proprietary controls. Therefore, the use of groundwater during the time when levels are decreasing is restricted by this alternative. This alternative potentially could accelerate meeting chemical-specific ARARs (i.e., MCLs) in the terrace and Kansas River alluvial aquifers by reducing dissolved phase contaminants. The elimination of the soil hot spot at Building 367 under the pilot study soil remediation treatment should also assist in meeting chemical-specific ARARs.

Preliminary location-specific ARARs for Alternative 3 mainly concern endangered species. Location-specific ARARs will be met by coordinating remedial activities with the Fort Riley DPW - Environmental Division personnel to minimize or eliminate adverse impacts on wildlife. Preliminary action-specific ARARs are anticipated to be met by this alternative as follows. An underground injection permit will not be required to inject MnO_4. However, the functional equivalent of a permit may be necessary for the KDHE concurrence because the substantive requirements of a permit must be satisfied. There should be no problems meeting all the OSHA requirements during implementation of this alternative.

2.9.1.4 Alternative 4 - Enhanced Anaerobic Bioremediation, MNA, and ICS

EAB involves the addition of carbon sources such as lactate, vegetable oil, or molasses to aquifer materials to enhance reductive dechlorination. A system of vertical or horizontal wells could deliver these nutrients to selected aquifer zones. For conceptual design, cost estimation, and applicability evaluation, the lactate technology is a representative option. Specifically, the sodium lactate option (slow release) was used for cost estimation purposes.

This alternative consists of installing an in-situ treatment system within the terrace aquifer portion of the plume to remediate the most contaminated area of the plume. Attenuation of contamination is occurring in the terrace aquifer, but monitoring indicates that biological processes may not be significant compared to physical attenuation mechanisms such as adsorption, dilution, and dispersion. Natural biological

degradation processes are indicated to be operating where the plume enters the Kansas River alluvial aquifer. No biostimulation was proposed for the down gradient portion of the plume because the natural attenuation rates appear adequate to polish any residual dissolved contamination that may escape an up-gradient treatment zone in the terrace aquifer. Specifically, existing attenuation rates appear sufficient in the alluvial portion of the plume because under the present conditions, where unremediated, terrace-aquifer, plume water enters the Kansas River alluvial aquifer, contamination is attenuated such that concentrations exceeding MCLs do not reach the Kansas River.

Conceptual design of this alternative makes use of two curtains spaced approximately 600 ft apart. The 600 ft curtain spacing will allow over one pore volume of groundwater to flow through the treatment curtains in approximately six months. Any contaminants remaining above MCLs following the lactate treatment are anticipated to be remediated through MNA.

The inclusion of ICS and MNA with this alternative reduces the potential for human ingestion, inhalation, or direct contact with contaminated groundwater at the 354 Site (OU 005). These ICS are the same as described for Alternative 2. At a minimum, CERCLA requires administrative re-assessments every five years whenever contaminants are left in place, if the she is not open for unrestricted use.

The pilot study soil remediation treatment virtually eliminated the shallow soil hot spot east of Building 367. This in-situ treatment and soil removal action was completed in December 2004. This will ensure that there is no re-mobilization of chlorinated solvent contamination from the shallow soils in this vicinity. The result should be decreasing concentrations of contaminants in groundwater both within the terrace aquifer and the Kansas River alluvial aquifer.

This alternative is anticipated to control exposure to the contaminated groundwater through governmental controls and proprietary controls. Therefore, the use of groundwater during the time when levels are decreasing to MCLs is restricted by this alternative. This alternative potentially could accelerate meeting chemical-specific ARARs (i.e., MCLs) in the terrace and Kansas River alluvial aquifer by stimulating microbes and accelerating natural biological processes that are operating at the 354 Site (OU 005). Groundwater monitoring will provide data for the continuing evaluation of progress. It is anticipated that ICS could also be relaxed at the time RAOs are achieved across the 354 Site (OU 005). The elimination of the soil hot spot at Building 367 under the pilot study soil remediation treatment program should also assist in meeting chemical-specific ARARs.

Preliminary location-specific ARARs for Alternative 4 mainly concern endangered species. Location-specific ARARs will be met by coordinating remedial activities with the Fort Riley DPW - Environmental Division personnel to minimize or eliminate adverse impacts on wildlife. Action-specific ARARs are anticipated to be met by this alternative as follows. An underground injection permit will not be required to inject lactate into the subsurface. However, the functional equivalent of a permit may be necessary for the KDHE concurrence because the substantive requirements of a permit must be satisfied. The OSHA requirements are anticipated to be met during implementation of this alternative.

2.9.1.5 Alternative 5 - Groundwater Extraction and Ex-Situ Treatment, MNA, and ICS

This alternative consists of installing a groundwater extraction system in the area of plume origin immediately east of Building 367 and additional wells along the axis of the dissolved plume within the terrace aquifer. For conceptual design purposes, a single extraction well is placed in the plume origin area (east of Building 367) and an additional four wells are placed as two extraction lines (two wells per line)

across the plume at the mid-plume, and down-plume positions. Due to extremely low VOC concentrations and evidence of natural biodegradation occurring in the Kansas River alluvial aquifer, no extraction wells are proposed to be placed in the Kansas River alluvial aquifer. The purpose of the groundwater extraction is to capture and remove contamination from the terrace aquifer and minimize any contamination that may enter the Kansas River alluvial aquifer. Groundwater extraction and treatment (pump and treat) is designed in this alternative to provide containment of concentrations above MCLs while NA processes in the Kansas River alluvial aquifer further reduce or polish any residual dissolved contaminants. While the limitations of pump and treat as a remediation technology are well documented (USEPA, 1996; National Academy Press [NAP], 1994; and United States Department of Energy [USDOE], 2002), pump and treat is still recognized as an effective method of providing containment while other technologies are used for remediation, and has been implemented at hundreds of sites (USEPA, 1996).

Groundwater is anticipated to be treated by air stripping, followed by discharging the treated water to the sanitary sewer, then ultimately to the Kansas River. Depending on final design/treatability testing, a combination of air stripping, followed by activated-carbon treatment is also an option. For cost estimating purposes, it is assumed that activated-carbon polishing will be used after air-stripping. No off-gas treatment of the air-stripper discharge is proposed due to the small mass of chlorinated compounds that are in the plume.

The inclusion of ICS and MNA with this alternative reduces the potential for human ingestion, inhalation, or direct contact with contaminated groundwater at the 354 Site (OU 005). These ICS are the same as described for Alternative 2.

The pilot study soil remediation treatment virtually eliminated the shallow soil hot spot east of Building 367. This in-situ treatment and soil removal action was completed in December 2004. This will ensure that there is no re-mobilization of chlorinated solvent contamination from the shallow soils in this vicinity.

The result should be decreasing concentrations of contaminants in ground water both within the terrace aquifer and the Kansas River alluvial aquifer.

This alternative is anticipated to control exposure to the contaminated groundwater through governmental controls and proprietary controls. Therefore, the use of groundwater during the time when levels are decreasing to MCLs is restricted by this alternative. With respect to the terrace aquifer where the higher concentrations are detected, the relatively thin nature of the aquifer (i.e., ten-ft average saturated zone) limits the potential use of this water given the option for better well yields in the thicker Kansas River alluvial aquifer. This alternative is anticipated to meet preliminary chemical-specific ARARs (i.e., MCLs) by reducing the contaminant mass already undergoing suspected natural biodegradation. The elimination of the soil hot spot at Building 367 under the pilot test program should also assist in meeting chemical-specific ARARs. Groundwater monitoring will provide data for the continuing evaluation of progress. It is anticipated that ICS could also be relaxed at the time RAOs are achieved across the 354 Site (OU 005).

Preliminary location-specific ARARs for Alternative 5 mainly concern endangered species, and archaeological and historical preservation. Location-specific ARARs will be met by coordinating remedial activities with Fort Riley DPW-Environmental Division personnel to minimize or eliminate adverse impacts on either wildlife, archaeological sites, or historical structures.

Action-specific ARARs are anticipated to be met by Alternative 5 as follows. This alternative will be compliant with air quality regulations because of the small quantities of VOCs that will be discharged to the

atmosphere during stripping. Treated water will be discharged to the Fort Riley sanitary sewer system under its National Pollutant Discharge Elimination System (NPDES) permit. The OSHA and water-well construction requirements are anticipated to be met during implementation of this alternative.

2.9.2 Common Elements and Distinguishing Features of Each Alternative

Many of the alternatives evaluated for the 354 Site (OU 005) include common components, while certain characteristics of some of the alternatives clearly distinguish them from the others. Table 2-34 presents the estimated time for design and construction, as well as the estimated time to reach remediation goals for each of the alternatives. In addition, Table 2-34 presents the estimated costs associated with each of the alternatives. Following are lists of many of these common elements and distinguishing features.

Common Elements

Common elements among the alternatives include:

- Alternatives 2 through 5 include some of the same ICS which will be detailed in the Remedial Design/Remedial Action Plan.
- Alternatives 1,2, and 4 involve biodegradation as the primary means of contaminant reduction.
- Alternatives 1, 2, and 4 result in the generation of intermediate daughter products.
- Alternatives 1, 2, 3, and 4 involve the destruction of contaminants in-situ, without transferring contaminants to other media.
- Alternatives 2 through 5 involve periodic or confirmational groundwater sampling, which will be detailed in the RD/RA Plan.
- Alternatives 3 through 5 involve the installation of treatment or extraction systems.
- Alternatives 3 and 4 involve the injection of foreign material into or down gradient of the plume.
- Alternatives 3, 4, and 5 involve down-gradient treatment via transport in the groundwater media.
- Alternatives 3, 4, and 5 involve treatment in the higher concentration areas within the terrace aquifer.
- All alternatives are anticipated to eventually meet the same chemical-specific ARAR (MCLs).
- All alternatives are anticipated to be in compliance with the same location-specific ARARs.
- Alternatives 3 through 5 require compliance with OSHA requirements (action-specific ARAR).
- Alternative 5 requires compliance with the Ambient Air Quality Standards and Air Pollution Control ARAR (action-specific ARAR).
- Alternatives 2, 3, and 4 are comparable in regard to cost.
- All alternatives require at least one five-year review and a closure report.

Distinguishing Features

Distinguishing features among the alternatives include:

- Alternative 1 does not include periodic groundwater sampling or ICS.

- Although quantitative modeling was not performed at the 354 Site (OU 005), a qualitative estimate was made of the relative rates of site cleanup, using these alternatives. Alternative 5 (Pump & Treat) would achieve cleanup levels most quickly and Alternative 2 (MNA) would take the longest to achieve cleanup levels. Alternatives 3 and 4 (Chemox and EAB) would probably take an intermediate length of time.
- Alternative 1 is considerably less expensive than the other alternatives.
- Alternative 5 is the most expensive alternative.

2.10 SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

Nine criteria are used to evaluate the different remediation alternatives individually and against each other in order to select a remedy. This section of the ROD profiles the relative performance of each alternative against the nine criteria, noting how it compares to the other options under consideration. The nine evaluation criteria are defined below in Section 2.10.1.

2.10.1 Evaluation Criteria for CERCLA Remedial Alternatives

The first two criteria are the "threshold" factors. Any alternative that does not satisfy both of the following criteria is dropped from further consideration in the remedy selection process:

- Overall Protectiveness of Human Health and the Environment
- Compliance with ARARs

Five "primary balancing" criteria are then used to make comparisons and to identify the major trade-offs between the remedial alternatives. Alternatives that satisfy the threshold criteria are therefore evaluated using the following balancing criteria:

- Long-term Effectiveness and Permanence
- Reduction of Toxicity, Mobility, or Volume of Contaminants through Treatment
- Short-term Effectiveness
- Implementability
- Cost

The remaining two criteria are "modifying" factors and are to be evaluated in the ROD. The evaluation of these two factors can only be complete after the PP is published for comment and the public comment period is completed. These modifying factors are:

- State/Support Agency Acceptance
- Community Acceptance

2.10.2 Evaluation Method

The alternatives were scored on a pass/fail basis for the two threshold criteria (protection of human health and environment, and compliance with ARARs). Those alternatives passing the threshold criteria were then evaluated for the five balancing criteria on the basis of incremental differences between alternatives (BMcD, 2004a). The final two modifying criteria were then evaluated for the selected remedy only.

An evaluation and comparison was performed to facilitate a rating of the alternatives evaluated in the detailed analysis. Evaluations were based on vendor information, published reports, past experiences, and professional judgment.

2.10.3 Comparative Analysis

This section of the ROD compares the alternatives against the nine criteria, noting how each compares to the other alternatives. Note that all alternatives are evaluated against the initial seven criteria, but only the selected remedy is evaluated against the final two criteria.

2.10.3.1 Overall Protection of Human Health and the Environment

Overall protectiveness of human health and the environment determines whether an alternative eliminates, reduces, or controls threats to public health and the environment through ICS, engineering controls, or treatment. This is a pass/fail criterion. Based on the risk assessments (human health and ecological) performed in the RI Report (BMcD, 2003a), all of the alternatives are protective of human health and the environment because the risk estimates for current and future RME scenarios do not exceed the USEPA accepted risk levels. However, for the purposes of this comparative analysis, Alternative 1 will be considered as not protective of human health and the environment. This is not unreasonable if an unforeseen exposure scenario develops and there are no ICS in place to deal with it.

2.10.3.2 Compliance with ARARs

CERCLA § 121(d) and NCP § 300.430(f)(l)(ii)(B) require that remedial actions at CERCLA sites at least attain legally applicable or relevant and appropriate Federal and state requirements, standards, criteria, and limitations which are collectively referred to as ARARs, unless such ARARs are waived under CERCLA § 12l(d)(4).

Applicable requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental, or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable. Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental, or facility siting laws that, while not applicable to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstances at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well-suited to the particular site. Only those state standards that are identified in a timely manner and are more stringent than federal requirements may be relevant and appropriate.

Compliance with ARARs evaluates whether the alternative meets Federal and State environmental statutes, regulations, and other requirements that pertain to a site, or whether a waiver is justified. This is a pass/fail criterion. All of the remedial alternatives, except Alternative 1 (No Action), are anticipated to comply with preliminary chemical-specific ARARs. Additionally, it appears that possible location- and action-specific ARARs will not be a factor. Alternative 1 does not comply with chemical-specific ARARs (i.e., MCLs) because contaminant levels are currently above MCLs and this alternative takes no action to address the ARAR. It is probable that Alternative 1 would eventually meet preliminary chemical-specific ARARs as a

result of NA processes active within the aquifer. However, Alternative 1 provides no mechanism to ensure that ARARs have been met. Therefore, Alternative 1 was dropped from further consideration because it does not meet one of the threshold criteria (i.e., either overall protection of human health and the environment; or compliance with ARARs).

2.10.3.3 Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence considers the ability of an alternative to maintain protection of human health and the environment over time. It is assumed that the shallow soil treatment (pilot study) eliminated the soil hot spot at the 354 Site (see Sections 1.3.6). Once RAOs are met, Alternatives 2 through 5 should all provide similar long-term effectiveness and permanence at the Site.

2.10.3.4 Reduction of Toxicity, Mobility, or Volume

Reduction of toxicity, mobility, or volume of contaminants through treatment evaluates an alternative's use of treatment to reduce the harmful effects of principal contaminants, their ability to move in the environment, and the amount of contamination present. Alternatives 3 through 5 are anticipated to provide similar levels of reduction in toxicity, mobility, and volume of contaminants in the plume through treatment. Alternative 2, MNA with ICS, uses microbial processes already on-going in the groundwater system to achieve cleanup goals in lieu of a more active treatment.

2.10.3.5 Short-Term Effectiveness

Short-term effectiveness considers the length of time needed to implement an alternative and the risks the alternative poses to workers, residents, and the environment during implementation until cleanup levels are achieved. Since there are no nearby residents or sensitive environments, none of the alternatives are expected to pose an unacceptable risk to these targets during implementation. Exposures to site workers that may result from exposures during implementation of Alternatives 3 and 5 can be mitigated through proper engineering controls and health and safely planning. Alternatives 2 and 4 would not pose unacceptable risks to site workers. Table 2-34 presents the estimated time for design and construction, as well as the estimated time to reach remediation goals for each of the alternatives. In addition, Table 2-34 presents the estimated costs associated with each of the alternatives.

2.10.3.6 Implementability

Implementability addresses the technical and administrative feasibility of a design through construction and operation. Factors such as availability of services and materials, administrative feasibility, and coordination with other government entities are also considered.

Alternative 2 (MNA) would be the simplest alternative to implement because there are no activities associated with this alternative other than groundwater monitoring and ensuring that the ICS remain effective. Administrative implementability of the ICS associated with this alternative would be the same as for the other alternatives.

Alternatives 3 and 4 (Chemox and EAB) would be fairly simple to implement since both require the use of direct-push equipment to inject treatment fluids into the aquifer. No permanent support infrastructure on the surface is required. Preferential pathways for the injected materials to move during injection may be an implementability issue with Alternatives 3 and 4. Administrative implementability of the ICS associated with this alternative would be the same as for the other alternatives.

Alternative 5 (Pump & Treat) would be the most difficult alternative to implement. This alternative would require an extensive surface support infrastructure and would likely require trenching during the construction phase. It would be difficult to perform these construction tasks because of the built-up nature of Main Post. Administrative implementability of the ICS associated with this alternative would be the same as for the other alternatives.

2.10.3.7 Cost

Cost includes estimated capital, periodic, and annual O&M costs, as well as present worth cost. Present worth cost is the total cost of an alternative over time in terms of today's dollar value. Cost estimates are expected to be accurate within a range of+50 to -30 percent. Alternative 5 (Pump & Treat) is the only alternative which requires a significant O& M cost. While cost estimates are sound, unexpected costs could occur during implementation of Alternatives 3, 4, or 5. The estimated present worth costs for the alternatives, not including the No Further Action alternative, range from $1,000,000 for Alternative 2 - MNA - to $3,700,000 for Alternative 5 - Pump & Treat. The cost of each alternative increases as the degree of soil treatment increases. Cost summaries are presented in Table 2-34.

2.10.3.8 State/Support Agency Acceptance

State/support agency acceptance considers whether the State agrees with DA's analyses and recommendations, as described in the RI and FS reports (BMcD, 2003a and 2004a) and PP (BMcD, 2005b). The KDHE supports the selected remedy presented in the PP for the 354 Site (OU 005).

2.10.3.9 Community Acceptance

Community acceptance considers whether the local community agrees with DA's analyses and preferred alternative. No comments were received on the PP (BMcD, 2005b) which is an important indicator of community acceptance. Based on the lack of comments from the public on the PP (BMcD, 2005b), the selected remedy for the 354 Site (OU 005) appears acceptable to the community.

