FEASIBILITY STUDY REPORT

FORMER FORBES ATLAS MISSILE SITE S-5 LYON COUNTY, KANSAS FUDS PROJECT NO. B07KS0204-01

January 2020

Prepared By

U.S. Army Corps of Engineers

Kansas City District

Kansas City, Missouri

This Page Intentionally Left Blank.

EXECUTIVE SUMMARY

This Feasibility Study (FS) Report was developed by the United States Army Corps of Engineers (USACE). The objective of the FS report is to evaluate remedial alternatives at the former Forbes Atlas Missile Site S-5 (site). Several remedial alternatives are presented and evaluated in this FS report for the purpose of aiding in selection of an appropriate remedy. The preferred remedial alternative will be presented in the Proposed Plan (PP).

The Former Forbes Atlas Missile Site S-5 is an Atlas F missile launch facility located in Lyon County, Kansas, approximately 45 miles southwest of Topeka, Kansas. The Site was an active military facility from 1961 until it was decommissioned in 1965. Between 1966 and 1994, the property was conveyed through various entities. The facility is currently privately owned.

The primary contaminant at the Site is Trichloroethene (TCE) and the contaminated medium at the Site is groundwater. TCE is present above the United States Environmental Protection Agency (USEPA) maximum concentration level (MCL) (5 µg/L) at onsite monitoring wells: MW-2S, MW-6S, MW-7S, MW-11S, and MW-13S (see Figure 10). Total area with TCE detected at concentrations greater than its MCL is believed to be approximately 320,000 square feet or approximately 7.3 acres. Historically, cis-1,2-dichloroethene (cis-DCE) was also detected at concentrations greater than its MCL. Site data indicate that contamination at the site exceeding MCLs is limited to the shallow groundwater. Shallow groundwater flow across the Site is predominantly from south to north with groundwater near the southwest corner of the Site flowing radially away from the groundwater high at MW-06S (see Figure 5). The highest concentrations of TCE within the operations area was detected in monitoring well MW-2S with concentrations ranging from 77µg/L to 120µg/L.

The following remedial alternatives were evaluated against the threshold and balancing criteria stipulated in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP):

- Alternative 1: No Further Action (NOFA)
- Alternative 2: Long-Term Monitoring (LTM) with contingent Alternate Water Supply (AWS)
- Alternative 3: In-Situ Treatment with LTM and contingent AWS

The evaluation of the remedial action alternatives was completed in comparison to one evaluation criteria and then with one another. For each criterion, comparisons between alternatives are made. Table 1 shows the Evaluation Criteria Comparison Chart of the Alternatives. The following discussions summarize the relative comparisons of each of the criteria.

Overall Protection of Human Health:
Alternatives 2 and 3 are protective of human health and the environment. Both alternatives use monitoring to measure the performance of the chosen alternative and to detect contamination before it reaches potential receptors. These alternatives also provide an AWS to the on-Site residence, which removes the direct exposure risk from ingestion or showering with

contaminated groundwater. Alternative 1 is not protective of human health and the environment as no action is performed with this alternative.

Compliance with Applicable or Relevant and Appropriate Requirements (ARARs):
Alternatives 2 and 3 would comply with ARARs. Alternative 1 would not comply with ARARs and thus does not meet either of the Threshold Criteria. Therefore, Alternative 1 was not evaluated further for Primary Balancing and Modifying Criteria.

Short-Term Effectiveness:
Alternatives 2 and 3 would be effective in protecting the community, worker health, and environment during the implementation.

Long-Term Effectiveness and Permanence:
Alternative 2 will have long-term effectiveness in preventing exposure to potential receptors by monitoring the groundwater for contaminants and providing alternate water supply, if required.

Alternative 3 would likely be effective at reducing TCE concentrations in the aquifer. However, reagent delivery may be challenging at this site given the local geology. The substrate for an enhanced anaerobic biodegradation (EAB) remedy could effectively last up to one year before a reinjection of substrate would be needed. For in-situ chemical oxidation (ISCO), there are chemical oxidation products that could last up to six months before a reinjection is needed. In-situ treatment would be more aggressive, potentially removing contamination faster than the other alternatives. In-situ treatment has the potential to produce treatment residuals that could degrade overall groundwater quality. In-situ treatment of contaminated groundwater could potentially reduce the remedial timeframe compared to Alternative 2.

Reduction of Toxicity, Mobility, or Volume through Treatment:
Alternative 2 does not provide active treatment. However, the contaminant concentration is expected to decrease over time due to physical non-destructive means such as dispersion and dilution of contamination in the aquifer. The low hydraulic conductivity of the site soils naturally reduce the mobility of the contaminated groundwater.

Additionally, the Remedial Investigation (RI) determined the sump structures (i.e., sediment trap, main sump, flame tunnel, and other various underground structures part of the missile coffin) were a potential continuing source of contaminants to the groundwater. The 2017 interim remedial action removed sediments and water from these structures. The recent interim remedial action (IRA) is expected to improve groundwater concentrations in the long term under all remedial alternatives.

Alternative 3 is the only remedial alternative that provides active treatment. In-situ treatment would be more aggressive, potentially removing contamination faster than the other alternatives, thus removing total volume and toxicity of contaminated groundwater quicker. However, this depends on an injection strategy that could optimally distribute the injected substrate or chemical oxidant. In-situ treatment of contaminated groundwater, if effective, can potentially reduce the remedial timeframe over Alternative 2.

Implementability:
Monitoring wells are already in place; however additional monitoring wells may be needed to finalize the monitoring well network. Thus, Alternative 2 can easily be implemented. Alternative 3 could be implemented by installing injection wells or utilizing temporary injection wells. However, in-situ treatment challenges include incomplete or poor distribution of the reagent due to low hydraulic conductivity of the site bedrock. In-situ treatment of site groundwater would be focused in areas of higher TCE concentration. Areas of treatment could include the vicinity of MW-02S and MW-11S (center of the site to the eastern property boundary) as well as higher concentrations south of the sump discharge (in the vicinity of MW-13S and MW-06S).
Cost:
The lowest to highest costing alternatives are in this order: Alternative 1, Alternative 2, and Alternative 3. The estimated costs and the present value cost for each alternative are summarized as follows:

Cost of Remedial Alternatives		
Alternative	**Estimated Cost**	**Present Value Cost**
Alternative 1 – NOFA	$0	$0
Alternative 2 –LTM with contingent AWS	$4,017,500	$3,099,900
Alternative 3 – In-Situ Treatment with LTM and contingent AWS	$6,360,900	$5,426,400
Cost estimates limited to 100 year reasonable timeframe.		

Conclusion:
Alternative 1 – No Action would not meet any of the remedial alternative evaluation criteria. This alternative is used as a baseline comparison for the other alternatives.

Alternative 2 – LTM would ensure contamination is detected before it reaches receptor sites and complies with ARARs. LTM is also low cost versus the more active alternative. At the site, dispersion and dilution are the primary natural attenuation mechanisms and are very gradual. Thus, plume modeling using SourceDK estimated that the groundwater will reach the preliminary remediation goal (PRG) in approximately 200 years. Costing of this alternative was limited to a 100 year reasonable costing duration. Providing an alternate water connection should current land use change would remove the risk of reaching a potential future receptor.

Alternative 3 – In-Situ treatment would reduce contaminant mass in groundwater through amendment injections. Treatment followed by groundwater monitoring would ensure remaining contamination is detected before it reaches receptor sites and would comply with ARARs. It would be an active remedial alternative, which potentially reduces the remediation timeframe to up to 100 years depending on the reagent used, which is half the 200 years estimated for Alternative 2. However, costing is limited to 100 years for both alternatives to provide a reasonable timeframe for evaluating alternatives. This is assuming that the in-situ treatment can

be properly distributed throughout the aquifer with low hydraulic conductivity. This remedial alternative would need to balance the cost benefit considerations versus the fact that there are currently no water supply wells at the site and the adjacent farmland, and therefore no exposure risks. The cost is almost double that of Alternative 2 to implement, but could potentially halve the remedial timeframe, though still require 100 years of monitoring. Providing an alternate water connection, if land use changes, would remove the risk of reaching a potential future receptor.

The comparative analysis of alternatives provides the basis for selecting the preferred alternative. The selected preferred alternative must meet the threshold criteria of overall protection of human health and the environment and compliance with ARARs, while the other primary balancing and modifying criteria should be considered in the selection process. The preferred alternative, which will be described in the PP, will be selected from among these alternatives.

TABLE OF CONTENTS

EXECUTIVE SUMMARY ..... **i**
TABLE OF CONTENTS ..... **v**
LIST OF TABLES ..... **viii**
LIST OF FIGURES ..... **viii**
LIST OF APPENDICES ..... **viii**
1.0 INTRODUCTION **1**
1.1 Purpose **1**
1.2 Report Organization **1**
1.3 Site Location **2**
1.4 Site History **2**
1.4.1 Missile Base Land Use 3
1.4.2 Surrounding Land Use 3
1.5 Topography and Surface Water Hygrology **3**
1.6 Climate **3**
1.7 Geology **3**
1.7.1 Regional Geology 3
1.7.2 Local Geology 4
1.8 Hydrogeology **4**
1.8.1 Site Hydrogeology 5
Schroyer Limestone Member 5
Threemile Limestone Member 5
1.9 Environmental History **6**
1.9.1 Preliminary Site Investigation (1988) 6
1.9.2 Confirmation Study (1991) 6
1.9.3 Preliminary Assessment (2007) 7
1.9.4 Remedial Investigation (2015-2018) 7
1.9.5 Interim Remedial Action (2017) 8
2.0 NATURE AND EXTENT OF CONTAMINATION **9**
2.1 Soil **9**
2.2 Sediment/Surface Water **9**
2.3 Groundwater **9**
2.4 Fate and Transport **10**
3.0 SUMMARY OF RISK ASSESSMENT **13**
3.1 Human Health Risk Assessment Summary **13**
3.2 Ecological Risk Assessment **13**
4.0 DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES AND GENERAL RESPONSE ACTIONS **15**
4.1 Preliminary Remedial Goals **15**
4.2 Remedial Action Objectives **15**

4.3 Potentially Applicable or Relevant and Appropriate Requirements and Criteria To-Be-Considered 15
4.3.1 Chemical-Specific ARARs 16
4.3.2 Location-Specific ARARs 16
4.3.3 Action-Specific ARARs 16
4.4 General Response Actions 16
4.4.1 Monitoring Actions 16
4.4.2 Alternate Water Supply 17
4.4.3 In-Situ Treatment Actions 17
4.4.4 Ex-Situ Treatment/Removal Action 17

5.0 SCREENING OF REMEDIAL TECHNOLOGIES AND DEVELOPMENT OF REMEDIAL ALTERNATIVES 18
5.1 Overview of the Remedial Alterative Development Process 18
5.2 Identification of Remedial Technologies 18
5.2.1 Groundwater Monitoring 18
5.2.2 Alternate Water Supply (AWS) 19
5.2.3 In-Situ Treatment Technologies 19
5.2.3.1 In-Situ Chemical Oxidation 19
5.2.3.2 In-Situ Chemical Reduction 19
5.2.3.3 Enhanced Anaerobic Bioremediation 20
5.2.4 Ex-Situ Treatment 20
5.3 Preliminary Screening of Remedial Technologies 20
5.4 Development of Remedial Alternatives 21

6.0 DESCRIPTION AND DETAILED ANALYSIS OF ALTERNATIVES 23
6.1 Evaluation Criteria 23
6.1.1 Threshold Criteria 23
6.1.1.1 Overall Protection of Human Health and Environment 23
6.1.1.2 Compliance with ARARs 23
6.1.2 Primary Balancing Criteria 23
6.1.2.1 Short-Term Effectiveness 23
6.1.2.2 Long-Term Effectiveness and Permanence 24
6.1.2.3 Reduction of Toxicity, Mobility, or Volume Through Treatment 24
6.1.2.4 Implementability 24
6.1.2.5 Cost 24
6.1.3 Modifying Criteria 24
6.1.3.1 State Acceptance 24
6.1.3.2 Community Acceptance 24
6.2 Description and Evaluation of Remedial Alternatives 24
6.2.1 Alternative 1 – No Action 24
6.2.1.1 Overall Protection of Human Health 25
6.2.1.2 Compliance with ARARs 25
6.2.1.3 Short-Term Effectiveness 25
6.2.1.4 Long-Term Effectiveness and Permanence 25
6.2.1.5 Reduction of Toxicity, Mobility, or Volume Through Treatment 25

6.2.1.6 Implementability 25
6.2.1.7 Cost 25
6.2.2 Alternative 2 – Groundwater Monitoring 25
6.2.2.1 Overall Protection of Human Health 26
6.2.2.2 Compliance with ARARs 26
6.2.2.3 Short-Term Effectiveness 26
6.2.2.4 Long-Term Effectiveness and Permanence 26
6.2.2.5 Reduction of Toxicity, Mobility, or Volume Through Treatment 26
6.2.2.6 Implementability 27
6.2.2.7 Cost 27
6.2.3 Alternative 3 – In-Situ Treatment with Groundwater Monitoring 27
6.2.3.1 Overall Protection of Human Health 28
6.2.3.2 Compliance with ARARs 28
6.2.3.3 Short-Term Effectiveness 28
6.2.3.4 Long-Term Effectiveness and Permanence 29
6.2.3.5 Reduction of Toxicity, Mobility, or Volume Through Treatment 29
6.2.3.6 Implementability 29
6.2.4.7 Cost 29
6.3 Comparative Analysis 29
6.3.1 Threshold Criteria 29
Overall protection of human health and the environment and compliance with ARARs (unless a specific ARAR is waived) are threshold requirements that each alternative must meet in order to be eligible for selection. 29
6.3.1.1 Overall Protection of Human Health 30
6.3.1.2 Compliance with ARARs 30
6.3.2 Primary Balancing Criteria 30
6.3.2.1 Short-Term Effectiveness 30
6.3.2.2 Long-Term Effectiveness and Permanence 30
6.3.2.3 Reduction of Toxicity, Mobility, or Volume Through Treatment 30
6.3.2.4 Implementability 31
6.3.2.5 Cost 31
6.4 Overall Comparison Summary 31
7.0 REFERENCES 33

LIST OF TABLES

Table No.	Title
1	Remedial Technologies Screening Evaluation Chart
2	Evaluation Criteria Comparison Chart of Alternatives

LIST OF FIGURES

Figure No.	Title
1	Regional Location Map
2	Aerial Overview
3	Former Site Layout
4	Monitoring Well Location Map
5	Typical Groundwater Elevation Map - Shallow Monitoring Well Locations
6	Historical Sampling - Onsite
7	Historical Sampling - Offsite
8	Soil Boring Locations Remedial Investigation
9	Surface Water & Sediment Sample Locations Remedial Investigation
10	TCE Isoconcentration Map
11	Potential Routes of Migration

LIST OF APPENDICES

Appendix A	Remedial Investigation Groundwater Data Tables
Appendix B	Cost Estimates of Remedial Alternatives
Appendix C	Input Parameters for SourceDK for Estimating Time to Reach Remedial Action Objectives
Appendix D	Representative Safety Data Sheets for In-Situ Remediation Amendments

LIST OF ABBREVIATIONS AND ACRONYMS

AMSL	Above Mean Sea Leve
ARARs	Applicable or Relevant and Appropriate Requirement
AWS	alternate water supply
bgs	below ground surface
BLRA	Baseline Risk Assessment
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
cis-1,2-DCE	*cis*-1,2-Dichloroethene
CO_2	carbon dioxide
COC	Chemicals of Concern
CS	confirmation study
DO	dissolved oxygen
DoD	Department of Defense
EAB	enhanced anaerobic biodegradation
Fe(III)	ferric iron
FS	Feasibility Study
GRA	general response action
H_2	hydrogen
HI	hazard index
HHRA	human health risk assessment
IRA	interim remedial action
ISCO	in-situ chemical oxidation
ISCR	in-situ chemical reduction
LOX	liquid oxygen
LTM	long-term monitoring
MCL	maximum contaminant level
mg/kg	milligrams per kilogram
MNA	monitored natural attenuation
mV	millivolt
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NOFA	No Further Action
NRCS	Natural Resource Conservation Service
O&M	operation and maintenance
ORP	oxidation-reduction potential
PA	Preliminary Assessment
PAH	polycyclic aromatic hydrocarbons
PP	Proposed Plan
PRG	preliminary remedial goals
RAO	remedial action objective
RI	Remedial Investigation
RSL	regional screening levels
SLERA	screening-level ecological risk assessment

SMS	Strategic Missile Squadron
TCE	trichloroethene
TOC	total organic carbon
USACE	United States Army Corps of Engineers
VC	vinyl chloride
VI	vapor intrusion
VISL	vapor intrusion screening level
VOC	volatile organic compound
µg/L	micrograms per liter

1.0 INTRODUCTION

1.1 Purpose

The objective of this Feasibility Study (FS) is to evaluate relevant remedial alternatives in order to select an appropriate remedy in accordance with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This FS was developed in accordance with "Guidance for Conducting Remedial Investigations and Feasibility Studies under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA)" (US Environmental Protection Agency [USEPA] 1988).

A Remedial Investigation (RI) was conducted by the United States Army Corps of Engineers (USACE, 2018a) at the former Forbes Atlas Missile Site S-5 (Site). Relatively low concentrations of trichloroethene (TCE), exceeding the MCL, were detected in groundwater monitoring wells located on the former missile base property. The RI determined the source of the contamination was from operations of the former missile site.

This FS identifies Remedial Action Objectives (RAOs), identifies and screens available remedial technologies, and evaluates feasible and cost-effective remedial alternatives to address site-related contaminants present at the Site. Remedial alternatives discussed will take into consideration the type and nature of the contamination, site geology and hydrogeology, the RAOs, and the efficacy of the selected remedial alternatives given the sites' physical setting.

1.2 Report Organization

This FS report is divided into five sections:

- **Section 1** Introduction: Summarizes the FS purpose, report organization, and site background.
- **Section 2** Summarizes the nature and extent of contamination outlined in the RI Report.
- **Section 3** Summarizes the results of the risk assessment conducted during the RI Report.
- **Section 4** Development of RAOs and general response actions (GRAs): Provides the rationale for the RAOs and discusses regulatory requirements.
- **Section 5** Screening of remedial technologies and development of remedial alternatives: identifies and screens remedial technologies that are potentially applicable to the Site, combines technologies to develop remedial alternatives.
- **Section 6** Detailed descriptions and analysis of remedial alternatives: describes and discusses the components of each remedial alternative and compares the remedial alternatives in detail, using the nine USEPA evaluation criteria.
- **Section 7** References: presents the list of reports, documents, and publications used to prepare the FS.

1.3 Site Location

The Forbes S-5 Site is located at 3627 Road D in Lyon County, Kansas. The site is approximately 8 miles west of Allen, Kansas and approximately 45 miles southwest of Topeka, Kansas (see Figure 1). The Forbes S-5 Site consists of approximately 23 acres within a general rectangular area and is surrounded by agricultural grazing lands (see Figures 2 and 3).

1.4 Site History

Construction started on the nine Forbes Atlas E missile facilities in 1959. Operation of the Forbes S-5 Site was the responsibility of the 548th Strategic Missile Squadron (SMS) assigned to the Former Forbes Air Force Base in Topeka, Kansas. The 548th SMS was activated in 1960 and missiles first started arriving at the SMS sites in January 1961. The 548th SMS was declared "Operationally Ready" in October of 1961.

The Atlas E type missiles were composed of the SM-65 variant and were housed in a "coffin launcher" style complex. The missile was kept in a horizontal position and in order to launch, a 400-ton hardened concrete overhead roof was rolled back after which the missile was elevated to a vertical launch position. Once upright, the rocket was fueled with RP-1 (kerosene) and liquid oxygen (LOX). The Atlas E missiles were equipped with a Mark IV re-entry vehicle and carried a type W-38 warhead which had a yield of approximately 4 megatons of trinitrotoluene. The Atlas E missile had a range of approximately 6,000 miles.

The Forbes S-5 facility operated from 1961 until 1965, when it was decommissioned. In 1965, the facility was reported as excess and was subsequently sold (USACE, 1993). The facility is currently privately owned, and the owners have recently expressed interest in renovating the structures for residential use.

A typical facility deactivation plan for Atlas missile facilities involved four phases:

- Removal/transportation/storage of missiles;
- Preservation of sites/complexes;
- Screening and re-utilization; and
- Disposition of real property and installed equipment.

Real property normally removed and disposed of at Atlas missile facilities included:

- Administrative building Quonset hut with lighting and electrical;
- Maintenance building Quonset hut with lighting and electrical;
- Underground fuel oil tank and fuel storage tank;
- Underground water storage reservoir tanks;
- Facility infrastructure including cooling tower, radar antenna, LOX tank, etc.;
- Street lights and poles; and
- All site designation signs.

Property allowed to remain on Site include the concrete foundations and pads, concrete missile silo housing and control structure, and perimeter fencing.

1.4.1 Missile Base Land Use

The facility is currently privately owned. Although not currently occupied, the current owners plan to live on the property in the future.

1.4.2 Surrounding Land Use

The present area of investigation consists of property within the original site boundaries, all topographic drainage areas surrounding the site, and all subsurface areas off site with impacted groundwater. Properties in the vicinity of the S-5 site are used for agriculture grazing lands.

1.5 Topography and Surface Water Hygrology

The Forbes S-5 Site is located within the eastern portion of the Flint Hills Upland Region of the Osage Plains physiographic province. From the Flint Hills Upland Region eastward in Kansas, outcropping Pennsylvanian and the overlying Permian rocks dip gently to the west and northwest with an average dip of 20 to 25 ft per mile. The topography at the Site is slightly undulated with an elevation difference of approximately 20 ft across the former Department of Defense (DoD) property (see Figure 3). Elevation at the Site above mean sea level (AMSL) ranges from approximately 1,404 ft AMSL at the northeastern corner of the Site; to 1,425 ft AMSL at the missile structure located in the middle of the Site; down to 1,410 ft AMSL at the southwestern corner of the Site. The greatest elevation change is located northeast of the missile structure where elevation drops approximately 21 ft to the northeast. Surface drainage generally flows from west to east/southeast following surface topography. The drainage empties into an unnamed tributary that parallels Road D and which eventually discharges to Bluff Creek. Surface water bodies in the immediate area include numerous farm ponds constructed with earthen dams.

1.6 Climate

The climate at the Forbes S-5 Site is dominated by typical continental interior conditions, with hot summers and cold, dry winters. The following discussion is based on climate data collected from Council Grove, Kansas, which is located approximately 11 miles to the west of the Site.

Average temperatures at the Site range from 18 to 89 degrees Fahrenheit (ºF). July and August are typically the hottest months, with daily maximum and minimum temperatures of 89 and 67 ºF, respectively. January is usually the coldest month, with daily maximum and minimum temperatures of 39 and 18 ºF, respectively. The mean annual precipitation is 34 inches, with approximately half of this falling in the months of May, June, July, and August. Approximately 13 inches of snow falls in an average year, with most snowfall occurring in December, January, and February. Severe thunderstorms, with high rainfall and the possibility of tornados, are common in late spring and early summer.

1.7 Geology

1.7.1 Regional Geology

Regionally, Lyon County lies within the Forest City basin, which is located in the northeastern part of the state. The Forest City basin lies east of the southwest to northeast trending Nemaha Uplift, an ancient granite range that was uplifted following the Mississippian Period (Merriam, 1963), and north of the Cherokee basin. Unconsolidated overburden deposits within Lyon County include but are not limited to soil that has been formed from residuum or colluvium

derived from Permian age shale and limestone. These soils are found on nearly level to moderately sloping areas on interfluves and hill slopes of uplands.

1.7.2 Local Geology

Soils in the vicinity of the Site are dominated by several mapped soil units. These include the Labette silty clay loam and the Florence-Labette complex (Natural Resource Conservation Service (NRCS), 2013).

The evaluation of soil in the vicinity of the Forbes S-5 Site is complicated by the historical DoD construction activities for the Atlas Missile Program. These anthropogenic activities have excavated, removed, stockpiled, and reshaped the area which probably mixed the soil types to some degree. Additionally, a portion of the Site was excavated into bedrock to enable construction of underground facilities for the Atlas site. Within this area, it is expected that the backfill consists of excavated material that was then replaced as engineered fill and bears little resemblance to pre-construction conditions.

Bedrock encountered in the subsurface from the Wreford Limestone Formation include the Schroyer Limestone Member, Havensville Shale Member, and the Threemile Limestone Member. A general description for these three members are provided below (Zeller, 1986; KGS, 1953):

- *Schroyer Limestone Member* – Is a light gray to nearly white chert bearing limestone. Member does contain a three-foot-thick non-chert bed approximately 3-foot-thick in the upper part of the member. Thickness of the Schroyer Limestone Member ranges from 6 to 13 ft. The member is observed in boring logs developed for the Site and appears as a yellowish-brown limestone with bluish gray chert. A thin shale can be present in the middle of the member. A four-foot section in the upper part of the member is non-cherty with oxidation, solution cavities, and vugs.

- *Havensville Shale Member* – Is a gray, calcareous shale that contains thin beds of limestone. The member thins considerably in the southeastern part of the state. Thickness of the Havensville Shale Member ranges from 1.5 to 27 ft. The lower half can be fossiliferous including brachiopods. The member can contain thin limestone beds. The member is observed in boring logs developed for the Site and appears greyish green to red with interbedded mudstone.

- *Threemile Limestone Member* – Is a light gray to nearly white limestone with chert in some parts, but contains massive and non-cherty beds in the middle and lower parts. Thickness of the Threemile Limestone Member ranges from 6 to 33 ft. The limestone unit does contain fossils including brachiopods, bryozoans, and echinoderms. The member is observed in boring logs developed for the Site and appears as a light to medium gray, somewhat fossiliferous limestone with thin bands of chert nodules.

1.8 Hydrogeology

The overburden at the Site is thin with a maximum thickness of less than ten feet. The overburden is typically dry and is not considered an aquifer at the Forbes S-5 Site. The bedrock

aquifers underlying the Site are Permian-age cyclothems of shale and limestone. Wells installed in these aquifer units derive water primarily from jointed and fractured limestone and from open joints and fractures in calcareous shales (KGS 1953). The general hydrogeological characteristics for the formations underlying the Site are as follows:

- *Matfield Shale Formation* – This formation is not utilized and is of little importance as an aquifer (KGS, 1953).
- *Wreford Limestone* – Small supplies of groundwater are obtained from this aquifer on a localized basis (KGS, 1953).
- *Speiser Shale Formation*- This formation is not utilized and is of little importance as an aquifer (KGS, 1953).

1.8.1 Site Hydrogeology

The primary aquifer formation at the Site is the Wreford Limestone which contains the Schroyer and Threemile Limestone Members. The Havensville Shale Member is situated between the two limestone units. The Schroyer Limestone Member acts as an unconfined aquifer, with water levels below the overlying Matfield Shale confining layer. Groundwater yields in these limestone units is highly variable, depending primarily on the amount of secondary permeability such as fractures and solution-enlarged features present. During the RI, 17 monitoring wells were installed at the Site in these limestone members (Figure 4). Eleven wells were classified as shallow bedrock monitoring wells and were screened in the Schroyer Limestone Member. Six monitoring wells were classified as deep bedrock wells and were screened in the Threemile Limestone Member. The Schroyer Limestone Member acts as an unconfined aquifer, with water levels below the confining layer, whereas the Threemile Limestone Member is a confined aquifer at the site.

Schroyer Limestone Member

Water levels were collected from each shallow and deep monitoring well on a quarterly basis for two years. Depth to water for the shallow bedrock wells generally ranged from 11 to 29 ft bgs. The horizontal hydraulic gradients for the shallow monitoring wells screened in the Schroyer Limestone Member ranged from a maximum of 0.026 ft/ft to a minimum of 0.002 ft/ft, with water flowing from south to north (Figure 5). Analysis of slug test data for the shallow bedrock wells during the RI resulted in hydraulic conductivity values ranging from $1.7\ E^{-5}$ to $5.6\ E^{-4}$ centimeters per second (cm/sec). The estimated linear groundwater velocities for the shallow monitoring wells screened in the Schroyer Limestone Member ranged from a maximum of 91.59 ft/year to a minimum of 0.29 ft/year.

Threemile Limestone Member

Depth to water for the deep bedrock wells generally ranged from 40 to 51 ft bgs. During the RI, the horizontal hydraulic gradients for the deep monitoring wells ranged from a maximum of 0.025 feet per foot (ft/ft) to a minimum of 0.01 ft/ft with groundwater flowing from south to north, similar to the shallow monitoring wells. Analysis of slug test data for the deep bedrock wells during the RI resulted in hydraulic conductivity values ranging from 9.406 E-7 to 2.52 E-5 cm/sec. The estimated linear groundwater velocities for the deep monitoring wells ranged from a maximum of 0.381 feet per year (ft/year) to a minimum of 0.07 ft/year. Vertical hydraulic

gradients were observed to be downward, with gradients ranging from a maximum of 0.78 ft/ft to a minimum of 0.54 ft/ft. Groundwater flow in the shallow monitoring wells flows in a radial direction away from the groundwater high at MW-06S, located in the southern portion of the site, and to the north (Figure 5)..

1.9 Environmental History

Several environmental studies have been conducted at the site beginning in 1988 and continuing through to the present. Intermittent site access impacted the timing of different phases of on-site investigation.

1.9.1 Preliminary Site Investigation (1988)

A preliminary site investigation was performed for USACE by O'Brien and Gere at the Forbes S-5 Site in October 1988. This investigation determined the current status and general information in regard to the Site including geographic location, site layout, site geology and shallow hydrogeology, and remaining infrastructure. The results of the preliminary site investigation are included in the Confirmation Study (CS) (USACE, 1991).

According to information obtained from USACE boring logs for the Site, the geology was described as four to nine feet (ft) of lean, fat, and organic fat clays, some very gravelly with cobbles overlying bedrock material consisting of limestone with alternating shales of the Chase and Council Grove Groups of Permian Age. Shallow ground water was approximately three to ten ft below existing grade.

1.9.2 Confirmation Study (1991)

O'Brien and Gere conducted a confirmation study (CS) for the Site in May-August 1990 (USACE, 1991). The objective of the CS was to provide a preliminary determination of the presence or absence of chemical contamination which may have resulted from DoD activities at the Site.