2.10.4 Summary of Comparative Analysis

The alternatives were first evaluated as either compliant or non-compliant with the threshold criteria (Protection of Human Health and the Environment, and Compliance with ARARs). The No Action alternative was the only alternative that does not comply with the threshold criteria (non-compliant with ARARs), and it was removed from further consideration in the ranking of alternatives. Each alternative that met the threshold criteria was then compared using the five balancing criteria. The preferred alternative with the most favorable ranking is Alternative 2 (MNA).

The favorable MNA rating was due to the ease of implementation (no physical systems required except for the groundwater monitoring system that is already in place), effectiveness of the microbial process already on-going in the groundwater system to achieve cleanup goals, and relatively low costs.

2.11 PRINCIPAL THREAT WASTES

The NCP establishes an expectation that treatment will be used to address the principal threats posed by a site wherever practicable. Identifying principal threat wastes combines concepts of both hazard and risk. In general, principal threat wastes are those source materials considered to be highly toxic or highly mobile

which cannot be contained in a reliable manner or would present a significant risk to human health or the environment should exposure occur. Contaminated groundwater is not considered to be a source material and is, therefore, not generally considered to be a principal threat waste (USEPA, 1998).

The principal threat waste source in soil was reduced to concentrations below the KDHE soil-to-groundwater protection pathway RSK levels. The source reduction occurred through a soil remediation treatment pilot study (using in-situ treatment and excavation) and was completed in November 2004. Therefore, there are no known principal threat wastes at the 354 Site (OU 005). Only the groundwater remains contaminated with VOCs above MCLs. Since there are no known principal threat wastes at the 354 Site (OU 005), the selected remedy will rely on natural processes to address the contaminated groundwater.

2.12 SELECTED REMEDY

Alternative 2: MNA with ICS, the selected remedy for the 354 Site (OU 005), will address the contaminated groundwater. Alternative 2 will use ICS to prevent exposure of receptors to contaminated groundwater. MNA relies on natural degradation processes already demonstrated to be occurring at the 354 Site (OU 005) to further reduce contaminant concentrations to or below the MCLs. Monitoring will be conducted to follow the effectiveness and progress of natural attenuation.

2.12.1 Summary of the Rationale for the Selected Remedy

This section provides a discussion of the principal factors upon which the remedy decision was based. The principal factors influencing the DA (Fort Riley) in its selection of Alternative 2 (MNA) are presented as follows:

- Soil contamination was reduced through a pilot study treatment to below levels determined by KDHE to prevent further leaching to groundwater.
- Current monitoring data indicate no evidence of principal threat waste.
- Natural attenuation combined with soil remediation treatment has resulted in a continuing decrease in contaminant concentrations in groundwater.
- The selected remedy is expected to continue to provide risk reduction through degradation of contaminants in the groundwater.
- The selected remedy provides measures to prevent future exposure to currently contaminated groundwater.
- The selected remedy provides the best balance of tradeoffs with respect to the balancing and modifying criteria.
- DA, USEPA, KDHE, and the public believe the selected remedy would be protective of human health and the environment, would comply with ARARs, would be cost effective, and would utilize permanent solutions to the maximum extent practicable.

2.12.2 Description of the Selected Remedy

The selected remedy for remediation of the groundwater contamination at the 354 Site is Alternative 2 (MNA with ICS). This alternative relies on natural degradation processes already occurring at the 354 Site to further reduce contaminant concentrations to levels below the MCLs. This section will provide a detailed description of the selected remedy.

MNA

The term MNA refers to the reliance on natural attenuation processes (within the context of a controlled and monitored, site-cleanup approach) to achieve site-specific, remediation objectives within a time frame that is reasonable compared to those time frames offered by other more active methods (KDHE, 2001). MNA relies on natural subsurface processes to reduce contaminant concentrations. Natural attenuation is composed of destructive and nondestructive mechanisms for reducing the principal contaminants to levels at or below their respective MCLs.

Nondestructive mechanisms include dispersion, diffusion, dilution, volatilization, and sorption. Dispersion, typically referred to as mechanical dispersion, is the process by which a contaminant plume spreads or disperses as it moves down gradient. Contaminated groundwater mixes with uncontaminated groundwater and produces a dilution of the plume along the leading edge (Fetter, 1999). Diffusion is the process by which contaminants move from an area of greater concentration toward an area of lesser concentration (Fetter, 1999). Diffusion processes are more pronounced in groundwater systems with very slow flow velocities. The faster the flow velocity, the less likely there will be a noticeable effect due to diffusion processes.

Dilution is the process by which contaminant levels are reduced by introducing clean water into an area of contaminated groundwater. The clean water mixes with the contaminated water and reduces the contaminant concentrations through dilution. Volatilization is the process by which groundwater concentrations of chlorinated solvents are reduced through mass transfer between liquid and gaseous phases. Contaminants that come in contact with air molecules may transfer from a liquid to gaseous phase and enter the air, thus decreasing the concentration in groundwater.

Adsorption is the process by which contaminants adhere to the solid surface of minerals or organic carbon present in the aquifer. These contaminants may later desorb from the solid surface and continue to flow along with the moving groundwater. This process of adsorption and desorption is generally referred to as sorption and is responsible for slowing the transport of contaminants relative to the transport of groundwater.

Destructive mechanisms include abiotic and biotic degradation processes. Abiotic degradation includes processes such as dechlorination of chlorinated aliphatic hydrocarbons through chemical reactions with ferrous iron. Biotic degradation includes degradation through mechanisms such as electron acceptor reactions, electron donor reactions, and co-metabolism. An important process of natural biodegradation of chlorinated solvents in groundwater is through reductive dechlorination (an electron acceptor reaction) (Wiedemeier and Chapelle. 1998). The reductive dechlorination pathway for PCE is as follows:

PCE →> TCE→> cis- or trans-1,2-DCE →> VC →> Ethene →> Carbon Dioxide + Water.

Implementation of MNA involves actively monitoring and evaluating the site to reduce the risk of exposure and to evaluate potential further degradation of the aquifer. Typical performance parameters monitored for natural attenuation include: temperature, pH, methane, ethane, ethene, alkalinity, nitrate, sulfate, sulfide, chloride, TOC, DO. ORP. ferrous iron, and contaminant concentrations. For the 354 Site, the MNA system components are groundwater wells. Contaminant concentrations will be monitored periodically to evaluate if the natural attenuation processes continue to reduce contaminant concentrations to below chemical-specific ARARs (MCLs).

Site geochemical and contaminant concentrations and results from USEPA reductive dechlorination screening protocol (USEPA, 1998) indicated that there is evidence for reductive dechlorination (and thus natural attenuation) of chlorinated solvents at the 354 Site (BMcD, 2003a). Samples are collected, analyzed, and evaluated on a periodic basis. If the groundwater MCLs are not exceeded for three consecutive years, the 354 Site will be recommended for the discontinuance of sampling and for site closeout during the next periodic review. At a minimum, CERCLA requires administrative re-assessments every five years, if the 354 Site is not open for unrestricted use, whenever contaminants are left in place.

Institutional Controls

The primary control for the 354 Site will be to restrict use through the environmental overlay of the RPMP. Master planning for Army installations is required by Army Regulation 210-20, which establishes a relationship between environmental planning and real property master planning to ensure that environmental factors are included in planning decisions and land use. The long-range component of the RPMP consists of narratives and supporting graphics that include a MPEO to reflect operational and environmental constraints. The 354 Site has been designated as restricted land use in the RPMP. The category directs the RPMP user to the MPEO that subsequently identifies the restrictions. Restrictions will limit exposure at the 354 Site by:

- Restricting use to non-residential
- Limiting public access
- Prohibiting installation of drinking water wells and groundwater use in the area
- Involving PWE personnel in proposed future plans for the 354 Site

The federal ownership of an active military base limits the layering of other proprietary or government controls. The only additional controls that will be implemented at the 354 Site are informational controls (KDHE Identified Site List and community awareness through the RAB).

2.12.3 Summary of the Estimated Remedy Costs

The costs for the selected remedy of MNA with ICS are summarized below:

Present Worth Cost:	$1,000,000
Capital Cost:	$ 48,000
Total O&M Cost:	$1,200,000
Periodic Costs:	$ 110,000
Total Project Cost:	$1,300,000

Detailed cost analysis tables are presented in Tables 2-35 and 2-36. For the cost estimation process, data were gathered from cost estimation software (Remediation Action Cost Engineering and Requirements [RACER], 2003), vendor quotations, prior expenses, and professional judgement. The Present Worth Cost is based on the discount rate of 3.2% following USEPA guidelines (USEPA, 1993b and 2000). The discount rate is based on the difference between the return rate on an annuity investment minus the inflation rate. The rate of return was based on a 30-year treasury bill of 5.2% and an inflation rate of 2%. This resulted in a discount rate of 3.2%. Capital cost includes cost for implementing ICS such as groundwater restrictions and access easements.

Total O&M costs are based on annual natural attenuation/groundwater monitoring and include groundwater sampling, laboratory analyses, quality control reporting, data summary reporting, electronic data submittals, and project administration. Periodic costs include five-year review reports and closure reports.

The information in this cost estimate summary is based on the best available information regarding the anticipated scope of the remedial alternative. Changes in the cost elements are likely to occur as a result of new information and data collected during operation and further design of the selected remedy. Major changes may be documented in the form of a memorandum in the Administrative Record file, an Explanation of Significant Differences, or a ROD amendment. This is an order-of-magnitude engineering cost estimate that is expected to be within +50 to -30 percent of the actual project cost.

2.12.4 Expected Outcomes of the Selected Remedy

The selected remedy relies on natural degradation processes already occurring at the 354 Site (OU 005) to further reduce contaminant concentrations to levels below the MCLs. With this alternative, the 354 Site (OU 005) will undergo groundwater sampling to monitor progress, and ICS will be put in place to prevent exposure of receptors where MCLs are exceeded. The USEPA and KDHE will provide oversight and will have the opportunity to collect split samples to confirm the results that will be used to evaluate the effectiveness of the selected remedy.

Currently, there is no human exposure to the contaminated groundwater and concentrations of contaminants in groundwater in the point bar are below MCLs based on the most recent groundwater sampling results (April 2005). The selected remedy will be considered complete when the following COCs are below their respective MCLs for three consecutive years post-ROD (CY 2006) in the Kansas River alluvial aquifer. The MCLs have not been exceeded in the Kansas River alluvial aquifer since April 2004:

- PCE (MCL is 5 µg/L)
- TCE (MCL is 5 µg/L)
- cis-1,2-DCE (MCL is 70 µg/L)
- Benzene (MCL is 5 µg/L)

If the groundwater MCLs are not exceeded for three consecutive years post-ROD (CY 2006) in the Kansas River alluvial aquifer, the 354 Site (OU 005) will be recommended for the discontinuance of sampling and for site close out during the next periodic review. CERCLA requires administrative re-assessments every five years if the Site is not open for unrestricted use whenever contaminants are left in place. Upon completion of the selected remedy, the land use at the 354 Site (OU 005) will be changed to unrestricted.

2.13 STATUTORY DETERMINATIONS

Under CERCLA § 121 and the NCP, the lead agency must select remedies that are protective of human health and the environment, comply with ARARs (unless a statutory waiver is justified), are cost effective, and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practical. In addition, CERCLA includes a preference for remedies that employ treatment that permanently and significantly reduces the volume, toxicity, or mobility of hazardous waste as a principal element and a bias against off-site disposal of untreated wastes. The following sections discuss how the selected remedy meets these statutory requirements.

2.13.1 Protection of Human Health and the Environment

The selected remedy will prevent future exposure to contaminated groundwater. Currently, there is no exposure to contaminated groundwater. The selected remedy includes monitoring of groundwater and restriction of groundwater use through the use of ICS to ensure receptors are not exposed to contaminant levels above MCLs. There is no evidence of ecological risk to the Kansas River from the contaminated groundwater plume based on the evaluations performed. The monitoring ensures that contaminant levels that could cause risk will be detected in time to take remedial action. The selected remedy relies on natural degradation processes already occurring at the 354 Site (OU 005) to continue to reduce contaminant concentrations to levels below the MCLs.

2.13.2 Compliance with Applicable or Relevant and Appropriate Requirements

The selected remedy must meet the federal and state environmental statutes, regulations, and other requirements that regulate the 354 Site (OU 005) and the actions in the MNA with ICS alternative. These criteria are known as ARARs and are placed into three categories: chemical-specific, location-specific, and action-specific.

The list of potential ARARs was evaluated according to each statutory program and the regulations specific to each program. The ARAR evaluation was conducted in accordance with the CERCLA Compliance with Other Laws Manual, Parts I and II (USEPA, 1989a and USEPA, 1989b). Following the ARAR evaluation process, chemical-, location-, and action-specific ARARs for the 354 Site (OU 005) were identified and are summarized below.

The chemical-specific ARARs for the 354 Site (OU 005) are:

- Kansas Surface Water Quality Standards (Kansas Administrative Record [KAR] § 28.16.28b)
- Kansas Water Pollution Control, Antidegradation Policy (KAR § 28.16.28c(a))
- Safe Drinking Water Act (SDWA), National Primary Drinking Water Regulations (40 CFR § 141 and 142)
- Kansas Drinking Water Standards (KAR § 28.15)

The location-specific ARARs for the 354 Site (OU 005) are:

- Archaeological and Historic Preservation Act of 1974 (16 USC § 469 et seq.)
- Endangered Species Act of 1973 (7 USC § 136 and 16 USC § 460 et seq.)
- Fish and Wildlife Conservation Act (16 USC § 2901 and 2911)
- Flood Control Act of 1944 (16 USC § 460)
- National Historic Preservation Act of 1966 (16 USC § 470 et seq.)
- Kansas Historic Preservations Act (KAR § 118-3)

- Non-Game, Threatened or Endangered Species (KAR § 115-15)

The action-specific ARARs for the 354 Site (OU 005) are:

- Clean Water Act (33 USC § 1251 et seq.)
- Clean Air Act (42 USC § 7401 et seq.)
- CERCLA of 1980 (42 USC § 9601 et seq. as amended by the SARA of 1986)
- OSHA of 1970 (29 USC § 651 et seq.). Includes both workplace standards (29 CFR 1910) and construction standards (29 CFR 1926)
- Ambient Air Quality Standards and Air Pollution Control (KAR § 28-19)
- Water Well Contractor's License; Water Well Construction and Abandonment (KAR § 28-30)
- Underground Injection Control Regulations (KAR § 28-46)
- Emergency Planning and Right-to-Know (KAR § 28-65)
- Kansas Board of Technical Professions (KAR § 66-6 through 66-14)

Based on the RI report, groundwater is the only environmental medium at the 354 Site (OU 005) that has constituent levels above their corresponding chemical-specific ARARs (MCLs). The selected remedy will eventually achieve compliance with the chemical-specific ARAR (MCLs) through the natural attenuation process. ICS will prevent exposure to groundwater with contamination levels in excess of MCLs until groundwater quality for unrestricted use is achieved. The selected remedy is in compliance with both action-and location-specific ARARs, including endangered and/or threatened species, floodplain, historical, or RCRA ARARs because there are no major construction activities associated with the selected remedy and no hazardous wastes produced by the remediation.

2.13.3 Cost Effectiveness

In the DA's judgment, the selected remedy is cost-effective and represents a reasonable value for the money to be spent. In making this determination, the following definition was used: "A remedy shall be cost-effective if its cost are proportional to its overall effectiveness" (NCP § 300.430(f)(l)(ii)(D)). This was accomplished by evaluating the "overall effectiveness" of those alternatives that satisfied the threshold criteria (i.e., were both protective of human health and the environment and ARAR-compliant). Overall effectiveness was evaluated by assessing three of the five balancing criteria in combination (long-term effectiveness and permanence; reduction in toxicity, mobility, and volume through treatment; and short-term effectiveness). Overall effectiveness was then compared to cost to determine cost-effectiveness. The relationship of the overall effectiveness of this remedial alternative was determined to be proportional to its cost and hence this alternative represents a reasonable value for the money to be spent.

The estimated present worth cost of the selected remedy is $1,000,000.00 while the total project cost is $1,300,000. Although the cost for Alternative 2 (MNA with ICS) is approximately $860,000.00 higher than

Alternative 1 (No Action), Alternative 1 was removed from consideration because it did not satisfy one of the threshold criteria (ARAR-compliant).

2.13.4 Use of Permanent Solutions and Alternative Treatment Technologies to the Maximum Extent Practicable

The DA has determined that the selected remedy represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a practicable manner at this site. This alternative will provide protection of human health and the environment and is ARAR-compliant. The DA has determined that the selected remedy does provide the best balance of trade-offs in terms of the five balancing criteria, while also considering the statutory preference for treatment as a principal element and bias against off-site treatment and disposal and considering State and community acceptance.

With this alternative, the 354 Site (OU 005) will undergo groundwater sampling to monitor progress, and ICS will be put in place to eliminate or minimize the chance of a receptor being exposed to the contaminated groundwater below and down gradient of the 354 Site (OU 005). Once RAOs are achieved at the 354 Site (OU 005), groundwater contaminant levels are anticipated to remain below MCLs because there is likely no on-going source at the 354 Site (OU 005). Therefore, the magnitude of risk to human health and the environment is anticipated to be less than current risk conditions, which are already within the USEPA accepted limits at the 354 Site (OU 005). ICS are anticipated to limit exposure to present and future users of the groundwater.

2.13.5 Preference for Treatment as a Principal Element

Following completion of the pilot study, no principal threat waste remains at the 354 Site; therefore, the remedy does not need to address contaminants through treatment technology. Instead, the selected remedy relies on natural degradation processes already occurring at the 354 Site (OU 005) to further reduce contaminant concentrations to levels below the MCLs.

The source of contamination in soil was reduced to concentrations below the levels determined by KDHE soil-to-groundwater protection RSK levels through the completion of a pilot study (in-situ treatment and excavation) in November of 2004. Natural attenuation combined with the treatment has been responsible for the continuing decrease of contaminant levels in groundwater. The selected remedy was chosen over the other alternatives because it is expected to continue to provide risk reduction through degradation of contaminants in the groundwater and provides measures to prevent future exposure to currently contaminated groundwater.

2.13.6 Five-Year Review Requirements

The purpose of this section is to explain the determinations for five-year reviews. The NCP states that the ROD must describe whether a five-year review is required (statutory review). Section 121 of CERCLA and the NCP § 300.430(f)(5)(iii)(C) provide the statutory and legal basis for conducting five-year reviews. The structure and content of the five-year review is the same for both statutory and policy reviews. If there are any hazardous substances, pollutants, or contaminants remaining at the site above levels that would not allow for unlimited use and unrestricted exposure, a review of remedial action no less often than five years after the initiation of such remedial action to assure that human health and the environment are being protected by the remedial action being implemented is required.

The ROD should also discuss whether the site is likely to undergo any discretionary policy reviews. The policy reviews are triggered by construction completion. Policy reviews are conducted at sites based on the following:

- A post-SARA remedial action will allow for unlimited use and unrestrictive exposure after completion of the remedial action, but where attainment of remedial action objectives and cleanup levels will take longer than five years to complete.
- Pre-SARA sites at which the remedy, upon attainment of the remedial action objectives and cleanup levels, will not allow unlimited use and unrestricted exposure.
- NPL removal-only sites where hazardous substances, pollutants, or contaminants are left on-site above levels that allow unlimited use and unrestricted exposure and where no remedial action has taken place.

Once PRGs are achieved at the 354 Site (OU 005), groundwater contaminant levels are anticipated to remain below MCLs because there is no known on-going source at the 354 Site (OU 005). The magnitude of risk to human health and the environment is anticipated to be less than current risk conditions, which are already within the USEPA accepted limits at the 354 Site (OU 005). Contaminants sorbed to the aquifer matrix may serve as a low-level source after remediation is completed, but natural attenuation will continue. ICS are anticipated to limit exposure to present and future users of the groundwater.

Because this remedy will result in hazardous substances, pollutants, or contaminants remaining at the 354 Site (OU 005) above levels that allow for unlimited use and unrestricted exposure, a review in accordance with the NCP will be conducted no less often than every five years after initiation of the selected remedial action to ensure that the remedy continues to be protective of human health and the environment. The first five-year review of the selected remedy will include consideration of the following factors:

- the performance of MNA in achieving cleanup levels (MCLs);
- the use of property above the groundwater plume to ensure that groundwater with contamination above cleanup levels (MCLs) is not used for incompatible uses; and
- if no wells exceed groundwater cleanup levels (MCLs) for three consecutive years in the Kansas River alluvial aquifer, a recommendation for discontinuing sampling and site close out will be made. The MCLs have not been exceeded since April 2004.
- Three consecutive years of groundwater monitoring will be performed post-ROD (CY 2006).

2.14 DOCUMENTATION OF SIGNIFICANT CHANGES

The revised (Draft Final) PP was submitted to the USEPA and KDHE on May 20, 2005 and was available to the public at the Fort Riley IRP administrative library located at 407 Pershing Court, Fort Riley, Kansas, the Dorothy Bramlage Public Library located at 230 West Seventh Street, Junction City, Kansas, and the Manhattan Public Library located at 629 Poyntz Avenue, Manhattan, Kansas. The PP was released to the public on June 12, 2005. The public comment period was from June 12, 2005 through July 12, 2005, which included the July 12, 2005 public meeting held concurrently with the public RAB meeting. Announcements regarding the Site were published in the *Junction City Daily Union* and the *Manhattan Mercury* newspapers. The PP identified Alternative 2 (MNA with ICS) as the preferred remedy. Fort Riley received no public comments on the PP during the designated public comment period. No significant changes to the remedy as it was originally identified in the PP are necessary.

3.0 RESPONSIVENESS SUMMARY

3.1 STAKEHOLDER COMMENTS AND LEAD AGENCY RESPONSES

During the public comment period from June 12, 2005 through July 12, 2005 for the Proposed Plan (BMcD, 2004c), no public comments regarding the selected remedy for the 354 Site (OU 005) were received. No comments were conveyed at the public meeting held on July 12, 2005. Because there was no public response to the selected remedy of the Proposed Plan, this Responsiveness Summary contains no comments.

3.2 TECHNICAL AND LEGAL ISSUES

3.2.1 Technical Issues

There are no outstanding technical issues at the 354 Site (OU 005).

3.2.2 Legal Issues

There are no outstanding legal issues at the 354 Site (OU 005). The DA (Fort Riley) will continue to coordinate with the USEPA and the State of Kansas acting through the KDHE regarding implementation of appropriate ICS to prevent use of the groundwater until concentrations decrease to at or below the MCLs for a consecutive period of three years post-ROD (CY 2006) in the Kansas River alluvial aquifer, and the MCLs have not been exceeded since April 2004. At this point, a recommendation for discontinuing sampling and site close out will be made.

4.0 REFERENCES

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Table 1-1
Groundwater Data (Chemicals of Concern Only)
July 2002 and April 2005
354 Area Solvent Detections ROD
Fort Riley, Kansas

Sample Point: / Date Sampled:		MCL/KSWQS	TSO292-01 July 2002	TSO292-01 April 2005	TSO292-02 July 2002	TSO292-02 April 2005	TSO292-02 April 2005 Field Duplicate	MW95-04 July 2002	MW95-04 April 2005	B354-99-09 July 2002
COCs	UNITS									
Benzene	ug/L	5	***0.4***	0.4 U	***40.3***	***24***	***26***	0.4 U	0.4 U	0.4 U
cis-1,2-Dichloroethylene	ug/L	70	***1.8***	***3.8***	***18***	***10***	***9.7***	0.5 U	0.5 U	0.5 U
Tetrachloroethylene	ug/L	5	***39***	***55.8***	1.1 U	4.4 U	4.4 U	***3.3***	***1.7***	***27.5***
Trichloroethylene	ug/L	5	***2.7***	***3.8***	0.6 U	2 U	2 U	0.6 U	0.6 U	0.6 U

MCL - Maximum Contaminant Level
J - Qualified as estimated
U - Qualified as undetected by laboratory
ug/L - micrograms per liter

KSWQS - Kansas State Water Quality Standard
Bold, Italics - Compound was detected below MCL / KSWQS
Bold, Italics, shaded - Compound detected above MCL / KSWQS

Table 1-1
Groundwater Data (Chemicals of Concern Only)
July 2002 and April 2005
354 Area Solvent Detections ROD
Fort Riley, Kansas

Sample Point: / Date Sampled:		MCL/KSWQS	B354-99-09 April 2005	B354-00-10 July 2002	B354-00-10 April 2005	B354-99-12c July 2002	B354-99-12c April 2005	B354-99-13c July 2002	B354-99-13c April 2005	B354-01-24 July 2002
COCs	UNITS									
Benzene	ug/L	5	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U
cis-1,2-Dichloroethylene	ug/L	70	0.5 U	0.5 U	0.5 U	***5.7 J***	***6.9***	***3.2***	0.5 U	0.5 U
Tetrachloroethylene	ug/L	5	***27.3***	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
Trichloroethylene	ug/L	5	0.6 U	0.6 U	0.6 U	***1.9***	***1.8***	0.6 U	0.6 U	0.6 U

MCL - Maximum Contaminant Level
J - Qualified as estimated
U - Qualified as undetected by laboratory
ug/L - micrograms per liter

KSWQS - Kansas State Water Quality Standard
Bold, Italics - Compound was detected below MCL / KSWQS
Bold, Italics, shaded - Compound detected above MCL / KSWQS

Table 1-1
Groundwater Data (Chemicals of Concern Only)
July 2002 and April 2005
354 Area Solvent Detections ROD
Fort Riley, Kansas

Sample Point: / Date Sampled:		MCL/KSWQS	B354-01-24 April 2005	B354-01-25 July 2002	B354-01-25 April 2005	B354-01-26 July 2002	B354-01-26 April 2005	B354-01-27 July 2002	B354-01-27 April 2005	B354-01-27 April 2005 Field Duplicate
COCs	UNITS									
Benzene	ug/L	5	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U
cis-1,2-Dichloroethylene	ug/L	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	***0.9***	0.5 U	0.5 U
Tetrachloroethylene	ug/L	5	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	***179***	***98.5***	***91.9***
Trichloroethylene	ug/L	5	0.6 U	0.6 U	0.6 U	0.6 U	0.6 U	***3.2***	***1***	***1***

MCL - Maximum Contaminant Level
J - Qualified as estimated
U - Qualified as undetected by laboratory
ug/L - micrograms per liter

KSWQS - Kansas State Water Quality Standard
Bold, Italics - Compound was detected below MCL / KSWQS
Bold, Italics, shaded - Compound detected above MCL / KSWQS

Table 1-1
Groundwater Data (Chemicals of Concern Only)
July 2002 and April 2005
354 Area Solvent Detections ROD
Fort Riley, Kansas

Sample Point: / Date Sampled:		MCL/KSWQS	B354-01-28 July 2002	B354-01-28 April 2005	B354-01-30c July 2002	B354-01-30c April 2005	B354-01-31c July 2002	B354-01-31c April 2005	PSF92-01 July 2002	PSF92-01 April 2005
COCs	UNITS									
Benzene	ug/L	5	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U
cis-1,2-Dichloroethylene	ug/L	70	0.5 U	0.5 U	*0.7*	0.5 U	0.5 UJ	0.5 U	0.5 U	0.5 U
Tetrachloroethylene	ug/L	5	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
Trichloroethylene	ug/L	5	0.6 U	0.6 U	0.6 U	0.6 U	0.6 U	0.6 U	0.6 U	0.6 U

MCL - Maximum Contaminant Level
J - Qualified as estimated
U - Qualified as undetected by laboratory
ug/L - micrograms per liter

KSWQS - Kansas State Water Quality Standard
Bold, Italics - Compound was detected below MCL / KSWQS
Bold, Italics, shaded - Compound detected above MCL / KSWQS

Table 1-1
Groundwater Data (Chemicals of Concern Only)
July 2002 and April 2005
354 Area Solvent Detections ROD
Fort Riley, Kansas

Sample Point: / Date Sampled:		MCL/KSWQS	PSF92-05 July 2002	PSF92-05 April 2005
COCs	UNITS			
Benzene	ug/L	5	0.4 U	0.4 U
cis-1,2-Dichloroethylene	ug/L	70	0.5 U	0.5 U
Tetrachloroethylene	ug/L	5	1.1 U	1.1 U
Trichloroethylene	ug/L	5	0.6 U	0.6 U

MCL - Maximum Contaminant Level
J - Qualified as estimated
U - Qualified as undetected by laboratory
ug/L - micrograms per liter

KSWQS - Kansas State Water Quality Standard
Bold, Italics - Compound was detected below MCL / KSWQS
Bold, Italics, shaded - Compound detected above MCL / KSWQS

Table 2-1
Positive Detections in Groundwater
November 1998 through April 2005
354 Area Solvent Detections ROD
Fort Riley, Kansas

Parameter	Units	MCL/ KSWQS	Highest Result	Lowest Result	Highest Detection in April 2005 Sampling Event
Volatile Organic Compounds					
1,1,2-Trichloroethane	ug/L	5	0.7	0.6 U	0.6 U
Benzene	ug/L	5	42.6	0.4 U	26
Bromodichloromethane	ug/L	100 (Note 1)	0.7	0.5 U	0.5 U
Carbon Disulfide	ug/L	9 (Note 3)	7.2	5 U	5 U
Carbon Tetrachloride	ug/L	5	5.3	0.7 U	3.5
Chloroform	ug/L	100 (Note 1)	2.2	0.5 U	2
cis-1,2-Dichloroethene	ug/L	70	260	0.5 U	10
Dibromochloromethane	ug/L	100 (Note 1)	0.9	0.7 U	0.7 U
Ethylbenzene	ug/L	700	8.5	0.7 U	4
m,p-Xylene	ug/L	10,000 (Note 2)	12.3	0.6 U	6.2
o-Xylene	ug/L	10,000 (Note 2)	1.3	0.6 U	0.6 U
Tetrachloroethene	ug/L	5	4,630	1.1 U	98.5
Toluene	ug/L	1,000	2.7	0.4 U	2
trans-1,2-Dichloroethene	ug/L	100	2	0.5 U	0.5 U
Trichloroethene	ug/L	5	160	0.6 U	3.8
Vinyl Chloride	ug/L	2	2.5	0.8 U	0.8 U
Semivolatile Organic Compounds					
Bis(2-ethylhexyl)phthalate	ug/L	6	63	10 U	NS
Diethyl Phthalate	ug/L	12,000 (Note 3)	7.3 J	10 U	NS
Miscellaneous Compounds					
Methane	ug/L	---	387	2 U	109 J
Inorganic Compounds					
Alkalinity	mg/L	---	577	149	536
Chloride	mg/L	250 (Note 4)	2,300	6	612
Nitrate	mg/L	10	34	0.1 U	23.7
Sulfate	mg/L	250 (Note 4)	670	1 U	681
Sulfide	mg/L	---	2.3	0.1 U	NS
Total Organic Carbon	mg/L	---	16.4	0.5 U	7.5
RCRA Metals					
Arsenic, Total	mg/L	0.05	0.175	0.005 U	0.04
Barium, Total	mg/L	2	1.35	0.1 U	NS
Chromium, Total	mg/L	0.1	0.086	0.002 U	NS
Lead, Total	mg/L	0.015	0.016	0.003 U	NS
Mercury, Total	mg/L	0.002	0.0002	0.0002 U	NS
Selenium, Total	mg/L	0.05	0.026	0.005 U	NS

Notes:
1. USEPA MCL for total trihalomethanes is 100 ug/L.
2. USEPA MCL for total xylenes is 10,000 ug/L.
3. KDHE RSK value for groundwater pathway
4. Secondary MCL.

J - Qualified as estimated.
U - Qualified as undetected by the laboratory.
NS - Not sampled.
mg/L - milligrams per liter.
ug/L - micrograms per liter.

Table 2-2
VOC Detections in Pre-Pilot Study Soil Borings
Building 367 Location
354 Area Solvent Detections ROD
Fort Riley, Kansas

Sample	Depth From (ft)	Depth To (ft)	Concentration	Units
Tetrachloroethene				
B2144/SB11R	1	4	2,140	ug/kg
B2322S/SB01	0	1	2,360	ug/kg
B2322S/SB02	1	4	1,400	ug/kg
B2322S/SB03	4	7	312 J	ug/kg
B2325S/SB02	1	4	404 J	ug/kg
B2333S/SB01	0	1	919	ug/kg
B2333S/SB02	1	4	608	ug/kg
B2335/SB01R	0	1	13,200	ug/kg
B2335S/SB11R	1	4	29,000	ug/kg
B2335S/SB03	4	7	328 J	ug/kg
B2336S/SB02	1	4	2,530 J	ug/kg
B2336S/SB03	4	7	714 J	ug/kg
B2336S/SB04	7	10	207 J	ug/kg
B2337S/SB01	0	1	1,010 J	ug/kg
B2337S/SB02	1	4	3,640 J	ug/kg
B2337S/SB03	4	7	860 J	ug/kg
B2344S/SB01	0	1	212 J	ug/kg
B2344S/SB02	1	4	311 J	ug/kg
B2345S/SB01R	0	1	4,160	ug/kg
B2345S/SB02R	1	4	1,120	ug/kg
B2347S/SB01	0	1	1,030 J	ug/kg
B2347S/SB11	1	4	4,870 J	ug/kg
B2347S/SB03	4	7	817 J	ug/kg
B2347S/SB04	7	10	262	ug/kg
B2350S/SB01	0	1	675	ug/kg
B2350S/SB02	1	4	465	ug/kg
B2358S/SB01	0	1	4,120 J	ug/kg
B2358S/SB02	1	4	2,000 J	ug/kg
B2358S/SB03	4	7	264 J	ug/kg
B2360S/SB02	1	4	608 J	ug/kg
B2360S/SB03	4	7	222 J	ug/kg
B2369S/SB01	0	1	572 J	ug/kg
B2369S/SB02R	1	4	5,160	ug/kg
B2370S/SB01	0	1	408	ug/kg
B2370S/SB02R	1	4	2,050	ug/kg
B2370S/SB03	4	7	290	ug/kg

Table 2-2 (continued)
VOC Detections in Pre-Pilot Study Soil Borings
Building 367 Location
354 Area Solvent Detections ROD
Fort Riley, Kansas

Sample	Depth From (ft)	Depth To (ft)	Concentration	Units
Trichloroethene				
B2335S/SB01	0	1	756 J	ug/kg
B2335S/SB11	1	4	340	ug/kg
B2336S/SB02	1	4	265	ug/kg
B2336S/SB03	4	7	230	ug/kg
B2337S/SB01	0	1	460	ug/kg
B2337S/SB02	1	4	733	ug/kg
B2337S/SB03	4	7	262	ug/kg
B2347S/SB11	1	4	356 J	ug/kg
cis-1,2-Dichloroethene				
B2144/SB03	4	7	827 J	ug/kg
B2335S/SB01	0	1	1,090 J	ug/kg
B2336S/SB01	0	1	1,480 J	ug/kg
B2337S/SB01	0	1	8,120 J	ug/kg
B2337S/SB02	1	4	1,080 J	ug/kg

Notes:

1. Only analytical results which exceed the Kansas Risk-Based Standards (RSK) for the soil-to-groundwater protection pathway (residential scenario) are presented. These values are: Tetrachloroethene -180 ug/kg; Trichloroethene - 200 ug/kg; and cis-1,2-Dichloroethene - 800 ug/kg.
2. ug/kg - micrograms per kilogram
3. J - qualified as estimated in data validation
4. ft - feet
5. All samples were collected in either October/November 2001 or October 2002.