Soil

Shallow soil samples were collected for chemical analysis at six locations. One of the locations was reported to represent background conditions. Soil samples were analyzed for volatile organic compounds (VOCs), polynuclear aromatic hydrocarbons (PAHs), and total metals.

TCE, the compound most likely to be associated with DoD operations, was detected in one sample located in the vicinity of the sediment trap. The TCE concentration of 0.01 milligram per kilogram (mg/kg) was less than the current U.S. Environmental Protection Agency (USEPA) Regional Screening Level (RSL) for residential soil of 0.41 mg/kg (USEPA, 2018). Figure 6 shows the historical sample locations.

Groundwater

Two shallow Monitoring Wells GMW501 and GMW502 were installed to assess specific subsurface areas at the Site (Figure 6). Monitoring well GMW501 was installed west of the missile housing structure. The well was located to assess shallow groundwater in the vicinity of the underground diesel fuel storage tank. Monitoring well GMW502 was installed east of the

missile structure to assess shallow groundwater in the vicinity of the LOX tank and the area east of the missile structure.

At Monitoring well GMW502, *trans*-l,2-dichloroethene (*trans*-1,2-DCE) was detected in the primary sample and field duplicate. TCE was also detected in Monitoring well GMW502 in the primary and duplicate samples at concentrations of 76 microgram per Liter (µg/L) and 85 µg/L, respectively. TCE was also detected in Monitoring well GMW501 at 2 µg/L.

1.9.3 Preliminary Assessment (2007)

A Preliminary Assessment (PA) was conducted by Tetra Tech in 2007 (USEPA, 2007) for USEPA Region 7 under the Superfund Technical Assessment and Response Team program. The general objective of the PA was to determine whether any threats to human health and environment existed as a result of releases to soil and groundwater. Figure 6 and Figure 7 shows the PA investigation locations.

Soil

Eleven boreholes were completed during PA. At each boring, soil samples were collected from a shallow interval ranging from 0 to 4 ft below ground surface (bgs) and, except when shallow probe refusal was encountered, from a second, deeper interval ranging from 4 to 18 ft bgs. Nineteen total soils samples were collected, all samples were non-detect for TCE and *cis*-1,2-DCE.

Sediment

Three sediment samples were collected from drainage features that appeared to receive storm water runoff from the facility. In addition, one background sediment sample was collected from a tributary of Bluff Creek at a location upgradient of the Site. The sediment samples were collected using hand tools from a shallow interval of approximately 0 to 6 inches bgs. At the time of sampling, no surface water was present in the drainage features; therefore, no surface water samples were collected. All sediment samples were non-detect for TCE and *cis*-1,2-DCE.

Groundwater

Three groundwater samples were collected, two from private wells and one sample from a former GMW502 located east of the missile structure. GMW502 was abandoned following the PA due to well damage. GMW501 was likely destroyed, as the well could not be located during the PA site work. TCE and *cis*- 1,2-DCE was detected in a monitoring well GMW#502 with concentrations of 87 µg/L and 57 µg/L, respectively. TCE and *cis*-1,2-DCE were non-detect in the two private wells.

1.9.4 Remedial Investigation (2015-2018)

Based on the previous investigation results, the objectives of the RI field activities were as follows:

- Determine TCE nature and extent of contamination in the soil and groundwater.
- Obtain additional data required to characterize TCE source areas.

- Collect hydrogeological, aquifer matrix, and geochemical parameters for evaluation of alternatives in the FS.

The following RI fieldwork was conducted between May 2015 and March 2017.

- Seventeen monitoring wells were installed, as shown on Figure 4,
    - Eleven shallow (less than 37 feet bgs) monitoring wells (MW-02S through MW-4S and MW-06S through MW-13S)
    - Six deep (greater than 51 feet bgs) monitoring wells (MW-01D through MW-06D)
- Twelve soil borings were drilled and sampled (Figure 8). Soil samples were collected for VOC and total organic carbon (TOC) analysis.
- Groundwater samples were collected for VOC, anions, methane, ethane, ethane, and sulfide collected using low-flow techniques.
- Monitored Natural Attenuation (MNA) parameters were measured during all sampling events.
- Sediment samples (7 locations) and surface water samples (10 locations) were collected and analyzed for VOCs (May 2015) (Figure 9). Two locations correspond with the two sewage lagoons, the remaining locations correspond with the main sump, sediment trap, flame tunnel, and various pits located in and around the missile base structure. Originally 11 sediment and water locations were planned, however due to debris present impeding collection or lacking media to sample, only seven sediment samples were collected.

The RI results were used to define the nature and extent of contamination at Forbes S-5 (Section 2.0) as well as the risks from exposure to contamination at the site (Section 3.0). Full details regarding the RI were presented in the RI report (USACE 2018a).

1.9.5 Interim Remedial Action (2017)

During the course of the RI sediment and water samples were taken from the main sump, sediment trap, flame tunnel, and various pits located in and around the missile base structure. Based on the results of these samples it was determined that the main sump and sediment-trap structures were potentially a source of groundwater contamination at the site (see Figure 11). An Interim Remedial Action IRA was performed to remove water and sediments from the sump, sediment-trap, and flame-pit structures. Field work started in October 2017 and was completed in January 2018. Contaminated water was pumped into a frac-tank, run through granular activated carbon to remove VOCs and placed into another frac-tank for sampling prior to surface discharge. Sediments were removed via a vacuum-truck and placed in a roll-off for off-site disposal. Following the removal of water and sediments the sump structures and flame tunnel were power washed to remove any residual sediments. Full details regarding the IRA are presented in the Interim Remedial Action Completion Report (USACE 2018b).

2.0 NATURE AND EXTENT OF CONTAMINATION

Contamination at the Site is limited to TCE and *cis*-1,2-DCE in groundwater.

2.1 Soil

Soil samples were collected during four separate field efforts (1991, 2007, 2015 and 2016), and in each case the TCE, *cis*-1,2-DCE, and vinyl chloride (VC) analytical results were either below detection limits, or below risk-based screening levels.

2.2 Sediment/Surface Water

Sediment and water samples were collected from the two site lagoons, the main sump, sediment trap, flame tunnel, and various pits located in and around the missile base structure. TCE, *cis*-1,2-DCE, and VC were detected exceeding the screening levels in the sump structures (sediment trap, main sump, and flame tunnel). These structures were determined to be a continuing potential source to groundwater contamination and potential risk to Site workers and potential future residents. As discussed in Section 1.9.5 an IRA was conducted to remove all sediments and water from the main sump, sediment trap, flame tunnel, and other various pits located in the missile base. Full details regarding the Interim Remedial Action are presented in the Interim Remedial Action Completion Report (USACE 2018b).

2.3 Groundwater

Groundwater data tables from the RI Report are included for reference in (Appendix A, Table 3-9 to 3-16 from the RI). TCE concentrations across the Site were detected above the USEPA MCL (5 µg/L) within monitoring wells MW-2S, MW-6S, MW-7S, MW-11S, and MW-13S. Site data indicates that contamination at the site exceeding MCLs is limited to the shallow groundwater. Shallow groundwater flow across the Site is predominantly from south to north with groundwater near the southwest corner of the Site flowing radially away from the groundwater high at MW-06S (see Figure 5). The highest concentrations of TCE within the operations area was detected in Monitoring Well MW-2S with concentrations ranging up to 120µg/L.

The detections of TCE and daughter products in sediment and water samples during RI field activities indicate that the likely contaminant sources are associated with the main sumps, the sediment trap at the sump discharge along the south perimeter fence, and the flame pit (see Figure 11). The contaminated water and sediments within these structures represented an ongoing release of contaminants to groundwater. Figure 10 illustrates the extent of the contaminant plume during the March 2017 sampling event and Figure 3 shows historical structures. The presence of surface water and sediment contamination within the structures presented an ongoing risk to Site workers and potential future residents; therefore, the USACE decided to perform the IRA on the contaminated surface water and sediments.

It should also be noted that access to the land surrounding the missile base was denied by the property owner. This prevented a more rigorous delineation of the southern and eastern areas of the plume. Property ownership of the land surrounding this site will be monitored and if property ownership changes, a request for access to the neighboring land will be made. Based on

the current understanding of the nature and extent of contamination enough information exists to evaluate remedial alternatives for remediation of the site.

2.4 Fate and Transport

TCE is the primary contaminant present at the Forbes S-5 Site. TCE exposure in humans can result in toxic effects to the nervous system, liver, and kidneys, and may cause fetal cardiac effects. Human exposure typically occurs through the ingestion of TCE-contaminated drinking water. TCE can also readily volatilize out of hot water, such as during showering, which could result in the inhalation of TCE.

TCE in the subsurface dissolves in groundwater (solubility of 1,100 mg/L (Schnoor et al 1987)) and volatilizes readily due to its relatively high Henry's Constant, allowing it to form vapor plumes above groundwater plumes. TCE can sorb to soil particles in the subsurface, providing retardation of a groundwater plume (estimated log Koc of 2.15 (Lyman et al. 1990)). In addition, TCE concentrations are influenced by groundwater advection and dispersion in the subsurface. TCE is heavier than water and as a free product behaves as a dense non-aqueous phase liquid (DNAPL), sinking to the bottom of a water column and acting as a constant source of dissolved TCE.

TCE and the other chlorinated solvents are subject to microbial degradation, a destructive process that physically changes the chemical structure of the compound. The chlorinated solvents can be used by microorganisms as either electron donors or electron acceptors, depending upon the redox conditions in the aquifer. These compounds can also be degraded by cometabolic processes (Weidemeier & Chapelle, 1998). Chlorinated solvents can be reductively dechlorinated under anoxic conditions.

The efficiency of dechlorination differs for particular compounds and for particular geochemical conditions. The dechlorination of TCE to *cis*-1,2-DCE occurs under both mild and strongly reducing conditions, whereas the transformation of *cis*-1,2-DCE to VC, and the transformation of VC to ethene, require the more strongly reducing conditions characteristic of methanogenesis.

Biodegradation of organic compounds, whether natural or anthropogenic, creates measurable changes in the groundwater chemistry. By measuring these changes, it is possible to document and qualitatively evaluate biodegradation in an aquifer. The following are those geochemical indicators typically evaluated (USEPA, 1998): oxidation/reduction potential (ORP), dissolved oxygen (DO), nitrate, iron, sulfate, methane, chloride, alkalinity, and TOC.

An application of several of these geochemical indicators to the Forbes S-5 Site can be made based on field data collected during the quarterly sampling conducted at the Site from July 2015 through March 2017. Specifically, data is available for ORP, DO, ferrous iron, sulfate, sulfide, chloride, sulfate, methane, ethane, and ethene which is presented in (Appendix A, Table 3-9 to 3-16 from the RI). This site-specific data is discussed in the following paragraphs.

Based on USEPA guidelines (USEPA, 1998), conditions are considered favorable for reductive dechlorination at ORPs of less than 50 millivolts (mV). At ORPs less than -100 mV, reductive

dechlorination is likely to occur. Data collected during the eight quarterly sampling events indicated that ORP conditions within the shallow and deep monitoring wells in most cases were within the favorable range of between 50 and -100 mV for reductive dechlorination in 82 of the 112 samples collected. However, measured ORP was above the favorable range of between 50 and -100 mV in 24 of the 64 samples collected in the shallow monitoring wells, and 1 of the 48 samples collected in the deep monitoring wells. Measured ORPs at MW-03D, MW-04D, MW-05D, and MW-06D were less than -100 mV, putting them in a range where reductive dechlorination is likely to occur.

In the case of chlorinated solvents, anaerobic bacteria optimally function at DO concentrations less than 0.5 milligram per liter (mg/L) (USEPA, 1998). None of the DO field measurements taken during the eight quarterly sampling events were less than 0.5 mg/L (the lowest DO measured was 0.54 mg/L at MW-02S in round six), which indicates that conditions at the Site are not favorable.

Ferrous iron concentration at or greater than 1.0 mg/L can provide evidence that reductive dechlorination is occurring in the aquifer (USEPA, 1998). Ferrous iron was detected in 73 of 101 samples during the seven rounds of sampling events. Although ferrous iron was detected in most of the samples, the concentrations were generally below 1.0 mg/L, which indicates that favorable conditions for reductive dechlorination are not present.

Sulfate may be used as an electron acceptor for anaerobic degradation, resulting in the formation of sulfide. In the case of chlorinated solvents, concentrations of sulfate greater than 20 mg/L may cause competitive exclusion of dechlorination, while the presence of sulfide at concentrations greater than 1 mg/L indicates that dechlorination may be occurring (USEPA, 1998). The sulfate data collected from the monitoring wells ranged from non-detections to 557 mg/L with only 8 detections below 20 mg/L. Based on the data collected, sulfate concentrations are well above what is considered favorable for biodegradation of chlorinated solvents. Sulfide was detected in approximately 50 percent or 66 of the samples collected during the eight groundwater monitoring events evaluated. Five of the detections were below 1 mg/L and 61 were above. Based on the data collected, approximately half of the samples were above what is considered favorable for biodegradation of chlorinated solvents. Taken together, the sulfate and sulfide results indicate that conditions are not favorable for biodegradation of chlorinated solvents.

During biodegradation of chlorinated hydrocarbons, chloride is released to the environment, and chloride concentrations in the plume will be elevated compared to background concentrations. Chloride can serve as a conservative tracer for reductive dechlorination (USEPA, 1998). For the chlorinated solvents plume, the background chloride concentration value was determined to be 19.9 mg/L (twice the background as calculated based upon Monitoring wells MW-08S and MW-09S). Chloride was detected in 110 samples during eight groundwater monitoring events with 56 samples above 19.9 mg/L. Chloride concentrations at most monitoring wells indicated that reductive dechlorination conditions are favorable.

During methanogenesis, organics are used as electron acceptors and are reduced to methane. For chlorinated solvents, the presence of methane in the groundwater is indicative of strongly reducing conditions. Methane concentrations greater than 500 µg/L indicate methanogenic conditions favorable to degradation of chlorinated solvents (USEPA, 1998). Methane was detected in 85 samples and below 5 µg/L in 56 samples. No wells had methane greater than 500 µg/L. The low methane levels detected suggest that methane reduction is not occurring.

In conclusion, the data support that aerobic conditions are present in the majority of the shallow and deep monitoring wells. However, the data also supports the presence of areas of reducing conditions, with conditions appearing to become more anaerobic and therefore more conducive to reductive dechlorination as the groundwater flows downgradient and also within the deeper aquifer. The increase in reducing conditions with depth and downgradient distance indicate a potential natural limiting effect on the extent of TCE migrating.

3.0 SUMMARY OF RISK ASSESSMENT

3.1 Human Health Risk Assessment Summary

A baseline human health risk assessment (HHRA) was completed and presented in the RI report for Forbes S-5 (USACE, 2018a). Based on the previous investigations, the levels of contamination, and the current and reasonably anticipated future uses of the Site, groundwater is of potential concern to human receptors should the groundwater be used in the future and was evaluated in the HHRA. Soil contamination was not detected in concentrations high enough to pose cancer risks above the CERCLA risk range of 10-4 to 10-6 or a non-cancer hazard index (HI) above 1. Sediment and surface water were evaluated in the HHRA for potential human health exposure in the RI report, however an IRA (USACE, 2018b) was conducted to remove all sediments and water from the main sump, sediment trap, flame tunnel, and other various pits located in the missile base, mitigating this potential risk by eliminating the potential for exposure.

In shallow groundwater, maximum concentrations of TCE exceeded the USEPA MCL (5 µg/L) screening level. Carcinogenic risks and HIs were estimated from exposure to TCE if the shallow groundwater were used as a drinking water source. The total groundwater cancer risk is at the high end of the USEPA's generally acceptable cancer risk range of 1E-06 to 1E-04 with a total cancer risk of 1E-04 (rounded) from TCE exposure. Although *cis*-1,2-DCE was also a groundwater COPC, it is not a carcinogen. The total non-cancer HIs range from 21 (adult) to 24 (child) and are primarily driven by the inhalation pathway. In both scenarios, the non-cancer point of departure of 1.0 was exceeded and was driven by TCE.

Based on the relatively shallow depth of groundwater at the Site, a vapor intrusion (VI) pathway was also evaluated for contaminants in groundwater that may volatilize into future indoor air in order to determine if additional characterization and/or evaluation of the VI exposure pathway is warranted. Furthermore, TCE exceeded the groundwater Vapor Intrusion Screening Level (VISL) of 1.2 µg/L (USEPA, 2018b), demonstrating additional evaluation of the VI exposure pathway may be warranted. However, given the current land use, there are no current receptors. In the event the current land use changes the evaluation of the VI exposure path way will be reevaluated.

3.2 Ecological Risk Assessment

As stated in the HHRA, the only sediment and surface water associated with the Site were located within deep pits and sumps. These locations are not natural habitats, they are small and relatively inaccessible to wildlife. Therefore, sediment and surface water was not evaluated for ecological risk considerations. In addition, groundwater was not a medium of concern for ecological receptors and was not evaluated. The nearest surface water bodies to the Site are shallow-bedded ephemeral streams as well as cattle stock ponds to the east and west of the site that capture overland flow during precipitation events. The downstream portions of these tanks are dry for the most part and are not recharged by bedrock groundwater. The streams are dry most of the year except during precipitation events. Through the site investigation, the static water levels in the shallow monitoring wells were found to be below the elevations of the bottom of the stream beds within bedrock. Further, Bluff creek to the east of the site is more than 7600 ft away; and over 5600 ft to the southeast. On a localized scale specific to the Site, the bedrock

groundwater will not recharge the ephemeral streams, the stock tank ponds, or Bluff Creek. Any ecological receptors in nearby surface water bodies are therefore not exposed to any groundwater recharge from the Site. The only medium of potential concern for ecological receptors was soil. Surface soil (0 to 1 ft bgs) was originally planned to be compared to ecological screening level benchmarks for soil. However, as stated previously, there were no detects in surface soil or subsurface soil (0 to 10 ft bgs) samples. Due to this lack of detected contaminants, the screening-level ecological risk assessment (SLERA) process was not required.

4.0 DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES AND GENERAL RESPONSE ACTIONS

RAOs are goals for protecting human health and the environment that are identified prior to the development of remedial alternatives. The RAOs are developed by evaluating Applicable or Relevant and Appropriate Requirements (ARARs) and the results of the RI including the Baseline Risk Assessment (BLRA). This section reviews the affected media and contaminant exposure pathways, and also identifies federal and state regulations that may affect remedial actions.

General Response Actions (GRAs) are proposed to satisfy RAOs and then refined into remedial alternatives as the feasibility process proceeds. The GRAs developed are monitoring, alternate water, in-situ treatment, and ex-situ treatment/removal action, which are taken singularly or in combination to satisfy RAOs for the Site.

4.1 Preliminary Remedial Goals

Preliminary Remedial Goals (PRG) are end point concentrations selected to provide adequate protection of human health and the environment. In the absence of protective ARARs, PRGs are quantitative chemical–specific concentrations for each individual chemical of concern (COC) identified in the BLRA as posing a cancer risk greater than $1x10^{-6}$ as a point of departure or a hazard quotient greater than 1 or exceeding a potential ARAR. During the BLRA, groundwater was the only medium with an identified COCs. Trichloroethene is the only COC at this site and its PRG is set at the primary MCL (5 μg/L).

4.2 Remedial Action Objectives

The RAO for the site focuses on groundwater to mitigate future potential exposure risks to residents. RAOs established for the site are:

- Prevent exposure to potable water from groundwater containing COCs above the groundwater PRGs.

4.3 Potentially Applicable or Relevant and Appropriate Requirements and Criteria To-Be-Considered

ARARs are limited to promulgated requirements that must relate to environmental or facility siting laws, are substantive requirements, and pertain to the circumstances at a given CERCLA site.

Potential ARARs are divided into three groups:

- Chemical-specific ARARs
- Location-specific ARARs
- Action-specific ARARs

The "Applicable" portion of the term is defined as: *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 (*40 Code of Federal Regulations [CFR] 300.5).

The "Relevant and Appropriate" portion of the ARAR term is defined as: *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 circumstance 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 by a state in a timely manner and that are more stringent than Federal requirements may be relevant and appropriate. (40 CFR 300.5)*

4.3.1 Chemical-Specific ARARs

Chemical-specific ARARs are defined as those that specify achievement of a particular cleanup level for specific chemicals or classes of chemicals. These standards usually take the form of health- or risk-based numerical limits that restrict concentrations of various chemical substances to a specified level. The chemical-specific ARARs are as follows:

- Federal Safe Drinking Water Act – National Revised Primary Drinking Water Regulations: Maximum Contaminant Level and Maximum Residential Disinfectant Levels (40 Code of Federal Regulations [CFR] 141 Subpart G)

4.3.2 Location-Specific ARARs

Location-specific ARARs are those which are applicable or relevant and appropriate due to the location of the site or area being remediated. There were no applicable or appropriate location-specific ARARs found for this site.

4.3.3 Action-Specific ARARs

Action-specific ARARs are those which are applicable or relevant and appropriate to particular remedial actions, technologies, or process options. These regulations do not define a site's cleanup levels but do affect the implementation of specific types of remediation. There were no applicable or appropriate action-specific ARARs found for this site.

4.4 General Response Actions

GRAs are broad remedial actions that are potentially capable of achieving RAOs at the Site either singularly or in combination. A description of each GRA considered is presented below.

4.4.1 Monitoring Actions

Monitoring actions would include sampling of groundwater to verify that future contaminant concentrations would not result in cancer risks above the CERCLA risk range of E-04 to E-06 or an HI above 1. Natural attenuation takes place by mechanisms which include: dispersion,

diffusion, dilution, volatilization, sorption, and reductive dechlorination. Monitoring technologies include LTM and MNA.

4.4.2 Alternate Water Supply

An AWS is not currently required since there are no water supply wells at the site at this time. If an AWS is required in the future, it would include bottled water, a treatment system (e.g. granular activated carbon), or a connection to an existing rural water or municipal water supply system.

4.4.3 In-Situ Treatment Actions

In-situ treatment occurs in the ground. There is no physical removal of groundwater that will be treated elsewhere as is the case with ex-situ treatment, but a removal or destruction of contaminants in place either through physical, chemical, or biological processes. A common form of in-situ treatment is injection of chemicals that destroy contaminants or substrates that help to set up conditions for biodegradation. For instance, a substrate could be added to the groundwater to enhance bioremediation by introducing an electron donor (i.e. carbon source) to the groundwater, thus creating more favorable conditions for biodegradation. Alternatively, a chemical oxidant could be added to the groundwater to chemically break down contamination.

4.4.4 Ex-Situ Treatment/Removal Action

Ex-situ treatment/removal actions are the physical removal of contaminated media (groundwater at Forbes S-5) from its location for treatment and/or disposal. Groundwater would be extracted through pumping wells, treated, and then discharged. This remediation method is commonly called “pump and treat.”

5.0 SCREENING OF REMEDIAL TECHNOLOGIES AND DEVELOPMENT OF REMEDIAL ALTERNATIVES

5.1 Overview of the Remedial Alterative Development Process

A preliminary technology screening was performed to select from a list of remedial technologies that are potentially applicable for remediation of the site. The preliminary screening took into consideration the site contaminants and their current disposition when evaluating technologies in terms of effectiveness, implementability, and cost. Table 1 shows how each technology rated in the Preliminary Remedial Technologies Screening Evaluation.

Each technology will be evaluated as to its effectiveness in providing protection and in reducing the toxicity, mobility, or volume of contaminants. Both short- and long-term components of the effectiveness will be evaluated; short-term referring to the construction and implementation period, and long-term referring to the period after the remedial action is complete.

The implementability criterion measures the technical and administrative feasibility of constructing, operating, and maintaining the remedial technology in respect to conditions at the site. Technical feasibility refers to the ability to construct, reliably operate, and meet technology-specific regulations for process options until a remedial action is complete; it also includes operation, maintenance, replacement, and monitoring of technical components of a technology, if required, into the future after the remedial action is complete. Administrative feasibility refers to the ability to obtain approvals from other offices and agencies such as Kansas Department of Health and Environment (KDHE), the availability of treatment, storage, and disposal services and capacity, and the requirement for, and availability of, specific equipment and technical specialists.

The objective of the cost criterion is to eliminate from further consideration those technologies whose costs are excessive for the effectiveness they provide.

5.2 Identification of Remedial Technologies

The remedial technologies considered for this FS are described in Sections 5.2.1 through 5.2.3.

5.2.1 Groundwater Monitoring

Monitoring technologies include groundwater sampling and analysis to document site conditions over time. The MNA technology, as defined by the USEPA, “refers to the reliance on natural attenuation processes (within the context of a carefully controlled and monitored site cleanup approach) to achieve site-specific remediation objectives within a time frame that is reasonable compared to that offered by other more active methods” (USEPA, 1998). Natural attenuation processes include a variety of physical, chemical, and biological processes that act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater. Relevant physical processes include dilution, dispersion, and sorption; chemical processes include stabilization, destruction, and volatilization; and biological processes include stabilization or degradation by plants or microorganisms. Given the site MNA geochemical parameters obtained during the RI, limited natural biological degradation appears to be present. However, after the Interim Remedial Action, the rate of contaminant attenuation may increase due to the removal of continuing sources. In addition, physical

processes of advection and dispersion due to groundwater movement are occurring, though limited by the slow moving groundwater at this site. Sorption of TCE to soil particles as well as volatilization of TCE in the subsurface also provide physical means of reducing the groundwater concentration over time. Groundwater monitoring alternatives focus on sampling COC concentrations over time along with monitoring water levels in monitoring wells to evaluate groundwater gradients. The LTM technology will involve long-term monitoring, sampling, data processing, analysis, and reporting to evaluate COC concentration and distribution onsite and at sentinel wells to detect any increases in concentrations off site.

5.2.2 Alternate Water Supply (AWS)

An AWS is not required since there are no active water supply wells at the Site or in the property surrounding the site. This technology would provide an AWS, either connection to a municipal or rural water district, water treatment, or installation of a new potable well to effectively protect human health. An AWS removes the exposure risk to the residents from drinking, showering, and other domestic groundwater use.

5.2.3 In-Situ Treatment Technologies

The important feature of in-situ treatment is that remediation occurs in place within the contaminated area. Three types of in-situ treated technologies are potentially applicable at the site. These are In-Situ Chemical Oxidation (ISCO),, and In-Situ Chemical Reduction (ISCR), and Enhanced Anaerobic Bioremediation (EAB). All three technologies require subsurface delivery of chemical reagents either through direct injection or groundwater recirculating systems. Subsurface reagent delivery can be very effective in homogeneous, moderate to highly permeable aquifers and are excellent options to decrease very high groundwater concentrations or non-aqueous phase liquids. However, adequate reagent delivery for depleting relatively low levels of contamination to MCLs may be difficult to achieve in heterogeneous aquifers, which is the case at the site.

5.2.3.1 In-Situ Chemical Oxidation

ISCO is the introduction of oxidants into the subsurface to degrade hazardous contaminants. Contaminant degradation occurs through oxidation-reduction reactions that involve the transfer of electrons from one compound to another. Specifically, the contaminant is oxidized (loses electrons) and oxidant is reduced (gains electrons). The oxidizing agents most commonly used for treatment of hazardous contaminants in soil are ozone, permanganate, persulfate, and Fentons reagent (hydrogen peroxide and iron catalyst such as iron sulfate). Some of these oxidizing agents such as permanganate can persist for longer than six months before another injection is needed, while others like ozone and hydrogen peroxide have much shorter persistence in the aquifer.

5.2.3.2 In-Situ Chemical Reduction

ISCR is the introduction of reductants or reductant generating material into the subsurface to degrade organic contaminants. The most commonly used reductant is zero valent iron (ZVI), which is often injected as a permeable reactive barrier, but injected into groundwater plumes more frequently in recent years. TCE can be reduced with ZVI to non-chlorinated products, like ethane, ethylene and acetylene, though this process is limited by ZVI surface area and sorption

sites. Other chemical reductants that may be injected to treat groundwater include zinc and sulfides capable of fully dechlorinating TCE, with acetylene the most common product.

5.2.3.3 Enhanced Anaerobic Bioremediation

EAB involves the delivery of organic substrates into the subsurface to stimulate anaerobic biodegradation of contaminants in groundwater. The microorganisms break down contaminants by using them as a food source or co-metabolizing them with a food source. In the case of TCE, TCE is an electron acceptor not a food source. For anaerobic biodegradation to occur, a favorable environment must be created in the subsurface for microorganisms to grow and use contaminants as a food and energy source. Generally, this means providing some combination of nutrients and controlling the temperature, as well as pH. Sometimes, non-native microorganisms that have been adapted for degradation of specific contaminants are injected into the subsurface to enhance the process. An EAB substrate, such as an emulsified vegetable oil, molasses, whey, etc., would be injected into the aquifer via injection wells. This substrate would be designed to help foster the conditions favorable for anaerobic reductive dechlorination.

5.2.4 Ex-Situ Treatment

Ex-situ treatment technologies address contamination through the physical removal of contaminated groundwater from its location for treatment. Ex-situ treatments include remedial technologies such as groundwater extraction/treatment.

Groundwater extraction/treatment, also known as “pump and treat”, is a process where contaminated groundwater is extracted from an aquifer and brought to the surface for remediation. Usually, vertical extraction wells, equipped with pumps, transfer the contaminated groundwater to a treatment system that either destroys the contamination or removes it from the water. Several treatment systems that can be used include air stripping and carbon adsorption. Contaminant destruction treatments include advanced oxidation and ultraviolet light treatments. The treated water can be injected back into the aquifer, sent to a public sewer, or discharged to a body of water.

5.3 Preliminary Screening of Remedial Technologies

Table 1 shows how each technology rated in the Remedial Technologies Screening.

The groundwater monitoring technology is retained for further screening. This technology alone while there is an incomplete drinking water exposure pathway or when combined with another treatment to address future risk of drinking water exposure is effective in protecting human health and the environment. LTM monitors the contaminant levels in the groundwater. Monitoring wells are already in place at the site and administrative effort would be minimal. The cost of this technology is low as there are already monitoring wells in place and additional monitoring wells that may be needed would be a low capital cost. The water quality parameters (see Section 2.4) measured at the site show that reductive intrinsic biodegradation conditions are generally unfavorable. However, the presence of the TCE breakdown product *cis*-1,2-DCE and geochemical indicators in the lower part of the aquifer at the distal end of the plume indicates that some conditions for dechlorination exist at the site.