Table 2-3
Shallow Subsurface Soil Data Summary
Building 367 Area
354 Area Solvent Detections ROD
Fort Riley, Kansas

Parameter	Number of Detections / Number of Samples	Percent Positive Detections	Range of Detected Concentrations			Location of Maximum Detection
PAHs (mg/kg)						
Acenaphthylene	1 / 68	2%		0.20		B2370S-SB01
Benzo(a)anthracene	22 / 68	32%	0.01	-	0.13	B2360S-SB01
Benzo(a)pyrene	20 / 68	29%	0.01	-	0.12	B2360S-SB01
Benzo(b)fluoranthene	24 / 68	35%	0.01	-	0.20	B2347S-SB-11
Benzo(g,h,i)perylene	23 / 68	34%	0.01	-	0.10	B2347S-SB-11 B2144S-SB01
Benzo(k)fluoranthene	9 / 68	13%	0.01	-	0.06	B2360S-SB01
Chrysene	25 / 68	37%	0.01	-	0.60	B2144S-SB03
Dibenz(a,h)anthracene	5 / 68	7%	0.01	-	0.06	B2347S-SB-11
Fluoranthene	19 / 68	28%	0.02	-	0.27	B2360S-SB01
Indeno(1,2,3-cd)pyrene	10 / 68	15%	0.01	-	0.08	B2360S-SB01
Naphthalene	1 / 68	2%		0.10		B2325S-SB01
Phenanthrene	6 / 35	17%	0.08	-	0.80	B2144S-SB02
Pyrene	19 / 68	28%	0.02	-	0.24	B2360S-SB01
Volatiles (ug/kg)						
Acetone	4 / 68	6%	110	-	220	B2360S-SB01
Carbon disulfide	2 / 68	4%	6.10	-	7.00	B2336S-SB01
cis-1,2-Dichloroethene	43 / 68	63%	6.30	-	8120	B2337S-SB01
Tetrachloroethene	62 / 68	91%	6.40	-	29000	B2335S-SB11R
trans-1,2-Dichloroethene	8 / 68	12%	6.20	-	58.4	B2337S-SB01
Trichloroethene	34 / 68	50%	6.70	-	756	B2335S-SB01
m,p-Xylene	1 / 68	2%		6.40		B2144S-SB01

Notes:
Data set includes 2001 data collected from 0-10 feet below ground surface.
Includes only those chemicals that were detected in at least one sample.
mg/kg - milligrams per kilogram
ug/kg - micrograms per kilogram

Table 2-4
Surface Soil Data Summary
Building 354/332/DPW Compound Area
354 Area Solvent Detections ROD
Fort Riley, Kansas

Parameter	Number of Detects/ Number of Samples	Percent Positive Detects	Range of Detected Concentrations	Location of Maximum Concentration
PAHs (mg/kg)				
Benzo(a)anthracene	3 / 4	75%	0.02 - 0.4	B163/SB01
Benzo(a)pyrene	3 / 4	75%	0.02 - 0.2	B163/SB01
Benzo(b)fluoranthene	3 / 4	75%	0.02 - 0.4	B163/SB01
Benzo(g,h,i)perylene	3 / 4	75%	0.04 - 0.2	B163/SB01
Benzo(k)fluoranthene	2 / 4	50%	0.04 - 0.2	B163/SB01
Chrysene	3 / 4	75%	0.02 - 0.4	B163/SB01
Dibenz(a,h)anthracene	1 / 4	25%	0.08	B163/SB01
Fluoranthene	3 / 4	75%	0.04 - 0.94	B163/SB01
Indeno(1,2,3-cd)pyrene	3 / 4	75%	0.02 - 0.2	B163/SB01
Phenanthrene	1 / 4	25%	0.71	B163/SB01
Pyrene	3 / 4	75%	0.03 - 0.77	B163/SB01

Notes:
Data set includes 2001 data collected from 0-1 ft bgs in unpaved areas.
Includes only those chemicals that were detected in at least one sample.
mg/kg - milligrams per kilogram

Table 2-5
Deep Subsurface Soil Data Summary
Building 354/332/DPW Compound Area
354 Area Solvent Detections ROD
Fort Riley, Kansas

Parameter	Number of Detects/ Number of Samples	Percent Positive Detects	Range of Detected Concentrations	Location of Maximum Concentration
Volatiles (ug/kg)				
Benzene	1 / 5	20%	124	B172/SB07
Ethylbenzene	3 / 5	60%	1,900 - 7,400	B172/SB07
Toluene	3 / 5	60%	99 - 220	Bldg354/SB-12N
Xylenes, total	4 / 5	80%	440 - 39,000	Bldg354/SB-12N

Notes:

Data set includes 2001 and 1995 data collected from 11-30 ft below ground surface which had detections of volatiles.

Includes only those chemicals that were detected in at least one sample.

Analytical data from 1995 reported total xylenes, but analytical data from 2001 reported m,p-xylenes and o-xylenes. To establish a consistent data set, the 2001 data for m,p- and o-xylenes were combined and evaluated as total xylenes.

ug/kg - micrograms per kilogram

Bldg - building

ft - feet

Table 2-6
Surface Soil Data Summary
Building 430 Area
354 Area Solvent Detections ROD
Fort Riley, Kansas

Parameter	Number of Detects/ Number of Samples	Percent Positive Detects	Range of Detected Concentrations	Location of Maximum Concentration
PAHs (mg/kg)				
Benzo(a)anthracene	3 / 4	75%	0.03 - 0.12	B916S
Benzo(a)pyrene	3 / 4	75%	0.03 - 0.1	B916S
Benzo(b)fluoranthene	3 / 4	75%	0.04 - 0.12	B916S
Benzo(g,h,i)perylene	3 / 4	75%	0.02 - 0.09	B916S
Benzo(k)fluoranthene	3 / 4	75%	0.02 - 0.06	B916S
Chrysene	3 / 4	75%	0.03 - 0.13	B916S
Dibenz(a,h)anthracene	1 / 4	25%	0.02	B916S
Fluoranthene	3 / 4	75%	0.06 - 0.29	B916S
Indeno(1,2,3-cd)pyrene	3 / 4	75%	0.02 - 0.07	B916S
Phenanthrene	2 / 4	50%	0.07 - 0.19	B916S
Pyrene	3 / 4	75%	0.04 - 0.21	B916S

Notes:
Includes 2001 data collected from 0-1 ft below ground surface in unpaved areas.
Includes only those chemicals that were detected in at least one sample.
mg/kg - milligrams per kilogram
ft - feet

Table 2-7
Groundwater Data Summary
Building 367 Area
354 Area Solvent Detections ROD
Fort Riley, Kansas

Parameter	Number of Detects/ Number of Samples	Percent Positive Detects	Range of Detected Concentrations			Location of Maximum Concentration	Sample Date
Volatiles (ug/L)							
1,1,2-Trichloroethane	1 / 6	17%		0.7		B354-99-08	March 2001
Carbon tetrachloride	6 / 6	100%	2.6	-	3.8	B354-99-08	July 2002
Chloroform	6 / 6	100%	1.4	-	2.2	B354-99-08	March 2001 & September 2001
cis-1,2-Dichloroethene	6 / 6	100%	41	-	150	B354-99-08	September 2001
Tetrachloroethene	6 / 6	100%	404	-	1640	B354-99-08	September 2001
trans-1,2-Dichloroethene	6 / 6	100%	0.6	-	1.6	B354-99-08	September 2001
Trichloroethene	6 / 6	100%	24	-	65.1	B354-99-08	September 2001
Vinyl chloride	1 / 6	17%		0.9		B354-00-10	October 2000

Notes:
Data set for all chemicals except vinyl chloride includes data collected from Monitoring Well B354-99-08 during sampling events from 10/00 through 7/02.
Data set for vinyl chloride includes data collected from Monitoring Well B354-00-10 during sampling events from 10/00 through 7/02.
Includes only those chemicals that were detected in at least one sample.
ug/L - micrograms per Liter

Table 2-8
Groundwater Data Summary
Building 354/332/DPW Compound Area
354 Area Solvent Detections ROD
Fort Riley, Kansas

Parameter	Number of Detects/ Number of Samples	Percent Positive Detects	Range of Detected Concentrations	Location of Maximum Concentration	Sample Date
Volatiles (ug/L)					
Benzene	10 / 18	56%	0.4 - 40.3	TSO292-02	July 2002
Carbon tetrachloride	12 / 18	67%	0.7 - 2.4	MW95-06	March 2001 & April 2002
Chloroform	12 / 18	67%	0.7 - 1.5	MW95-06	March 2001
cis-1,2-Dichloroethene	11 / 18	61%	0.7 - 19.2	TSO292-02	January 2002
Ethylbenzene	8 / 18	44%	1.3 - 8.5	TSO292-02	April 2002
Tetrachloroethene	12 / 18	67%	27.9 - 95.2	MW95-06	October 2000
Toluene	8 / 18	44%	1.1 - 2.7	TSO292-02	April 2002
trans-1,2-Dichloroethene	6 / 18	33%	0.6 - 1.7	TSO292-02	October 2001
Trichloroethene	12 / 18	67%	1.3 - 3.6	TSO292-01	October 2000 & March 2001
m,p-Xylene	8 / 18	44%	2.0 - 8.7	TSO292-02	April 2002
o-Xylene	6 / 18	33%	0.6 - 1.2	TSO292-02	April 2002

Notes:
Includes data collected from monitoring wells TSO292-01, TSO292-02, and MW95-06 during sampling events from 10/00 through 7/02.
Includes only those chemicals that were detected in at least one sample.
ug/L - micrograms per Liter
MW - Monitoring Well

Table 2-9
Groundwater Data Summary
Building 430 Area
354 Area Solvent Detections ROD
Fort Riley, Kansas

Parameter	Number of Detects/ Number of Samples	Percent Positive Detects	Range of Detected Concentrations	Location of Maximum Concentration
Volatiles (ug/L)				
Chloroform	4 / 4	100%	0.9 - 1.8	B354-01-26

Notes:
Includes data collected from monitoring well B354-01-26 during sampling events from 10/00 through 7/02.
Includes only those chemicals that were detected in at least one sample and were not analyzed in soil gas.
ug/L - micrograms per Liter

Table 2-10
Groundwater Data Summary
Point Bar Area
354 Area Solvent Detections ROD
Fort Riley, Kansas

Parameter	Number of Detects/ Number of Samples	Percent Positive Detects	Range of Detected Concentrations	Location of Maximum Concentration	Sample Date
Volatiles (ug/L)					
Benzene	1 / 128	0.7%	1.00	MW95-03	July 2002
Bromodichloromethane	1 / 128	0.7%	0.70	MW95-04	October 2001
Carbon tetrachloride	4 / 128	3.1%	0.80 - 1.6	PZ-D	March 2001
Chloroform	4 / 128	3.1%	0.50 - 1.0	MW95-04	March 2001
cis-1,2-Dichloroethene	59 / 128	46%	0.50 - 7.9	354-99-12b	October 2000
Dibromochloromethane	1 / 128	0.7%	0.90	MW95-04	October 2001
Tetrachloroethene	19 / 128	15%	1.2 - 9.7	PZ-D	March 2001
trans-1,2-Dichloroethene	3 / 128	2.3%	0.50	354-99-12b & 354-99-12c	March 2001 & October 2001
Trichloroethene	26 / 128	20%	0.60 - 1.9	354-99-12c	July 2002

Notes:
Includes data collected from the 22 point bar wells during sampling events from 10/00 through 7/02.
Includes only those chemicals that were detected in at least one sample.
ug/L - micrograms per Liter
MW - Monitoring Well

Table 2-11
Soil-Gas Data Summary
Building 430 Area
354 Area Solvent Detections ROD
Fort Riley, Kansas

Parameter	Number of Detects/ Number of Samples	Percent Positive Detects	Range of Detected Concentrations	Location of Maximum Concentration
Volatiles (ug/L)				
Carbon tetrachloride	72 / 80	90%	0.12 - 15.7	B-915
Trichloroethene	12 / 80	15%	0.11 - 0.80	B-924

Notes:
Data set includes 2001 data collected from nine ft below ground surface.
Includes only those chemicals that were detected in at least one sample.
ug/L - micrograms per Liter
ft - feet

Table 2-12
Exposure Concentrations in Shallow Subsurface Soil
Building 367 Area
354 Area Solvent Detections ROD
Fort Riley, Kansas

Parameter	Maximum Detected Concentration (mg/kg)	95 Percent Upper Confidence Limit (UCL) (mg/kg)	Exposure Concentration Used in HHBRA (mg/kg)
PAHs			
Acenaphthylene	2.00E-01	1.50E-01	1.50E-01
Benzo(a)anthracene	1.30E-01	2.57E-02	2.57E-02
Benzo(a)pyrene	1.20E-01	2.27E-02	2.27E-02
Benzo(b)fluoranthene	2.00E-01	3.36E-02	3.36E-02
Benzo(g,h,i)perylene	1.00E-01	2.32E-02	2.32E-02
Benzo(k)fluoranthene	6.00E-02	1.15E-02	1.15E-02
Chrysene	6.00E-01	3.72E-02	3.72E-02
Dibenz(a,h)anthracene	6.00E-02	9.17E-03	9.17E-03
Fluoranthene	2.70E-01	3.67E-02	3.67E-02
Indeno(1,2,3-cd)pyrene	8.00E-02	1.29E-02	1.29E-02
Naphthalene	1.00E-01	7.37E-02	7.37E-02
Phenanthrene	8.00E-01	1.02E-01	1.02E-01
Pyrene	2.40E-01	4.07E-02	4.07E-02
Volatiles			
Acetone	2.20E-01	8.86E-02	8.86E-02
Carbon disulfide	7.00E-03	4.07E-03	4.07E-03
cis-1,2-Dichloroethene	8.12E+00	7.63E-01	7.63E-01
Tetrachloroethene	2.90E+01	5.92E+00	5.92E+00
trans-1,2-Dichloroethene	5.80E-02	5.96E-03	5.96E-03
Trichloroethene	7.60E-01	9.63E-02	9.63E-02
m,p-Xylene	6.40E-03	4.01E-03	4.01E-03

Notes:

Concentration used in HHBRA represents the lower of the 95 percent UCL or maximum detected concentration (USEPA, 1992).

One-half of the detection limit was used as a proxy concentration for results that were non-detect.

The 95 percent UCLs were calculated assuming a log-normal distribution.

HHBRA - Human Health Baseline Risk Assessment

mg/kg - milligrams per kilogram

Table 2-13
Exposure Concentrations in Groundwater
Building 367 Area
354 Area Solvent Detections ROD
Fort Riley, Kansas

Parameter	Maximum Detected Concentration (mg/L)	95 Percent Upper Confidence Limit (UCL) (mg/L)	Exposure Concentration Used in HHBRA (mg/L)
Volatiles			
1,1,2-Trichloroethane	7.00E-04	5.20E-04	5.20E-04
Carbon tetrachloride	3.80E-03	3.69E-03	3.69E-03
Chloroform	2.20E-03	2.27E-03	2.20E-03
cis-1,2-Dichloroethene	1.50E-01	1.50E-01	1.50E-01
Tetrachloroethene	1.64E+00	2.23E+00	1.64E+00
trans-1,2-Dichloroethene	1.60E-03	1.55E-03	1.55E-03
Trichloroethene	6.51E-02	6.27E-02	6.27E-02
Vinyl chloride	9.00E-04	6.80E-04	6.80E-04

Notes:
Concentration used in HHBRA represents the lower of the 95 percent UCL or maximum detected concentration (USEPA, 1992).
One-half of the detection limit was used as a proxy concentration for results that were non-detect.
The 95 percent UCLs were calculated assuming a log-normal distribution.
HHBRA - Human Health Baseline Risk Assessment
mg/L - milligrams per Liter

Table 2-14
Exposure Concentrations in Surface Soil
Building 354/332/DPW Compound Area
354 Area Solvent Detections ROD
Fort Riley, Kansas

Parameter	Maximum Detected Concentration (mg/kg)	95 Percent Upper Confidence Limit (UCL) (mg/kg)	Exposure Concentration Used in HHBRA (mg/kg)
PAHs			
Benzo(a)anthracene	4.00E-01	1.57E+05	4.00E-01
Benzo(a)pyrene	2.00E-01	2.51E+03	2.00E-01
Benzo(b)fluoranthene	4.00E-01	1.98E+05	4.00E-01
Benzo(g,h,i)perylene	2.00E-01	1.27E+03	2.00E-01
Benzo(k)fluoranthene	2.00E-01	1.97E+04	2.00E-01
Chrysene	4.00E-01	1.57E+05	4.00E-01
Dibenz(a,h)anthracene	8.00E-02	1.97E+01	8.00E-02
Fluoranthene	9.40E-01	1.54E+06	9.40E-01
Indeno(1,2,3-cd)pyrene	2.00E-01	9.81E+02	2.00E-01
Phenanthrene	7.10E-01	1.50E+03	7.10E-01
Pyrene	7.70E-01	1.92E+05	7.70E-01

Notes:
Concentration used in HHBRA represents the lower of the 95 percent UCL or maximum detected concentration (USEPA, 1992).
One-half of the detection limit was used as a proxy concentration for results that were non-detect.
The 95 percent UCLs were calculated assuming a log-normal distribution.
HHBRA - Human Health Baseline Risk Assessment
mg/kg - milligrams per kilogram

Table 2-15
Exposure Concentrations in Deep Subsurface Soil
Building 354/332/DPW Compound Area
354 Area Solvent Detections ROD
Fort Riley, Kansas

Parameter	Maximum Detected Concentration (mg/kg)	95 Percent Upper Confidence Limit (UCL) (mg/kg)	Exposure Concentration Used in HHBRA (mg/kg)
Volatiles			
Benzene	1.24E-01	2.39E+05	1.24E-01
Ethylbenzene	7.40E+00	8.68E+12	7.40E+00
Toluene	2.20E-01	1.52E+05	2.20E-01
Xylenes, total	3.90E+01	2.45E+17	3.90E+01

Notes:

Concentration used in HHBRA represents the lower of the 95 percent UCL or maximum detected concentration (USEPA, 1992).

Analytical data from 1995 reported total xylenes, but analytical data from 2001 reported m,p-xylenes and o-xylenes. To establish a consistent data set, the 2001 data for m,p- and o-xylenes were combined and evaluated as total xylenes.

One-half of the detection limit was used as a proxy concentration for results that were non-detect.

The 95 percent UCLs were calculated assuming a log-normal distribution.

HHBRA - Human Health Baseline Risk Assessment

mg/kg - milligrams per kilogram

Table 2-16
Exposure Concentrations in Groundwater
Building 354/332/DPW Compound Area
354 Area Solvent Detections ROD
Fort Riley, Kansas

Parameter	Maximum Detected Concentration (mg/L)	95 Percent Upper Confidence Limit (UCL) (mg/L)	Exposure Concentration Used in HHBRA (mg/L)
Volatiles			
Benzene	4.03E-02	2.66E-01	4.03E-02
Carbon tetrachloride	2.40E-03	1.82E-03	1.82E-03
Chloroform	1.50E-03	1.28E-03	1.28E-03
cis-1,2-Dichloroethene	1.92E-02	4.88E-02	1.92E-02
Ethylbenzene	8.50E-03	3.67E-03	3.67E-03
Tetrachloroethene	9.52E-02	1.80E+00	9.52E-02
Toluene	2.70E-03	1.97E-03	1.97E-03
trans-1,2-Dichloroethene	1.70E-03	5.43E-04	5.43E-04
Trichloroethene	3.60E-03	3.65E-03	3.60E-03
m,p-Xylene	8.70E-03	8.01E-03	8.01E-03
o-Xylene	1.20E-03	6.03E-04	6.03E-04

Notes:
Concentration used in HHBRA represents the lower of the 95 percent UCL or maximum detected concentration (USEPA, 1992).
One-half of the detection limit was used as a proxy concentration for results that were non-detect.
The 95 percent UCLs were calculated assuming a log-normal distribution.
HHBRA - Human Health Baseline Risk Assessment
mg/L - milligrams per Liter

Table 2-17
Exposure Concentrations in Surface Soil
Building 430 Area
354 Area Solvent Detections ROD
Fort Riley, Kansas

Parameter	Maximum Detected Concentration (mg/kg)	95 Percent Upper Confidence Limit (UCL) (mg/kg)	Exposure Concentration Used in HHBRA (mg/kg)
PAHs			
Benzo(a)anthracene	1.20E-01	2.24E+02	1.20E-01
Benzo(a)pyrene	1.00E-01	9.91E+01	1.00E-01
Benzo(b)fluoranthene	1.20E-01	3.62E+02	1.20E-01
Benzo(g,h,i)perylene	9.00E-02	6.69E+01	9.00E-02
Benzo(k)fluoranthene	6.00E-02	4.80E+00	6.00E-02
Chrysene	1.30E-01	3.29E+02	1.30E-01
Dibenz(a,h)anthracene	2.00E-02	8.20E-02	2.00E-02
Fluoranthene	2.90E-01	9.66E+02	2.90E-01
Indeno(1,2,3-cd)pyrene	7.00E-02	8.90E+00	7.00E-02
Phenanthrene	1.90E-01	2.80E+00	1.90E-01
Pyrene	2.10E-01	1.71E+02	2.10E-01

Notes:
Concentration used in HHBRA represents the lower of the 95 percent UCL or maximum detected concentration (USEPA, 1992).
One-half of the detection limit was used as a proxy concentration for results that were non-detect.
The 95 percent UCLs were calculated assuming a log-normal distribution.
HHBRA - Human Health Baseline Risk Assessment
mg/kg - milligrams per kilogram
PAHs - Polycyclic Aromatic Hydrocarbons

Table 2-18
Exposure Concentrations in Soil Gas
Building 430 Area
354 Area Solvent Detections ROD
Fort Riley, Kansas

Parameter	Maximum Detected Concentration (mg/m^3)	95 Percent Upper Confidence Limit (UCL) (mg/m^3)	Concentration Used in HHBRA (mg/m^3)
Volatiles			
Carbon tetrachloride	1.57E+01	4.06E+00	4.06E+00
Trichloroethene	8.00E-01	1.05E+00	8.00E-01

Notes:
Concentration used in HHBRA represents the lower of the 95 percent UCL or maximum detected concentration (USEPA, 1992).
One-half of the detection limit was used as a proxy concentration for results that were non-detect.
The 95 percent UCLs were calculated assuming a log-normal distribution.
HHBRA - Human Health Baseline Risk Assessment
mg/m^3 - milligrams per cubic meter

Table 2-19
Exposure Concentrations in Groundwater
Building 430 Area
354 Area Solvent Detections ROD
Fort Riley, Kansas

Parameter	Maximum Detected Concentration (mg/L)	95 Percent Upper Confidence Limit (UCL) (mg/L)	Exposure Concentration Used in HHBRA (mg/L)
Volatiles			
Chloroform	1.80E-03	2.29E-03	1.80E-03

Notes:
Concentration used in HHBRA represents the lower of the 95 percent UCL or maximum detected concentration (USEPA, 1992).
One-half of the detection limit was used as a proxy concentration for results that were non-detect.
The 95 percent UCLs were calculated assuming a log-normal distribution.
HHBRA - Human Health Baseline Risk Assessment
mg/L - milligrams per Liter

Table 2-20
Hazard Index Estimates for
Future Indoor Worker Scenario
Building 367 Area
354 Area Solvent Detections ROD
Fort Riley, Kansas

Chemical	Daily Intake (mg/kg/day)	RfD (mg/kg/day)	Hazard Quotient	Pathway Hazard Index	Total Hazard Index
Exposure Pathway: Inhalation of chemical vapors					
Volatiles					
1,1,2-Trichlorethane	2.1E-10	NAv	NAp		
Acetone	3.9E-08	NAv	NAp		
Carbon disulfide	2.0E-07	2E-01	1E-06		
Carbon tetrachloride	5.1E-08	6E-04	9E-05		
Chloroform	4.9E-09	NAv	NAp		
cis-1,2-Dichloroethene	5.1E-06	NAv	NAp		
Tetrachloroethene	3.2E-05	2E-01	2E-04		
trans-1,2-Dichloroethene	8.2E-08	NAv	NAp		
Trichloroethene	8.1E-07	1E-02	8E-05		
m,p-Xylene	9.5E-09	3E-02	3E-07		
Vinyl chloride	1.2E-08	3E-02	4E-07		
				3E-04	
					3E-04

Notes:
NAv - Not available
NAp - Not applicable
mg/kg/day - milligrams per kilogram per day
RfD - Reference Dose

Table 2-21
Hazard Index Estimates for
Future Utility Excavation Worker Scenario
Building 367 Area
354 Area Solvent Detections ROD
Fort Riley, Kansas

Chemical	Daily Intake (mg/kg/day)	RfD (mg/kg/day)	Hazard Quotient	Pathway Hazard Index	Total Hazard Index
Exposure Pathway: Incidental ingestion of chemicals in soil					
PAHs					
Acenaphthylene	1.2E-08	NAv	NAp		
Benzo(a)anthracene	2.0E-09	NAv	NAp		
Benzo(a)pyrene	1.8E-09	NAv	NAp		
Benzo(b)fluoranthene	2.6E-09	NAv	NAp		
Benzo(g,h,i)perylene	1.8E-09	NAv	NAp		
Benzo(k)fluoranthene	8.9E-10	NAv	NAp		
Chrysene	2.9E-09	NAv	NAp		
Dibenz(a,h)anthracene	7.1E-10	NAv	NAp		
Fluoranthene	2.8E-09	4E-02	7E-08		
Indeno(1,2,3-cd)pyrene	1.0E-09	NAv	NAp		
Naphthalene	5.7E-09	2E-02	3E-07		
Phenanthrene	7.9E-09	NAv	NAp		
Pyrene	3.2E-09	3E-02	1E-07		
Volatiles					
Acetone	6.9E-09	1E-01	7E-08		
Carbon disulfide	3.2E-10	1E-01	3E-09		
cis-1,2-Dichloroethene	5.9E-08	1E-02	6E-06		
Tetrachloroethene	4.6E-07	1E-02	5E-05		
trans-1,2-Dichloroethene	4.6E-10	2E-02	2E-08		
Trichloroethene	7.5E-09	3E-04	2E-05		
m,p-Xylene	3.1E-10	2E-01	2E-09		
				8E-05	
Exposure Pathway: Dermal contact with chemicals in soil					
PAHs					
Acenaphthylene	3.3E-09	NAv	NAp		
Benzo(a)anthracene	5.6E-10	NAv	NAp		
Benzo(a)pyrene	5.0E-10	NAv	NAp		
Benzo(b)fluoranthene	7.4E-10	NAv	NAp		
Benzo(g,h,i)perylene	5.1E-10	NAv	NAp		
Benzo(k)fluoranthene	2.5E-10	NAv	NAp		
Chrysene	8.2E-10	NAv	NAp		
Dibenz(a,h)anthracene	2.0E-10	NAv	NAp		
Fluoranthene	8.1E-10	4E-02	2E-08		
Indeno(1,2,3-cd)pyrene	2.8E-10	NAv	NAp		
Naphthalene	1.6E-09	2E-02	8E-08		
Phenanthrene	2.2E-09	NAv	NAp		
Pyrene	8.9E-10	3E-02	3E-08		
Volatiles					
Acetone	0.0E+00	1E-01	NAp		
Carbon disulfide	0.0E+00	1E-01	NAp		
cis-1,2-Dichloroethene	0.0E+00	1E-02	NAp		
Tetrachloroethene	0.0E+00	1E-02	NAp		
trans-1,2-Dichloroethene	0.0E+00	2E-02	NAp		
Trichloroethene	0.0E+00	3E-04	NAp		
m,p-Xylene	0.0E+00	2E-01	NAp		
				1E-07	

Table 2-21 (continued)
Hazard Index Estimates for
Future Utility Excavation Worker Scenario
Building 367 Area
354 Area Solvent Detections ROD
Fort Riley, Kansas

Chemical	Daily Intake (mg/kg/day)	RfD (mg/kg/day)	Hazard Quotient	Pathway Hazard Index	Total Hazard Index
Exposure Pathway: Inhalation of chemicals in fugitive dust from soil					
PAHs					
Acenaphthylene	6.0E-13	NAv	NAp		
Benzo(a)anthracene	1.0E-13	NAv	NAp		
Benzo(a)pyrene	9.0E-14	NAv	NAp		
Benzo(b)fluoranthene	1.3E-13	NAv	NAp		
Benzo(g,h,i)perylene	9.2E-14	NAv	NAp		
Benzo(k)fluoranthene	4.6E-14	NAv	NAp		
Chrysene	1.5E-13	NAv	NAp		
Dibenz(a,h)anthracene	3.7E-14	NAv	NAp		
Fluoranthene	1.5E-13	NAv	NAp		
Indeno(1,2,3-cd)pyrene	5.1E-14	NAv	NAp		
Naphthalene	2.9E-13	9E-04	3E-10		
Phenanthrene	4.1E-13	NAv	NAp		
Pyrene	1.6E-13	NAv	NAp		
Volatiles					
Acetone	3.5E-13	NAv	NAp		
Carbon disulfide	1.6E-14	2E-01	8E-14		
cis-1,2-Dichloroethene	3.0E-12	NAv	NAp		
Tetrachloroethene	2.4E-11	2E-01	1E-10		
trans-1,2-Dichloroethene	2.4E-14	NAv	NAp		
Trichloroethene	3.8E-13	1E-02	4E-11		
m,p-Xylene	1.6E-14	3E-02	5E-13		
				5E-10	
Exposure Pathway: Inhalation of chemical vapors					
Volatiles					
1,1,2-Trichloroethane	7.4E-14	NAv	NAp		
Acetone	1.3E-08	NAv	NAp		
Carbon disulfide	6.3E-09	2E-01	3E-08		
Carbon tetrachloride	1.5E-11	6E-04	3E-08		
Chloroform	1.6E-12	0E+00	NAp		
cis-1,2-Dichloroethene	4.3E-07	NAv	NAp		
Tetrachloroethene	2.9E-06	2E-01	1E-05		
trans-1,2-Dichloroethene	4.8E-09	NAv	NAp		
Trichloroethene	6.0E-08	1E-02	6E-06		
m,p-Xylene	1.3E-09	3E-02	4E-08		
Vinyl chloride	3.3E-12	3E-02	1E-10		
				2E-05	
					1E-04

Notes:

NAv - Not available

NAp - Not applicable

PAH - Polycyclic Aromatic Hydrocarbons

mg/kg/day - milligrams per kilogram per day

RfD - Reference Dose

Table 2-22
Hazard Index Estimates for
Current Indoor Worker Scenario
Building 354/332/DPW Compound Area
354 Area Solvent Detections ROD
Fort Riley, Kansas

Chemical	Daily Intake (mg/kg/day)	RfD (mg/kg/day)	Hazard Quotient	Pathway Hazard Index	Total Hazard Index
Exposure Pathway: Incidental ingestion of chemicals in surface soil					
PAHs					
Benzo(a)anthracene	2.0E-07	NAv	NAp		
Benzo(a)pyrene	9.8E-08	NAv	NAp		
Benzo(b)fluoranthene	2.0E-07	NAv	NAp		
Benzo(g,h,i)perylene	9.8E-08	NAv	NAp		
Benzo(k)fluoranthene	9.8E-08	NAv	NAp		
Chrysene	2.0E-07	NAv	NAp		
Dibenz(a,h)anthracene	3.9E-08	NAv	NAp		
Fluoranthene	4.6E-07	4E-02	1E-05		
Indeno(1,2,3-cd)pyrene	9.8E-08	NAv	NAp		
Phenanthrene	3.5E-07	NAv	NAp		
Pyrene	3.8E-07	3E-02	1E-05		
				2E-05	
Exposure Pathway: Inhalation of chemical vapors					
Volatiles					
Benzene	1.2E-06	9E-03	1E-04		
Carbon tetrachloride	2.6E-08	6E-04	4E-05		
Chloroform	3.0E-09	NAv	NAp		
cis-1,2-Dichloroethene	3.5E-08	NAv	NAp		
Ethylbenzene	3.4E-05	3E-01	1E-04		
Tetrachloroethene	7.6E-07	2E-01	4E-06		
Toluene	1.3E-06	1E-01	1E-05		
trans-1,2-Dichloroethene	2.2E-09	NAv	NAp		
Trichloroethene	1.8E-08	1E-02	2E-06		
Xylenes, total	9.0E-05	3E-02	3E-03		
				3E-03	
					3E-03

Notes:
NAv - Not available
NAp - Not applicable
mg/kg/day - milligrams per kilogram per day
RfD - Reference Dose

Table 2-23
Hazard Index Estimates for
Current Groundskeeper Scenario
Building 354/332/DPW Compound Area
354 Area Solvent Detections ROD
Fort Riley, Kansas

Chemical	Daily Intake (mg/kg/day)	RfD (mg/kg/day)	Hazard Quotient	Pathway Hazard Index	Total Hazard Index
Exposure Pathway: Incidental ingestion of chemicals in surface soil					
PAHs					
Benzo(a)anthracene	4.1E-08	NAv	NAp		
Benzo(a)pyrene	2.0E-08	NAv	NAp		
Benzo(b)fluoranthene	4.1E-08	NAv	NAp		
Benzo(g,h,i)perylene	2.0E-08	NAv	NAp		
Benzo(k)fluoranthene	2.0E-08	NAv	NAp		
Chrysene	4.1E-08	NAv	NAp		
Dibenz(a,h)anthracene	8.1E-09	NAv	NAp		
Fluoranthene	9.6E-08	4E-02	2E-06		
Indeno(1,2,3-cd)pyrene	2.0E-08	NAv	NAp		
Phenanthrene	7.2E-08	NAv	NAp		
Pyrene	7.8E-08	3E-02	3E-06		
				5E-06	
Exposure Pathway: Dermal contact with chemicals in surface soil					
PAHs					
Benzo(a)anthracene	3.8E-09	NAv	NAp		
Benzo(a)pyrene	1.9E-09	NAv	NAp		
Benzo(b)fluoranthene	3.8E-09	NAv	NAp		
Benzo(g,h,i)perylene	1.9E-09	NAv	NAp		
Benzo(k)fluoranthene	1.9E-09	NAv	NAp		
Chrysene	3.8E-09	NAv	NAp		
Dibenz(a,h)anthracene	7.6E-10	NAv	NAp		
Fluoranthene	9.0E-09	4E-02	2E-07		
Indeno(1,2,3-cd)pyrene	1.9E-09	NAv	NAp		
Phenanthrene	6.8E-09	NAv	NAp		
Pyrene	7.3E-09	3E-02	2E-07		
				5E-07	
Exposure Pathway: Inhalation of chemicals in fugitive dust from surface soil					
PAHs					
Benzo(a)anthracene	2.1E-12	NAv	NAp		
Benzo(a)pyrene	1.0E-12	NAv	NAp		
Benzo(b)fluoranthene	2.1E-12	NAv	NAp		
Benzo(g,h,i)perylene	1.0E-12	NAv	NAp		
Benzo(k)fluoranthene	1.0E-12	NAv	NAp		
Chrysene	2.1E-12	NAv	NAp		
Dibenz(a,h)anthracene	4.1E-13	NAv	NAp		
Fluoranthene	4.9E-12	NAv	NAp		
Indeno(1,2,3-cd)pyrene	1.0E-12	NAv	NAp		
Phenanthrene	3.7E-12	NAv	NAp		
Pyrene	4.0E-12	NAv	NAp		
				NAp	

Table 2-23 (continued)
Hazard Index Estimates for
Current Groundskeeper Scenario
Building 354/332/DPW Area
354 Area Solvent Detections ROD
Fort Riley, Kansas

Chemical	Daily Intake (mg/kg/day)	RfD (mg/kg/day)	Hazard Quotient	Pathway Hazard Index	Total Hazard Index
Exposure Pathway: Inhalation of chemical vapors					
Volatiles					
Benzene	1.3E-07	9E-03	1E-05		
Carbon tetrachloride	7.4E-10	6E-04	1E-06		
Chloroform	9.8E-11	0E+00	NAp		
cis-1,2-Dichloroethene	1.2E-09	NAv	NAp		
Ethylbenzene	5.3E-06	3E-01	2E-05		
Tetrachloroethene	2.2E-08	2E-01	1E-07		
Toluene	1.8E-07	1E-01	2E-06		
trans-1,2-Dichloroethene	6.9E-11	NAv	NAp		
Trichloroethene	5.4E-10	1E-02	5E-08		
Xylenes, total	2.4E-05	3E-02	8E-04		
				8E-04	
					9E-04

Notes:
NAv - Not available
NAp - Not applicable
PAH - Polycyclic Aromatic Hydrocarbons
RfD - Reference Dose
mg/kg/day - milligrams per kilogram per day

Table 2-24
Hazard Index Estimates for
Current Child Resident Scenario
Building 430 Area
354 Area Solvent Detections ROD
Fort Riley, Kansas

Chemical	Daily Intake (mg/kg/day)	RfD (mg/kg/day)	Hazard Quotient	Pathway Hazard Index	Total Hazard Index
Exposure Pathway: Incidental ingestion of chemicals in surface soil					
PAHs					
Benzo(a)anthracene	1.5E-06	NAv	NAp		
Benzo(a)pyrene	1.3E-06	NAv	NAp		
Benzo(b)fluoranthene	1.5E-06	NAv	NAp		
Benzo(g,h,i)perylene	1.2E-06	NAv	NAp		
Benzo(k)fluoranthene	7.7E-07	NAv	NAp		
Chrysene	1.7E-06	NAv	NAp		
Dibenz(a,h)anthracer	2.6E-07	NAv	NAp		
Fluoranthene	3.7E-06	4E-02	9E-05		
Indeno(1,2,3-cd)pyre	8.9E-07	NAv	NAp		
Phenanthrene	2.4E-06	NAv	NAp		
Pyrene	2.7E-06	3E-02	9E-05		
				2E-04	
Exposure Pathway: Dermal contact with chemicals in surface soil					
PAHs					
Benzo(a)anthracene	5.6E-07	NAv	NAp		
Benzo(a)pyrene	4.7E-07	NAv	NAp		
Benzo(b)fluoranthene	5.6E-07	NAv	NAp		
Benzo(g,h,i)perylene	4.2E-07	NAv	NAp		
Benzo(k)fluoranthene	2.8E-07	NAv	NAp		
Chrysene	6.1E-07	NAv	NAp		
Dibenz(a,h)anthracer	9.3E-08	NAv	NAp		
Fluoranthene	1.3E-06	4E-02	3E-05		
Indeno(1,2,3-cd)pyre	3.3E-07	NAv	NAp		
Phenanthrene	8.8E-07	NAv	NAp		
Pyrene	9.8E-07	3E-02	3E-05		
				7E-05	
Exposure Pathway: Inhalation of chemicals in fugitive dust from s					
PAHs					
Benzo(a)anthracene	4.2E-11	NAv	NAp		
Benzo(a)pyrene	3.5E-11	NAv	NAp		
Benzo(b)fluoranthene	4.2E-11	NAv	NAp		
Benzo(g,h,i)perylene	3.2E-11	NAv	NAp		
Benzo(k)fluoranthene	2.1E-11	NAv	NAp		
Chrysene	4.6E-11	NAv	NAp		
Dibenz(a,h)anthracer	7.1E-12	NAv	NAp		
Fluoranthene	1.0E-10	NAv	NAp		
Indeno(1,2,3-cd)pyre	2.5E-11	NAv	NAp		
Phenanthrene	6.7E-11	NAv	NAp		
Pyrene	7.4E-11	NAv	NAp		
				NAp	