The AWS technology is retained for further screening. This technology is effective in protecting human health as it eliminates direct exposure risks through both ingestion and inhalation. Based on current land use, an alternate water supply is not required since there are no active water supply wells at the site or on the properties surrounding the site. Should the property owners decide to reside at the site, which is currently under consideration by the owners, potable water could be supplied by either a well drilled to an aquifer below the impacted Wreford Limestone, or public rural water could be piped to the site. The well option would most likely be less expensive, and by casing off the Wreford Limestone would provide water of acceptable quality. However, this technology will not be implemented unless/until the property use changes, requiring a water source.

ISCO is retained for further screening. This technology would be effective in breaking down TCE to nonhazardous constituents if the oxidizing chemicals come in contact with the contaminant. This technology can be implemented at the site using drilled injection wells although it may be difficult to distribute the oxidants into the shallow limestone aquifer at the site. The Schroyer Limestone was subjected to slug testing during the RI, and the results indicated that the low hydraulic conductivity would be marginally conducive to ISCO injections. The relative costs of performing this technology would be moderately higher in comparison to the other technologies being considered. However, if successful, this option could potentially reduce the overall remediation time since it is generally faster at attaining goals when compared to in-situ bioremediation.

EAB is retained for further screening. This technology has been demonstrated to be effective in degrading TCE although complete dechlorination of TCE to ethene requires optimum biogeochemical conditions. Incomplete dechlorination of TCE can lead to the accumulation of vinyl chloride, which is more toxic than TCE. This technology can be implemented at the site using drilled injection wells. Similar to ISCO, it may be difficult to distribute the organic substrate into the shallow limestone aquifer at the site due to low hydraulic conductivity. The relative costs of performing this technology would be higher in comparison to the other technologies being considered.

Ex-situ treatment/removal ("pump and treat") is not retained for further screening. In terms of effectiveness, this technology can be used for controlling contaminant migration and could significantly reduce contaminant concentration in the groundwater. However, this technology typically takes a long time to clean up an aquifer, and rebound is known to occur after the system is shut down. Implementation of a pump and treat system is both technically and administratively possible; however, the cost of this technology would be high due to the capital cost of building a treatment plant and the operation and maintenance (O&M) costs associated with running it.

5.4 Development of Remedial Alternatives

Based on the technology screening criteria of effectiveness, implementability, and cost, the following were chosen to be the remedial alternatives:

Alternative 1 – No Action
Alternative 2 – LTM with contingent AWS
Alternative 3 – In-Situ Injection Treatment with LTM and contingent AWS

Alternative 1 is meant to serve as a baseline for comparison with the other proposed alternatives. Alternatives 2 and 3 include notifying owners of the site regarding the potential for vapor intrusion risks from groundwater. In accordance with DoD policy (DoD 2012), action to address the potential vapor intrusion risk beyond notification of property owners is not required because there are currently no existing occupied structures on the property. Alternatives 2 and 3 also include a provision to install an AWS should the land use change to on-site residential use.

The selected alternative will be evaluated throughout construction and subsequent monitoring events. Remedy modifications will be assessed if the remedy is not performing as expected within five years of remedial action completion.

6.0 DESCRIPTION AND DETAILED ANALYSIS OF ALTERNATIVES

The information presented in this section serves as the overall basis for selecting the preferred alternative from the remedial alternatives presented in Section 5. The preferred alternative will be presented in the Proposed Plan (PP).

6.1 Evaluation Criteria

A detailed analysis of the remedial alternatives was performed using the nine evaluation criteria specified in §300.430(e)(9)(iii) of the National Oil and Hazardous Substances Pollution Contingency Plan. The nine evaluation criteria are grouped into three different categories: threshold criteria, primary balancing criteria, and modifying criteria. Table 1, Evaluation Criteria Comparison Chart of the Alternatives, shows the results for each alternative in meeting the evaluation criteria.

6.1.1 Threshold Criteria

There are two Threshold Criteria that must be met by any potential remedial alternative. The threshold criteria relate to statutory requirements that each alternative must satisfy in order to be eligible for selection. If threshold criteria are not met, then no further evaluation is needed.

6.1.1.1 Overall Protection of Human Health and Environment

Overall protection of human health and the environment addresses if a remedy provides adequate protection and describes how risks posed through each pathway are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls.

6.1.1.2 Compliance with ARARs

Remedial alternatives will be required to achieve ARARs unless specifically waived. ARARs include substantive provisions of any promulgated Federal or more stringent State environmental standards, requirements, criteria, or limitations that are determined to be legally applicable or relevant and appropriate requirements for a CERCLA site. ARARs include clean-up standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstances found at a CERCLA site.

6.1.2 Primary Balancing Criteria

There are five primary balancing criteria representing technical considerations of the effectiveness of the remedial alternatives and management considerations of the remedial alternatives in addressing the environmental problems at the facility.

6.1.2.1 Short-Term Effectiveness

Short-term effectiveness addresses the time needed to achieve protection and any adverse impacts on human health and the environment that may be posed during the construction and implementation period until cleanup goals are achieved.

6.1.2.2 Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence refers to the ability of a remedy to maintain reliable protection of human health and the environment over time, once cleanup goals have been met.

6.1.2.3 Reduction of Toxicity, Mobility, or Volume Through Treatment

Reduction of toxicity, mobility, or volume through treatment is the anticipated ability of the treatment to reduce the toxicity, mobility, or volume of the waste and, if possible, to what extent.

6.1.2.4 Implementability

Implementability includes the following considerations:

- Administrative activities needed to implement the alternative (e.g., permits, rights of way, off-site approvals, etc.) and the length of time these activities will take;
- Availability of adequate off-site treatment, storage capacity, disposal services, needed technical services and materials;
- Constructability, reliability, operation, and maintenance of the remedial alternative; and
- Possible problems while implementing the remedial alternative.

6.1.2.5 Cost

The cost criterion addresses the relative magnitude of the capital and O&M costs. Capital costs consist of the costs of construction, equipment, and start-up. O&M costs include those associated with operation, maintenance, energy, residual disposal, monitoring, and support. Direct costs include costs associated with construction, equipment, materials, transportation, disposal, analytical sampling services, treatment, and operation. Indirect costs include expenses related to engineering, design, legal fees, permits, and start-up. Note the typical accuracy of a FS level cost analysis is +50 % to -30% (USEPA 1988).

6.1.3 Modifying Criteria

The modifying criteria represent the concerns of regulatory agencies and the public in regards to the remedial alternatives presented in this report. For Forbes S-5, they will be evaluated following the regulatory review and public comment period for the PP.

6.1.3.1 State Acceptance

Regulatory agencies will review and have the opportunity to comment on the PP and the recommended remedial alternative.

6.1.3.2 Community Acceptance

A public comment period will be implemented to allow for public review and comment on the recommended remedial alternative for the site. The final evaluation of community acceptance will occur after the close of the public comment period.

6.2 Description and Evaluation of Remedial Alternatives

6.2.1 Alternative 1 – No Action

Alternative 1 is required by the NCP to be carried through the FS process as a baseline for comparison to other alternatives. This alternative allows the Site to remain in its current state

with no monitoring or remedial actions implemented. Alternative 1 will not meet threshold criteria.

6.2.1.1 Overall Protection of Human Health

Alternative 1 will not ensure the overall protection of human health and the environment. There would be no monitoring to track the fate and transport of contaminants in the shallow groundwater, including the potential migration of these contaminants into the deep groundwater. Future water supply wells, if installed, will likely be completed in the deep groundwater system at the site, with the Wreford Limestone cased off.

6.2.1.2 Compliance with ARARs

Alternative 1 will not comply with ARARs, since no groundwater sampling will be performed to confirm if groundwater will meet ARARs. The PRGs are set at MCLs under the Federal Safe Drinking Water Act, which is a chemical-specific ARAR that is relevant and appropriate at this site.

6.2.1.3 Short-Term Effectiveness

Alternative 1 will not provide any action and therefore, will have no short-term effect on the site.

6.2.1.4 Long-Term Effectiveness and Permanence

Alternative 1 will not provide any action and will not be able to verify any long-term natural attenuation of contaminant concentrations at the site.

6.2.1.5 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternative 1 will not provide any treatment to reduce the toxicity, mobility, or volume of contamination at the site.

6.2.1.6 Implementability

Alternative 1 provides no action and therefore, there is nothing to implement.

6.2.1.7 Cost

Alternative 1 has no costs associated with it.

6.2.2 Alternative 2 – Groundwater Monitoring

Alternative 2 will be to monitor the migration and attenuation of the TCE plume. After the interim remedial action was completed, no known source material remains on site. The remaining COC concentrations in groundwater should decrease over time without a source to sustain the plume. Alternative 2 would include a provision to provide a drinking water supply not impacted by the Site-related COCs above the MCLs should land use change. This would prevent direct exposure, and therefore remove risk to human health.

A monitoring network will be developed during the remedial design. This monitoring network would be subject to change as the plume changes. Additional monitoring wells may be added as needed during the remedial design to finalize the monitoring network. Five-Year Reviews of the remedial action will be conducted. This alternative will include an educational outreach and

awareness notice to the property owner(s) regarding the contaminated groundwater. The area will also be periodically monitored both visually and in the KDHE well database to verify that no new wells have been installed near the plume.

Groundwater monitoring will continue until RAOs are reached. Appendix B includes additional details for this alternative developed during costing. The timeframe for groundwater to reach PRGs (for TCE) is estimated at 200 years. SourceDK (GSI 2011), a remediation support system model, was used to estimate the time required for TCE to decrease from 82ug/L (the maximum detected concentration at the Site) to 5ug/L (see Appendix C for input parameters). It was assumed that TCE was being depleted primarily by advection discounting reductive dechlorination and other degradation processes that are less likely occurring at the site

Alternative 2 meets the threshold and most primary balancing criteria.

6.2.2.1 Overall Protection of Human Health

Alternative 2 would be protective of human health and the environment. The monitoring well network will be effective in monitoring remedy performance and groundwater contaminant levels to ensure protection of human health. Additional information collected for this alternative would lead to a better understanding of the fate and transport of contamination.

6.2.2.2 Compliance with ARARs

Alternative 2 will comply with ARARs. Groundwater monitoring will continue to determine when ARARs (MCLs) are being met.

6.2.2.3 Short-Term Effectiveness

Alternative 2 would be effective in protecting the community, worker health, and environment during the implementation of groundwater sampling and if needed, any monitoring well installation. A notice to the landowner(s) will be made to educate the property owner about the contaminated groundwater. The area will also be periodically monitored both visually and by reviewing the KDHE well database to verify that no new wells have been installed near the plume. Risks of adverse effects to human health during the remedial phase are low.

6.2.2.4 Long-Term Effectiveness and Permanence

Alternative 2 provides long-term effectiveness and permanence by the gradual natural degradation of contaminants and continued monitoring to ensure potential receptors are not being affected.

6.2.2.5 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternative 2 consists of natural attenuation processes, which act without human intervention, and includes dispersion, dilution, biodegradation, sorption, volatilization, and chemical or biological stabilization, transformation, or destruction of contaminants. However, it is not a treatment to reduce the toxicity, mobility, or volume of groundwater contamination. But, it does include testing to demonstrate that conditions are favorable for natural degradation processes to be active in reducing toxicity, mobility, or volume of contamination in groundwater.

6.2.2.6 Implementability

Alternative 2 is easily implemented since there is already an existing monitoring well network. Installation of southern and eastern plume-delineation wells would require cooperation with the adjacent landowner, and efforts to obtain right-of-entry were not successful during the RI. However, monitoring of the onsite wells would enable long-term trend analysis to confirm the COC concentrations are decreasing. Administrative activities would not significantly affect the ability and time to implement the alternative.

6.2.2.7 Cost

For estimating costs, a reasonable costing duration of 100 years was used. The estimated cost of Alternative 2 is $4,017,500 for VOC sampling of the groundwater for 100 years. Table B-1 in Appendix B contains the basis for this cost estimate. The present value cost for Alternative 2 was calculated at $3,099,900 using the 0.6% 30-Year Real Interest Rate on Treasury Notes and Bonds as the discount factor (OMB 2017).

6.2.3 Alternative 3 – In-Situ Treatment with Groundwater Monitoring

Alternative 3 involves the implementation of either EAB, ISCR or ISCO injections into the contaminated shallow groundwater, as described in Section 5.2.3. Amendments to be injected can include oxidants such as permanganate or persulfate to chemically oxidize the TCE. To reduce TCE, a chemical reductant amendment like ZVI can be used to dechlorinate the TCE without relying on soil microbes to breakdown the TCE. Reductive dechlorination of TCE can also be achieved by injecting emulsified vegetable oil, sodium lactate, or other carbon source into the subsurface through enhanced anaerobic biodegradation. Anaerobic bacteria can use the carbon as an electron donor while the TCE is consumed by the bacteria as the electron acceptor. Typical safety data sheets for each of these amendment types are included in Appendix D.

For this alternative, in-situ treatment with EAB was used as the example injection scenario for timeline and costing (see Appendix B for additional details). As part of the injection remedy, a treatability test will be conducted to refine the injection design and assess the radius of influence to be expected from injection wells into the aquifer. Amendment delivery would be through gravity fed injection wells or infiltration galleries to reduce the risk of fracture placement and allow the amendment to flow into the target zone in a controlled manner. Groundwater data suggest biological reductive dechlorination is occurring but is not a dominant process at the site based on the limited presence of the TCE degradation products *cis*-1,2-DCE and vinyl chloride. Substrate injection or reductant injection would accelerate the reductive dechlorination process in the shallow groundwater. .

Prior to injections, authorization will be obtained by submitting an application to the KDHE Bureau of Water which administers the state's Underground Injection Control (UIC) program. Injections included in in-situ treatment actions would be considered Class V wells, defined as any system used to inject non-hazardous fluids underground including remedial compounds.

Following injections, contaminant concentrations will be monitored for reduction of TCE concentrations. Priority metals will also need to be measured since metals can potentially be mobilized because of altered groundwater chemistry induced by oxidation or reduction.

Performance monitoring would be used to evaluate the effects of the in-situ treatment to groundwater concentrations of TCE and other VOCs. To estimate the time required to reach 5µg/L, SourceDK (GSI 2011) was used assuming 75% reduction in the mass as a result of two rounds of injections (see Table C-1 in Appendix C for input parameters). The SourceDK model estimated approximately 100 years to reach the TCE MCL following in-situ treatment. Modifying assumptions in the SourceDK model alters the calculated cleanup time. Cleanup timeframe estimates varied from 80 to 100 years, during various model runs. Model scenarios included altering the TCE anaerobic degradation rate constant, hydraulic conductivity, and groundwater gradient between midpoint and maximum observed or literature values.

If during treatability testing or after implementation of this remedy, if distribution of amendment within the aquifer is not feasible due to site geology, alternative remedial strategies will be evaluated.

Under this alternative, additional monitoring well(s) would be installed to supplement the existing network as a sentinel well(s). This monitoring network may be subject to change as the plume changes or as access to the neighboring property changes. Additional monitoring wells would be added as needed during remedial design to finalize the monitoring network. Alternative 3 would include a provision for providing a drinking water supply not impacted by the COCs above the MCLs if site land use changes to a land use that involves groundwater use. This will prevent direct exposure, and therefore remove risk to human health. Five-year reviews of the remedial action will be conducted. This alternative will include a notice to the property owner(s) to provide awareness and education about the contaminated groundwater. The area will also be periodically monitored both visually and by reviewing the KDHE well database to verify that no new wells have been installed near the plume.

Alternative 3 meets all threshold and primary balancing criteria.

6.2.3.1 Overall Protection of Human Health

Alternative 3 would be protective of human health and the environment. The in-situ treatment of the contaminated groundwater will potentially result in mass removal of contamination from the groundwater using EAB to create conditions conducive for reductive dechlorination to take place or by ISCO to destroy the contamination through oxidizing chemicals. The performance monitoring well network will be effective in monitoring remedy performance and groundwater contaminant levels to ensure protection of human health.

6.2.3.2 Compliance with ARARs

Alternative 3 will comply with ARARs. Groundwater treatment followed by monitoring will continue to determine if ARARs (MCLs) are being met.

6.2.3.3 Short-Term Effectiveness

Alternative 3 would be effective in protecting the community, worker health, and environment during the implementation of in-situ treatment, injection well and monitoring well installation, and groundwater sampling. An informational notice to the landowner(s) will be made to provide awareness regarding the contaminated groundwater. The area will also be periodically

monitored both visually and by reviewing the KDHE well database to verify that no new wells have been installed near the plume.

6.2.3.4 Long-Term Effectiveness and Permanence

Alternative 3 provides long-term effectiveness and permanence by first conducting an in-situ treatment for a mass reduction of the groundwater contamination, followed by continued monitoring to ensure potential receptors are not being affected. It should be noted that oxidants and carbon sources injected into groundwater can mobilize redox-sensitive metals such as chromium, iron, and arsenic. Injection of carbon sources can have a significant aesthetic impact on groundwater as well, as it would create anaerobic conditions within the aquifer that could persist for an extended period of time.

6.2.3.5 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternative 3 can potentially reduce the mass of contamination through in-situ treatment (EAB or ISCO). The in-situ treatment can break down TCE to harmless by-products, thus reducing the toxicity of the groundwater. In addition, natural attenuation processes, which act without human intervention, include dispersion, dilution, biodegradation, sorption, volatilization, and chemical or biological stabilization, transformation, or destruction of contaminants can further reduce concentrations.

6.2.3.6 Implementability

Alternative 3 is implementable; however, an injection strategy must be designed for delivering of reagents into the low hydraulic conductivity Schroyer Limestone at the site. A pilot study to determine the best injection technologies suited for the site may be required. In-situ treatment would likely involve installing injection wells into the aquifer to allow for multiple treatments if required. Note that Alternative 3 would need to balance the cost benefit considerations versus the technical feasibility of overcoming the potential for further degrading the aquifer with in-situ treatment residuals.

6.2.4.7 Cost

The estimated cost of Alternative 3 is $6,360,900 for in-situ treatment, LTM, and contingent AWS. This cost assumes a 75% mass removal (see Table B-2 in Appendix B). The present value cost for Alternative 3 was calculated at $5,426,400, using a 0.6% discount.

6.3 Comparative Analysis

This section presents an evaluation of the remedial action alternatives in relation to one another. For each criterion, comparisons between alternatives are made. Table 2 shows the Evaluation Criteria Comparison Chart of the Alternatives. The following discussions summarize the relative comparisons of each of the criteria.

6.3.1 Threshold Criteria

Overall protection of human health and the environment and compliance with ARARs (unless a specific ARAR is waived) are threshold requirements that each alternative must meet in order to be eligible for selection.

6.3.1.1 Overall Protection of Human Health

Alternatives 2 and 3 are protective of human health and the environment. Both alternatives use monitoring to measure the performance of the chosen alternative and to detect contamination before it reaches potential receptors. These alternatives also provide a provision for an alternative water supply to the on-Site residence if the property use changes, which removes the direct exposure risk from ingestion or showering with contaminated groundwater. Alternative 1 is not protective of human health and the environment as no action is performed with this alternative.

Alternative 2 would ultimately render the site suitable for Unlimited Use/Unrestricted Exposure (UU/UE) as a result of natural processes (including dilution) operating over a period of time (estimated at 200 years). For Alternative 3, active remediation may result in lower groundwater contaminant concentrations although it is considered unlikely that UU/UE conditions (MCLs in groundwater) can be achieved at the conclusion of active remediation; UU/UE conditions are estimated to be reached following 100 years of groundwater monitoring.

6.3.1.2 Compliance with ARARs

Alternatives 2 and 3 would comply with ARARs. Alternative 1 would not comply with ARARs and thus does not meet either of the Threshold Criteria. Therefore, Alternative 1 is not evaluated further for Primary Balancing and Modifying Criteria.

6.3.2 Primary Balancing Criteria

6.3.2.1 Short-Term Effectiveness

Alternatives 2 and 3 would be effective in protecting the community, worker health, and environment during the implementation. These alternatives are immediately effective due to the connection of an on-Site residence to an AWS if site use changes to residential.

6.3.2.2 Long-Term Effectiveness and Permanence

Alternative 2 would provide long-term effectiveness in preventing exposure to potential receptors by monitoring the groundwater for contaminants and assess whether TCE is undergoing natural attenuation.

Alternative 3 would be effective at reducing TCE concentrations in the aquifer and provide long-term effectiveness in preventing exposure to potential receptors with monitoring the groundwater following treatment. However, reagent delivery may be challenging at this site given the local geology. The substrate for an EAB injection could effectively last one to three years before a reinjection of substrate would be needed. For ISCO, there are chemical oxidation products that could last up to six months before a reinjection is needed. Multiple injection rounds would likely be needed to treat site groundwater. In-situ treatment would be more aggressive, potentially removing contamination faster than the other alternatives. In-situ treatment has the potential to produce treatment residuals that could degrade overall groundwater quality. In-situ treatment of contaminated groundwater would reduce the remedial timeframe over Alternative 2.

6.3.2.3 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternative 2 does not provide active treatment. However, the contaminant concentration is expected to decrease over time due to physical non-destructive means such as dispersion and

dilution of contamination in the aquifer following the IRA removal of potential sources to the groundwater contamination.

Alternative 3 is the only remedial alternative that provides active treatment. Alternative 3 depends on the ability to deliver treatment reagents into the subsurface, whether these reagents consist of organic substrates for EAB or chemical oxidants for ISCO. In-situ treatment would be more aggressive, potentially removing contamination faster than the other alternatives. However, this depends on an injection strategy that could optimally distribute the injected substrate or chemical oxidant. In-situ treatment of contaminated groundwater, if effective, can potentially reduce the remedial timeframe over Alternative 2.

6.3.2.4 Implementability

Monitoring wells are already in place; however additional monitoring wells may be needed to finalize the monitoring well network. Thus, Alternative 2 can easily be implemented. Alternative 3 could be implemented by installing injection wells or utilizing temporary injection wells. However, an injection strategy would be needed to ensure delivery of the substrates.

6.3.2.5 Cost

The lowest to highest costing alternatives are in this order: Alternative 1, Alternative 2, and Alternative 3. The estimated costs and the present value cost for each alternative are summarized as follows:

Cost of Remedial Alternatives		
Alternative	**Estimated Cost**	**Present Value Cost**
Alternative 1 – No Action	$0	$0
Alternative 2 – LTM and contingent AWS	$4,017,500	$3,099,900
Alternative 3 – In-Situ Treatment, LTM, and contingent AWS	$6,360,900	$5,426,4000
A reasonable timeframe of 100 years was assumed for cost estimating purposes. The remedial timeframe for both alternatives was limited to 100 years.		

6.4 Overall Comparison Summary

- Alternative 1 – No Action would not meet any of the remedial alternative evaluation criteria. This alternative is used as a baseline comparison for the other alternatives.

- Alternative 2 – LTM would ensure contamination is detected before it reaches receptor sites and comply with ARARs. It would measure and report any natural attenuation that is taking place in the groundwater. LTM is also low cost versus the more active alternative. At the site, dispersion and dilution are the primary natural attenuation mechanisms and are very gradual. Thus, it is estimated that the groundwater will reach the PRGs in 200 years (see Appendix C for SourceDK model). Providing an alternate water connection would remove risks should current land use change.

- Alternative 3 – In-Situ Treatment with Groundwater Monitoring would provide mass removal of groundwater contamination through either an EAB or ISCO treatment, followed by monitoring to ensure remaining contamination is detected before it reaches receptor sites and would comply with ARARs. It would be an active remedial alternative, which potentially reduces the remediation timeframe to 100 years, which is below the 200 years estimated for Alternative 2. This is assuming that the in-situ treatment can be properly distributed throughout the aquifer with low hydraulic conductivity. For costing purposes, two rounds of injections were anticipated for treating the highest concentrations of groundwater for this alternative. This remedial alternative would need to balance the cost benefit considerations versus the fact that there are currently no water supply wells at the site and the adjacent farmland, and therefore no exposure risks. The cost is higher than Alternative 2 to implement in the first few years for the in-situ injections, but could potentially reduce the remedial timeframe from 100 to 200 years and thus the overall monitoring duration (See Appendix C for SourceDK model).

The comparative analysis of alternatives based on the above criteria provides the basis for selecting the preferred alternative. The selected preferred alternative must meet the threshold criteria of Overall Protection of Human Health and the Environment and Compliance with ARARs, while the other primary balancing and modifying criteria should be considered in the selection process.

The preferred alternative, which will be described in the PP, will be selected from among these alternatives. In accordance with the NCP, the PP, this FS and other documents in the Administrative Record regarding this decision will be released to the public for review and comment. Public input on the alternatives is paramount in the selection process. The preferred remedy may be modified based on the comments received.

7.0 REFERENCES

USEPA (U.S. Environmental Protection Agency). *1988. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*. EPA/540/G-89/004, Office of Solid Waste and Emergency Response (OSWER) Directive 9355.3-01. OSWER Washington, D.C., EPA/600/R-98/128, var. pg., September.

USEPA. 2018. Regional Screening Level Table. May 2018 Version.

DoD (Department of Defense) 2012. Defense Environmental Restoration Program (DERP) Management Manual, Number 4715.20, March 9.

GSI 2011. SourceDK, Remediation Timeframe Decision Support System. Developed by GSI Environmental for the Air Force Center for Engineering and the Environment.

Office of Management and Budget (OMB) 2017. Discount Rates for Cost-Effectiveness, Lease Purchase, and Related Analyses. OMB Circular No. A-94. https://www.whitehouse.gov/wp-content/uploads/2017/11/Appendix-C-revised.pdf

Bouwer, H and R.C Rice, 1976. *A slug Test Method for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells*, Water Resources Research, vol. 12, no. 3, pp 423-428.

Hvorslev, M.J., 1951. Time Lag and Soil Permeability in Ground-Water Observations, Bull. No. 36, Waterways Exper. Sta. Corps of Engrs, U.S. Army, Vicksburg, Mississippi, pp. 1-50.

Kansas Geological Survey (KGS), 1953. *Geology, Mineral Resources, and Ground-water Resources of Lyon County, Kansas, Part 1-Rock Formations of Lyon County*, Kansas Geological Survey Volume 12.

Lyman, W.J., Reehl, W.F., and Rosenbaltt, D.H., 1990. Handbook of Chemical Property Estimation Methods, American Chemical Society, Washington, DC.

NRCS, 2013. Web Soil Survey. http://websoilsurvey.nrcs.usda.gov Accessed May 14, 2013.

Schnoor J.L., et al., 1987. *Processes, Coefficients, and Models for Simulating Toxic Organics and Heavy Metals in Surface Waters*, EPA/600/3-87-015, U.S. Environmental Protection Agency, Athens Environmental Research Laboratory, Athens, GA.

Springer, R.K. and L.W. Gelhar, 1991. Characterization of large-scale aquifer heterogeneity in glacial outwash by analysis of slug tests with oscillatory response, Cape Cod, Massachusetts, U.S. Geol. Surv. Water Res. Invest. Rep. 91-4034, pp. 36-40.

USACE, 1991. Confirmation Study for the Former Forbes Atlas Missile Site S-5, Bushong, Kansas. Final.

USACE, 1993. Defense Environmental Restoration Program Formerly Used Defense Sites Program Findings and Determination of Eligibility, Former Forbes AFB, Facility S-5. Site No. B07KS020400. Forbes Atlas Missile Base S-5. April 5.

USACE, 2018a. *Final Remedial Investigation Report. Former Forbes Atlas Missile Site S-5,* Lyon County, KS, FUDS No. B07KS0204-01. May 2018.

USACE, 2018b. *Final Interim Remedial Action Construction Completion Report. Former Forbes Atlas Missile Site S-5,* Lyon County, KS, FUDS No. B07KS0204-01. May 2018.

USEPA, 1998. Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water.

USEPA, 2007. Preliminary Assessment, Forbes (EX) Atlas Missile Site S-5, Allen, Kansas. CERCLIS ID KSSFN0703129. Prepared for the USEPA Region 7.

Weidemeier, T. H. and F. H. Chapelle. 1998. *Technical Guidelines for Evaluating Monitored Natural Attenuation of Petroleum Hydrocarbons and Chlorinated Solvents in Ground Water at Naval and Marine Corps Facilities*, Naval Facilities Engineering Command.

Zeller, 1986. *The Stratigraphic Succession in Kansas*. Kansas Geological Survey Bulletin 189.