Table 2-24 (continued)
Hazard Index Estimates for
Current Child Resident Scenario
Building 430 Area
354 Area Solvent Detections ROD
Fort Riley, Kansas

Chemical	Daily Intake (mg/kg/day)	RfD (mg/kg/day)	Hazard Quotient	Pathway Hazard Index	Total Hazard Index
Exposure Pathway: Inhalation of chemical vapors					
Volatiles					
Carbon tetrachloride	2.4E-08	6E-04	4E-05		
Chloroform	4.7E-09	0E+00	NAp		
Trichloroethene	4.3E-09	1E-02	4E-07		
				4E-05	
					3E-04

Notes:
NAv - Not available
NAp - Not applicable
PAH - Polycyclic Aromatic Hydrocarbon
RfD - Reference Dose
mg/kg/day - milligrams per kilogram per day

Table 2-25
Excess Lifetime Cancer Risk Estimate for
Future Indoor Worker Scenario
Building 367 Area
354 Area Solvent Detections ROD
Fort Riley, Kansas

Chemical	Daily Intake (mg/kg/day)	Slope Factor (mg/kg/day)-1	Excess Cancer Risk	Pathway Cancer Risk	Total Cancer Risk
Exposure Pathway: Inhalation of chemical vapors					
Volatiles					
1,1,2-Trichlorethane	7.6E-11	5.6E-02	4E-12		
Carbon tetrachloride	1.8E-08	5.3E-02	1E-09		
Chloroform	1.8E-09	8.1E-02	1E-10		
Tetrachloroethene	1.1E-05	1.1E-02	1E-07		
Trichloroethene	2.9E-07	4.0E-01	1E-07		
Vinyl chloride	4.2E-09	1.5E-02	6E-11		
				2E-07	
					2E-07

Note:
mg/kg/day - milligrams per kilogram per day

Table 2-26
Excess Lifetime Cancer Risk Estimate for
Future Utility Excavation Worker Scenario
Building 367 Area
354 Area Solvent Detections ROD
Fort Riley, Kansas

Chemical	Daily Intake (mg/kg/day)	Slope Factor (mg/kg/day)$^{-1}$	Excess Cancer Risk	Pathway Cancer Risk	Total Cancer Risk
Exposure Pathway: Incidental ingestion of chemicals in soil					
PAHs					
Benzo(a)anthracene	7.1E-10	7.3E-01	5E-10		
Benzo(a)pyrene	6.3E-10	7.3E+00	5E-09		
Benzo(b)fluoranthene	9.3E-10	7.3E-01	7E-10		
Benzo(k)fluoranthene	3.2E-10	7.3E-02	2E-11		
Chrysene	1.0E-09	7.3E-03	8E-12		
Dibenz(a,h)anthracene	2.5E-10	7.3E+00	2E-09		
Indeno(1,2,3-cd)pyrene	3.6E-10	7.3E-01	3E-10		
Naphthalene	2.0E-09	NAv	NAp		
Volatiles					
Tetrachloroethene	1.6E-07	5.2E-02	9E-09		
Trichloroethene	2.7E-09	4.0E-01	1E-09		
				2E-08	
Exposure Pathway: Dermal contact with chemicals in soil					
PAHs					
Benzo(a)anthracene	2.0E-10	7.3E-01	1E-10		
Benzo(a)pyrene	1.8E-10	7.3E+00	1E-09		
Benzo(b)fluoranthene	2.6E-10	7.3E-01	2E-10		
Benzo(k)fluoranthene	9.0E-11	7.3E-02	7E-12		
Chrysene	2.9E-10	7.3E-03	2E-12		
Dibenz(a,h)anthracene	7.2E-11	7.3E+00	5E-10		
Indeno(1,2,3-cd)pyrene	1.0E-10	7.3E-01	7E-11		
Naphthalene	5.8E-10	NAv	NAp		
Volatiles					
Tetrachloroethene	0.0E+00	5.2E-02	0E+00		
Trichloroethene	0.0E+00	4.0E-01	0E+00		
				2E-09	
Exposure Pathway: Inhalation of chemicals in fugitive dust from soil					
PAHs					
Benzo(a)anthracene	3.7E-14	NAv	NAp		
Benzo(a)pyrene	3.2E-14	3.1E+00	1E-13		
Benzo(b)fluoranthene	4.8E-14	NAv	NAp		
Benzo(k)fluoranthene	1.6E-14	NAv	NAp		
Chrysene	5.3E-14	NAv	NAp		
Dibenz(a,h)anthracene	1.3E-14	NAv	NAp		
Indeno(1,2,3-cd)pyrene	1.8E-14	NAv	NAp		
Naphthalene	1.0E-13	NAv	NAp		
Volatiles					
Tetrachloroethene	8.4E-12	1.1E-02	9E-14		
Trichloroethene	1.4E-13	4.0E-01	5E-14		
				2E-13	

Table 2-26 (continued)
Excess Lifetime Cancer Risk Estimate for
Future Utility Excavation Worker Scenario
Building 367 Area
354 Area Solvent Detections ROD
Fort Riley, Kansas

Chemical	Daily Intake (mg/kg/day)	Slope Factor (mg/kg/day)$^{-1}$	Excess Cancer Risk	Pathway Cancer Risk	Total Cancer Risk
Exposure Pathway: Inhalation of chemical vapors					
Volatiles					
1,1,2-Trichlorethane	2.6E-14	5.6E-02	1E-15		
Carbon tetrachloride	5.4E-12	5.3E-02	3E-13		
Chloroform	5.6E-13	8.1E-02	5E-14		
Tetrachloroethene	1.0E-06	1.1E-02	1E-08		
Trichloroethene	2.1E-08	4.0E-01	9E-09		
Vinyl chloride	1.2E-12	1.5E-02	2E-14		
				2E-08	
					4E-08

Notes:
NAv - Not available
NAp - Not applicable
PAH - Polycyclic Aromatic Hydrocarbons
mg/kg/day - milligrams per kilogram per day

Table 2-27
Excess Lifetime Cancer Risk Estimate for
Current Indoor Worker Scenario
Building 354/332/DPW Compound Area
354 Area Solvent Detections ROD
Fort Riley, Kansas

Chemical	Daily Intake (mg/kg/day)	Slope Factor (mg/kg/day)-1	Excess Cancer Risk	Pathway Cancer Risk	Total Cancer Risk
Exposure Pathway: Incidental Ingestion of chemicals in surface soil					
PAHs					
Benzo(a)anthracene	7.0E-08	7.3E-01	5E-08		
Benzo(a)pyrene	3.5E-08	7.3E+00	3E-07		
Benzo(b)fluoranthene	7.0E-08	7.3E-01	5E-08		
Benzo(k)fluoranthene	3.5E-08	7.3E-02	3E-09		
Chrysene	7.0E-08	7.3E-03	5E-10		
Dibenz(a,h)anthracene	1.4E-08	7.3E+00	1E-07		
Indeno(1,2,3-cd)pyrene	3.5E-08	7.3E-01	3E-08		
				5E-07	
Exposure Pathway: Inhalation of chemical vapors					
Volatiles					
Benzene	4.1E-07	2.7E-02	1E-08		
Carbon tetrachloride	9.3E-09	5.3E-02	5E-10		
Chloroform	1.1E-09	8.1E-02	9E-11		
Ethylbenzene	1.2E-05	NAv	NAp		
Tetrachloroethene	2.7E-07	1.1E-02	3E-09		
Trichloroethene	6.3E-09	4.0E-01	3E-09		
				2E-08	
					5E-07

Notes:
NAv - Not available
NAp - Not applicable
mg/kg/day - milligrams per kilogram per day

Table 2-28
Excess Lifetime Cancer Risk Estimate for
Current Groundskeeper Scenario
Building 354/332/DPW Compound Area
354 Area Solvent Detections ROD
Fort Riley, Kansas

Chemical	Daily Intake (mg/kg/day)	Slope Factor (mg/kg/day)-1	Excess Cancer Risk	Pathway Cancer Risk	Total Cancer Risk
Exposure Pathway: Incidental ingestion of chemicals in surface soil					
PAHs					
Benzo(a)anthracene	1.5E-08	7.3E-01	1E-08		
Benzo(a)pyrene	7.3E-09	7.3E+00	5E-08		
Benzo(b)fluoranthene	1.5E-08	7.3E-01	1E-08		
Benzo(k)fluoranthene	7.3E-09	7.3E-02	5E-10		
Chrysene	1.5E-08	7.3E-03	1E-10		
Dibenz(a,h)anthracene	2.9E-09	7.3E+00	2E-08		
Indeno(1,2,3-cd)pyrene	7.3E-09	7.3E-01	5E-09		
				1E-07	
Exposure Pathway: Dermal contact with chemicals in surface soil					
PAHs					
Benzo(a)anthracene	1.4E-09	7.3E-01	1E-09		
Benzo(a)pyrene	6.8E-10	7.3E+00	5E-09		
Benzo(b)fluoranthene	1.4E-09	7.3E-01	1E-09		
Benzo(k)fluoranthene	6.8E-10	7.3E-02	5E-11		
Chrysene	1.4E-09	7.3E-03	1E-11		
Dibenz(a,h)anthracene	2.7E-10	7.3E+00	2E-09		
Indeno(1,2,3-cd)pyrene	6.8E-10	7.3E-01	5E-10		
				9E-09	
Exposure Pathway: Inhalation of chemicals in fugitive dust from surface soil					
PAHs					
Benzo(a)anthracene	7.4E-13	NAv	NAp		
Benzo(a)pyrene	3.7E-13	3.1E+00	1E-12		
Benzo(b)fluoranthene	7.4E-13	NAv	NAp		
Benzo(k)fluoranthene	3.7E-13	NAv	NAp		
Chrysene	7.4E-13	NAv	NAp		
Dibenz(a,h)anthracene	1.5E-13	NAv	NAp		
Indeno(1,2,3-cd)pyrene	3.7E-13	NAv	NAp		
				1E-12	
Exposure Pathway: Inhalation of vapors					
Volatiles					
Benzene	4.6E-08	2.7E-02	1E-09		
Carbon tetrachloride	2.6E-10	5.3E-02	1E-11		
Chloroform	3.5E-11	8.1E-02	3E-12		
Ethylbenzene	1.9E-06	0.0E+00	NAp		
Tetrachloroethene	7.9E-09	1.1E-02	9E-11		
Trichloroethene	1.9E-10	4.0E-01	8E-11		
				1E-09	
					1E-07

Notes:
NAv - Not available
NAp - Not applicable
PAH = Polycyclic Aromatic Hydrocarbon
mg/kg/day = milligrams per kilogram per day

Table 2-29
Excess Lifetime Cancer Risk Estimate for
Current Child Resident Scenario
Building 430 Area
354 Area Solvent Detections ROD
Fort Riley, Kansas

Chemical	Daily Intake (mg/kg/day)	Slope Factor (mg/kg/day)-1	Excess Cancer Risk	Pathway Cancer Risk	Total Cancer Risk
Exposure Pathway: Incidental ingestion of chemicals in surface soil					
PAHs					
Benzo(a)anthracene	6.6E-08	7.3E-01	4.8E-08		
Benzo(a)pyrene	5.5E-08	7.3E+00	4.0E-07		
Benzo(b)fluoranthene	6.6E-08	7.3E-01	4.8E-08		
Benzo(k)fluoranthene	3.3E-08	7.3E-02	2.4E-09		
Chrysene	7.1E-08	7.3E-03	5.2E-10		
Dibenz(a,h)anthracene	1.1E-08	7.3E+00	8.0E-08		
Indeno(1,2,3-cd)pyrene	3.8E-08	7.3E-01	2.8E-08		
				6E-07	
Exposure Pathway: Dermal contact with chemicals in surface soil					
PAHs					
Benzo(a)anthracene	2.4E-08	7.3E-01	2E-08		
Benzo(a)pyrene	2.0E-08	7.3E+00	1E-07		
Benzo(b)fluoranthene	2.4E-08	7.3E-01	2E-08		
Benzo(k)fluoranthene	1.2E-08	7.3E-02	9E-10		
Chrysene	2.6E-08	7.3E-03	2E-10		
Dibenz(a,h)anthracene	4.0E-09	7.3E+00	3E-08		
Indeno(1,2,3-cd)pyrene	1.4E-08	7.3E-01	1E-08		
				2E-07	
Exposure Pathway: Inhalation of chemicals in fugitive dust from surface soil					
PAHs					
Benzo(a)anthracene	1.8E-12	NAv	NAp		
Benzo(a)pyrene	1.5E-12	3.1E+00	5E-12		
Benzo(b)fluoranthene	1.8E-12	NAv	NAp		
Benzo(k)fluoranthene	9.1E-13	NAv	NAp		
Chrysene	2.0E-12	NAv	NAp		
Dibenz(a,h)anthracene	3.0E-13	NAv	NAp		
Indeno(1,2,3-cd)pyrene	1.1E-12	NAv	NAp		
				5E-12	
Exposure Pathway: Inhalation of chemical vapors					
Volatiles					
Carbon tetrachloride	1.0E-09	5.3E-02	5E-11		
Chloroform	2.0E-10	8.1E-02	2E-11		
Trichloroethene	1.9E-10	4.0E-01	7E-11		
				1E-10	
					8E-07

Notes:
NAv - Not available
NAp - Not applicable
PAH - Polycyclic Aromatic Hydrocarbon
mg/kg/day - milligrams per kilogram per day

Table 2-30
Formula for Calculating Preliminary Ingestion Dose in Soil
354 Area Solvent Detections ROD
Fort Riley, Kansas

Representative Wildlife Species	Average Body Weight (kg)	Food Ingestion Rate (kg/kg-day)	Percent of Soil in Diet	Estimated Consumption Rate of Soil in Diet (kg/day) [e]
Short-tailed Shrew	1.50E-02 [a]	9.00E-03 [a]	13.0 [a]	1.17E-03
White-footed Mouse	2.20E-02 [a]	3.40E-03 [a]	2.0 [a]	6.80E-05
Meadow Vole	4.40E-02 [b]	5.00E-03 [c]	2.4 [d]	1.20E-04
Cottontail Rabbit	1.20E+00 [b]	2.37E-01 [c]	6.3 [d]	1.49E-02
Red Fox	4.50E+00 [a]	4.50E-01 [a]	2.8 [a]	1.26E-02
White-tailed Deer	5.65E+01 [a]	1.74E+00 [a]	2.0 [a]	3.50E-02

Notes:
[a] – Based on reported body weight, food intake, and soil intake information from Efroymson et al. (1997)
[b] – Schwartz and Schwartz, 1981
[c] – Based on body weight and food intake information from Oak Ridge National Laboratory (1996).
[d] – Estimated fraction of soil or sediment in diet as reported in USEPA, 1993a (The fraction of soil in diet for the jackrabbit was substituted for the cottontail rabbit).
[e] – Food Ingestion Rate x Percent of Soil in Diet (USEPA, 1993a)

Table 2-31
Preliminary Screening of Soil Analytical Data to Wildlife Benchmarks
354 Area Solvent Detections RI Report
Fort Riley, Kansas

Chemical	Maximum Concentration in Surface Soil[1] (mg/kg)	Representative Wildlife Species	No Observed Adverse Effects Level (NOAEL)[2] (mg/kg/day)	Weight Normalized NOAEL (mg/day)[3]	Consumption Rate of Soil (kg/day)[4]	Dose Received from Soil (mg/kg/day)[5]	Ecological Hazard Quotient	Chemical of Potential Ecological Concern[6]
PAHs								
Benzo(a)anthracene[7]	0.40	Short-tailed Shrew	1.19	1.79E-02	1.17E-03	4.68E-04	2.62E-02	No
		White-footed Mouse	1.08	2.38E-02	6.80E-05	2.72E-05	1.14E-03	
		Meadow Vole	0.91	4.00E-02	1.20E-04	4.80E-05	1.20E-03	
		Cottontail Rabbit	0.40	4.80E-01	1.49E-02	5.97E-03	1.24E-02	
		Red Fox	0.29	1.31E+00	1.26E-02	5.04E-03	3.86E-03	
		White-tailed Deer	0.15	8.48E+00	3.50E-02	1.40E-02	1.65E-03	
Benzo(a)pyrene	0.20	Short-tailed Shrew	1.19	1.79E-02	1.17E-03	2.34E-04	1.31E-02	No
		White-footed Mouse	1.08	2.38E-02	6.80E-05	1.36E-05	5.72E-04	
		Meadow Vole	0.91	4.00E-02	1.20E-04	2.40E-05	5.99E-04	
		Cottontail Rabbit	0.40	4.80E-01	1.49E-02	2.99E-03	6.22E-03	
		Red Fox	0.29	1.31E+00	1.26E-02	2.52E-03	1.93E-03	
		White-tailed Deer	0.15	8.48E+00	3.50E-02	7.00E-03	8.26E-04	
Benzo(b)fluoranthene[7]	0.40	Short-tailed Shrew	1.19	1.79E-02	1.17E-03	4.68E-04	2.62E-02	No
		White-footed Mouse	1.08	2.38E-02	6.80E-05	2.72E-05	1.14E-03	
		Meadow Vole	0.91	4.00E-02	1.20E-04	4.80E-05	1.20E-03	
		Cottontail Rabbit	0.40	4.80E-01	1.49E-02	5.97E-03	1.24E-02	
		Red Fox	0.29	1.31E+00	1.26E-02	5.04E-03	3.86E-03	
		White-tailed Deer	0.15	8.48E+00	3.50E-02	1.40E-02	1.65E-03	
Benzo(g,h,i)perylene[7]	0.20	Short-tailed Shrew	1.19	1.79E-02	1.17E-03	2.34E-04	1.31E-02	No
		White-footed Mouse	1.08	2.38E-02	6.80E-05	1.36E-05	5.72E-04	
		Meadow Vole	0.91	4.00E-02	1.20E-04	2.40E-05	5.99E-04	
		Cottontail Rabbit	0.40	4.80E-01	1.49E-02	2.99E-03	6.22E-03	
		Red Fox	0.29	1.31E+00	1.26E-02	2.52E-03	1.93E-03	
		White-tailed Deer	0.15	8.48E+00	3.50E-02	7.00E-03	8.26E-04	

Table 2-31 (continued)
Preliminary Screening of Soil Analytical Data to Wildlife Benchmarks
354 Area Solvent Detections RI Report
Fort Riley, Kansas

Chemical	Maximum Concentration in Surface Soil[1] (mg/kg)	Representative Wildlife Species	No Observed Adverse Effects Level (NOAEL)[2] (mg/kg/day)	Weight Normalized NOAEL (mg/day)[3]	Consumption Rate of Soil (kg/day)[4]	Dose Received from Soil (mg/kg/day)[5]	Ecological Hazard Quotient	Chemical of Potential Ecological Concern[6]
PAHs (continued)								
Benzo(k)fluoranthene[7]	0.20	Short-tailed Shrew	1.19	1.79E-02	1.17E-03	2.34E-04	1.31E-02	No
		White-footed Mouse	1.08	2.38E-02	6.80E-05	1.36E-05	5.56E-04	
		Meadow Vole	0.91	4.00E-02	1.20E-04	2.40E-05	5.80E-04	
		Cottontail Rabbit	0.40	4.80E-01	1.49E-02	2.99E-03	6.30E-03	
		Red Fox	0.29	1.31E+00	1.26E-02	2.52E-03	1.93E-03	
		White-tailed Deer	0.15	8.48E+00	3.50E-02	7.00E-03	8.00E-04	
Chrysene[7]	0.40	Short-tailed Shrew	1.19	1.79E-02	1.17E-03	4.68E-04	2.62E-02	No
		White-footed Mouse	1.08	2.38E-02	6.80E-05	2.72E-05	1.11E-03	
		Meadow Vole	0.91	4.00E-02	1.20E-04	4.80E-05	1.16E-03	
		Cottontail Rabbit	0.40	4.80E-01	1.49E-02	5.97E-03	1.26E-02	
		Red Fox	0.29	1.31E+00	1.26E-02	5.04E-03	3.86E-03	
		White-tailed Deer	0.15	8.48E+00	3.50E-02	1.40E-02	1.60E-03	
Dibenz(a,h)anthracene[7]	0.08	Short-tailed Shrew	1.19	1.79E-02	1.17E-03	9.36E-05	5.24E-03	No
		White-footed Mouse	1.08	2.38E-02	6.80E-05	5.44E-06	2.22E-04	
		Meadow Vole	0.91	4.00E-02	1.20E-04	9.60E-06	2.32E-04	
		Cottontail Rabbit	0.40	4.80E-01	1.49E-02	1.19E-03	2.52E-03	
		Red Fox	0.29	1.31E+00	1.26E-02	1.01E-03	7.72E-04	
		White-tailed Deer	0.15	8.48E+00	3.50E-02	2.80E-03	3.20E-04	
Fluoranthene[7]	0.94	Short-tailed Shrew	1.19	1.79E-02	1.17E-03	1.10E-03	6.16E-02	No
		White-footed Mouse	1.08	2.38E-02	6.80E-05	6.40E-05	2.61E-03	
		Meadow Vole	0.91	4.00E-02	1.20E-04	1.13E-04	2.73E-03	
		Cottontail Rabbit	0.40	4.80E-01	1.49E-02	1.40E-02	2.96E-02	
		Red Fox	0.29	1.31E+00	1.26E-02	1.18E-02	9.08E-03	
		White-tailed Deer	0.15	8.48E+00	3.50E-02	3.29E-02	3.76E-03	

Table 2-31 (continued)
Preliminary Screening of Soil Analytical Data to Wildlife Benchmarks
354 Area Solvent Detections RI Report
Fort Riley, Kansas

Chemical	Maximum Concentration in Surface Soil[1] (mg/kg)	Representative Wildlife Species	No Observed Adverse Effects Level (NOAEL)[2] (mg/kg/day)	Weight Normalized NOAEL (mg/day)[3]	Consumption Rate of Soil (kg/day)[4]	Dose Received from Soil (mg/kg/day)[5]	Ecological Hazard Quotient	Chemical of Potential Ecological Concern[6]
PAHs (continued)								
Indeno(1,2,3-cd)pyrene[7]	0.20	Short-tailed Shrew	1.19	1.79E-02	1.17E-03	2.34E-04	1.31E-02	No
		White-footed Mouse	1.08	2.38E-02	6.80E-05	1.36E-05	5.72E-04	
		Meadow Vole	0.91	4.00E-02	1.20E-04	2.40E-05	5.99E-04	
		Cottontail Rabbit	0.40	4.80E-01	1.49E-02	2.99E-03	6.22E-03	
		Red Fox	0.29	1.31E+00	1.26E-02	2.52E-03	1.93E-03	
		White-tailed Deer	0.15	8.48E+00	3.50E-02	7.00E-03	8.26E-04	
Phenanthrene[7]	0.71	Short-tailed Shrew	1.19	1.79E-02	1.17E-03	8.31E-04	4.65E-02	No
		White-footed Mouse	1.08	2.38E-02	6.80E-05	4.83E-05	2.03E-03	
		Meadow Vole	0.91	4.00E-02	1.20E-04	8.52E-05	2.13E-03	
		Cottontail Rabbit	0.40	4.80E-01	1.49E-02	1.06E-02	2.21E-02	
		Red Fox	0.29	1.31E+00	1.26E-02	8.95E-03	6.86E-03	
		White-tailed Deer	0.15	8.48E+00	3.50E-02	2.49E-02	2.93E-03	
Pyrene[7]	0.77	Short-tailed Shrew	1.19	1.79E-02	1.17E-03	9.01E-04	5.05E-02	No
		White-footed Mouse	1.08	2.38E-02	6.80E-05	5.24E-05	2.20E-03	
		Meadow Vole	0.91	4.00E-02	1.20E-04	9.24E-05	2.31E-03	
		Cottontail Rabbit	0.40	4.80E-01	1.49E-02	1.15E-02	2.40E-02	
		Red Fox	0.29	1.31E+00	1.26E-02	9.70E-03	7.43E-03	
		White-tailed Deer	0.15	8.48E+00	3.50E-02	2.70E-02	3.18E-03	

Notes:
[1] – Surface soil data set consists of soil samples collected in the vicinity of Building 430 and Building 354/332/DPW Areas, from 0-1 ft bgs in unpaved locations.
[2] – (ORNL 1996)
[3] – NOAEL x Average Body Weight
[4] – Food Ingestion Rate x Percent of Soil in Diet x Percent of Foraging Range within 354 Area (assumed to be 100%)
[5] – Estimated Value = Consumption Rate of Soil x Maximum Concentration Detected in Soil
[6] – A COPEC was determined by comparing Dose Received from Soil to the Weight-Normalized NOAEL.
[7] – Toxicity information was not available from the reference. Toxicity information for Benzo(a)pyrene was substituted for other PAHs.

Table 2-32
Listed and Rare Species Occurring and Potentially Occurring in the Fort Riley Area
354 Area Solvent Detections ROD
Fort Riley, Kansas

Common Name	Scientific Name	Federal Status	State Status
American Burying Beetle	*Nicrophorus americanus*	E	E
Baird's sparrow	*Ammodramus bairdii*	SOC	-
Bald Eagle	*Haliaeetus leucocephalus*	T-PD	T
Black Rail	*Laterallus jamaicensis*	SOC	SINC
Black Tern	*Chlidonias niger*	SOC	SINC
Blue Sucker	*Cycleptus elogatus*	SOC	SINC
Eastern Hognose Snake	*Heterodon platirhinos*	-	SINC
Eastern Spotted Skunk	*Spilogale putorius*	-	T
Eskimo Cerlew	*Numenius borealis*	E	E
False Map Turtle	*Graptemys pseudogeographica*	SOC	-
Ferruginous Hawk	*Buteo regalis*	SOC	SINC
Golden Eagle	*Aquila chrysaetos*	-	SINC
Henslow's Sparrow	*Ammodramus henslowii*	SOC	SINC
Least Tern	*Sterna antillarum*	E	E
Loggerhead Shrike	*Lanius ludovicianus*	SOC	-
Northern Goshawk	*Accipiter gentilis*	SOC	-
Paddlefish	*Polyodon spatula*	SOC	-
Peregrine Falcon	*Falco peregrinus*	E	E
Piping Plover	*Charadrius melodus*	T	T
Plains Minnow	*Hybognathus placitus*	SOC	SINC
Prairie Mole Cricket	*Gryllotalpa major*	SOC	SINC
Red-shouldered Hawk	*Buteo lineatus*	-	SINC
Regal fritillary Butterfly	*Speyeria idalia*	SOC	-
Short-eared owl	*Asio flammeus*	-	SINC
Snowy Plover	*Charadrius alexandrinus*	-	T
Southern Bog Lemming	*Synaptomys copperi*	-	SINC
Sturgeon Chub	*Macrhybopsis gelida*	C	T
Texas Horned Lizard	*Phrynosoma cornutum*	SOC	-
Timber Rattlesnake	*Crotalus horridus*	-	SINC
Topeka Shiner	*Notropis topeka*	E	T
Western Burrowing Owl	*Athene cunicularia*	SOC	-
Western Hognose Snake	*Heterodon nasicus*	-	SINC
Western Prairie Fringed Orchid	*Platanthera praeclara*	T	-
Whip-poor-will	*Caprimulgus vociferus*	-	SINC
White-faced Ibis	*Plegadis chini*	SOC	T
Whooping Crane	*Grus americana*	E	E

C = Candidate
E = Endangered
SINC = Species in Need of Conservation
SOC = Species of Concern
T = Threatened
T-PD = Threatened but Proposed for Delisting

Table 2-33
Comparison of Current Concentrations in Groundwater to Benthic Organism Benchmarks
354 Area Solvent Detections RI Report
Fort Riley, Kansas

Chemical	Maximum Concentration Detected in Groundwater[1] (ug/L)	Benchmark (ug/L)	Source	Ecological Hazard Quotient	Chemical of Potential Ecological Concern
Volatiles					
Benzene	1.0	130	USEPA Tier II Secondary Chronic Value	7.69E-03	No
Bromodichloromethane	0.7	NAv	--	--	
Carbon tetrachloride	1.6	240	USEPA Tier II Secondary Chronic Value	6.67E-03	No
Chloroform	1.0	28	USEPA Tier II Secondary Chronic Value	3.57E-02	No
cis-1,2-Dichloroethene	7.9	590	USEPA Tier II Secondary Chronic Value	1.34E-02	No
Dibromochloromethane	0.9	NAv	--	--	
Tetrachloroethene	9.7	840	KS Surface Water Quality Criteria[2]	1.15E-02	No
trans-1,2-Dichloroethene	0.5	590	USEPA Tier II Secondary Chronic Value	8.47E-04	No
Trichloroethene	1.9	21,900	KS Surface Water Quality Criteria[2]	8.68E-05	No
Vinyl chloride	0.8 U	NAv	--	--	

Notes:
[1] – Groundwater data set consists of samples collected from alluvial wells during sampling events from 10/00 through 7/02.
[2] – Chronic Value for Aquatic Life
U = Undetected
NAv = Not Available

Table 2-34
Alternative Comparison
354 Area Solvent Detections ROD
Fort Riley, Kansas

	No Action	Monitored Natural Attenuation	Chemical Oxidation	Enhanced Anaerobic Bioremediation	Pump & Treat
Estimated Time					
Estimated Time for Design and Construction	0 months	0 months (already in place)	6 months	6 months	1 year
Estimated Time to Reach Remediation Goals	unknown	15 years	20 years	15 years	20 years
Estimated Costs					
Total Capital Cost[1]	$0	$48,000	$650,000	$470,000	$590,000
Total Operation & Maintenance Cost[2]	$0	$1,200,000	$1,600,000	$1,200,000	$4,100,000
Total Periodic Cost[3]	$440,000	$110,000	$130,000	$270,000	$130,000
Total Project Cost[4]	$440,000	$1,300,000	$2,300,000	$1,900,000	$4,800,000
Total Present Value Cost at 3.2%[5]	$300,000	$1,000,000	$1,900,000	$1,600,000	$3,700,000

[1] Includes costs for design, bench and pilot testing (if necessary), equipment/chemical costs, construction and implementation, and institutional controls.

[2] Includes costs for groundwater monitoring, reporting (when necessary), electricity (when necessary), periodic maintenance (when necessary), and periodic parts (when necessary).

[3] Includes costs for five-year reviews and closure reporting.

[4] Total Capital Costs + Total O&M Costs + Total Periodic Costs = Total Project Cost

[5] Present value cost using a 3.2 percent discount rate (EPA, 1993). For this analysis, the rate of return was based on the 30-year treasury bill of 5.2 percent and an inflation rate of 2 percent (formula = 1 - 1.052/1.02), which yields a value of 3.14 percent,

All costs are rounded to two significant figures.

Table 2-35
Cost Estimate for Alternative 2
354 Area Solvent Detections ROD
Fort Riley, Kansas

Monitored Natural Attenuation with Institutional Controls

	Description	Unit	Quantity	Unit Cost	Line Cost	Source[1]
Capital Costs						
2.1	Institutional Controls: Groundwater Restrictions and Access Easements	ls	1	$ 40,000.00	$ 40,000	BMcD
				Subtotal Capital Costs	**$ 40,000**	
				Contingency (20%)[2]	**$ 8,000**	
				Total Capital Costs	**$ 48,000**	
Annual Operation and Maintenance Costs						
2.2	Annual Natural Attenuation/Groundwater Monitoring[3]					
	Groundwater Sampling	ea	1	$ 16,000.00	$ 16,000	BMcD
	Laboratory Analyses	ea	1	$ 18,000.00	$ 18,000	BMcD
	Quality Control Summary Report (QCSR)	ea	1	$ 7,000.00	$ 7,000	BMcD
	Data Summary Report (DSR)	ea	1	$ 16,000.00	$ 16,000	BMcD
	E Data Submittal	ea	1	$ 5,000.00	$ 5,000	BMcD
	Project Administration	ea	1	$ 3,000.00	$ 3,000	BMcD
				Subtotal Annual O&M	**$ 65,000**	
				Contingency (20%)[2]	**$ 13,000**	
				Total Annual O&M	**$ 78,000**	
Periodic Costs						
2.3	Five-Year Review of Remedial Action	ea	1	$ 20,000.00	$ 20,000	BMcD
2.4	Closure Report	ls	1	$ 30,000.00	$ 30,000	BMcD
				Subtotal Periodic Costs	**$ 50,000**	
				Contingency (20%)[2]	**$ 10,000**	
				Total Periodic Costs	**$ 60,000**	
				Total Project Cost	**$ 1,326,000**	
				Total Present Value Project Cost at 3.2%[4]	**$ 1,041,256**	

Notes:

1) BMcD costs represent estimates obtained from similar projects and/or professional experience.
2) Contingency covers unknowns, unforeseen circumstances, or unanticipated conditions associated with remediation. Twenty percent is an average contingency factor (EPA, 2000a).
3) Monitoring costs are based on current costs per round for the Area 354 monitoring network. Monitoring costs are revised for decreasing existing well network to a focused 16 monitoring well network. Current costs of approximately $104,000 per round for the larger well network are revised to approx. $65,000 per round for the focused network.
4) Total present value based on 15 years with 5-year reviews and monitoring until closure.

BMcD Burns & McDonnell Engineering Company, Inc.
ea Each
ls Lump Sum

Table 2-36
Present Value Costs for Alternative 2
354 Area Solvent Detections ROD
Fort Riley, Kansas

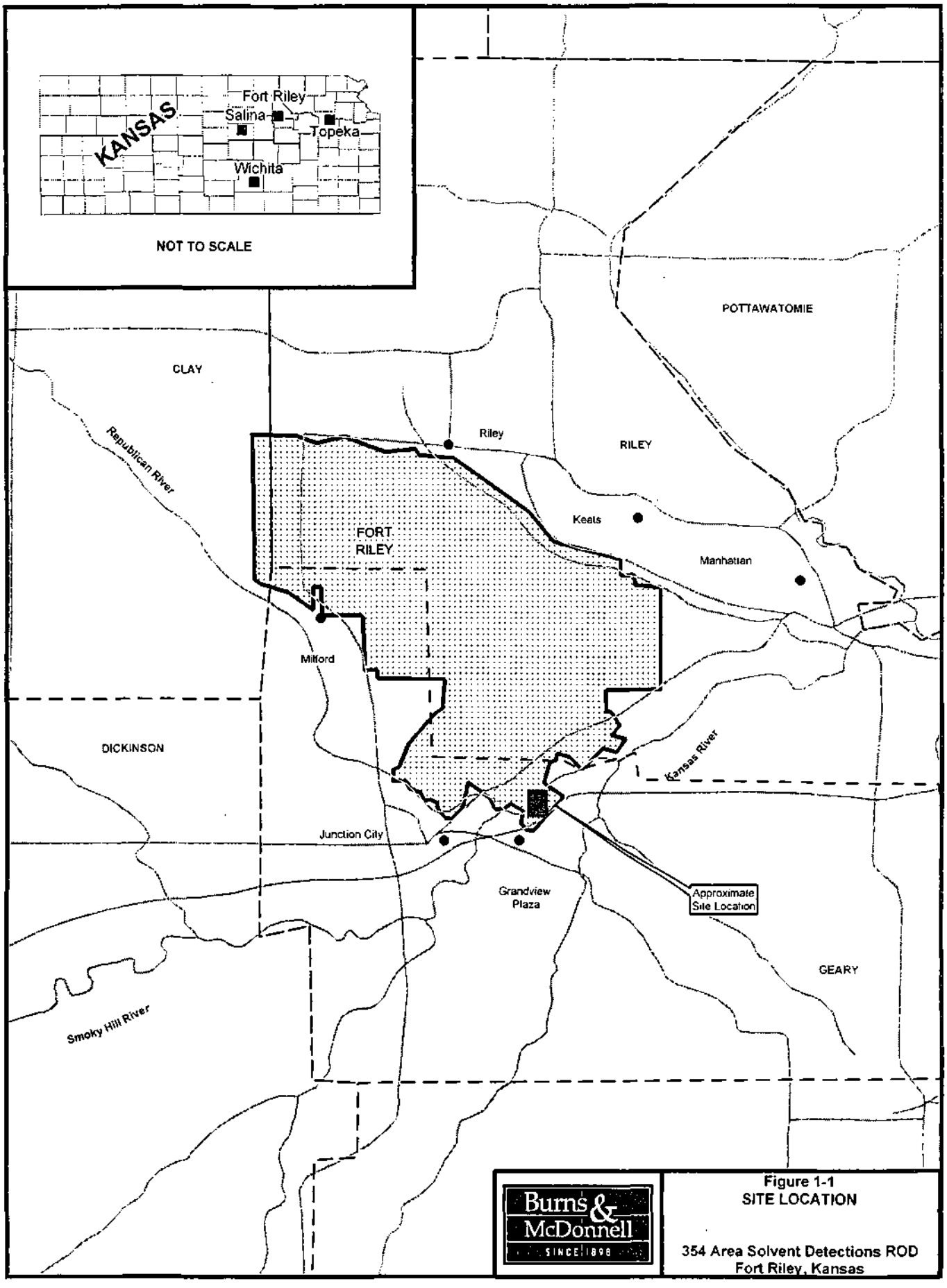
Monitored Natural Attenuation with Institutional Controls

Year	Capital Costs	Annual O&M Costs[1,2]	Periodic Costs[3]	Total Cost	Discount Factor at 3.2%	Total Present Value Cost at 3.2%
0	$ 48,000	$ -	$ -	$ 48,000	1.000	$ 48,000
1	$ -	$ 78,000	$ -	$ 78,000	0.969	$ 75,581
2	$ -	$ 78,000	$ -	$ 78,000	0.939	$ 73,238
3	$ -	$ 78,000	$ -	$ 78,000	0.910	$ 70,967
4	$ -	$ 78,000	$ -	$ 78,000	0.882	$ 68,766
5	$ -	$ 78,000	$ 24,000	$ 102,000	0.854	$ 87,137
6	$ -	$ 78,000	$ -	$ 78,000	0.828	$ 64,568
7	$ -	$ 78,000	$ -	$ 78,000	0.802	$ 62,566
8	$ -	$ 78,000	$ -	$ 78,000	0.777	$ 60,626
9	$ -	$ 78,000	$ -	$ 78,000	0.753	$ 58,746
10	$ -	$ 78,000	$ 24,000	$ 102,000	0.730	$ 74,439
11	$ -	$ 78,000	$ -	$ 78,000	0.707	$ 55,159
12	$ -	$ 78,000	$ -	$ 78,000	0.685	$ 53,449
13	$ -	$ 78,000	$ -	$ 78,000	0.664	$ 51,792
14	$ -	$ 78,000	$ -	$ 78,000	0.643	$ 50,186
15	$ -	$ 78,000	$ 60,000	$ 138,000	0.623	$ 86,037
Total	**$ 48,000**	**$ 1,170,000**	**$ 108,000**	**$ 1,326,000**		**$ 1,041,256**

Notes:

1. Assume 15 years until closure.
2. Assume annual monitoring.
3. $24,000 includes the cost of a five-year review. $60,000 includes the cost of a five-year review and a closure report.