TABLES

Table 1. Remedial Technologies Screening Evaluation Chart

Remedial Technolgoy	Effectiveness (protectiveness of human health and environment)	Implementability (feasibility of the technology)	Cost (relative value of expenditures)	Retained for Further Screening
No Further Action	Low	High	Low	Yes
Groundwater Monitoring	Moderate to High	High	Low to Moderate	Yes
Alternate Water Supply	High	Moderate	Low to Moderate	Yes[4]
In-Situ Treatment	Moderate to High	Moderate to Difficult	Moderate	Yes
Ex-Situ Treatment	Low to Moderate	Difficult	High	No
Groundwater Extraction/Treatment	Low to Moderate	Difficult	High	No

Notes:

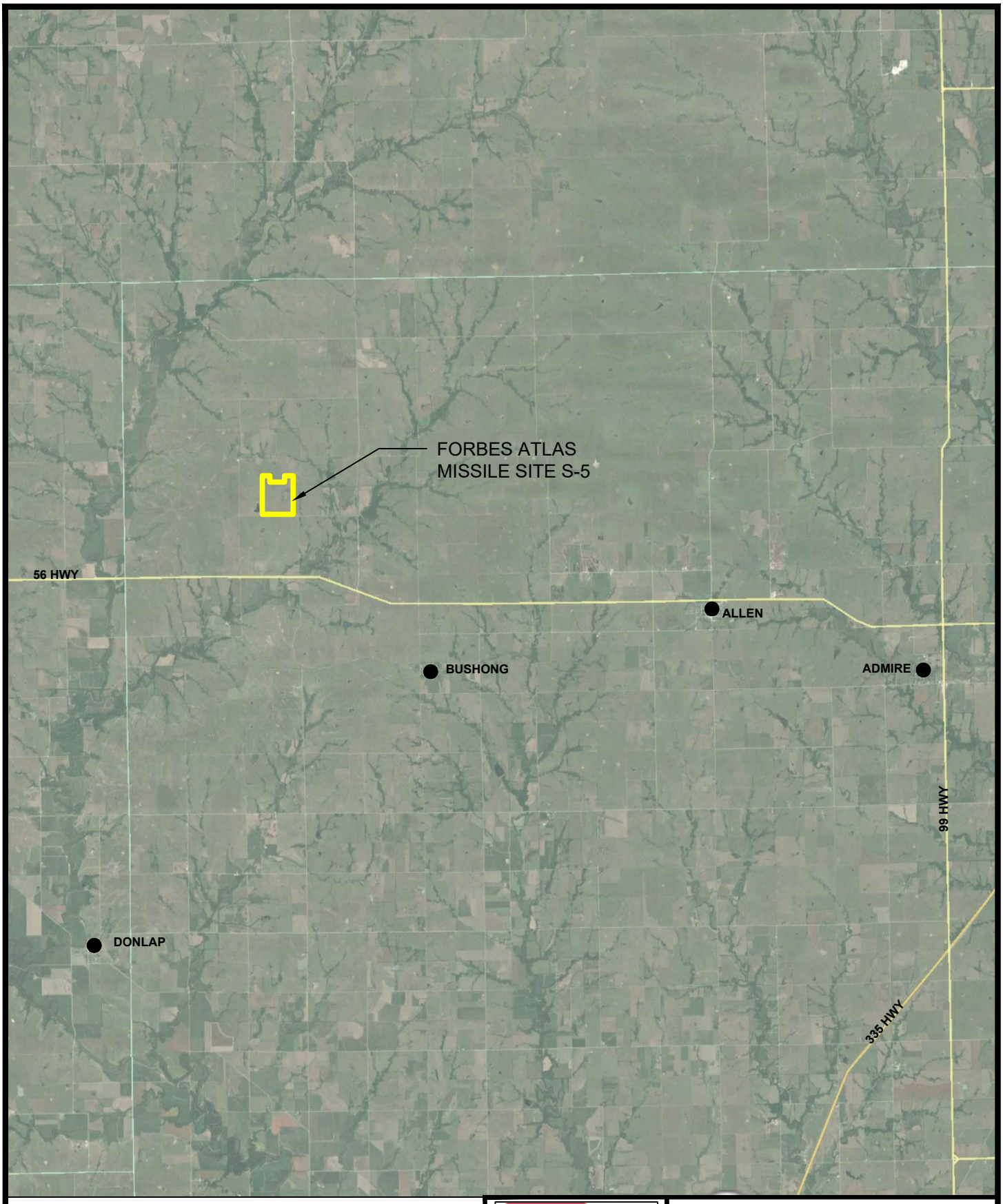
1. Effectiveness: A rating of high is best. Moderate is better than low.
2. Implementability: A rating of high is the best. Moderate is better than difficult.
3. Cost: A rating of low is best. Moderate is better than high.
4. Alternate water supply retained as a component of Alternatives 2 and 3, but will not be implemented unless site use changes.

Table 2. Evaluation Criteria Comparison Chart of the Alternatives

	Evaluation Criterion	Alternative 1 No Further Action	Alternative 2 Long-Term Groundwater Monitoring	Alternative 3 In-situ treatment with Long-Term Groundwater Monitoring
Threshold Criteria	Overall Protection of Health and Environment	Criterion not met. There would be no monitoring to track the fate and transport of contaminants in the shallow perched groundwater, including the potential migration of these contaminants into the deep groundwater.	Criterion Met. The MNA monitoring well network will be effective in monitoring remedy performance and groundwater contaminant levels to ensure protection of human health.	Criterion Met. The performance monitoring well network will be effective in monitoring remedy performance and groundwater contaminant levels to ensure protection of human health.
	Compliance With ARARs	Criterion not met. Data would not be available to determine if contaminant concentrations had decreased to chemical specific ARARs for the contaminants of concern.	Criterion Met. Groundwater monitoring shall continue to determine if applicable requirements, such as the RAOs, are being met.	Criterion Met. Groundwater treatment followed by monitoring shall continue to determine if RAOs are being met.
Primary Balancing Criteria	Short-Term Effectiveness	Criterion not met. There are no actions taken and thus, this alternative would have no short-term effect.	Criterion Met. Alternative 2 would be effective in protecting the community, worker health, and environment during the implementation of groundwater sampling and if needed, any monitoring well installation. An educational notice to provide awareness to the landowner(s) will be made regarding the contaminated groundwater. The area will also be periodically monitored both visually and in the KDHE database to verify that no new wells have been installed near the plume.	Criterion Met. Alternative 3 would be effective in protecting the community, worker health, and environment during the implementation of in-situ treatment, injection well and monitoring well installation and groundwater sampling. A notice to the landowner(s) will be made regarding the contaminated groundwater. The area will also be periodically monitored both visually and in the KDHE database to verify that no new wells have been installed near the plume.
	Long-Term Effectiveness and Permanence	Criterion not met. There are no actions taken and thus, this alternative would not be able to verify if natural attenuation is having any long-term effect on contamination.	Criterion Met. Groundwater monitoring monitors contaminant reduction over time and continued monitoring also identifies if contamination has spread to sentinel wells installed upgradient of potential receptors. Groundwater monitoring identifies if potential receptors are at risk of being affected.	Criterion Met. In-situ treatment will be conducted for mass reduction of contamination, assuming reagents can be effectively delivered into the low hydraulic conductivity subsurface. Performance monitoring also identifies if groundwater contamination is moving toward potential receptors. Even with active treatment, long-term groundwater monitoring will be required. Sentinel wells will be installed upgradient of potential receptors.
	Reduction of Toxicity, Mobility, or Volume through Treatment	Criterion not met. There are no actions taken and thus, this alternative would not be able to verify if natural attenuation is causing any reductive action on contamination.	Criterion Not Met. Groundwater monitoring is not an active remedy and is not considered treatment. However, the contaminant concentration is expected to decrease over time due to physical non-destructive means such as dispersion and dilution of contamination in the aquifer and the removal of source mass during the interim removal action completed in 2017	Criterion Met. In-Situ Treatment is an active remedy that potentially can reduce the mass of contamination . Treatment has the potential to break down contamination to harmless by-products, thus reducing toxicity.
	Implementability	Criterion Met. The No Action alternative is easily implementable as there are no actions to be conducted.	Criterion Met. Alternative 2 is easily implemented since there is already an existing monitoring well network. Installation of the southern and eastern wells would require coordination with the Forbes S-5 and the surounding property owners, but this is not considered prohibitive.	Criterion Met. In-Situ Treatment would use injection wells/points to introduce substrate or chemical oxidant into the subsurface. An injection strategy, likely including a pilot-scale test, must be designed for delivering of reagents into the low hydraulicly conductive Schroyer limestone at Forbes S-5. There is also a potential for the production of contaminant residuals and the mobilization of metals that could reduce overall water quality.
	Cost	No costs are associated with No Action.	Long-term groundwater monitoring for VOCs is estimated at $3,809,600 with a Present Value Cost of $2,902,900 using a 0.6% Discount Rate.	In-Situ treatment and sampling monitoring wells for VOC parameters is estimated at $6,153,000 with a Present Value Cost of $5,229,300 using a 0.6% Discount Rate.
Modifying Criteria	State Acceptance	To be determined after regulator review and public comment periods.	To be determined after regulator review and public comment periods.	To be determined after regulator review and public comment periods.
	Community Acceptance	To be determined after regulator review and public comment periods.	To be determined after regulator review and public comment periods.	To be determined after regulator review and public comment periods.

ARARs: Applicable and Relevant or Appropriate Requirement; MCL: Maximum Contaminant Level; PRG: Preliminary Remediation Goal; VOC: volatile organic compound,

FIGURES



NOTES:

1. IMAGE PROVIDED BY GOOGLE EARTH.
2. IFIGURE ADAPTED FROM REMEDIAL INVESTIGATION REPORT (2018).

N

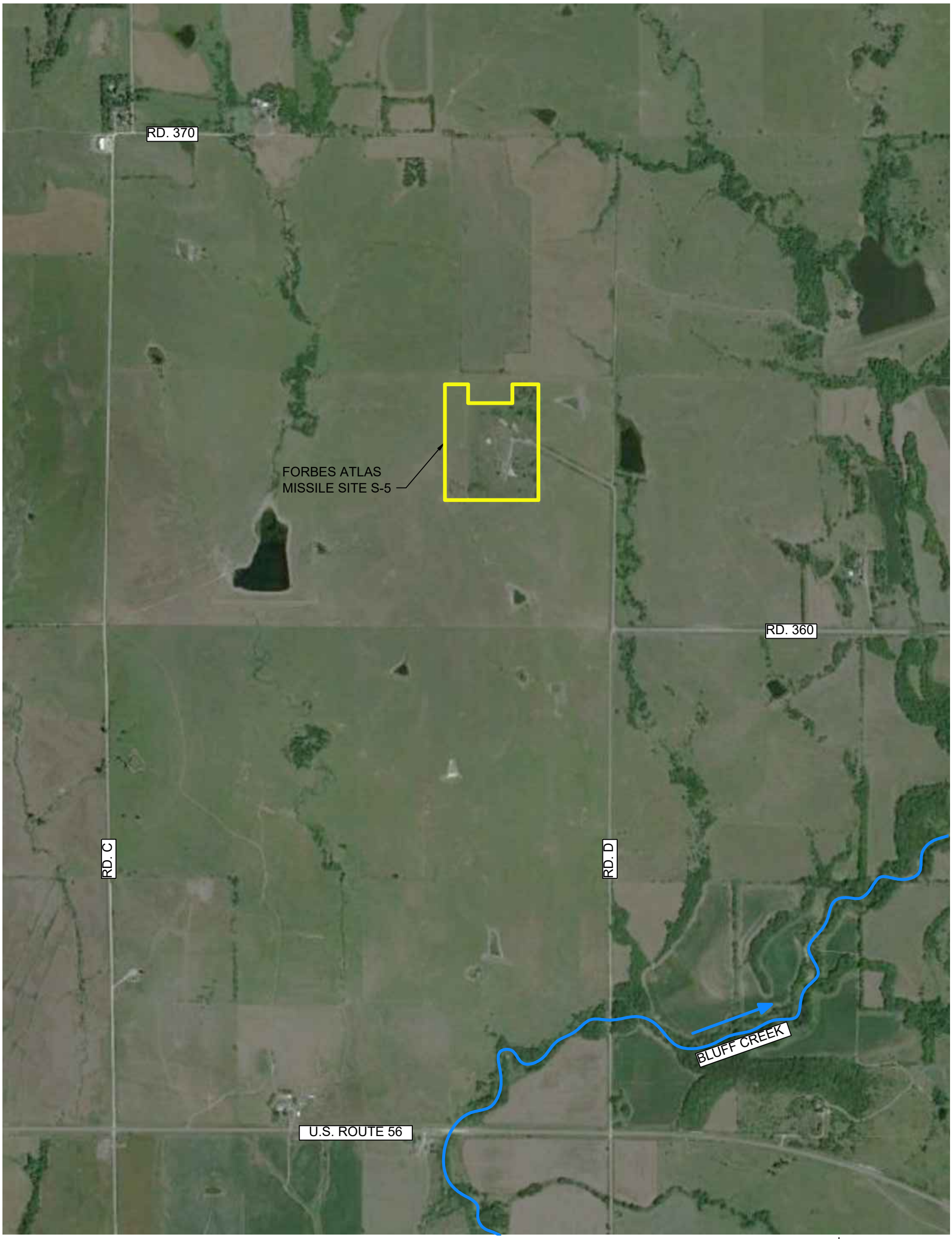
0 12000' 24000'

SCALE IN FEET

US Army Corps of Engineers ®
Kansas City District

FIGURE 1

REGIONAL LOCATION MAP
FORBES ATLAS S-5
ALLEN, KANSAS



LEGEND:

RIVER

FLOW DIRECTION

N

0 1000' 2000'

SCALE IN FEET

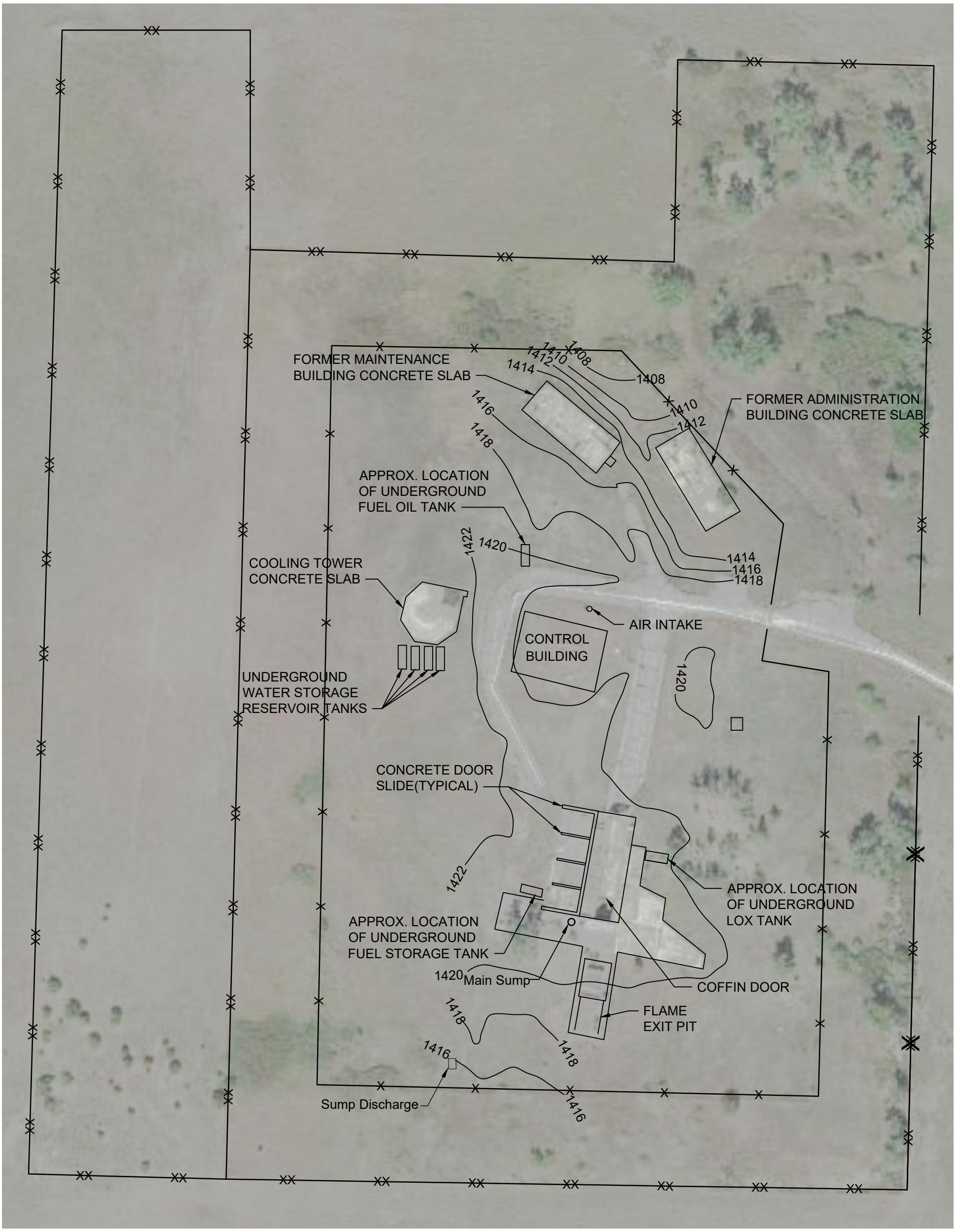
NOTE:

1. AERIAL IMAGE PROVIDED BY GOOGLE EARTH.
2. FIGURE ADAPTED FROM REMEDIAL INVESTIGATION (2018).

US Army Corps of Engineers ®
Kansas City District

Figure 2
AERIAL OVERVIEW
FORBES ATLAS S-5
ALLEN, KANSAS

PW\ Avatar Environmental LLC\ Project Numbers\ 80447 AVATAR FORBES ATLAS S-5 RI\ Cadd\ Figures\ 80447-FIG 1-2-AERIAL OVERVIEW.dwg DHINEMAN October 16, 2017



LEGEND:

CHAIN LINK FENCE

BARB WIRE FENCE

CONTOUR

N

0 100' 200'

SCALE IN FEET

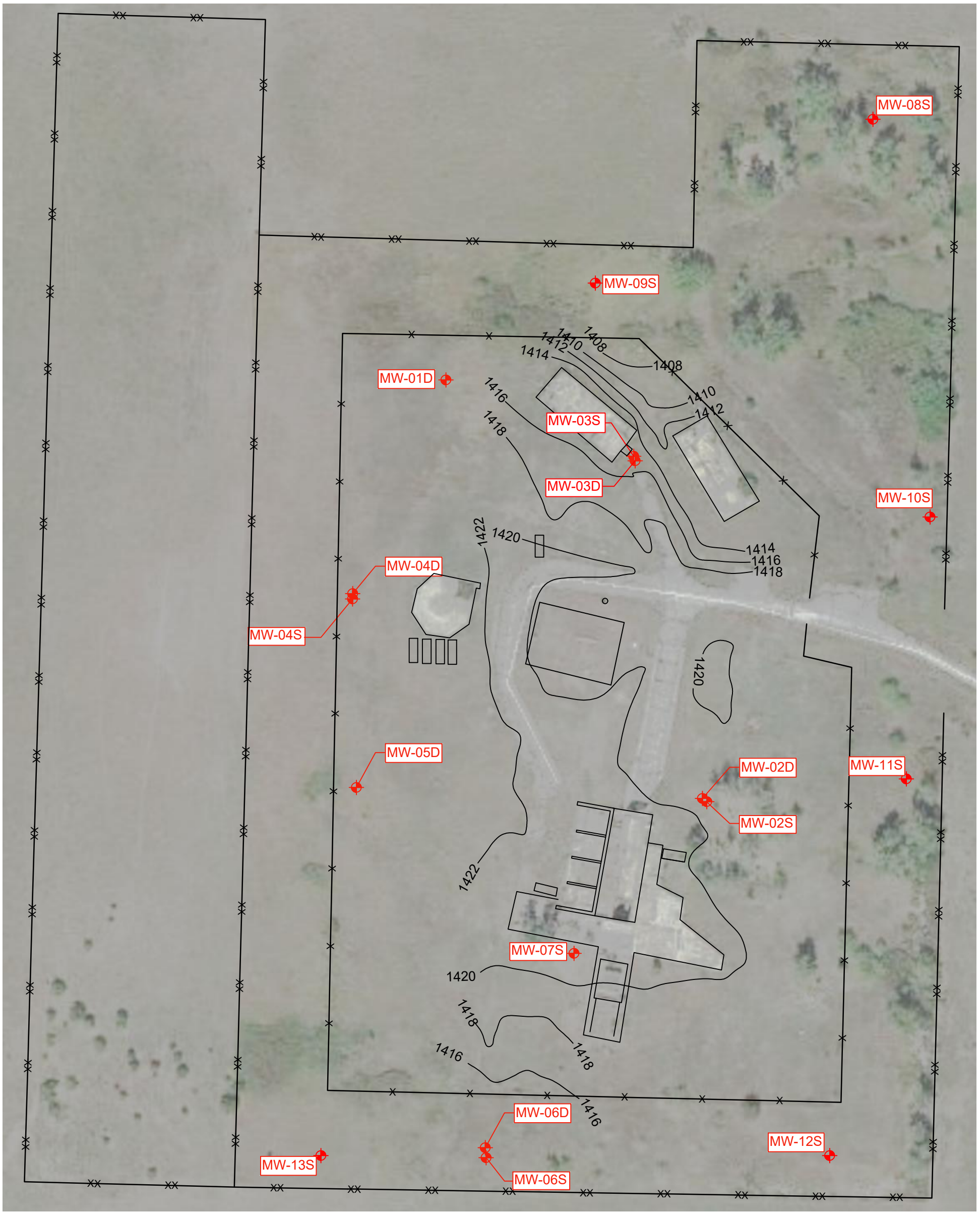
NOTES:

1. SITE PLAN AND ELEVATIONS BASED ON TOPOGRAPHIC SURVEY PERFORMED BY FORGY SURVEYING, ON JULY 13, 1990. FIGURE ADAPTED FROM REMEDIAL INVESTIGATION (2018).
2. AERIAL IMAGE PROVIDED BY GOOGLE EARTH.

US Army Corps of Engineers ®
Kansas City District

Figure 3

FORMER SITE LAYOUT
FORBES ATLAS S-5
ALLEN, KANSAS



LEGEND:

MW-01	MONITORING WELL
——x——	CHAIN LINK FENCE
——xx——	BARB WIRE FENCE

N

0 100' 200'

SCALE IN FEET

NOTES:

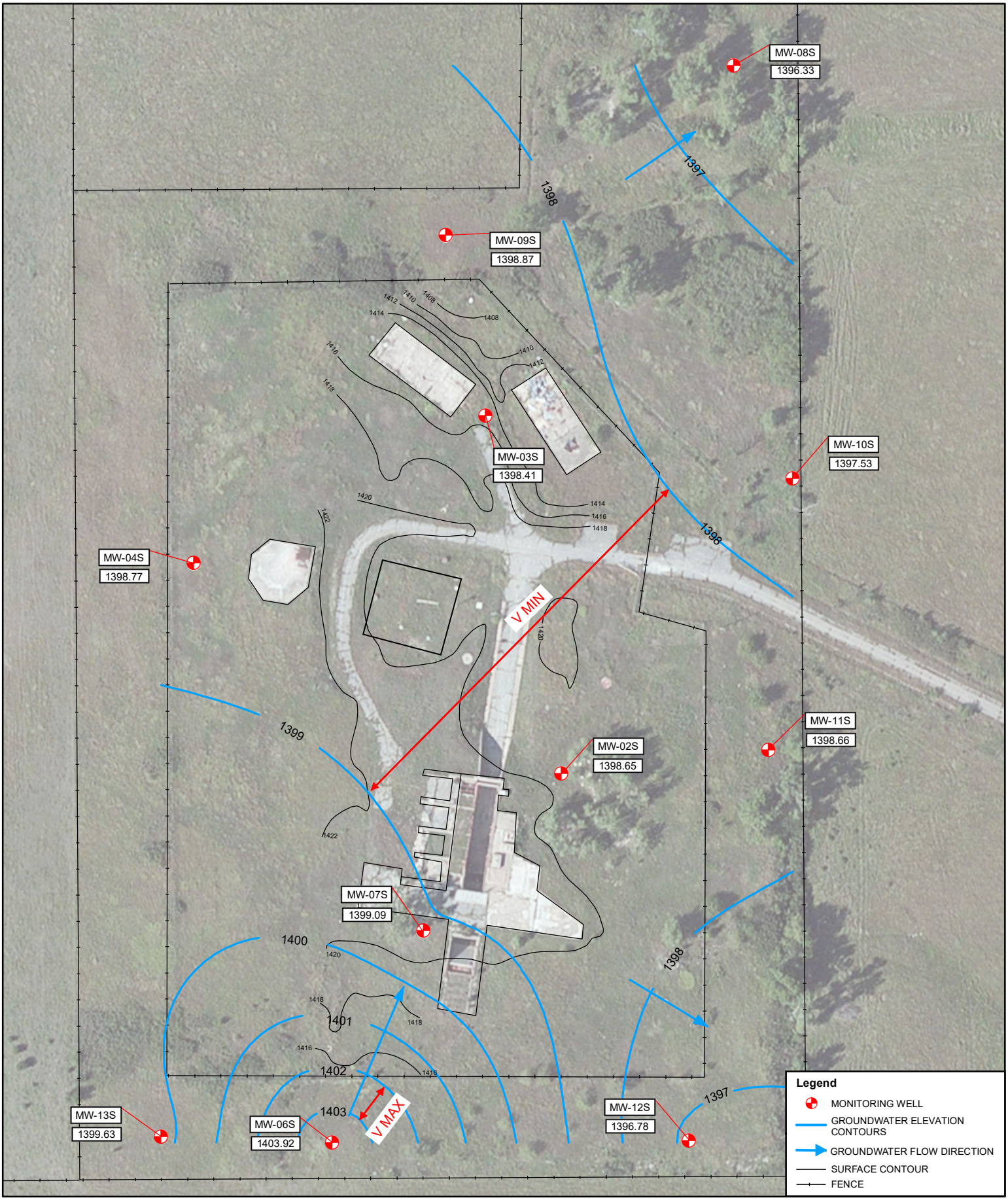
1. AERIAL IMAGE PROVIDED BY GOOGLE EARTH.

2. SITE PLAN AND ELEVATIONS BASED ON TOPOGRAPHICAL SURVEY PERFORMED BY FORGY SURVEYING, ON JULY 13, 1990.

3. SURVEY SITE DATA FROM KAW VALLEY ENGINEERING INC. SURVEY DATES JUNE 12, 2015 AND JUNE 29, 2016. FIGURE ADAPTED FROM REMEDIAL INVESTIGATION (2018).

US Army Corps of Engineers ®
Kansas City District

Figure 4
MONITORING WELL LOCATIONS
FORBES ATLAS S-5
ALLEN, KANSAS



NOTES:

1. AERIAL IMAGE PROVIDED BY ESRI. FIGURE ADAPTED FROM REMEDIAL INVESTIGATION (2018)
2. SITE PLAN AND ELEVATION BASED ON TOPOGRAPHIC SURVEY PERFORMED BY FORGY SURVEYING, ON JULY 13,1990
3. V MAX - MAXIMUM AVERAGE GROUNDWATER VELOCITY.
4. V MIN - MINIMUM AVERAGE GROUNDWATER VELOCITY.

N
W E
S

0 50 100 200 Feet

US Army Corps of Engineers Kansas City District

FIGURE 5
SHALLOW GROUNDWATER ELEVATION MAP
FORBES ATLAS S-5
ALLEN, KANSAS

FIGURE ADAPTED FROM REMEDIAL INVESTIGATION (2018).

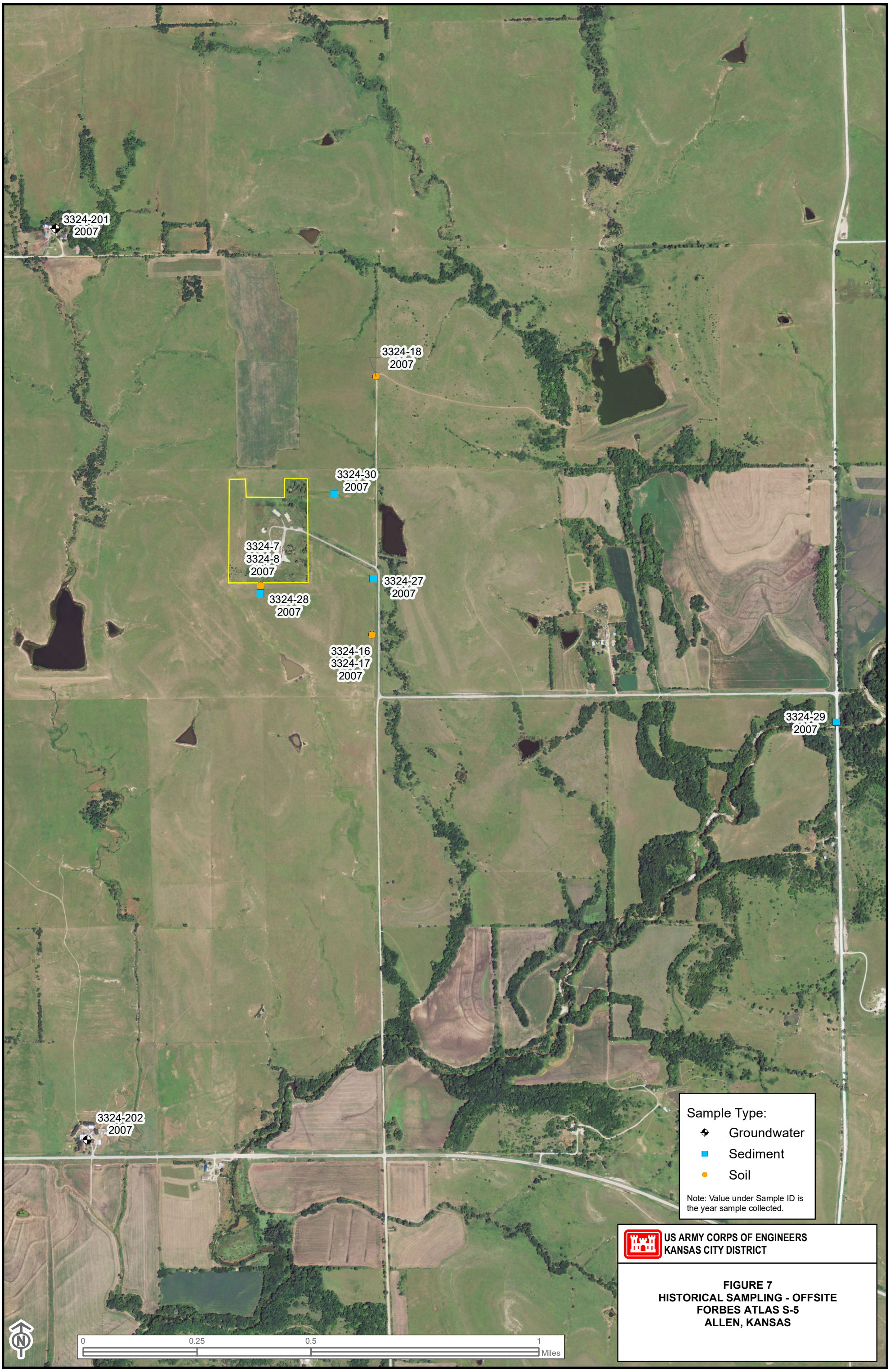


FIGURE ADAPTED FROM REMEDIAL INVESTIGATION (2018).

LEGEND:

SB-01	SOIL BORING
——x——	CHAIN LINK FENCE
——xx——	BARB WIRE FENCE

N

0 100' 200'

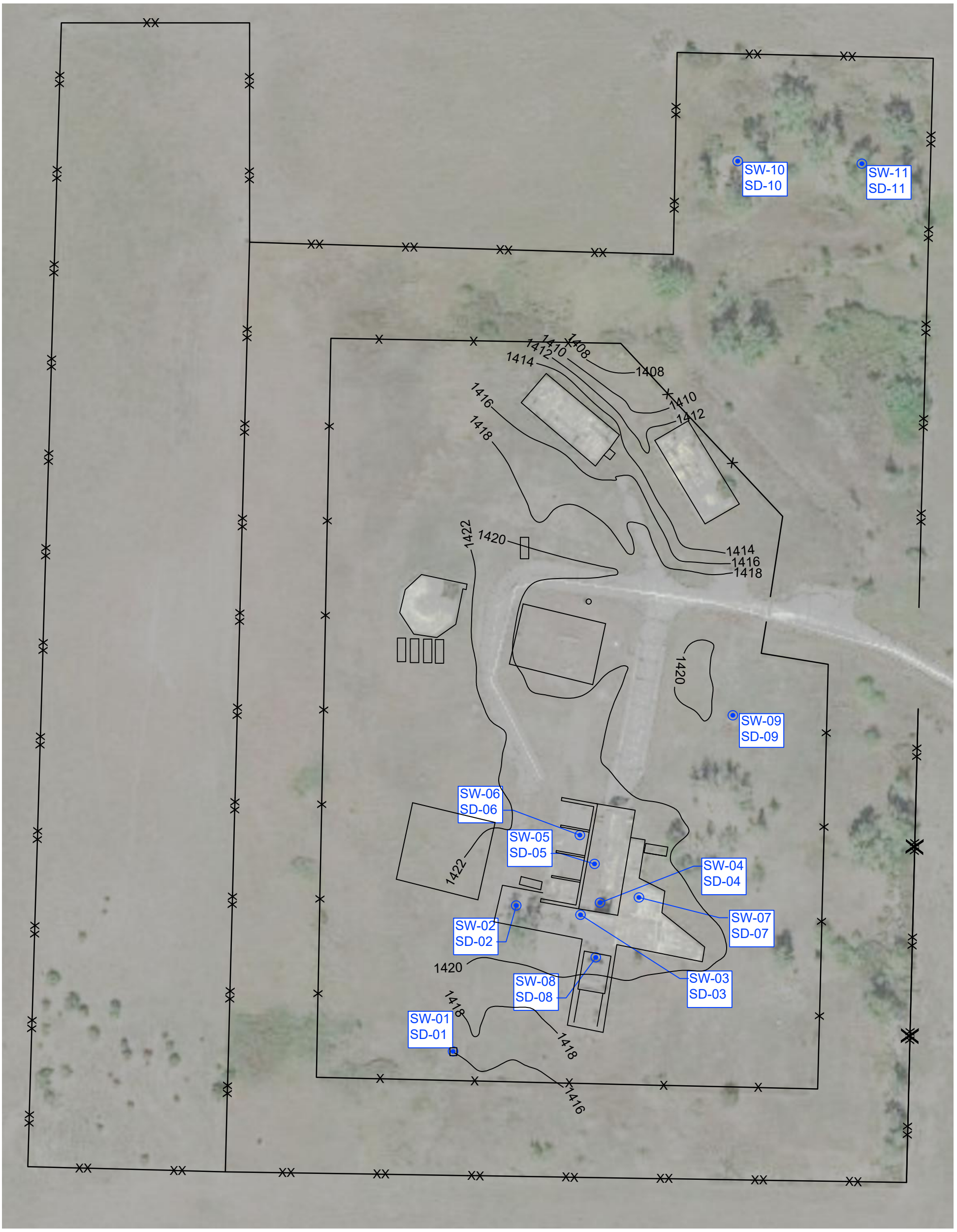
SCALE IN FEET

NOTES:

1. AERIAL IMAGE PROVIDED BY GOOGLE EARTH. FIGURE ADAPTED FROM REMEDIAL INVESTIGATION (2018).
2. SITE PLAN AND ELEVATIONS BASED ON TOPOGRAPHICAL SURVEY PERFORMED BY FORGY SURVEYING, ON JULY 13, 1990.
3. SURVEY SITE DATA FROM KAW VALLEY ENGINEERING INC. SURVEY DATES JUNE 12, 2015 AND JUNE 29, 2016.

US Army Corps of Engineers ®
Kansas City District

Figure 8
SOIL BORING LOCATIONS
REMEDIAL INVESTIGATION
FORBES ATLAS S-5
ALLEN, KANSAS



LEGEND:

SW-01 / SD-01 — SURFACE WATER / SEDIMENT SAMPLE

CHAIN LINK FENCE

BARB WIRE FENCE

N

0 100' 200'

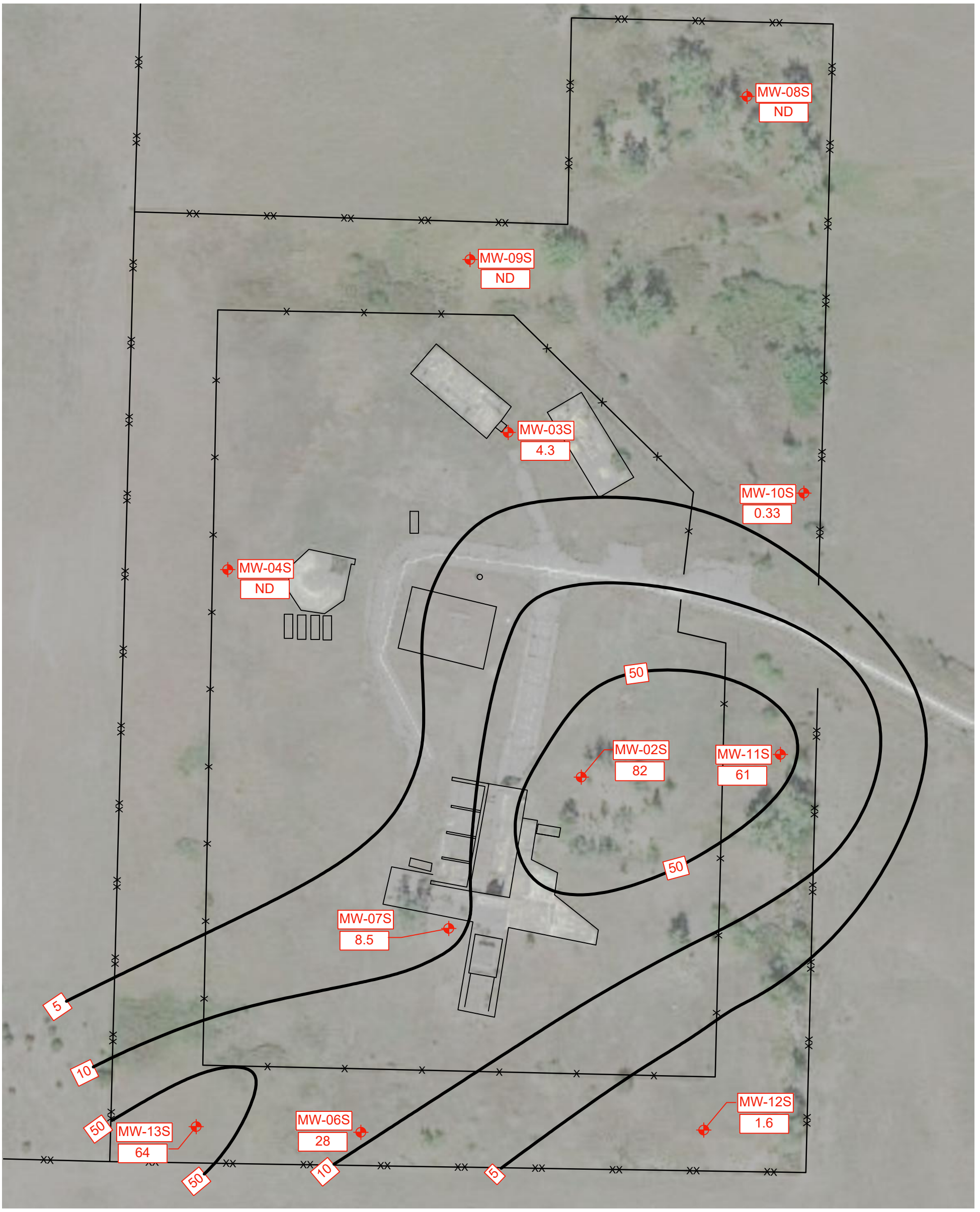
SCALE IN FEET

NOTES:

1. AERIAL IMAGE PROVIDED BY GOOGLE EARTH.
2. SITE PLAN AND ELEVATIONS BASED ON TOPOGRAPHICAL SURVEY PERFORMED BY FORGY SURVEYING, ON JULY 13, 1990.
3. FIGURE ADAPTED FROM REMEDIAL INVESTIGATION (2018).

US Army Corps of Engineers ®
Kansas City District

Figure 9
SURFACE WATER & SEDIMENT SAMPLE LOCATIONS
REMEDIAL INVESTIGATION
FORBES ATLAS S-5
ALLEN, KANSAS



NOTES:

1. AERIAL IMAGE PROVIDED BY GOOGLE EARTH.

2. SITE PLAN AND ELEVATIONS BASED ON TOPOGRAPHICAL SURVEY PERFORMED BY FORGY SURVEYING, ON JULY 13, 1990.

3. SURVEY SITE DATA FROM KAW VALLEY ENGINEERING INC. SURVEY DATES JUNE 12, 2015 AND JUNE 29, 2016.

4. MARCH 2017 TCE ISOCONCENTRATION CONTOURS GENERATED FROM SHALLOW MONITORING WELLS.

5. FIGURE ADAPTED FROM REMEDIAL INVESTIGATION (2018).

LEGEND:

- MONITORING WELL
- 6.6 — ANALYTICAL RESULT (µg/L)
- ND — NON-DETECT
- CHAIN LINK FENCE
- BARB WIRE FENCE
- TCE ISOCONCENTRATION CONTOUR

N

0 100' 200'

SCALE IN FEET

US Army Corps of Engineers ®
Kansas City District

FIGURE 10
TCE ISOCONCENTRATION MAP
FORBES ATLAS S-5
ALLEN, KANSAS

APPENDIX A

Remedial Investigation Groundwater Data Tables

Table 3-9
Groundwater Sample Results (Collected July 2015)
Remedial Investigation, Former Forbes Atlas S-5 Missile Site
Lyon County, Kansas

			Sample ID:	Natural Attenuation	Natural Attenuation	MW-01D-01	MW-02S-01	MW-02D-01	MW-02D-11	MW-03S-01	MW-03S-11
			Lab ID:	Screening	Screening	HS15070362-05	HS15070362-01	HS15070362-02	HS15070362-03	HS15070305-01	HS15070305-02
			Date Collected:	(Wiedemier)	(Wiedemier)	7/8/2015	7/8/2015	7/8/2015	7/8/2015	7/7/2015	7/7/2015
		Screening Level		Favorable					Duplicate		Duplicate
Analyte	**Units**	**USEPA MCL**		**Concentration**	**Points****	**Result**	**Result**	**Result**	**Result**	**Result**	**Result**
cis-1,2-Dichloroethene	ug/L	70		Daughter	2	0.5 U	**4.3 J**	0.5 U	0.5 U	**0.44 J**	**0.46 J**
Trichloroethene	ug/L	5		Released	0	**0.25 J**	**65 J**	**0.92 J**	**0.65 J**	**4.6 J**	**4.5 J**
Vinyl Chloride	ug/L	2		Daughter	2	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Natural Attenuation Parameters											
Alkalinity as CaCO3	mg/L	NA		2 times background	1	**201**	**311**	**237**	**236**	**299**	**301**
Alkalinity, Bicarbonate (As CaCO3)	mg/L	NA		-	-	**201**	**311**	**237**	**236**	**299**	**301**
Alkalinity, Carbonate (As CaCO3)	mg/L	NA		-	-	5 U	5 U	5 U	5 U	5 U	5 U
Alkalinity, Hydroxide (As CaCO3)	mg/L	NA		-	-	5 U	5 U	5 U	5 U	5 U	5 U
Bromide	mg/L	NA		-	-	**0.476 J**	**0.383 J**	**0.397 J**	**0.401 J**	0.1 U	0.1 U
Chloride	mg/L	* 250		2 times background	2	**49.8**	**4.74**	**29.8**	**30**	**4.62**	**4.68**
Ethane	ug/L	NA		>10/>100 ug/L	2.0/3.0	**1.28**	**0.758**	**1.86**	**1.59**	**1.12**	**1.1**
Ethene	ug/L	NA		>10/>100 ug/L	2.0/3.0	**3.8**	**0.838**	**3.03**	**2.63**	**1.12**	**0.998**
Fluoride	mg/L	* 4		-	-	**0.802**	0.382 U	**1**	**1**	**0.332**	**0.361**
Methane	ug/L	NA		>100/1,000 ug/L	2.0/3.0	**4.21**	**0.519**	**7.95**	**8.28**	**1.28**	**0.758**
Nitrate As N	mg/L	10		<1 mg/L	2	0.1 U	0.264 U	0.1 U	0.1 U	**0.472**	**0.47**
Nitrate/Nitrite	mg/L	10		-	-	0.1 U	0.315 U	0.1 U	0.1 U	**0.524**	**0.521**
Nitrite As N	mg/L	1		-	-	0.1 U	**0.051**	0.1 U	0.1 U	**0.052**	**0.051**
Phosphorus	mg/L	NA		-	-	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	**0.223**
Sulfate	mg/L	* 250		<20 mg/L	2	**223**	**36.6**	**139**	**139**	**38.2**	**38.6**
Sulfide	mg/L	NA		>1 mg/L	3	0.3 U	**0.4**	**0.8**	**0.6**	0.3 U	0.3 U
pH	SU	* 6.5 to 8.5		5<pH<9	0	**6.68**	**5.91**	**7.13**	**NA**	**7.32**	**NA**
Temperature	°C	NA		>20 C	1	**18.50**	**14.73**	**16.90**	**NA**	**15.76**	**NA**
Oxidation-Reduction Potential	mV	NA		< 50 mv/<-100 mv	1.0/2.0	**-21.0**	**19.3**	**-18.3**	**NA**	**-34.9**	**NA**
Disolved Oxygen	mg/L	NA		<0.5 />1 mg/L	3.0/-3.0	**1.49**	**1.01**	**1.15**	**NA**	**1.22**	**NA**
Ferrous iron	mg/L	0.3 for total iron		>1 mg/L	3	**0.1**	ND	**0.1**	**NA**	ND	**NA**
Natural Biodegradation Scoring						**0**	**2**	**0**		**2**	
Other Parameters											
Conductivity	mmhos/cm	NA				**0.893**	**0.520**	**0.897**	**NA**	**0.570**	**NA**
Turbidity	NTUs	NA				**5.27**	**2.33**	**9.05**	**NA**	**3.02**	**NA**
Depth to water	ft TOC	NA				**48.99**	**20.15**	**44.20**	**NA**	**19.96**	**NA**

D = Deep well
J = Estimated value
mg/L = milligrams per liter
MCL = Maximum contaminant level from May 2016 EPA RSL Table.
* = Secondary MCL
mmhos/com = milli mhos per centimeter
mV = millivolts
NTU = Nephelometric Turbidity Unit
S = Shallow well
U = Compound was not detected
ug/L = micrograms per liter
Bold indicates detected results.
Dark gray shading indicates screening level exceedance for VOCs.
- = No natural attenuation criteria

** - Equals points assignment for determining favorable conditions for biodegradation
0-5 = Inadequate
6-14 = Limited Evidence
15-20 = Adequate Evidence
>20 = Strong Evidence
Light gray shading indicates evidence for biodegradation

Table 3-9
Groundwater Sample Results (Collected July 2015)
Remedial Investigation, Former Forbes Atlas S-5 Missile Site
Lyon County, Kansas

		Sample ID:	Natural Attenuation	Natural Attenuation	MW-03D-01	MW-04S-01	MW-04D-01	MW-05D-01	MW-06S-01
		Lab ID:	Screening	Screening	HS15070305-03	HS15070428-01	HS15070428-02	HS15070305-05	HS15070362-04
		Date Collected:	(Wiedemier)	(Wiedemier)	7/7/2015	7/9/2015	7/9/2015	7/7/2015	7/8/2015
		Screening Level	Favorable						
Analyte	**Units**	**USEPA MCL**	**Concentration**	**Points****	**Result**	**Result**	**Result**	**Result**	**Result**
cis-1,2-Dichloroethene	ug/L	70	Daughter	2	0.5 U	0.5 U	0.5 U	0.5 U	**0.81 J**
Trichloroethene	ug/L	5	Released	0	0.5 U	0.5 U	0.5 U	0.5 U	**24 J**
Vinyl Chloride	ug/L	2	Daughter	2	0.5 U	0.5 UJ	0.5 UJ	0.5 U	0.5 U
Natural Attenuation Parameters									
Alkalinity as CaCO3	mg/L	NA	2 times background	1	**143**	**215**	**183**	**184**	**368**
Alkalinity, Bicarbonate (As CaCO3)	mg/L	NA	-	-	**143**	**215**	**183**	**184**	**368**
Alkalinity, Carbonate (As CaCO3)	mg/L	NA	-	-	5 U	5 U	5 U	5 U	5 U
Alkalinity, Hydroxide (As CaCO3)	mg/L	NA	-	-	5 U	5 U	5 U	5 U	5 U
Bromide	mg/L	NA	-	-	**0.385**	**0.426**	**0.397**	**0.429**	**0.376 J**
Chloride	mg/L	* 250	2 times background	2	**25.8**	**32.8**	**24.2**	**35.4**	**2.98**
Ethane	ug/L	NA	>10/>100 ug/L	2.0/3.0	0.361 U	**1.701**	**0.777**	**0.795**	**0.896**
Ethene	ug/L	NA	>10/>100 ug/L	2.0/3.0	**4.08**	**3.721**	**2.26**	**4.19**	**0.789**
Fluoride	mg/L	* 4	-	-	**0.824**	**0.648**	**1.01**	**0.974**	0.225 U
Methane	ug/L	NA	>100/1,000 ug/L	2.0/3.0	**2.77**	**3.196**	**1.5**	**3.77**	**0.351**
Nitrate As N	mg/L	10	<1 mg/L	2	**0.161**	0.129 U	0.1 U	**0.124**	0.456 U
Nitrate/Nitrite	mg/L	10	-	-	**0.196**	0.129 U	0.1 U	**0.124**	0.456 U
Nitrite As N	mg/L	1	-	-	**0.035**	0.1 U	0.1 U	0.1 U	0.1 U
Phosphorus	mg/L	NA	-	-	0.1 U	0.1 UJ	**0.152 J**	**0.141**	0.1 U
Sulfate	mg/L	* 250	<20 mg/L	2	**99.7**	**77.8**	**178**	**162**	**41.6**
Sulfide	mg/L	NA	>1 mg/L	3	0.3 U	**6**	**1**	0.3 U	**0.8**
pH	SU	* 6.5 to 8.5	5<pH<9	0	**6.77**	**7.49**	**6.5**	**7.64**	**6.94**
Temperature	°C	NA	>20 C	1	**15.59**	**20.05**	**24.11**	**17.09**	**16.28**
Oxidation-Reduction Potential	mV	NA	< 50 mv/<-100 mv	1.0/2.0	**-26.3**	**-7.5**	**-70.8**	**-38.1**	**-15.5**
Disolved Oxygen	mg/L	NA	<0.5 />1 mg/L	3.0/-3.0	**2.42**	**1.99**	**1.57**	**1.53**	**1.84**
Ferrous iron	mg/L	0.3 for total iron	>1 mg/L	3	ND	ND	ND	**0.1**	ND
Natural Biodegradation Scoring					**0**	**4**	**1**	**0**	**2**
Other Parameters									
Conductivity	mmhos/cm	NA			**0.504**	**0.580**	**0.867**	**0.904**	**0.618**
Turbidity	NTUs	NA			**12.9**	**256**	**20.0**	**21.3**	**9.5**
Depth to water	ft TOC	NA			**45.64**	**29.53**	**53.51**	**51.94**	**11.45**

D = Deep well
J = Estimated value
mg/L = milligrams per liter
MCL = Maximum contaminant level from May 2016 EPA RSL Table.
* = Secondary MCL
mmhos/com = milli mhos per centimeter
mV = millivolts
NTU = Nephelometric Turbidity Unit
S = Shallow well
U = Compound was not detected
ug/L = micrograms per liter
Bold indicates detected results.
Dark gray shading indicates screening level exceedance for VOCs.
- = No natural attenuation criteria

** - Equals points assignment for determining favorable conditions for biodegradation
0-5 = Inadequate
6-14 = Limited Evidence
15-20 = Adequate Evidence
>20 = Strong Evidence
Light gray shading indicates evidence for biodegradation

Table 3-9
Groundwater Sample Results (Collected July 2015)
Remedial Investigation, Former Forbes Atlas S-5 Missile Site
Lyon County, Kansas

		Sample ID:	Natural Attenuation	Natural Attenuation	MW-06D-01	MW-07S-01
		Lab ID:	Screening	Screening	HS15070230-01	HS15070305-04
		Date Collected:	(Wiedemier)	(Wiedemier)	7/6/2015	7/7/2015
		Screening Level	Favorable			
Analyte	**Units**	**USEPA MCL**	**Concentration**	**Points****	**Result**	**Result**
cis-1,2-Dichloroethene	ug/L	70	Daughter	2	0.5 U	0.5 U
Trichloroethene	ug/L	5	Released	0	0.5 U	**1.9 J**
Vinyl Chloride	ug/L	2	Daughter	2	0.5 U	0.5 U
Natural Attenuation Parameters						
Alkalinity as CaCO3	mg/L	NA	2 times background	1	**245**	**313**
Alkalinity, Bicarbonate (As CaCO3)	mg/L	NA	-	-	**245**	**313**
Alkalinity, Carbonate (As CaCO3)	mg/L	NA	-	-	5 U	5 U
Alkalinity, Hydroxide (As CaCO3)	mg/L	NA	-	-	5 U	5 U
Bromide	mg/L	NA	-	-	**0.383**	0.1 U
Chloride	mg/L	* 250	2 times background	2	**22.6**	**4.13**
Ethane	ug/L	NA	>10/>100 ug/L	2.0/3.0	**2.38**	**0.985**
Ethene	ug/L	NA	>10/>100 ug/L	2.0/3.0	**2.47**	**1.13**
Fluoride	mg/L	* 4	-	-	**1.03**	**0.291**
Methane	ug/L	NA	>100/1,000 ug/L	2.0/3.0	**14.4**	**1.02**
Nitrate As N	mg/L	10	<1 mg/L	2	**0.13**	**0.139**
Nitrate/Nitrite	mg/L	10	-	-	**0.13**	**0.139**
Nitrite As N	mg/L	1	-	-	0.1 U	0.1 U
Phosphorus	mg/L	NA	-	-	0.1 U	0.1 U
Sulfate	mg/L	* 250	<20 mg/L	2	**112**	**29.5**
Sulfide	mg/L	NA	>1 mg/L	3	**1.04**	0.3 U
pH	SU	* 6.5 to 8.5	5<pH<9	0	**7.51**	**7.15**
Temperature	°C	NA	>20 C	1	**26.71**	**15.33**
Oxidation-Reduction Potential	mV	NA	< 50 mv/<-100 mv	1.0/2.0	**-18.2**	**-27.0**
Disolved Oxygen	mg/L	NA	<0.5 />1 mg/L	3.0/-3.0	**1.84**	**0.80**
Ferrous iron	mg/L	0.3 for total iron	>1 mg/L	3	ND	ND
Natural Biodegradation Scoring					**4**	**3**
Other Parameters						
Conductivity	mmhos/cm	NA			**0.744**	**0.503**
Turbidity	NTUs	NA			**9.5**	**15.8**
Depth to water	ft TOC	NA			**33.6**	**23.12**

D = Deep well
J = Estimated value
mg/L = milligrams per liter
MCL = Maximum contaminant level from May 2016 EPA RSL Table.
* = Secondary MCL
mmhos/com = milli mhos per centimeter
mV = millivolts
NTU = Nephelometric Turbidity Unit
S = Shallow well
U = Compound was not detected
ug/L = micrograms per liter
Bold indicates detected results.
Dark gray shading indicates screening level exceedance for VOCs.
- = No natural attenuation criteria

** - Equals points assignment for determining favorable conditions for biodegradation.
0-5 = Inadequate
6-14 = Limited Evidence
15-20 = Adequate Evidence
>20 = Strong Evidence
Light gray shading indicates evidence for biodegradation.

Table 3-10
Groundwater Sample Results (Collected September 2015)
Remedial Investigation, Former Forbes Atlas S-5 Missile Site
Lyon County, Kansas

Analyte	Units	Screening Level USEPA MCL	Natural Attenuation Screening (Wiedemier) Favorable Concentration	Natural Attenuation Screening (Wiedemier) Points**	MW-01D-02 HS15091050-02 9/23/2015 Result	MW-02S-02 HS15091050-05 9/23/2015 Result	MW-02D-02 HS15091050-03 9/23/2015 Result	MW-02D-12 HS15091050-04 9/23/2015 Duplicate Result	MW-03S-02 HS15090927-02 9/21/2015 Result	MW-03S-12 HS15090927-03 9/21/2015 Duplicate Result
cis-1,2-Dichloroethene	ug/L	70	Daughter	2	0.5 U	**5.5**	0.5 U	0.5 U	**1.1**	**0.96 J**
Trichloroethene	ug/L	5	Released	0	0.5 U	**95**	0.5 U	0.5 U	**5.4**	**5.3**
Vinyl Chloride	ug/L	2	Daughter	2	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Natural Attenuation Parameters										
Alkalinity as CaCO3	mg/L	NA	2 times background	1	**244**	**345**	**282**	**282**	**330**	**329**
Alkalinity, Bicarbonate (As CaCO3)	mg/L	NA	-	-	**244**	**345**	**282**	**282**	**330**	**329**
Alkalinity, Carbonate (As CaCO3)	mg/L	NA	-	-	5 U	5 U	5 U	5 U	5 U	5 U
Alkalinity, Hydroxide (As CaCO3)	mg/L	NA	-	-	5 U	5 U	5 U	5 U	5 U	5 U
Bromide	mg/L	NA	-	-	**0.171 J**	**0.113 J**	**0.094 J**	**0.091 J**	0.05 UJ	0.05 UJ
Chloride	mg/L	* 250	2 times background	2	**64.3 J**	9.86 UJ	**30.2 J**	**30.3 J**	**3.81**	**3.71**
Ethane	ug/L	NA	>10/>100 ug/L	2.0/3.0	0.361 U	0.361 UJ	0.361 U	0.361 U	0.361 U	0.361 U
Ethene	ug/L	NA	>10/>100 ug/L	2.0/3.0	**1.87**	0.337 UJ	**1.06**	**0.911 J**	0.337 U	**0.746 J**
Fluoride	mg/L	* 4	-	-	**1.29 J**	0.484 UJ	**1.33 J**	**1.3 J**	**0.413 J**	**0.418 J**
Methane	ug/L	NA	>100/1,000 ug/L	2.0/3.0	**1.65**	0.2 UJ	**3.51**	**4.06**	0.2 U	0.2 U
Nitrate as N	mg/L	10	<1 mg/L	2	0.05 U	0.072 U	**0.056 J**	**0.099 J**	**0.33**	**0.349**
Nitrate/Nitrite	mg/L	10	-	-	**0.046 J**	0.072 U	**0.056 J**	**0.099 J**	**0.33**	**0.349**
Nitrite as N	mg/L	1	-	-	**0.046 J**	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
Phosphorus	mg/L	NA	-	-	0.058 U	0.058 U	0.058 U	0.058 U	0.058 U	0.058 U
Sulfate	mg/L	* 250	<20 mg/L	2	**300**	**48.6**	**124**	**110**	**40.8**	**42**
Sulfide	mg/L	NA	>1 mg/L	3	**1.8 J**	**16.2 J**	0.3 UJ	0.3 UJ	**1.8**	**2.2**
pH	SU	* 6.5 to 8.5	5<pH<9	0	**5.6**	**5.55**	**6.02**	NA	**5.61**	NA
Temperature	°C	NA	>20 C	1	**21.73**	**18.15**	**23.58**	NA	**22.95**	NA
Oxidation-Reduction Potential	mV	NA	< 50 mv/<-100 mv	1.0/2.0	**11.7**	**63.4**	**17.8**	NA	**36.9**	NA
Disolved Oxygen	mg/L	NA	<0.5 />1 mg/L	3.0/-3.0	**1.8**	**0.9**	**2.5**	NA	**1.62**	NA
Ferrous iron	mg/L	0.3 for total iron	>1 mg/L	3	**0.6**	**0.1**	**0.1**	NA	**0.2**	NA
Natural Biodegradation Scoring					**4**	**7**	**1**		**6**	
Other Parameters										
Conductivity	mmhos/cm	NA			**1.186**	**0.631**	**0.347**	NA	**0.708**	NA
Turbidity	NTUs	NA			**23.2**	**3.19**	**3.2**	NA	**25.1**	NA
Depth to water	ft TOC	NA			**50.7**	**25.45**	**46.6**	NA	**23.76**	NA

D = Deep well
J = Estimated value
mg/L = milligrams per liter
MCL = Maximum contaminant level from May 2016 EPA RSL Table.
* = Secondary MCL
mmhos/com = milli mhos per centimeter
mV = millivolts
NTU = Nephelometric Turbidity Unit
S = Shallow well
U = Compound was not detected
ug/L = micrograms per liter
Bold indicates detected results.
Dark gray shading indicates screening level exceedance for VOCs.
- = No natural attenuation criteria

** - Equals points assignment for determining favorable conditions for biodegradation
0-5 = Inadequate
6-14 = Limited Evidence
15-20 = Adequate Evidence
>20 = Strong Evidence
Light gray shading indicates Evidence for biodegradation

Table 3-10
Groundwater Sample Results (Collected September 2015)
Remedial Investigation, Former Forbes Atlas S-5 Missile Site
Lyon County, Kansas