Figures


KANSAS
Fort Riley
Salina
Topeka
Wichita
NOT TO SCALE
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SINCE 1898
Figure 1-1
SITE LOCATION
354 Area Solvent Detections ROD
Fort Riley, Kansas

Unscanned Items

A map or maps that could not be scanned
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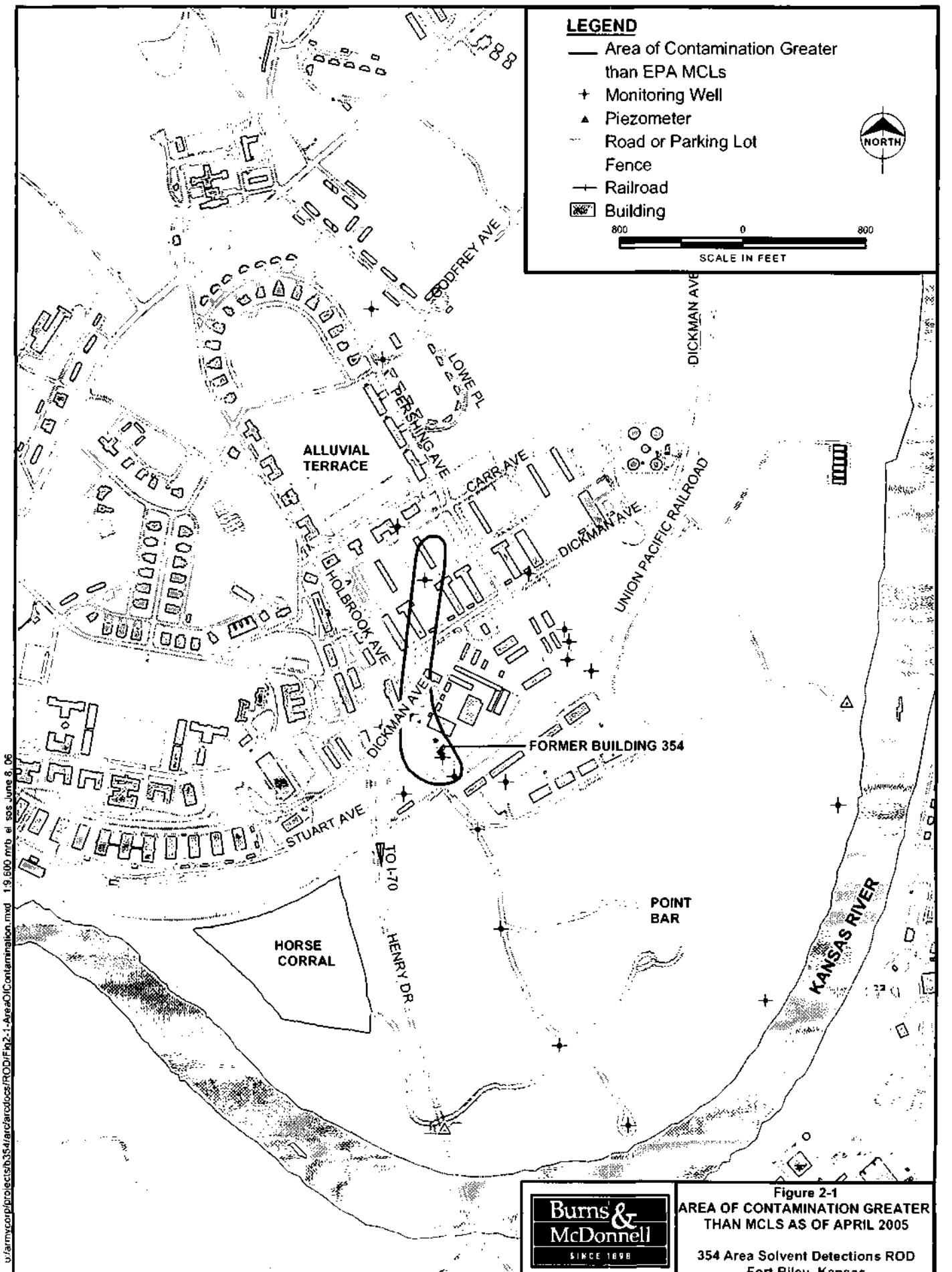

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Burns & McDonnell SINCE 1898

Figure 2-1
AREA OF CONTAMINATION GREATER THAN MCLS AS OF APRIL 2005

354 Area Solvent Detections ROD
Fort Riley, Kansas

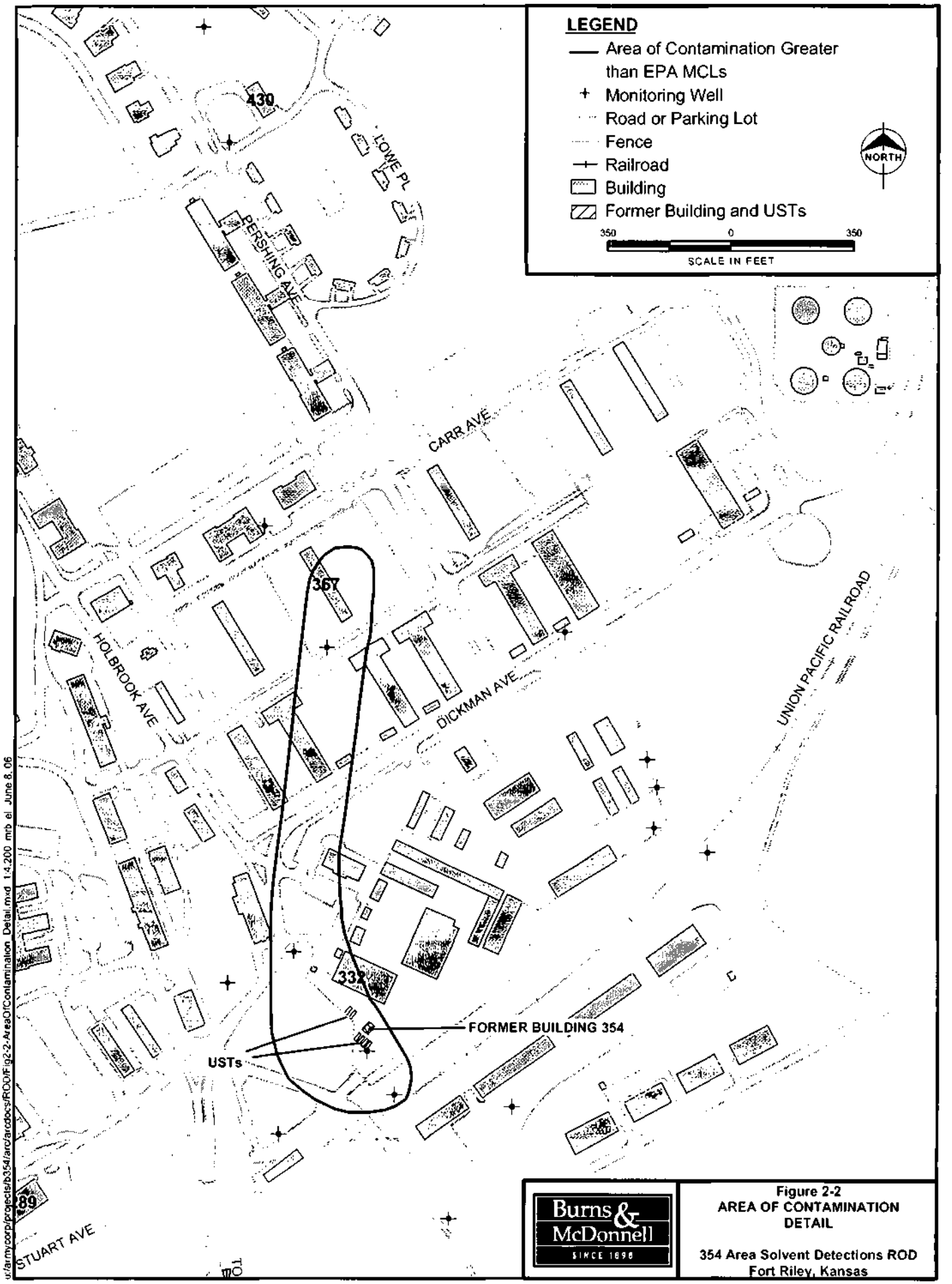

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Figure 2-2
AREA OF CONTAMINATION DETAIL

354 Area Solvent Detections ROD
Fort Riley, Kansas

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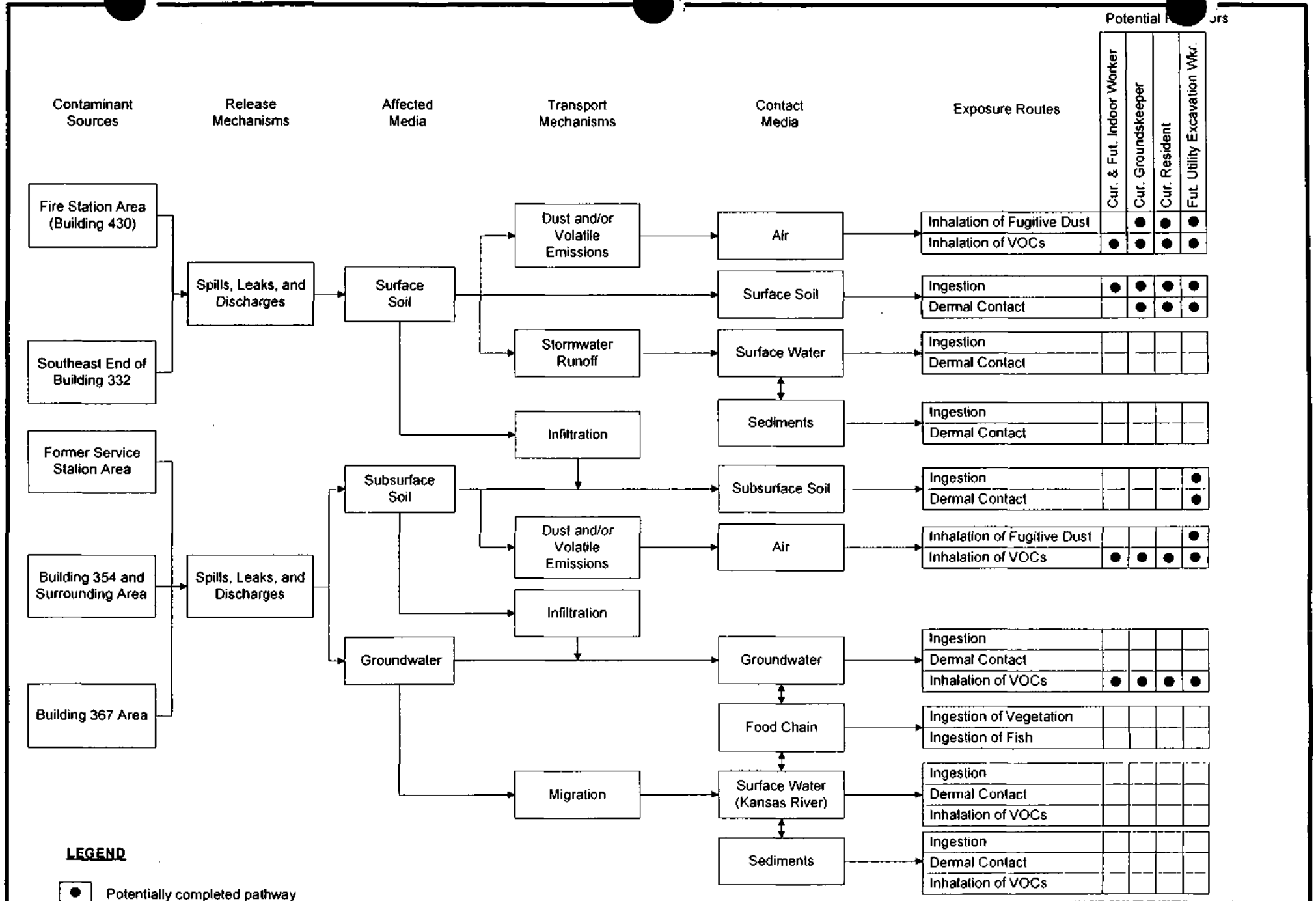

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Figure 2-3
Human Health Conceptual Model
354 Area Solvent Detections ROD
Fort Riley, Kansas

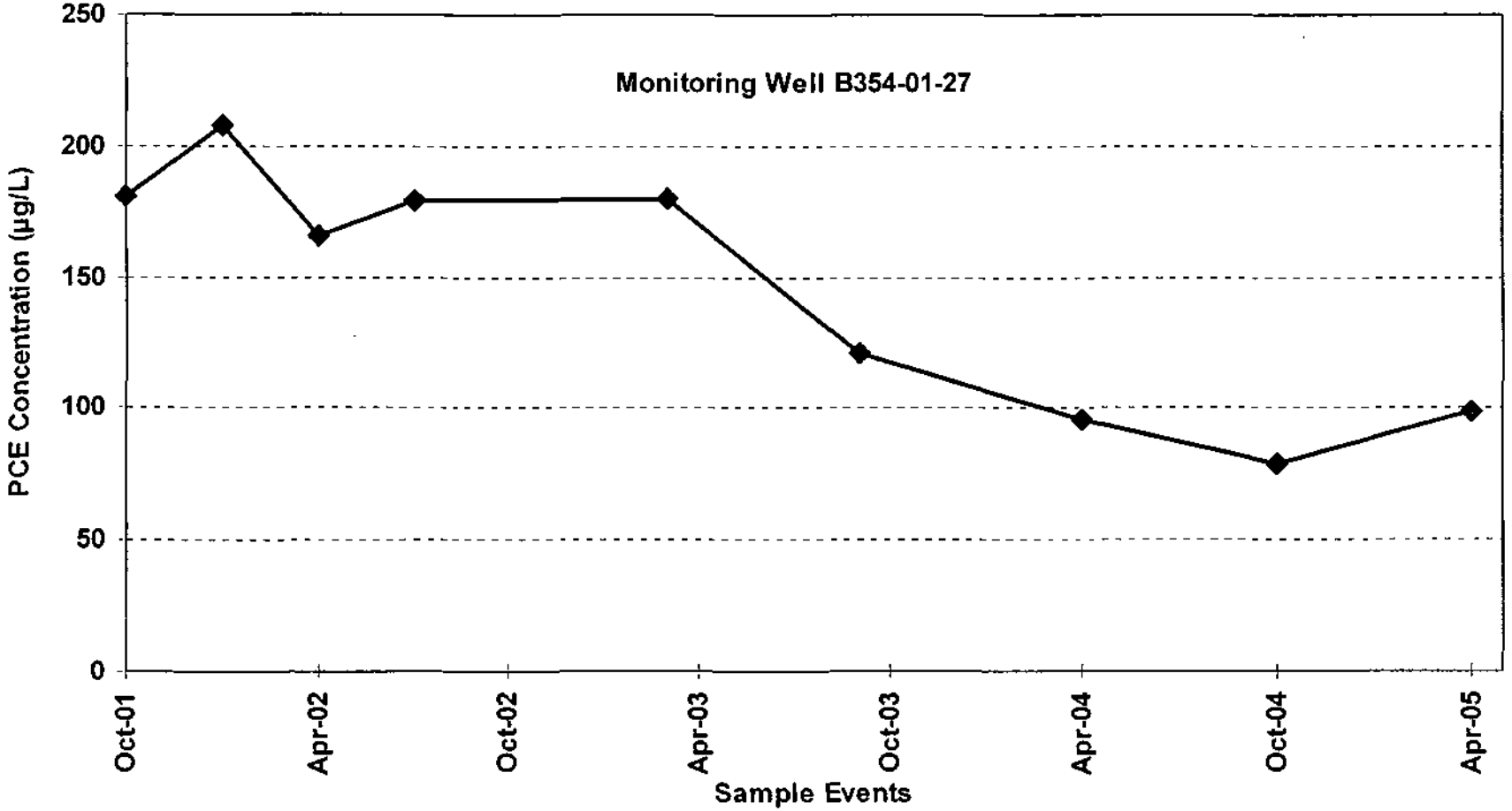

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Figure 2-4
PCE TRENDS IN
MONITORING WELL B354-01-27

354 Area Solvent Detections ROD
Fort Riley, Kansas

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