Analyte	Units	Screening Level USEPA MCL	Favorable Concentration	Points**	Sample ID: / Lab ID: / Date Collected: MW-03D-02 / HS15090927-01 / 9/21/2015 Result	MW-04S-02 / HS15090989-04 / 9/22/2015 Result	MW-04D-02 / HS15090989-03 / 9/22/2015 Result	MW-05D-02 / HS15090989-02 / 9/22/2015 Result	MW-06S-02 / HS15090989-05 / 9/22/2015 Result
cis-1,2-Dichloroethene	ug/L	70	Daughter	2	0.5 U	0.5 U	0.5 U	0.5 U	**0.82 J**
Trichloroethene	ug/L	5	Released	0	0.5 U	0.5 U	0.5 U	0.5 U	**25**
Vinyl Chloride	ug/L	2	Daughter	2	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Natural Attenuation Parameters									
Alkalinity as CaCO3	mg/L	NA	2 times background	1	**174**	**299**	**297**	**219**	**368**
Alkalinity, Bicarbonate (As CaCO3)	mg/L	NA	-	-	**174**	**299**	**297**	**219**	**368**
Alkalinity, Carbonate (As CaCO3)	mg/L	NA	-	-	5 U	5 U	5 U	5 U	5 U
Alkalinity, Hydroxide (As CaCO3)	mg/L	NA	-	-	5 U	5 U	5 U	5 U	5 U
Bromide	mg/L	NA	-	-	**0.119 J**	**0.329 J**	**0.125 J**	**0.151 J**	**0.1 J**
Chloride	mg/L	* 250	2 times background	2	**43**	**64.5 J**	**39.1 J**	**48.9 J**	**3.11 J**
Ethane	ug/L	NA	>10/>100 ug/L	2.0/3.0	0.361 U	**0.754 J**	0.361 U	0.361 U	0.361 U
Ethene	ug/L	NA	>10/>100 ug/L	2.0/3.0	**1.25**	**1.78**	**2.12**	**2.27**	0.337 U
Fluoride	mg/L	* 4	-	-	**1.11 J**	**0.608 J**	**1.02 J**	**1.08 J**	**0.397 J**
Methane	ug/L	NA	>100/1,000 ug/L	2.0/3.0	**0.289 J**	**0.905**	**1.58**	**1.62**	0.2 U
Nitrate as N	mg/L	10	<1 mg/L	2	**0.053 J**	**0.096 J**	0.05 U	**0.141**	**0.332**
Nitrate/Nitrite	mg/L	10	-	-	**0.093 J**	**0.096 J**	0.1 U	**0.141**	**0.332**
Nitrite as N	mg/L	1	-	-	**0.04 J**	0.05 U	0.05 U	0.05 U	0.05 U
Phosphorus	mg/L	NA	-	-	0.058 U	0.058 U	0.058 U	0.058 U	0.058 U
Sulfate	mg/L	* 250	<20 mg/L	2	**170**	**394**	**248**	**291**	**50.4**
Sulfide	mg/L	NA	>1 mg/L	3	**5**	**1.6**	**4.4**	**1.8**	0.4 U
pH	SU	* 6.5 to 8.5	5<pH<9	0	**4.85**	**7.07**	**6.18**	**6.23**	**7.14**
Temperature	°C	NA	>20 C	1	**20.47**	**21.2**	**30.3**	**23.87**	**21.23**
Oxidation-Reduction Potential	mV	NA	< 50 mv/<-100 mv	1.0/2.0	**7.7**	**-91.6**	**-27.9**	**-54.6**	**-9.3**
Disolved Oxygen	mg/L	NA	<0.5 />1 mg/L	3.0/-3.0	**1.6**	**0.9**	**2.62**	**2.58**	**0.95**
Ferrous iron	mg/L	0.3 for total iron	>1 mg/L	3	**0.4**	**0.9**	**1.1**	**0.7**	**0.2**
Natural Biodegradation Scoring					**4**	**7**	**7**	**4**	**6**
Other Parameters									
Conductivity	mmhos/cm	NA			**0.79**	**1.497**	**1.369**	**1.216**	**0.72**
Turbidity	NTUs	NA			**15.7**	**49**	**38**	**18**	**17.6**
Depth to water	ft TOC	NA			**46.65**	**32.64**	**53.79**	**53.86**	**18.16**

D = Deep well
J = Estimated value
mg/L = milligrams per liter
MCL = Maximum contaminant level from May 2016 EPA RSL Table.
* = Secondary MCL
mmhos/com = milli mhos per centimeter
mV = millivolts
NTU = Nephelometric Turbidity Unit
S = Shallow well
U = Compound was not detected
ug/L = micrograms per liter
Bold indicates detected results.
Dark gray shading indicates screening level exceedance for VOCs.
- = No natural attenuation criteria

** - Equals points assignment for determining favorable conditions for biodegradation
0-5 = Inadequate
6-14 = Limited Evidence
15-20 = Adequate Evidence
>20 = Strong Evidence
Light gray shading indicates Evidence for biodegradation

Table 3-10
Groundwater Sample Results (Collected September 2015)
Remedial Investigation, Former Forbes Atlas S-5 Missile Site
Lyon County, Kansas

			Sample ID:	Natural Attenuation	Natural Attenuation	MW-06D-02	MW-07S-02
			Lab ID:	Screening	Screening	HS15091050-01	HS15090989-01
			Date Collected:	(Wiedemier)	(Wiedemier)	9/23/2015	9/22/2015
Analyte	Units	Screening Level USEPA MCL		Favorable Concentration	Points**	Result	Result
cis-1,2-Dichloroethene	ug/L	70		Daughter	2	0.5 U	0.5 U
Trichloroethene	ug/L	5		Released	0	**0.42 J**	**4.5**
Vinyl Chloride	ug/L	2		Daughter	2	0.5 U	0.5 U
Natural Attenuation Parameters							
Alkalinity as CaCO3	mg/L	NA		2 times background	1	**276**	**308**
Alkalinity, Bicarbonate (As CaCO3)	mg/L	NA		-	-	**276**	**308**
Alkalinity, Carbonate (As CaCO3)	mg/L	NA		-	-	5 U	5 U
Alkalinity, Hydroxide (As CaCO3)	mg/L	NA		-	-	5 U	5 U
Bromide	mg/L	NA		-	-	**0.096 J**	0.05 UJ
Chloride	mg/L	* 250		2 times background	2	**20.7 J**	**5.44 J**
Ethane	ug/L	NA		>10/>100 ug/L	2.0/3.0	**0.93 J**	**1.05**
Ethene	ug/L	NA		>10/>100 ug/L	2.0/3.0	**1.58**	**3.34**
Fluoride	mg/L	* 4		-	-	**1.08 J**	**0.368 J**
Methane	ug/L	NA		>100/1,000 ug/L	2.0/3.0	**0.898**	**1.68**
Nitrate as N	mg/L	10		<1 mg/L	2	**0.144**	**0.065 J**
Nitrate/Nitrite	mg/L	10		-	-	**0.176**	**0.065 J**
Nitrite as N	mg/L	1		-	-	**0.032 J**	0.05 U
Phosphorus	mg/L	NA		-	-	0.058 U	0.058 U
Sulfate	mg/L	* 250		<20 mg/L	2	**142**	**36.3**
Sulfide	mg/L	NA		>1 mg/L	3	0.3 UJ	0.3 U
pH	SU	* 6.5 to 8.5		5<pH<9	0	**7.32**	**7.28**
Temperature	°C	NA		>20 C	1	**19.3**	**21.37**
Oxidation-Reduction Potential	mV	NA		< 50 mv/<-100 mv	1.0/2.0	**10.7**	**-23.8**
Disolved Oxygen	mg/L	NA		<0.5 />1 mg/L	3.0/-3.0	**2.4**	**2.22**
Ferrous iron	mg/L	0.3 for total iron		>1 mg/L	3	**0**	**0.3**
Natural Biodegradation Scoring						**0**	**1**
Other Parameters							
Conductivity	mmhos/cm	NA				**0.763**	**0.607**
Turbidity	NTUs	NA				**6**	**27.9**
Depth to water	ft TOC	NA				**32.61**	**27.98**

D = Deep well
J = Estimated value
mg/L = milligrams per liter
MCL = Maximum contaminant level from May 2016 EPA RSL Table.
* = Secondary MCL
mmhos/com = milli mhos per centimeter
mV = millivolts
NTU = Nephelometric Turbidity Unit
S = Shallow well
U = Compound was not detected
ug/L = micrograms per liter
Bold indicates detected results.
Dark gray shading indicates screening level exceedance for VOCs.
- = No natural attenuation criteria

** - Equals points assignment for determining favorable conditions for biodegradation.
0-5 = Inadequate
6-14 = Limited Evidence
15-20 = Adequate
>20 = Strong Evidence
Light gray shading indicates Evidence for biodegradation.

Table 3-11
Groundwater Sample Results (Collected December 2015)
Remedial Investigation, Former Forbes Atlas S-5 Missile Site
Lyon County, Kansas

		Sample ID:	Natural Attenuation	Natural Attenuation	MW-01D-03	MW-02S-03	MW-02D-03	MW-02D-13	MW-03S-03	MW-03S-13
		Lab ID:	Screening	Screening	HS15120645-04	HS15120645-03/ HS15120645-03DUP	HS15120645-01	HS15120645-02	HS15120573-02	HS15120573-03
		Date Collected:	(Wiedemier)	(Wiedemier)	12/15/2015	12/15/2015	12/15/2015	12/15/2015	12/14/2015	12/14/2015
		Screening Level	Favorable	Points**				Duplicate		Duplicate
Analyte	**Units**	**USEPA MCL**	**Concentration**		**Result**	**Result**	**Result**	**Result**	**Result**	**Result**
cis-1,2-Dichloroethene	ug/L	70	Daughter	2	0.62 U	**6.5**	0.62 U	0.62 U	0.62 U	0.62 U
Trichloroethene	ug/L	5	Released	0	0.62 U	**80**	0.62 U	0.62 U	**5.9**	**5.8**
Vinyl Chloride	ug/L	2	Daughter	2	0.62 U	0.62 U	0.62 U	0.62 U	0.62 U	0.62 U
Natural Attenuation Parameters										
Alkalinity as CaCO3	mg/L	NA	2 times background	1	**381**	**350.8**	**281**	**281**	**311**	**315**
Alkalinity, Bicarbonate (As CaCO3)	mg/L	NA	-	-	**381**	**350.8**	**281**	**281**	**311**	**315**
Alkalinity, Carbonate (As CaCO3)	mg/L	NA	-	-	5 U	5 U	5 U	5 U	5 U	5 U
Alkalinity, Hydroxide (As CaCO3)	mg/L	NA	-	-	5 U	5 U	5 U	5 U	5 U	5 U
Bromide	mg/L	NA	-	-	0.1 UJ	**0.123 J**	**0.09 J**	**0.097 J**	0.1 UJ	0.1 UJ
Chloride	mg/L	* 250	2 times background	2	**66.5**	**5.04**	**24.9**	**25.7**	**2.1**	**2.27**
Ethane	ug/L	NA	>10/>100 ug/L	2.0/3.0	0.361 U	0.361 U	0.361 U	0.361 U	0.361 U	0.361 U
Ethene	ug/L	NA	>10/>100 ug/L	2.0/3.0	0.337 U	0.337 U	0.337 U	0.337 U	0.337 U	0.337 U
Fluoride	mg/L	* 4	-	-	**0.906**	**0.443**	**1.19**	**1.27**	**0.409**	**0.415**
Methane	ug/L	NA	>100/1,000 ug/L	2.0/3.0	0.2 U	**0.426 J**	**1.32**	**3.03**	0.2 U	0.2 U
Nitrate as N	mg/L	10	<1 mg/L	2	0.1 U	**0.123**	0.1 U	0.1 U	**0.683**	**0.645**
Nitrate/Nitrite	mg/L	10	-	-	0.1 U	**0.123**	**0.08 J**	**0.079 J**	**0.683**	**0.645**
Nitrite as N	mg/L	1	-	-	0.1 U	0.1 U	**0.08 J**	**0.079 J**	0.1 U	0.1 U
Phosphorus	mg/L	NA	-	-	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Sulfate	mg/L	* 250	<20 mg/L	2	**340**	**47.8**	**117**	**116**	**31.7**	**32.7**
Sulfide	mg/L	NA	>1 mg/L	3	**3.08**	**0.68**	**2.08**	**0.88**	**0.88**	**1.68**
pH	SU	* 6.5 to 8.5	5<pH<9	0	**6.79**	**6.03**	**7.29**	NA	**6.9**	NA
Temperature	°C	NA	>20 C	1	**13.15**	**12.32**	**10.75**	NA	**12.33**	NA
Oxidation-Reduction Potential	mV	NA	< 50 mv/<-100 mv	1.0/2.0	**-47.6**	**40.9**	**-39.6**	NA	**-9**	NA
Dissolved Oxygen	mg/L	NA	<0.5 />1 mg/L	3.0/-3.0	**0.76**	**0.7**	**1.14**	NA	**0.66**	NA
Ferrous iron	mg/L	0.3 for total iron	>1 mg/L	3	NS	NS	NS	NS	NS	NS
Natural Biodegradation Scoring					**6**	**5**	**3**		**3**	
Other Parameters										
Conductivity	mmhos/cm	NA			**1.71**	**0.792**	**0.852**	NA	**0.747**	NA
Turbidity	NTUs	NA			**18.5**	**1.43**	**8.09**	NA	**8.04**	NA
Depth to water	ft TOC	NA			**50.55**	**24.57**	**47.56**	NA	**22.87**	NA

D = Deep well
J = Estimated value
mg/L = milligrams per liter
MCL = Maximum contaminant level from May 2016 EPA RSL Table.
* = Secondary MCL
mmhos/com = milli mhos per centimeter
mV = millivolts
NS = Not Sampled
NTU = Nephelometric Turbidity Unit
S = Shallow well
U = Compound was not detected
ug/L = micrograms per liter
Bold indicates detected results.
Dark gray shading indicates screening level exceedance for VOCs.
- = No natural attenuation criteria

** - Equals points assignment for determining favorable conditions for biodegradation
0-5 = Inadequate
6-14 = Limited Evidence
15-20 = Adequate Evidence
>20 = Strong Evidence
Light gray shading indicates Evidence for biodegradation

Table 3-11
Groundwater Sample Results (Collected December 2015)
Remedial Investigation, Former Forbes Atlas S-5 Missile Site
Lyon County, Kansas

		Sample ID:	Natural Attenuation	Natural Attenuation	MW-03D-03	MW-04S-03	MW-04D-03	MW-05D-03	MW-06S-03
		Lab ID:	Screening	Screening	HS15120573-01	HS15120645-06	HS15120645-05	HS15120703-01	HS15120703-03
		Date Collected:	(Wiedemier)	(Wiedemier)	12/14/2015	12/15/2015	12/15/2015	12/16/2015	12/16/2015
		Screening Level	Favorable	Points**					
Analyte	**Units**	**USEPA MCL**	**Concentration**		**Result**	**Result**	**Result**	**Result**	**Result**
cis-1,2-Dichloroethene	ug/L	70	Daughter	2	0.62 U	0.62 U	0.62 U	0.62 U	0.62 U
Trichloroethene	ug/L	5	Released	0	0.62 U	0.62 U	0.62 U	0.62 U	**21**
Vinyl Chloride	ug/L	2	Daughter	2	0.62 U	0.62 U	0.62 U	0.62 U	0.62 U
Natural Attenuation Parameters									
Alkalinity as CaCO3	mg/L	NA	2 times background	1	**242**	**305**	**406**	**281**	**375**
Alkalinity, Bicarbonate (As CaCO3)	mg/L	NA	-	-	**242**	**305**	**406**	**281**	**375**
Alkalinity, Carbonate (As CaCO3)	mg/L	NA	-	-	5 U	5 U	5 U	5 U	5 U
Alkalinity, Hydroxide (As CaCO3)	mg/L	NA	-	-	5 U	5 U	5 U	5 U	5 U
Bromide	mg/L	NA	-	-	**0.164 J**	**0.124 J**	**0.114 J**	0.1 U	**0.091 J**
Chloride	mg/L	* 250	2 times background	2	**53.1**	**27.8**	**46.2**	**56.7**	**2.79**
Ethane	ug/L	NA	>10/>100 ug/L	2.0/3.0	0.361 U	0.361 U	**1.34**	0.361 U	0.361 U
Ethene	ug/L	NA	>10/>100 ug/L	2.0/3.0	**5.84**	0.337 U	**5.9**	**6.25**	0.337 U
Fluoride	mg/L	* 4	-	-	**1.03**	**0.573**	**0.938**	**1.02**	**0.342**
Methane	ug/L	NA	>100/1,000 ug/L	2.0/3.0	**4.63**	0.2 U	**8.65**	**4.1**	0.2 U
Nitrate as N	mg/L	10	<1 mg/L	2	0.1 U	0.1 U	0.1 U	0.1 U	**0.585**
Nitrate/Nitrite	mg/L	10	-	-	0.1 U	0.1 U	0.1 U	0.1 U	**0.585**
Nitrite as N	mg/L	1	-	-	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Phosphorus	mg/L	NA	-	-	0.1 U	**0.341**	0.1 U	**0.274**	0.1 U
Sulfate	mg/L	* 250	<20 mg/L	2	**257**	**154**	**255**	**348**	**54.8**
Sulfide	mg/L	NA	>1 mg/L	3	**0.88**	0.3 U	**3.28**	**2.28**	**1.48**
pH	SU	* 6.5 to 8.5	5<pH<9	0	**6.01**	**7.15**	**6.57**	**6.37**	**6.83**
Temperature	°C	NA	>20 C	1	**9.99**	**14.85**	**15.93**	**7.12**	**11.95**
Oxidation-Reduction Potential	mV	NA	< 50 mv/<-100 mv	1.0/2.0	**16.2**	**-90.9**	**-56.2**	**-41.6**	**1.2**
Dissolved Oxygen	mg/L	NA	<0.5 />1 mg/L	3.0/-3.0	**0.83**	**0.75**	**1.02**	**1.29**	**3.65**
Ferrous iron	mg/L	0.3 for total iron	>1 mg/L	3	NS	NS	NS	NS	NS
Natural Biodegradation Scoring					**3**	**3**	**3**	**3**	**3**
Other Parameters									
Conductivity	mmhos/cm	NA			**1.232**	**1.08**	**1.626**	**1.483**	**0.889**
Turbidity	NTUs	NA			**11.3**	**259**	**92.9**	**7.28**	**15.7**
Depth to water	ft TOC	NA			**48.65**	**33.2**	**54.96**	**55.09**	**17.19**

D = Deep well
J = Estimated value
mg/L = milligrams per liter
MCL = Maximum contaminant level from May 2016 EPA RSL Table.
* = Secondary MCL
mmhos/com = milli mhos per centimeter
mV = millivolts
NS = Not Sampled
NTU = Nephelometric Turbidity Unit
S = Shallow well
U = Compound was not detected
ug/L = micrograms per liter
Bold indicates detected results.
Dark gray shading indicates screening level exceedance for VOCs.
- = No natural attenuation criteria

** - Equals points assignment for determining favorable conditions for biodegradation
0-5 = Inadequate
6-14 = Limited Evidence
15-20 = Adequate Evidence
>20 = Strong Evidence
Light gray shading indicates Evidence for biodegradation

Table 3-11
Groundwater Sample Results (Collected December 2015)
Remedial Investigation, Former Forbes Atlas S-5 Missile Site
Lyon County, Kansas

		Sample ID:	Natural Attenuation	Natural Attenuation	MW-06D-03	MW-07S-03
		Lab ID:	Screening	Screening	HS15120703-02	HS15120573-04
		Date Collected:	(Wiedemier)	(Wiedemier)	12/16/2015	12/14/2015
Analyte	Units	Screening Level USEPA MCL	Favorable Concentration	Points**	Result	Result
cis-1,2-Dichloroethene	ug/L	70	Daughter	2	0.62 U	0.62 U
Trichloroethene	ug/L	5	Released	0	0.62 U	**4.1**
Vinyl Chloride	ug/L	2	Daughter	2	0.62 U	0.62 U
Natural Attenuation Parameters						
Alkalinity as CaCO3	mg/L	NA	2 times background	1	**286**	**320**
Alkalinity, Bicarbonate (As CaCO3)	mg/L	NA	-	-	**286**	**320**
Alkalinity, Carbonate (As CaCO3)	mg/L	NA	-	-	5 U	5 U
Alkalinity, Hydroxide (As CaCO3)	mg/L	NA	-	-	5 U	5 U
Bromide	mg/L	NA	-	-	0.1 U	0.1 UJ
Chloride	mg/L	* 250	2 times background	2	**19.8**	**2.73**
Ethane	ug/L	NA	>10/>100 ug/L	2.0/3.0	**1.43**	0.361 U
Ethene	ug/L	NA	>10/>100 ug/L	2.0/3.0	**4.3**	**1.39**
Fluoride	mg/L	* 4	-	-	**1.04**	**0.34**
Methane	ug/L	NA	>100/1,000 ug/L	2.0/3.0	**9.09**	**0.637**
Nitrate as N	mg/L	10	<1 mg/L	2	0.1 U	**0.096 J**
Nitrate/Nitrite	mg/L	10	-	-	0.1 U	**0.096 J**
Nitrite as N	mg/L	1	-	-	0.1 U	0.1 U
Phosphorus	mg/L	NA	-	-	0.1 U	0.1 U
Sulfate	mg/L	* 250	<20 mg/L	2	**140**	**28.8**
Sulfide	mg/L	NA	>1 mg/L	3	**1.68**	**1.88**
pH	SU	* 6.5 to 8.5	5<pH<9	0	**7.24**	**7.02**
Temperature	°C	NA	>20 C	1	**7.32**	**11.76**
Oxidation-Reduction Potential	mV	NA	< 50 mv/<-100 mv	1.0/2.0	**-90.4**	**-35.2**
Dissolved Oxygen	mg/L	NA	<0.5 />1 mg/L	3.0/-3.0	**1.3**	**0.56**
Ferrous iron	mg/L	0.3 for total iron	>1 mg/L	3	NS	NS
Natural Biodegradation Scoring					**3**	**6**
Other Parameters						
Conductivity	mmhos/cm	NA			**0.867**	**0.724**
Turbidity	NTUs	NA			**7.84**	**5.89**
Depth to water	ft TOC	NA			**33.61**	**27.59**

D = Deep well
J = Estimated value
mg/L = milligrams per liter
MCL = Maximum contaminant level from May 2016 EPA RSL Table.
* = Secondary MCL
mmhos/com = milli mhos per centimeter
mV = millivolts
NS = Not Sampled
NTU = Nephelometric Turbidity Unit
S = Shallow well
U = Compound was not detected
ug/L = micrograms per liter
Bold indicates detected results.
Dark gray shading indicates screening level exceedance for VOCs.
- = No natural attenuation criteria

** - Equals points assignment for determining favorable conditions for biodegradation.
0-5 = Inadequate
6-14 = Limited Evidence
15-20 = Adequate
>20 = Strong Evidence
Light gray shading indicates Evidence for biodegradation.

Table 3-12
Groundwater Sample Results (Collected March 2016)
Remedial Investigation, Former Forbes Atlas S-5 Missile Site
Lyon County, Kansas

		Sample ID:	Natural Attenuation	Natural Attenuation	MW-01D-04		MW-02S-04		MW-02D-04		MW-02D-14		MW-03S-04	
		Lab ID:	Screening	Screening	HS16030437-03		HS16030437-06		HS16030437-04		HS16030437-05		HS16030331-02	
		Date Collected:	(Wiedemier)	(Wiedemier)	3/9/2016		3/9/2016		3/9/2016		3/9/2016		3/7/2016	
		Screening Level	Favorable	Points**							Duplicate			
Analyte	Units	USEPA MCL	Concentration		Result		Result		Result		Result		Result	
cis-1,2-Dichloroethene	ug/L	70	Daughter	2	0.62	U	**5.8**		0.62	U	0.62	U	**0.81**	J
Trichloroethene	ug/L	5	Released	0	0.62	U	**120**	J	0.62	U	0.62	U	**4.7**	
Vinyl Chloride	ug/L	2	Daughter	2	0.62	U	0.62	U	0.62	U	0.62	U	0.62	U
Natural Attenuation Parameters														
Alkalinity as CaCO3	mg/L	NA	2 times background	1	**385**		**351**		**278**		**276**		**308**	
Alkalinity, Bicarbonate (As CaCO3)	mg/L	NA	-	-	**385**		**351**		**278**		**276**		**308**	
Alkalinity, Carbonate (As CaCO3)	mg/L	NA	-	-	5	U	5	U	5	U	5	U	5	U
Alkalinity, Hydroxide (As CaCO3)	mg/L	NA	-	-	5	U	5	U	5	U	5	U	5	U
Bromide	mg/L	NA	-	-	**0.202**		0.1	U	**0.097**	J	**0.096**	J	0.1	U
Chloride	mg/L	* 250	2 times background	2	**73.2**		**5.02**		**27.5**		**27.4**		**2.46**	
Ethane	ug/L	NA	>10/>100 ug/L	2.0/3.0	**1.79**		0.361	UJ	0.361	U	0.361	U	0.361	U
Ethene	ug/L	NA	>10/>100 ug/L	2.0/3.0	**1.75**		0.337	UJ	**1.11**		**1.16**		**0.665**	J
Fluoride	mg/L	* 4	-	-	**0.967**		**0.369**		**1.27**		**1.27**		**0.338**	
Methane	ug/L	NA	>100/1,000 ug/L	2.0/3.0	**13.6**		**1.59**		**5.1**		**4.9**		0.2	U
Nitrate as N	mg/L	10	<1 mg/L	2	0.1	U	**0.223**		**0.061**	J	**0.06**	J	**0.667**	
Nitrate/Nitrite	mg/L	10	-	-	0.1	U	**0.223**		**0.061**	J	**0.06**	J	**0.667**	
Nitrite as N	mg/L	1	-	-	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U
Phosphorus	mg/L	NA	-	-	**0.105**		0.1	U	0.1	U	0.1	U	0.1	U
Sulfate	mg/L	* 250	<20 mg/L	2	**371**		**43.9**		**121**		**130**		**33.4**	
Sulfide	mg/L	NA	>1 mg/L	3	**2.28**		**4.28**		**2.08**		**1.28**		3.96	U
pH	SU	* 6.5 to 8.5	5<pH<9	0	**6.84**		**5.61**		**6.53**		NA		**6.94**	
Temperature	˚C	NA	>20 C	1	**16.06**		**15.57**		**17.88**		NA		**19.5**	
Oxidation-Reduction Potential	mV	NA	< 50 mv/<-100 mv	1.0/2.0	**-30.9**		**108.4**		**24.2**		NA		**-2.1**	
Dissolved Oxygen	mg/L	NA	<0.5 />1 mg/L	3.0/-3.0	**2.04**		**1.66**		**1.46**		NA		**1.4**	
Ferrous iron	mg/L	0.3 for total iron	>1 mg/L	3	**1.2**		**0.0**		**0.1**		NA		**0.0**	
Natural Biodegradation Scoring					**6**		**2**		**3**		**5**		**3**	
Other Parameters														
Conductivity	mmhos/cm	NA			**1.453**		**0.655**		**0.79**		NA		**0.58**	
Turbidity	NTUs	NA			**41.6**		**3.5**		**7.6**		NA		**15.4**	
Depth to water	ft TOC	NA			**48.58**		**24.45**		**44.67**		NA		**22.15**	

D = Deep well
J = Estimated value
mg/L = milligrams per liter
MCL = Maximum contaminant level from May 2016 EPA RSL Table.
* = Secondary MCL
mmhos/com = milli mhos per centimeter
mV = millivolts
NS = Not Sampled
NTU = Nephelometric Turbidity Unit
S = Shallow well
U = Compound was not detected
ug/L = micrograms per liter
Bold indicates detected results.
Dark gray shading indicates screening level exceedance for VOCs.
- = No natural attenuation criteria
OOR - Out of Range

** - Equals points assignment for determining favorable conditions for biodegradation
0-5 = Inadequate
6-14 = Limited Evidence
15-20 = Adequate Evidence
>20 = Strong Evidence
Light gray shading indicates Evidence for biodegradation

Table 3-12
Groundwater Sample Results (Collected March 2016)
Remedial Investigation, Former Forbes Atlas S-5 Missile Site
Lyon County, Kansas

		Sample ID:	Natural Attenuation	Natural Attenuation	MW-03S-14		MW-03D-04		MW-04S-04		MW-04D-04		MW-05D-04		MW-06S-04	
		Lab ID:	Screening	Screening	HS16030331-03		HS16030331-01		HS16030390-04		HS16030390-03		HS16030437-02		HS16030390-02	
		Date Collected:	(Wiedemier)	(Wiedemier)	3/7/2016		3/7/2016		3/8/2016		3/8/2016		3/9/2016		3/8/2016	
		Screening Level	Favorable	Points**	Duplicate											
Analyte	**Units**	**USEPA MCL**	**Concentration**		**Result**		**Result**		**Result**		**Result**		**Result**		**Result**	
cis-1,2-Dichloroethene	ug/L	70	Daughter	2	**0.85**	**J**	0.62	U	0.62	U	0.62	U	0.62	U	**0.69**	**J**
Trichloroethene	ug/L	5	Released	0	**4.6**		0.62	U	0.62	U	0.62	U	**0.24**	**J**	**16**	
Vinyl Chloride	ug/L	2	Daughter	2	0.62	U	0.62	U	0.62	U	0.62	U	0.62	U	0.62	U
Natural Attenuation Parameters																
Alkalinity as CaCO3	mg/L	NA	2 times background	1	**306**		**329**		**301**		**370**		**333**		**362**	
Alkalinity, Bicarbonate (As CaCO3)	mg/L	NA	-	-	**306**		**329**		**301**		**370**		**333**		**362**	
Alkalinity, Carbonate (As CaCO3)	mg/L	NA	-	-	5	U	5	U	5	U	5	U	5	U	5	U
Alkalinity, Hydroxide (As CaCO3)	mg/L	NA	-	-	5	U	5	U	5	U	5	U	5	U	5	U
Bromide	mg/L	NA	-	-	0.1	U	**0.184**		**0.108**		**0.154**		**0.219**		**0.101**	
Chloride	mg/L	* 250	2 times background	2	**2.36**		**66.7**		**16.5**		**47.3**		**68.8**		**3.44**	
Ethane	ug/L	NA	>10/>100 ug/L	2.0/3.0	0.361	U	0.361	U	**1.03**		**0.99**	**J**	**1.05**		0.361	U
Ethene	ug/L	NA	>10/>100 ug/L	2.0/3.0	**0.912**	**J**	**4.68**		**4.91**		**5.88**		**5.19**		0.337	U
Fluoride	mg/L	* 4	-	-	**0.334**		**0.875**		**0.42**		**0.899**		**1.18**		**0.273**	
Methane	ug/L	NA	>100/1,000 ug/L	2.0/3.0	0.2	U	**10.1**		**2.05**		**7.98**		**10.4**		0.2	U
Nitrate as N	mg/L	10	<1 mg/L	2	**0.655**		**0.053**	**J**	0.05	U	0.05	U	0.1	U	**0.478**	
Nitrate/Nitrite	mg/L	10	-	-	**0.655**		**0.053**	**J**	0.1	U	0.1	U	0.1	U	**0.478**	
Nitrite as N	mg/L	1	-	-	0.1	U	0.1	U	0.05	U	0.05	U	0.1	U	0.05	U
Phosphorus	mg/L	NA	-	-	0.1	U	**0.159**		0.05	UJ	0.05	UJ	**0.113**		0.05	UJ
Sulfate	mg/L	* 250	<20 mg/L	2	**32.2**		**324**		**80.6**		**248**		**462**		**53.3**	
Sulfide	mg/L	NA	>1 mg/L	3	**1.76**		**1.96**		2.48	U	**2.68**		**2.88**		**2.28**	
pH	SU	* 6.5 to 8.5	5<pH<9	0	NA		**6.84**		**7.01**		**6.12**		**7.06**		**6.77**	
Temperature	°C	NA	>20 C	1	NA		**21.3**		**14.02**		**14.94**		**12.6**		**15.01**	
Oxidation-Reduction Potential	mV	NA	< 50 mv/<-100 mv	1.0/2.0	NA		**-81.1**		**-55.1**		**19.1**		**-74.1**		**49.9**	
Dissolved Oxygen	mg/L	NA	<0.5 />1 mg/L	3.0/-3.0	NA		**1.33**		**3.12**		**3.06**		**2.5**		**3.65**	
Ferrous iron	mg/L	0.3 for total iron	>1 mg/L	3	NA		**0.7**		**0.8**		**0**		**1.1**		**0**	
Natural Biodegradation Scoring					**5**		**4**		**3**		**3**		**6**		**3**	
Other Parameters																
Conductivity	mmhos/cm	NA			NA		**1.388**		**0.671**		**1.143**		**1.447**		**0.682**	
Turbidity	NTUs	NA			NA		**26.6**		**OOR**		**104**		**17**		**20.1**	
Depth to water	ft TOC	NA			NA		**45.5**		**31.59**		**53.4**		**51.54**		**15.17**	

D = Deep well
J = Estimated value
mg/L = milligrams per liter
MCL = Maximum contaminant level from May 2016 EPA RSL Table.
* = Secondary MCL
mmhos/com = milli mhos per centimeter
mV = millivolts
NS = Not Sampled
NTU = Nephelometric Turbidity Unit
S = Shallow well
U = Compound was not detected
ug/L = micrograms per liter
Bold indicates detected results.
Dark gray shading indicates screening level exceedance for VOCs.
- = No natural attenuation criteria
OOR - Out of Range

** - Equals points assignment for determining favorable conditions for biodegradation
0-5 = Inadequate
6-14 = Limited Evidence
15-20 = Adequate Evidence
>20 = Strong Evidence
Light gray shading indicates Evidence for biodegradation

Table 3-12
Groundwater Sample Results (Collected March 2016)
Remedial Investigation, Former Forbes Atlas S-5 Missile Site
Lyon County, Kansas

Analyte	Units	Screening Level USEPA MCL	Natural Attenuation Screening (Wiedemier) Favorable Concentration	Natural Attenuation Screening (Wiedemier) Points**	MW-06D-04 HS16030390-01 3/8/2016 Result		MW-07S-04 HS16030437-01 3/9/2016 Result	
cis-1,2-Dichloroethene	ug/L	70	Daughter	2	0.62	U	**0.45**	**J**
Trichloroethene	ug/L	5	Released	0	0.62	U	**5.1**	
Vinyl Chloride	ug/L	2	Daughter	2	0.62	U	0.62	U
Natural Attenuation Parameters								
Alkalinity as CaCO3	mg/L	NA	2 times background	1	**293**		**318**	
Alkalinity, Bicarbonate (As CaCO3)	mg/L	NA	-	-	**293**		**318**	
Alkalinity, Carbonate (As CaCO3)	mg/L	NA	-	-	5	U	5	U
Alkalinity, Hydroxide (As CaCO3)	mg/L	NA	-	-	5	U	5	U
Bromide	mg/L	NA	-	-	**0.098**	**J**	0.1	U
Chloride	mg/L	* 250	2 times background	2	**19.2**		**3.23**	
Ethane	ug/L	NA	>10/>100 ug/L	2.0/3.0	**1.96**		**0.727**	**J**
Ethene	ug/L	NA	>10/>100 ug/L	2.0/3.0	**5.48**		**2.38**	
Fluoride	mg/L	* 4	-	-	**0.931**		**0.308**	
Methane	ug/L	NA	>100/1,000 ug/L	2.0/3.0	**19.3**		**0.489**	**J**
Nitrate as N	mg/L	10	<1 mg/L	2	0.05	U	**0.149**	
Nitrate/Nitrite	mg/L	10	-	-	0.1	U	**0.149**	
Nitrite as N	mg/L	1	-	-	0.05	U	0.1	U
Phosphorus	mg/L	NA	-	-	**0.175**	**J**	0.1	U
Sulfate	mg/L	* 250	<20 mg/L	2	**140**		**31.6**	
Sulfide	mg/L	NA	>1 mg/L	3	**4.48**		1	U
pH	SU	* 6.5 to 8.5	5<pH<9	0	**7.13**		**6.91**	
Temperature	°C	NA	>20 C	1	**16.21**		**10.91**	
Oxidation-Reduction Potential	mV	NA	< 50 mv/<-100 mv	1.0/2.0	**-125.3**		**-29.2**	
Dissolved Oxygen	mg/L	NA	<0.5 />1 mg/L	3.0/-3.0	**1.92**		**2.75**	
Ferrous iron	mg/L	0.3 for total iron	>1 mg/L	3	**0.5**		**0.7**	
Natural Biodegradation Scoring					**4**		**0**	
Other Parameters								
Conductivity	mmhos/cm	NA			**0.807**		**0.506**	
Turbidity	NTUs	NA			**5.71**		**270**	
Depth to water	ft TOC	NA			**29.7**		**27**	

D = Deep well
J = Estimated value
mg/L = milligrams per liter
MCL = Maximum contaminant level from May 2016 EPA RSL Table.
* = Secondary MCL
mmhos/com = milli mhos per centimeter
mV = millivolts
NS = Not Sampled
NTU = Nephelometric Turbidity Unit
S = Shallow well
U = Compound was not detected
ug/L = micrograms per liter
Bold indicates detected results.
Dark gray shading indicates screening level exceedance for VOCs.
- = No natural attenuation criteria
OOR - Out of Range

** - Equals points assignment for determining favorable conditions for
0-5 = Inadequate
6-14 = Limited Evidence
15-20 = Adequate
>20 = Strong Evidence
Light gray shading indicates Evidence for biodegradation.

Table 3-13
Groundwater Sample Results (Collected June 2016)
Remedial Investigation, Former Forbes Atlas S-5 Missile Site
Lyon County, Kansas

		Sample ID:	Natural Attenuation	Natural Attenuation	MW-01D-05		MW-02S-05		MW-02D-05		MW-02D-15		MW-03S-05		MW-03S-15	
		Lab ID:	Screening	Screening	HS16061535-08		HS16061470-03 and HS16061535-03		HS16061470-01 & HS16061535-01		HS16061470-02 & HS16061535-02		HS16061535-04		HS16061535-05	
		Date Collected:	(Wiedemier)	(Wiedemier)	6/28/2016		6/27/2016		6/27/2016		6/27/2016		6/28/2016		6/28/2016	
		Screening Level	Favorable	Points**							Duplicate				Duplicate	
Analyte	Units	USEPA MCL	Concentration		Result		Result		Result		Result		Result		Result	
cis-1,2-Dichloroethene	ug/L	70	Daughter	2	0.5	U	0.5	U	0.5	U	0.5	U	**0.62**	**J**	**0.56**	**J**
Trichloroethene	ug/L	5	Released	0	0.5	U	**77**	**J**	0.5	U	0.5	U	**4.5**	**J**	**4.5**	**J**
Vinyl Chloride	ug/L	2	Daughter	2	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U
Natural Attenuation Parameters																
Alkalinity as CaCO3	mg/L	NA	2 times background	1	**347**		**402**		**282**		**279**		**302**		**303**	
Alkalinity, Bicarbonate (As CaCO3)	mg/L	NA	-	-	**347**		**402**		**282**		**279**		**302**		**303**	
Alkalinity, Carbonate (As CaCO3)	mg/L	NA	-	-	5	U	5	U	5	U	5	U	5	U	5	U
Alkalinity, Hydroxide (As CaCO3)	mg/L	NA	-	-	5	U	5	U	5	U	5	U	5	U	5	U
Bromide	mg/L	NA	-	-	0.05	U	**0.123**		0.05	U	0.05	U	0.05	U	0.05	U
Chloride *	mg/L	250	2 times background	2	**72.2**		**6.03**		**25.9**		**26.2**		**2.29**		**2.31**	
Ethane	ug/L	NA	>10/>100 ug/L	2.0/3.0	**1.75**		0.361	U	0.361	U	0.361	U	0.361	U	0.361	U
Ethene	ug/L	NA	>10/>100 ug/L	2.0/3.0	**2.11**		0.337	U	**0.821**	**J**	**0.946**	**J**	0.337	U	0.337	U
Fluoride *	mg/L	4	-	-	**1.08**		**0.386**		**1.25**		**1.27**		**0.366**		**0.367**	
Methane	ug/L	NA	>100/1,000 ug/L	2.0/3.0	**11.8**		**1.11**		**6.83**		**5.09**		0.2	U	0.2	U
Nitrate as N	mg/L	10	<1 mg/L	2	**0.79**	**J**	0.05	U	**0.057**	**J**	0.05	U	**0.717**		**0.706**	
Nitrate/Nitrite	mg/L	10	-	-	**0.79**	**J**	0.1	U	**0.057**	**J**	0.1	U	**0.717**		**0.706**	
Nitrite as N	mg/L	1	-	-	1	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U
Phosphorus	mg/L	NA	-	-	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U
Sulfate *	mg/L	250	<20 mg/L	2	**392**		**66.7**		**120**		**123**		**29.1**		**28.9**	
Sulfide	mg/L	NA	>1 mg/L	3	1	U	1	U	1	U	1	U	1	U	1	U
pH *	SU	6.5 to 8.5	5<pH<9	0	**6.4**		**6.1**		**6.92**		NA		**6.8**		NA	
Temperature	°C	NA	>20 C	1	**24.15**		**23.39**		**28.12**		NA		**17.44**		NA	
Oxidation-Reduction Potential	mV	NA	< 50 mv/<-100 mv	1.0/2.0	**-67.0**		**119.3**		**-14.5**		NA		**141.6**		NA	
Dissolved Oxygen	mg/L	NA	<0.5 />1 mg/L	3.0/-3.0	**1.27**		**1.25**		**1.7**		NA		**4.0**		NA	
Ferrous iron	mg/L	0.3 for total iron	>1 mg/L	3	**1.2**		**0.1**		**0.1**		NA		**0.1**		NA	
Natural Biodegradation Scoring					**4**		**0**		**1**		**2**		**1**		**4**	
Other Parameters																
Conductivity	mmhos/cm	NA			**1.200**		**0.684**		**0.714**				**0.416**			
Turbidity	NTUs	NA			**22.0**		**2.9**		**16.5**				**9.6**			
Depth to water	ft TOC	NA			**51.36**		**22.33**		**47.05**				**21.3**			

D = Deep well
J = Estimated value
mg/L = milligrams per liter
MCL = Maximum contaminant level from May 2016 EPA RSL Table.
* = Secondary MCL
mmhos/com = milli mhos per centimeter
Bold indicates detected results.
Dark gray shading indicates screening level exceedance for VOCs.
- = No natural attenuation criteria

mV = millivolts
NS = Not Sampled
NTU = Nephelometric Turbidity Unit
OOR - Out of Range
S = Shallow well
U = Compound was not detected
ug/L = micrograms per liter

** - Equals points assignment for determining favorable conditions for biodegradation
0-5 = Inadequate
6-14 = Limited Evidence
15-20 = Adequate Evidence
>20 = Strong Evidence
Light gray shading indicates Evidence for biodegradation

Table 3-13
Groundwater Sample Results (Collected June 2016)
Remedial Investigation, Former Forbes Atlas S-5 Missile Site
Lyon County, Kansas

		Sample ID:	Natural Attenuation	Natural Attenuation	MW-03D-05	MW-04S-05	MW-04D-05	MW-05D-05	MW-06S-05	MW-06D-05
		Lab ID:	Screening	Screening	HS16061535-07	HS16061535-10	HS16061535-09	HS16070012-01	HS16070012-05	HS16070012-03
		Date Collected:	(Wiedemier)	(Wiedemier)	6/28/2016	6/28/2016	6/28/2016	6/30/2016	6/30/2016	6/30/2016
		Screening Level	Favorable	Points**						
Analyte	Units	USEPA MCL	Concentration		Result	Result	Result	Result	Result	Result
cis-1,2-Dichloroethene	ug/L	70	Daughter	2	0.5 U	0.5 U	0.5 U	0.5 U	**1.5 J**	0.5 U
Trichloroethene	ug/L	5	Released	0	**0.3 J**	0.5 U	0.5 U	0.5 U	**23 J**	**0.34 J**
Vinyl Chloride	ug/L	2	Daughter	2	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Natural Attenuation Parameters										
Alkalinity as CaCO3	mg/L	NA	2 times background	1	**335**	**312**	**365**	**352**	**351**	**300**
Alkalinity, Bicarbonate (As CaCO3)	mg/L	NA	-	-	**335**	**312**	**365**	**352**	**351**	**300**
Alkalinity, Carbonate (As CaCO3)	mg/L	NA	-	-	5 U	5 U	5 U	5 U	5 U	5 U
Alkalinity, Hydroxide (As CaCO3)	mg/L	NA	-	-	5 U	5 U	5 U	5 U	5 U	5 U
Bromide	mg/L	NA	-	-	0.05 U	0.05 U	0.05 U	1 U	0.05 U	0.05 U
Chloride *	mg/L	250	2 times background	2	**71.5**	**11.7**	**55.2**	**68.6**	**2.61**	**20.1**
Ethane	ug/L	NA	>10/>100 ug/L	2.0/3.0	0.361 U	**0.632 J**	**1.08**	**0.925 J**	0.361 U	0.361 U
Ethene	ug/L	NA	>10/>100 ug/L	2.0/3.0	**3.57**	**1.79**	**6.46**	**4.15**	0.337 U	0.337 U
Fluoride *	mg/L	4	-	-	**0.972**	**0.434**	**1.09**	**1.2**	**0.305**	**1.08**
Methane	ug/L	NA	>100/1,000 ug/L	2.0/3.0	**7.87**	0.2 U	**12.2**	**8.58**	0.2 U	0.2 U
Nitrate as N	mg/L	10	<1 mg/L	2	0.05 U	**0.048 J**	0.05 U	**0.152**	**0.459**	**0.106**
Nitrate/Nitrite	mg/L	10	-	-	0.1 U	**0.048 J**	0.1 U	**0.152**	**0.459**	**0.106**
Nitrite as N	mg/L	1	-	-	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
Phosphorus	mg/L	NA	-	-	0.05 U	0.05 U	0.05 U	0.07 J	0.05 U	0.05 U
Sulfate *	mg/L	250	<20 mg/L	2	**376**	**67.7**	**292**	**439**	**43.2**	**154**
Sulfide	mg/L	NA	>1 mg/L	3	1 U	1 U	1 U	**2.4**	**1.6**	1 U
pH *	SU	6.5 to 8.5	5<pH<9	0	**6.9**	**7.1**	**6.6**	**7.0**	**6.9**	**7.1**
Temperature	˚C	NA	>20 C	1	**20.29**	**24.98**	**22.61**	**26.28**	**25.28**	**27.82**
Oxidation-Reduction Potential	mV	NA	< 50 mv/<-100 mv	1.0/2.0	**-112.1**	**-25.7**	**-37.0**	**-70.2**	**101.0**	**-82.7**
Dissolved Oxygen	mg/L	NA	<0.5 />1 mg/L	3.0/-3.0	**0.92**	**3.89**	**1.63**	**1.89**	**3.45**	**1.64**
Ferrous iron	mg/L	0.3 for total iron	>1 mg/L	3	**1.0**	**0.5**	**0.5**	**1.5**	**0.1**	**0.60**
Natural Biodegradation Scoring					**5**	**1**	**1**	**7**	**5**	**1**
Other Parameters										
Conductivity	mmhos/cm	NA			**1.088**	**0.574**	**1.033**	**1.456**	**0.59**	**0.761**
Turbidity	NTUs	NA			**23.0**	**99**	**75.0**	**19.5**	**22.0**	**20.2**
Depth to water	ft TOC	NA			**46.91**	**31.62**	**55.32**	**52.2**	**14.13**	**31.52**

D = Deep well
J = Estimated value
mg/L = milligrams per liter
MCL = Maximum contaminant level from May 2016 EPA RSL Table.
* = Secondary MCL
mmhos/com = milli mhos per centimeter
Bold indicates detected results.
Dark gray shading indicates screening level exceedance for VOCs.
- = No natural attenuation criteria

mV = millivolts
NS = Not Sampled
NTU = Nephelometric Turbidity Unit
OOR - Out of Range
S = Shallow well
U = Compound was not detected
ug/L = micrograms per liter

** - Equals points assignment for determining favorable conditions for biodegradation
0-5 = Inadequate
6-14 = Limited Evidence
15-20 = Adequate Evidence
>20 = Strong Evidence
Light gray shading indicates Evidence for biodegradation

Table 3-13
Groundwater Sample Results (Collected June 2016)
Remedial Investigation, Former Forbes Atlas S-5 Missile Site
Lyon County, Kansas

			Sample ID:	Natural Attenuation	Natural Attenuation	MW-07S-05	MW-08S-01	MW-09S-01	MW-10S-01	MW-11S-01	MW-12S-01	MW-13S-01
			Lab ID:	Screening	Screening	HS16070012-02	HS16061651-02	HS16061651-01	HS16061651-03	HS16061651-04	HS16061651-05	HS16070012-04
			Date Collected:	(Wiedemier)	(Wiedemier)	6/30/2016	6/29/2016	6/29/2016	6/29/2016	6/29/2016	6/29/2016	6/30/2016
		Screening Level		Favorable	Points**							
Analyte	Units	USEPA MCL		Concentration		Result	Result	Result	Result	Result	Result	Result
cis-1,2-Dichloroethene	ug/L	70		Daughter	2	**0.73** J	0.5 U	0.5 U	0.5 U	**12** J	0.5 U	**5.5** J
Trichloroethene	ug/L	5		Released	0	**6.6** J	**0.44** J	0.5 U	0.5 U	**61** J	**2** J	**51** J
Vinyl Chloride	ug/L	2		Daughter	2	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Natural Attenuation Parameters												
Alkalinity as CaCO3	mg/L	NA		2 times background	1	**322**	**318**	**337**	**351**	**444**	**547**	**364**
Alkalinity, Bicarbonate (As CaCO3)	mg/L	NA		-	-	**322**	**318**	**337**	**351**	**444**	**547**	**364**
Alkalinity, Carbonate (As CaCO3)	mg/L	NA		-	-	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Alkalinity, Hydroxide (As CaCO3)	mg/L	NA		-	-	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Bromide	mg/L	NA		-	-	0.05 U	0.05 U	**0.084** J	**0.058** J	**0.173**	**0.884**	**0.051** J
Chloride *	mg/L	250		2 times background	2	**3.23**	**6.07**	**7.85**	**2.84**	**7.86**	**36.7**	**4.18**
Ethane	ug/L	NA		>10/>100 ug/L	2.0/3.0	0.361 U	0.361 U	**1.39**	0.361 U	0.361 U	**0.753** J	0.361 U
Ethene	ug/L	NA		>10/>100 ug/L	2.0/3.0	0.337 U	0.337 U	**1.83**	**1.05**	**1.62**	**1.45**	0.337 U
Fluoride *	mg/L	4		-	-	**0.33**	**0.476**	**0.509**	**0.48**	**0.291**	**0.491**	**0.469**
Methane	ug/L	NA		>100/1,000 ug/L	2.0/3.0	**1.45**	**0.334** J	**1.91**	0.2 U	0.2 U	**0.45** J	0.2 U
Nitrate as N	mg/L	10		<1 mg/L	2	0.05 U	**0.044** J	**0.111**	**0.112**	**0.4**	**0.426**	**0.429**
Nitrate/Nitrite	mg/L	10		-	-	0.1 U	**0.044** J	**0.111**	**0.112**	**0.556**	**0.426**	**0.429**
Nitrite as N	mg/L	1		-	-	0.05 U	0.05 U	0.05 U	0.05 U	**0.156** J	0.05 U	0.05 U
Phosphorus	mg/L	NA		-	-	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
Sulfate *	mg/L	250		<20 mg/L	2	**31**	**42**	**59.9**	**31.1**	**69.9**	**87.2**	**32.9**
Sulfide	mg/L	NA		>1 mg/L	3	**1**	1 U	1 U	1 U	1 U	1 U	2.6 U
pH *	SU	6.5 to 8.5		5<pH<9	0	**7.1**	**7.1**	**7.2**	**7.0**	**6.8**	**6.9**	**7.2**
Temperature	°C	NA		>20 C	1	**23.52**	**21.6**	**19.66**	**23.91**	**27.53**	**25.24**	**25.22**
Oxidation-Reduction Potential	mV	NA		< 50 mv/<-100 mv	1.0/2.0	**76.6**	**104.6**	**129.6**	**108.0**	**99.6**	**110.1**	**114.6**
Dissolved Oxygen	mg/L	NA		<0.5 />1 mg/L	3.0/-3.0	**2.43**	**1.64**	**2.81**	**6.0**	**2.04**	**2.98**	**6.01**
Ferrous iron	mg/L	0.3 for total iron		>1 mg/L	3	**0.3**	**0.1**	**0.0**	**0.1**	**0.55**	**0.1**	**0.0**
Natural Biodegradation Scoring						**2**	**0**	**-1**	**0**	**2**	**0**	**5**
Other Parameters												
Conductivity	mmhos/cm	NA				**0.49**	**0.537**	**0.533**	**0.614**	**0.788**	**1.009**	**0.593**
Turbidity	NTUs	NA				**131**	**13.0**	**7.62**	**14.3**	**33.8**	**80.0**	**11.0**
Depth to water	ft TOC	NA				**25.47**	**17.4**	**15.7**	**16.17**	**18.3**	**19.44**	**11.46**

D = Deep well
J = Estimated value
mg/L = milligrams per liter
MCL = Maximum contaminant level from May 2016 EPA RSL Table.
* = Secondary MCL
mmhos/com = milli mhos per centimeter
Bold indicates detected results.
Dark gray shading indicates screening level exceedance for VOCs.
- = No natural attenuation criteria

mV = millivolts
NS = Not Sampled
NTU = Nephelometric Turbidity Unit
OOR - Out of Range
S = Shallow well
U = Compound was not detected
ug/L = micrograms per liter

** - Equals points assignment for determining favorable conditions for biodegradation
0-5 = Inadequate
6-14 = Limited Evidence
15-20 = Adequate Evidence
>20 = Strong Evidence
Light gray shading indicates Evidence for biodegradation

Table 3-14
Groundwater Sample Results (Collected September 2016)
Remedial Investigation, Former Forbes Atlas S-5 Missile Site
Lyon County, Kansas

		Sample ID:	Natural Attenuation	Natural Attenuation	MW-01D-06	MW-02S-06	MW-02D-06	MW-02D-16	MW-03S-06	MW-03S-16
		Lab ID:	Screening	Screening	HS16090578-01	HS16090724-05	HS16090578-06	HS16090578-05	HS16090663-02	HS16090663-04
		Date Collected:	(Wiedemier)	(Wiedemier)	9/13/2016	9/15/2016	9/13/2016	9/13/2016	9/14/2016	9/14/2016
		Screening Level	Favorable	Points**				Duplicate		Duplicate
Analyte	Units	USEPA MCL	Concentration		Result	Result	Result	Result	Result	Result
cis-1,2-Dichloroethene	ug/L	70	Daughter	2	0.62 U	**6.9**	0.62 U	0.62 U	**0.45 J**	**0.43 J**
Trichloroethene	ug/L	5	Released	0	0.62 U	**96**	0.62 U	0.62 U	**4.4**	**4.3**
Vinyl Chloride	ug/L	2	Daughter	2	0.62 U	0.5 U	0.62 U	0.62 U	0.5 U	0.5 U
Natural Attenuation Parameters										
Alkalinity as CaCO3	mg/L	NA	2 times background	1	**357**	**382**	**283**	**283**	**320**	**320**
Alkalinity, Bicarbonate (As CaCO3)	mg/L	NA	-	-	**357**	**382**	**283**	**283**	**320**	**320**
Alkalinity, Carbonate (As CaCO3)	mg/L	NA	-	-	5 U	5 U	5 U	5 U	5 U	5 U
Alkalinity, Hydroxide (As CaCO3)	mg/L	NA	-	-	5 U	5 U	5 U	5 U	5 U	5 U
Bromide	mg/L	NA	-	-	**0.241**	**0.435 J**	**0.122**	**0.123**	0.05 UJ	0.05 UJ
Chloride *	mg/L	250	2 times background	2	**77.4**	**5.08**	**26.9**	**26.7**	**2.45**	**2.53**
Ethane	ug/L	NA	>10/>100 ug/L	2.0/3.0	**2.04**	0.772 U	0.772 U	0.772 U	0.772 U	0.772 U
Ethene	ug/L	NA	>10/>100 ug/L	2.0/3.0	**1.8**	0.674 U	0.674 U	0.674 U	0.674 U	0.674 U
Fluoride *	mg/L	4	-	-	**1.15**	**0.382**	**1.25**	**1.24**	**0.313**	**0.323**
Methane	ug/L	NA	>100/1,000 ug/L	2.0/3.0	**13.4**	**0.623**	**1.41**	**1.35**	**0.955**	0.384 U
Nitrate as N	mg/L	10	<1 mg/L	2	0.07 U	**0.209**	0.162 U	0.155 U	**0.597**	**0.701**
Nitrate/Nitrite	mg/L	10	-	-	0.07 U	**0.209**	0.162 U	0.155 U	**0.597**	**0.701**
Nitrite as N	mg/L	1	-	-	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
Phosphorus	mg/L	NA	-	-	**0.229**	**0.252**	0.05 U	0.05 U	0.05 UJ	0.05 UJ
Sulfate *	mg/L	250	<20 mg/L	2	**390**	**49.3**	**124**	**122**	**29.5**	**33.6**
Sulfide	mg/L	NA	>1 mg/L	3	**5.2**	**2.28**	**5.8**	**1.4**	**2.68**	**1.48**
pH *	SU	6.5 to 8.5	5<pH<9	0	**6.46**	**5.93**	**7.38**	NA	**6.31**	NA
Temperature	°C	NA	>20 C	1	**17.87**	**17.79**	**24.1**	NA	**18**	NA
Oxidation-Reduction Potential	mV	NA	< 50 mv/<-100 mv	1.0/2.0	**-84.7**	**56.9**	**-28.6**	NA	**41.6**	NA
Dissolved Oxygen	mg/L	NA	<0.5 />1 mg/L	3.0/-3.0	**1.11**	**0.54**	**1.87**	NA	**1.94**	NA
Ferrous iron	mg/L	0.3 for total iron	>1 mg/L	3	**1.4**	**0.1**	**0.0**	NA	**0.0**	NA
Natural Biodegradation Scoring					**6**	**5**	**4**	**5**	**3**	**5**
Other Parameters										
Conductivity	mmhos/cm	NA			**1.229**	**0.691**	**0.78**	NA	**0.411**	NA
Turbidity	NTUs	NA			**87.4**	**1.55**	**2.65**	NA	**8.07**	NA
Depth to water	ft TOC	NA			**52.33**	**22.05**	**48.51**	NA	**19.76**	NA

D = Deep well
J = Estimated value
mg/L = milligrams per liter
MCL = Maximum contaminant level from May 2016 EPA RSL Table.
* = Secondary MCL
mmhos/com = milli mhos per centimeter
Bold indicates detected results.
Dark gray shading indicates screening level exceedance for VOCs.
- = No natural attenuation criteria

mV = millivolts
NS = Not Sampled
NTU = Nephelometric Turbidity Unit
OOR - Out of Range
S = Shallow well
U = Compound was not detected
ug/L = micrograms per liter

** - Equals points assignment for determining favorable conditions for biodegradation
0-5 = Inadequate
6-14 = Limited Evidence
15-20 = Adequate Evidence
>20 = Strong Evidence
Light gray shading indicates Evidence for biodegradation

Table 3-14
Groundwater Sample Results (Collected September 2016)
Remedial Investigation, Former Forbes Atlas S-5 Missile Site
Lyon County, Kansas

			Sample ID:	Natural Attenuation	Natural Attenuation	MW-03D-06	MW-04S-06	MW-04D-06	MW-05D-06	MW-06S-06	MW-06D-06
			Lab ID:	Screening	Screening	HS16090663-01	HS16090529-02	HS16090529-01	HS16090529-03	HS16090724-01	HS16090663-06
			Date Collected:	(Wiedemier)	(Wiedemier)	9/14/2016	9/12/2016	9/12/2016	9/12/2016	9/15/2016	9/14/2016
Analyte	**Units**	**Screening Level USEPA MCL**		**Favorable Concentration**	**Points****	**Result**	**Result**	**Result**	**Result**	**Result**	**Result**
cis-1,2-Dichloroethene	ug/L	70		Daughter	2	0.5 U	0.62 U	0.62 U	0.62 U	**2.3**	0.5 U
Trichloroethene	ug/L	5		Released	0	0.5 U	0.62 U	0.62 U	0.62 U	**24**	0.5 U
Vinyl Chloride	ug/L	2		Daughter	2	0.5 U	0.62 U	0.62 U	0.62 U	0.5 U	0.5 U
Natural Attenuation Parameters											
Alkalinity as CaCO3	mg/L	NA		2 times background	1	**331**	**297**	**325**	**402**	**368**	**315**
Alkalinity, Bicarbonate (As CaCO3)	mg/L	NA		-	-	**331**	**297**	**325**	**402**	**368**	**315**
Alkalinity, Carbonate (As CaCO3)	mg/L	NA		-	-	5 U	5 U	5 U	5 U	5 U	5 U
Alkalinity, Hydroxide (As CaCO3)	mg/L	NA		-	-	5 U	5 U	5 U	5 U	5 U	5 U
Bromide	mg/L	NA		-	-	**0.239 J**	**0.123**	**0.2**	**0.265**	**0.392 J**	**0.119 J**
Chloride *	mg/L	250		2 times background	2	**73**	**14.6**	**62.3**	**77.1**	**2.73**	**20.2**
Ethane	ug/L	NA		>10/>100 ug/L	2.0/3.0	0.772 U	**1.62**	**1.13**	**0.921 J**	0.772 U	**1.82**
Ethene	ug/L	NA		>10/>100 ug/L	2.0/3.0	**3.7**	**2.53**	**3.96**	**4.1**	0.674 U	**2.06**
Fluoride *	mg/L	4		-	-	**0.943**	**0.483**	**1.18**	**1.21**	**0.344**	**1.04**
Methane	ug/L	NA		>100/1,000 ug/L	2.0/3.0	**4.52**	**5.04**	**15.2**	**11.1**	0.384 U	**19.3**
Nitrate as N	mg/L	10		<1 mg/L	2	0.07 U	**0.072 J**	0.05 U	0.05 U	**0.503**	0.07 U
Nitrate/Nitrite	mg/L	10		-	-	0.07 U	**0.072 J**	0.1 U	0.1 U	**0.503**	0.07 U
Nitrite as N	mg/L	1		-	-	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
Phosphorus	mg/L	NA		-	-	**0.238 J**	0.05 U	**0.067 J**	**0.174**	0.05 U	**0.213 J**
Sulfate *	mg/L	250		<20 mg/L	2	**453**	**69.7**	**324**	**492**	**45.2**	**166**
Sulfide	mg/L	NA		>1 mg/L	3	**4.08**	**2.2**	**4.4**	**5.4**	1 U	**6.08**
pH *	SU	6.5 to 8.5		5<pH<9	0	**5.99**	**7.2**	**6.9**	**7.1**	**6.8**	**7.16**
Temperature	°C	NA		>20 C	1	**16.88**	**28.34**	**23.8**	**26.64**	**19.56**	**23.29**
Oxidation-Reduction Potential	mV	NA		< 50 mv/<-100 mv	1.0/2.0	**-3.7**	**-89.7**	**-78.9**	**-112.2**	**29.0**	**-88.4**
Dissolved Oxygen	mg/L	NA		<0.5 />1 mg/L	3.0/-3.0	**1.73**	**0.64**	**1.42**	**1.07**	**2.44**	**1.2**
Ferrous iron	mg/L	0.3 for total iron		>1 mg/L	3	**0.6**	**0.0**	**0.8**	**0.7**	**0.1**	**0.5**
Natural Biodegradation Scoring						**3**	**7**	**4**	**5**	**0**	**4**
Other Parameters											
Conductivity	mmhos/cm	NA				**0.722**	**0.824**	**1.433**	**2.099**	**0.697**	**0.951**
Turbidity	NTUs	NA				**10.4**	**OOR**	**36.8**	**23.4**	**10.7**	**7.86**
Depth to water	ft TOC	NA				**46.71**	**31.57**	**53.85**	**53.77**	**10.98**	**31.09**

D = Deep well
J = Estimated value
mg/L = milligrams per liter
MCL = Maximum contaminant level from May 2016 EPA RSL Table.
* = Secondary MCL
mmhos/com = milli mhos per centimeter
Bold indicates detected results.
Dark gray shading indicates screening level exceedance for VOCs.
- = No natural attenuation criteria

mV = millivolts
NS = Not Sampled
NTU = Nephelometric Turbidity Unit
OOR - Out of Range
S = Shallow well
U = Compound was not detected
ug/L = micrograms per liter

** - Equals points assignment for determining favorable conditions for biodegradation
0-5 = Inadequate
6-14 = Limited Evidence
15-20 = Adequate Evidence
>20 = Strong Evidence
Light gray shading indicates Evidence for biodegradation

Table 3-14
Groundwater Sample Results (Collected September 2016)
Remedial Investigation, Former Forbes Atlas S-5 Missile Site
Lyon County, Kansas

		Sample ID:	Natural Attenuation	Natural Attenuation	MW-07S-06	MW-08S-02	MW-09S-02	MW-10S-02	MW-11S-02	MW-12S-02	MW-13S-02
		Lab ID:	Screening	Screening	HS16090663-05	HS16090578-07	HS16090578-02	HS16090578-03	HS16090724-04	HS16090663-03	HS16090724-02
		Date Collected:	(Wiedemier)	(Wiedemier)	9/14/2016	9/13/2016	9/13/2016	9/13/2016	9/15/2016	9/14/2016	9/15/2016
		Screening Level	Favorable	Points**							
Analyte	**Units**	**USEPA MCL**	**Concentration**		**Result**	**Result**	**Result**	**Result**	**Result**	**Result**	**Result**
cis-1,2-Dichloroethene	ug/L	70	Daughter	2	**0.55 J**	0.62 U	0.62 U	0.62 U	**17**	0.5 U	0.5 U
Trichloroethene	ug/L	5	Released	0	**7.4**	0.62 U	0.62 U	0.62 U	**65**	**1.6**	**4**
Vinyl Chloride	ug/L	2	Daughter	2	0.5 U	0.62 U	0.62 U	0.62 U	0.5 U	0.5 U	0.5 U
Natural Attenuation Parameters											
Alkalinity as CaCO3	mg/L	NA	2 times background	1	**324**	**216**	**353**	**409**	**486**	**600**	**184**
Alkalinity, Bicarbonate (As CaCO3)	mg/L	NA	-	-	**324**	**216**	**353**	**409**	**486**	**600**	**184**
Alkalinity, Carbonate (As CaCO3)	mg/L	NA	-	-	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Alkalinity, Hydroxide (As CaCO3)	mg/L	NA	-	-	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Bromide	mg/L	NA	-	-	0.05 UJ	0.05 U	**0.137**	**0.132**	**0.482 J**	**1.01 J**	**0.364 J**
Chloride *	mg/L	250	2 times background	2	**2.97**	**3.85**	**6.62**	**1.16**	**6.3**	**37.4**	**2.97**
Ethane	ug/L	NA	>10/>100 ug/L	2.0/3.0	0.772 U	0.772 U	0.772 U	0.772 U	0.772 U	**0.732 J**	0.772 U
Ethene	ug/L	NA	>10/>100 ug/L	2.0/3.0	**0.707 J**	0.674 U	**0.937 J**	0.674 U	0.674 U	**1.02**	0.674 U
Fluoride *	mg/L	4	-	-	**0.263**	**0.373**	**0.406**	**0.471**	**0.234**	**0.397**	**0.241**
Methane	ug/L	NA	>100/1,000 ug/L	2.0/3.0	**1.21**	**6.1**	0.384 U	0.384 U	0.384 U	**0.743**	0.384 U
Nitrate as N	mg/L	10	<1 mg/L	2	0.0852 U	0.076 U	0.167 U	0.103 U	**0.295**	**0.366**	0.351 U
Nitrate/Nitrite	mg/L	10	-	-	0.0852 U	0.076 U	0.167 U	0.103 U	**0.295**	**0.366**	0.351 U
Nitrite as N	mg/L	1	-	-	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
Phosphorus	mg/L	NA	-	-	**0.119 J**	0.05 U	**0.049 J**	0.05 U	**0.229**	0.05 UJ	0.05 U
Sulfate *	mg/L	250	<20 mg/L	2	**28**	**8.93**	**48.1**	**20.9**	**68**	**75.4**	**9.03**
Sulfide	mg/L	NA	>1 mg/L	3	**4.08**	**3.6**	**2.6**	3.2 U	**3.28**	**3.08**	1 U
pH *	SU	6.5 to 8.5	5<pH<9	0	**7.06**	**7.07**	**7.05**	**7.0**	**6.9**	**6.99**	**7.41**
Temperature	°C	NA	>20 C	1	**23.01**	**19.29**	**18.43**	**19.99**	**24.3**	**21.63**	**22.28**
Oxidation-Reduction Potential	mV	NA	< 50 mv/<-100 mv	1.0/2.0	**3.3**	**6.9**	**0.4**	**11.7**	**26.6**	**39.1**	**25.9**
Dissolved Oxygen	mg/L	NA	<0.5 />1 mg/L	3.0/-3.0	**1.17**	**1**	**1.74**	**1.87**	**1.39**	**1.69**	**1.95**
Ferrous iron	mg/L	0.3 for total iron	>1 mg/L	3	**0.2**	**0.0**	**0.0**	**0.1**	**0.1**	**0.1**	**0.0**
Natural Biodegradation Scoring					**4**	**8**	**3**	**0**	**4**	**4**	**3**
Other Parameters											
Conductivity	mmhos/cm	NA			**0.509**	**0.349**	**0.658**	**0.687**	**1.049**	**1.223**	**0.375**
Turbidity	NTUs	NA			**26.5**	**38.2**	**14**	**14.5**	**24.5**	**147.0**	**35.3**
Depth to water	ft TOC	NA			**24.68**	**12.86**	**14.01**	**15.63**	**17.23**	**21.75**	**11.18**

D = Deep well
J = Estimated value
mg/L = milligrams per liter
MCL = Maximum contaminant level from May 2016 EPA RSL Table.
* = Secondary MCL
mmhos/com = milli mhos per centimeter
Bold indicates detected results.
Dark gray shading indicates screening level exceedance for VOCs.
- = No natural attenuation criteria

mV = millivolts
NS = Not Sampled
NTU = Nephelometric Turbidity Unit
OOR - Out of Range
S = Shallow well
U = Compound was not detected
ug/L = micrograms per liter

** - Equals points assignment for determining favorable conditions for biodegradation
0-5 = Inadequate
6-14 = Limited Evidence
15-20 = Adequate Evidence
>20 = Strong Evidence
Light gray shading indicates Evidence for biodegradation

Table 3-15
Groundwater Sample Results (Collected December 2016)
Remedial Investigation, Former Forbes Atlas S-5 Missile Site
Lyon County, Kansas

		Sample ID:	Natural Attenuation	Natural Attenuation	MW-01D-07	MW-02S-07	MW-02S-17	MW-02D-07	MW-02D-17	MW-03S-07
		Lab ID:	Screening	Screening	HS16120711-01	HS16120899-06	HS16120899-07	HS16120711-04	HS16120711-05	HS16120767-03
		Date Collected:	(Wiedemier)	(Wiedemier)	12/13/2016	12/15/2016	12/15/2016	12/13/2016	12/13/2016	12/14/2016
		Screening Level	Favorable	Points**			Duplicate		Duplicate	
Analyte	Units	USEPA MCL	Concentration		Result	Result	Result	Result	Result	Result
cis-1,2-Dichloroethene	ug/L	70	Daughter	2	0.62 U	**6.1**	**5.9**	0.62 U	0.62 U	0.62 U
Trichloroethene	ug/L	5	Released	0	0.5 U	**100**	**100**	0.5 U	0.5 U	**3.4**
Vinyl Chloride	ug/L	2	Daughter	2	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Natural Attenuation Parameters										
Alkalinity as CaCO3	mg/L	NA	2 times background	1	**459**	**444**	**444**	**304**	**303**	**341**
Alkalinity, Bicarbonate (As CaCO3)	mg/L	NA	-	-	**459**	**444**	**444**	**304**	**303**	**341**
Alkalinity, Carbonate (As CaCO3)	mg/L	NA	-	-	5 U	5 U	5 U	5 U	5 U	5 U
Alkalinity, Hydroxide (As CaCO3)	mg/L	NA	-	-	5 U	5 U	5 U	5 U	5 U	5 U
Bromide	mg/L	NA	-	-	**0.683**	**0.07 J**	**0.21**	0.05 U	0.05 U	0.05 U
Chloride *	mg/L	250	2 times background	2	**81.8**	**4.31**	**4.36**	**26.6**	**27.7**	**2.7**
Ethane	ug/L	NA	>10/>100 ug/L	2.0/3.0	**2.17**	0.772 U	0.772 U	0.772 U	0.772 U	0.772 U
Ethene	ug/L	NA	>10/>100 ug/L	2.0/3.0	**1.55**	0.674 U	0.674 U	**0.617 J**	**0.795 J**	0.674 U
Fluoride *	mg/L	4	-	-	**1.21**	**0.334**	**0.34**	**1.24**	**1.32**	**0.337**
Methane	ug/L	NA	>100/1,000 ug/L	2.0/3.0	**16.2**	**1.53**	**1.67**	**5.39**	**5.54**	0.384 U
Nitrate as N	mg/L	10	<1 mg/L	2	**0.266**	**0.036 J**	0.05 U	0.05 U	**0.125**	**0.638**
Nitrate/Nitrite	mg/L	10	-	-	**0.266**	**0.036 J**	0.1 U	0.1 U	**0.125**	**0.638**
Nitrite as N	mg/L	1	-	-	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
Phosphorus	mg/L	NA	-	-	**0.198**	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
Sulfate *	mg/L	250	<20 mg/L	2	**409**	**47.1**	**48**	**125**	**129**	**34.4**
Sulfide	mg/L	NA	>1 mg/L	3	**4.52**	1 U	1 U	1 U	1 U	**1.32**
pH *	SU	6.5 to 8.5	5<pH<9	0	**8.25**	**6.89**	NA	**7.06**	NA	**7.7**
Temperature	°C	NA	>20 C	1	**10.65**	**13.67**	NA	**5.9**	NA	**10.46**
Oxidation-Reduction Potential	mV	NA	< 50 mv/<-100 mv	1.0/2.0	**-61.2**	**65.4**	NA	**46.2**	NA	**26.6**
Dissolved Oxygen	mg/L	NA	<0.5 />1 mg/L	3.0/-3.0	**1.28**	**0.58**	NA	**1.26**	NA	**1.54**
Ferrous iron	mg/L	0.3 for total iron	>1 mg/L	3	**0.3**	0	NA	0	NA	0
Natural Biodegradation Scoring					**3**	**2**	**2**	**0**	**2**	**3**
Other Parameters										
Conductivity	mmhos/cm	NA			**1.817**	**0.953**	NA	**0.757**	NA	**0.664**
Turbidity	NTUs	NA			**31.2**	**3.12**	NA	**4.46**	NA	**14.1**
Depth to water	ft TOC	NA			**50.9**	**25.28**	NA	**48.26**	NA	**22.81**

D = Deep well
J = Estimated value
mg/L = milligrams per liter
MCL = Maximum contaminant level from May 2016 EPA RSL Table.
* = Secondary MCL
mmhos/com = milli mhos per centimeter
Bold indicates detected results.
Dark gray shading indicates screening level exceedance for VOCs.
- = No natural attenuation criteria

mV = millivolts
NS = Not Sampled
NTU = Nephelometric Turbidity Unit
S = Shallow well
U = Compound was not detected
ug/L = micrograms per liter
NA = Not available

** - Equals points assignment for determining favorable conditions for biodegradation
0-5 = Inadequate
6-14 = Limited Evidence
15-20 = Adequate Evidence
>20 = Strong Evidence
Light gray shading indicates Evidence for biodegradation

Table 3-15
Groundwater Sample Results (Collected December 2016)
Remedial Investigation, Former Forbes Atlas S-5 Missile Site
Lyon County, Kansas

		Sample ID:	Natural Attenuation	Natural Attenuation	MW-03D-07	MW-04S-07	MW-04D-07	MW-05D-07	MW-06S-07	MW-06D-07
		Lab ID:	Screening	Screening	HS16120767-02	HS16120645-02	HS16120645-01	HS16120645-03	HS16120899-02	HS16120899-01
		Date Collected:	(Wiedemier)	(Wiedemier)	12/14/2016	12/12/2016	12/12/2016	12/12/2016	12/15/2016	12/15/2016
		Screening Level	Favorable	Points**						
Analyte	Units	USEPA MCL	Concentration		Result	Result	Result	Result	Result	Result
cis-1,2-Dichloroethene	ug/L	70	Daughter	2	0.62 U	0.62 U	0.62 U	0.62 U	**0.88 J**	0.62 U
Trichloroethene	ug/L	5	Released	0	0.5 U	0.5 U	0.5 U	0.5 U	**15**	0.5 U
Vinyl Chloride	ug/L	2	Daughter	2	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Natural Attenuation Parameters										
Alkalinity as CaCO3	mg/L	NA	2 times background	1	**377**	**300**	**301**	**419**	**405**	**344**
Alkalinity, Bicarbonate (As CaCO3)	mg/L	NA	-	-	**377**	**300**	**301**	**419**	**405**	**344**
Alkalinity, Carbonate (As CaCO3)	mg/L	NA	-	-	5 U	5 U	5 U	5 U	5 U	5 U
Alkalinity, Hydroxide (As CaCO3)	mg/L	NA	-	-	5 U	5 U	5 U	5 U	5 U	5 U
Bromide	mg/L	NA	-	-	0.05 U	**0.109**	**0.203**	**0.272**	0.05 U	0.05 U
Chloride *	mg/L	250	2 times background	2	**91.5**	**11.4**	**69.3**	**82**	**2.74**	**19.9**
Ethane	ug/L	NA	>10/>100 ug/L	2.0/3.0	0.772 U	**0.964 J**	**1.08**	**0.671 J**	0.772 U	**1.56**
Ethene	ug/L	NA	>10/>100 ug/L	2.0/3.0	**1.31**	**1.71**	**4.91**	**4.59**	0.674 U	**2.72**
Fluoride *	mg/L	4	-	-	**1.15**	**0.486**	**1.34**	**1.32**	**0.326**	**1.05**
Methane	ug/L	NA	>100/1,000 ug/L	2.0/3.0	**5.38**	**1.35**	**12.9**	**10.5**	0.384 U	**15.2**
Nitrate as N	mg/L	10	<1 mg/L	2	0.05 U	0.05 U	0.05 U	0.05 U	**0.36 J**	0.05 UJ
Nitrate/Nitrite	mg/L	10	-	-	0.1 U	0.1 U	0.1 U	0.1 U	**0.36 J**	0.1 UJ
Nitrite as N	mg/L	1	-	-	0.05 U	0.05 U	0.05 U	0.05 U	0.05 UJ	0.05 UJ
Phosphorus	mg/L	NA	-	-	0.05 U	0.05 U	**0.066 J**	**0.071 J**	0.05 U	**0.162**
Sulfate *	mg/L	250	<20 mg/L	2	**473**	**43.2**	**351**	**519**	**49.3**	**159**
Sulfide	mg/L	NA	>1 mg/L	3	**2.72**	**5.12**	**2.92**	**4.52**	1 U	1 U
pH *	SU	6.5 to 8.5	5<pH<9	0	**7.14**	**8.54**	**8.6**	**8.68**	**7.62**	**7.54**
Temperature	°C	NA	>20 C	1	**9.7**	**5.95**	**6.29**	**6.86**	**9.74**	**10.85**
Oxidation-Reduction Potential	mV	NA	< 50 mv/<-100 mv	1.0/2.0	**-4.6**	**-61.4**	**-105.9**	**-54.2**	**15**	**-45.3**
Dissolved Oxygen	mg/L	NA	<0.5 />1 mg/L	3.0/-3.0	**1.56**	**1.84**	**1.09**	**1.11**	**2.11**	**1**
Ferrous iron	mg/L	0.3 for total iron	>1 mg/L	3	0	**0.3**	**0.5**	**0.3**	**0.1**	**0.3**
Natural Biodegradation Scoring					**3**	**4**	**5**	**4**	**1**	**3**
Other Parameters										
Conductivity	mmhos/cm	NA			**1.683**	**0.614**	**1.343**	**2.107**	**0.784**	**1.008**
Turbidity	NTUs	NA			**14.1**	**354**	**35.1**	**19**	**11.3**	**6.4**
Depth to water	ft TOC	NA			**46.63**	**32.94**	**57.94**	**55.86**	**17.58**	**33.62**

D = Deep well
J = Estimated value
mg/L = milligrams per liter
MCL = Maximum contaminant level from May 2016 EPA RSL Table.
* = Secondary MCL
mmhos/com = milli mhos per centimeter
Bold indicates detected results.
Dark gray shading indicates screening level exceedance for VOCs.
- = No natural attenuation criteria

mV = millivolts
NS = Not Sampled
NTU = Nephelometric Turbidity Unit
S = Shallow well
U = Compound was not detected
ug/L = micrograms per liter
NA = Not available

** - Equals points assignment for determining favorable conditions for biodegradation
0-5 = Inadequate
6-14 = Limited Evidence
15-20 = Adequate Evidence
>20 = Strong Evidence
Light gray shading indicates Evidence for biodegradation

Table 3-15
Groundwater Sample Results (Collected December 2016)
Remedial Investigation, Former Forbes Atlas S-5 Missile Site
Lyon County, Kansas

		Sample ID:	Natural Attenuation	Natural Attenuation	MW-07S-07	MW-08S-03	MW-09S-03	MW-10S-03	MW-11S-03	MW-12S-03	MW-13S-03
		Lab ID:	Screening	Screening	HS16120767-05	HS16120767-01	HS16120711-02	HS16120711-03	HS16120899-05	HS16120767-04	HS16120899-03
		Date Collected:	(Wiedemier)	(Wiedemier)	12/14/2016	12/14/2016	12/13/2016	12/13/2016	12/15/2016	12/14/2016	12/15/2016
		Screening Level	Favorable	Points**							
Analyte	**Units**	**USEPA MCL**	**Concentration**		**Result**	**Result**	**Result**	**Result**	**Result**	**Result**	**Result**
cis-1,2-Dichloroethene	ug/L	70	Daughter	2	0.62 U	0.62 UJ	0.62 U	0.62 U	**18**	0.62 U	**8.6**
Trichloroethene	ug/L	5	Released	0	**6.7**	0.5 UJ	0.5 U	0.5 U	**69**	**1.3**	**97**
Vinyl Chloride	ug/L	2	Daughter	2	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	2 U
Natural Attenuation Parameters											
Alkalinity as CaCO3	mg/L	NA	2 times background	1	**354**	**396**	**373**	**442**	**495**	**658**	**336**
Alkalinity, Bicarbonate (As CaCO3)	mg/L	NA	-	-	**354**	**396**	**373**	**442**	**495**	**658**	**336**
Alkalinity, Carbonate (As CaCO3)	mg/L	NA	-	-	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Alkalinity, Hydroxide (As CaCO3)	mg/L	NA	-	-	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Bromide	mg/L	NA	-	-	0.05 U	**0.034 J**	0.05 U	0.05 U	**0.14**	**1.02**	0.05 U
Chloride *	mg/L	250	2 times background	2	**2.35**	**8.57**	**6.5**	**0.971**	**7.2**	**42.1**	**2.76**
Ethane	ug/L	NA	>10/>100 ug/L	2.0/3.0	0.772 U	0.772 U	0.772 U	0.772 U	0.772 U	**0.674 J**	0.772 U
Ethene	ug/L	NA	>10/>100 ug/L	2.0/3.0	0.674 U	**1.1**	**2.05**	**1.75**	**2.09**	0.674 U	0.674 U
Fluoride *	mg/L	4	-	-	**0.258**	**0.278**	**0.397**	**0.459**	**0.256**	**0.39**	**0.293**
Methane	ug/L	NA	>100/1,000 ug/L	2.0/3.0	**0.19 J**	**34.7**	0.384 U	0.384 U	0.384 U	0.384 U	0.384 U
Nitrate as N	mg/L	10	<1 mg/L	2	0.05 U	0.05 U	**0.064 J**	0.05 U	**0.043 J**	**0.581**	**0.414**
Nitrate/Nitrite	mg/L	10	-	-	0.1 U	0.1 U	**0.064 J**	0.1 U	**0.043 J**	**0.581**	**0.414**
Nitrite as N	mg/L	1	-	-	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
Phosphorus	mg/L	NA	-	-	0.05 U	0.05 U	0.05 U	0.05 U	**0.081 J**	0.05 U	0.05 U
Sulfate *	mg/L	250	<20 mg/L	2	**29**	**43**	**45.5**	**19.7**	**68.9**	**68.6**	**19.6**
Sulfide	mg/L	NA	>1 mg/L	3	1 U	1 U	**1.52**	**2.12**	1 U	1 U	1 U
pH *	SU	6.5 to 8.5	5<pH<9	0	**7.8**	**6.61**	**8.06**	**7.82**	**7.09**	**7.13**	**7.91**
Temperature	°C	NA	>20 C	1	**11.16**	**11.31**	**10.02**	**9.24**	**10.72**	**10.87**	**9.88**
Oxidation-Reduction Potential	mV	NA	< 50 mv/<-100 mv	1.0/2.0	**7.3**	**54**	**-3.5**	**13.1**	**56.6**	**62**	**21.7**
Dissolved Oxygen	mg/L	NA	<0.5 />1 mg/L	3.0/-3.0	**1.33**	**1.8**	**1.4**	**1.34**	**2.12**	**2.4**	**3.32**
Ferrous iron	mg/L	0.3 for total iron	>1 mg/L	3	**0.2**	**0.3**	**0.1**	0	**0.2**	**0.1**	0
Natural Biodegradation Scoring					**1**	**1**	**3**	**5**	**0**	**0**	**3**
Other Parameters											
Conductivity	mmhos/cm	NA			**0.66**	**0.815**	**0.758**	**0.752**	**0.973**	**1.364**	**0.625**
Turbidity	NTUs	NA			**57.9**	**44.8**	**13.2**	**20.6**	**29.1**	**168**	**44.7**
Depth to water	ft TOC	NA			**27.85**	**15.19**	**16.6**	**18.8**	**20.64**	**22.12**	**14.71**

D = Deep well
J = Estimated value
mg/L = milligrams per liter
MCL = Maximum contaminant level from May 2016 EPA RSL Table.
* = Secondary MCL
mmhos/com = milli mhos per centimeter
Bold indicates detected results.
Dark gray shading indicates screening level exceedance for VOCs.
- = No natural attenuation criteria

mV = millivolts
NS = Not Sampled
NTU = Nephelometric Turbidity Unit
S = Shallow well
U = Compound was not detected
ug/L = micrograms per liter
NA = Not available

** - Equals points assignment for determining favorable conditions for biodegradation
0-5 = Inadequate
6-14 = Limited Evidence
15-20 = Adequate Evidence
>20 = Strong Evidence
Light gray shading indicates Evidence for biodegradation

Table 3-16
Groundwater Sample Results (Collected March 2017)
Remedial Investigation, Former Forbes Atlas S-5 Missile Site
Lyon County, Kansas

			Sample ID:	Natural Attenuation	Natural Attenuation	MW-01D-08	MW-02S-08	MW-02S-18	MW-02D-08	MW-03S-08	MW-03D-08
			Lab ID:	Screening	Screening	HS17031470-04	HS17031646-05	HS17031646-06	HS17031611-03	HS17031646-01	HS17031611-05
			Date Collected:	(Wiedemier)	(Wiedemier)	3/28/2017	3/30/2017	3/30/2017	3/29/2017	3/30/2017	3/29/2017
		Screening Level		Favorable	Points**			Duplicate			
Analyte	Units	Federal MCL		Concentration		Result	Result	Result	Result	Result	Result
Cis-1,2-Dichloroethene	ug/L	70		Daughter	2	0.5 U	**7.5**	**7**	0.5 U	0.5 U	0.5 U
Trichloroethene	ug/L	5		Released	0	0.5 U	**82**	**77**	0.5 U	**4.3**	0.5 U
Vinyl Chloride	ug/L	2		Daughter	2	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Natural Attenuation Parameters											
Alkalinity as CaCO3	mg/L	NA		2 times background	1	**459**	**439**	**444**	**299**	**430**	**399**
Alkalinity, Bicarbonate (As CaCO3)	mg/L	NA		-	-	**459**	**439**	**444**	**299**	**430**	**399**
Alkalinity, Carbonate (As CaCO3)	mg/L	NA		-	-	5 U	5 U	5 U	5 U	5 U	5 U
Alkalinity, Hydroxide (As CaCO3)	mg/L	NA		-	-	5 U	5 U	5 U	5 U	5 U	5 U
Bromide	mg/L	NA		-	-	**0.518 J**	**0.45**	**0.448**	0.05 U	0.05 U	**0.52**
Chloride *	mg/L	250		2 times background	2	**83.1**	**4.11**	**3.97**	**25.7**	**3.18**	**84.2**
Ethane	ug/L	NA		>10/>100 ug/L	2.0/3.0	**0.575 J**	0.361 U	0.361 U	0.361 U	0.361 U	**0.267 J**
Ethene	ug/L	NA		>10/>100 ug/L	2.0/3.0	**0.693 J**	0.337 U	0.337 U	0.337 U	0.337 U	1.2 U
Fluoride *	mg/L	4		-	-	**1.24 J**	**0.409**	**0.414**	**1.35**	**0.394**	**1.05**
Methane	ug/L	NA		>100/1,000 ug/L	2.0/3.0	**3.67**	**2.09**	**1.96**	**3.33**	**0.635**	**5.29**
Nitrate as N	mg/L	10		<1 mg/L	2	0.05 U	**0.24**	**0.224**	0.05 U	**1.24**	0.05 U
Nitrate/Nitrite	mg/L	10		-	-	0.05 U	**0.24**	**0.224**	0.05 U	**1.24**	0.05 U
Nitrite as N	mg/L	1		-	-	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
Phosphorus	mg/L	NA		-	-	**4.29**	0.1 U	0.1 U	0.1 U	0.1 U	**1.54**
Sulfate *	mg/L	250		<20 mg/L	2	**399**	**40.9**	**40.4**	**115**	**29**	**451**
Sulfide	mg/L	NA		>1 mg/L	3	**4.84**	**2.16**	**1.16**	1 U	**1.96**	1 U
pH *	SU	6.5 to 8.5		5<pH<9	0	**7.11**	**6.93**	NA	**7.41**	**6.97**	**6.66**
Temperature	˚C	NA		>20 C	1	**13.29**	**12.7**	NA	**13.63**	**11.51**	**15.95**
Oxidation-Reduction Potential	mV	NA		< 50 mv/<-100 mv	1.0/2.0	**-89.6**	**89.8**	NA	**0.2**	**118**	**-50**
Dissolved Oxygen	mg/L	NA		<0.5 />1 mg/L	3.0/-3.0	**5.97**	**2.96**	NA	**2.92**	**1.4**	**1.97**
Ferrous iron	mg/L	0.3 for total iron		>1 mg/L	3	**0.7**	0	NA	**0.1**	**0.1**	**0.8**
Natural Biodegradation Scoring						**3**	**4**	NA	**0**	**0**	**0**
Other Parameters											
Conductivity	mmhos/cm	NA				**1.260**	**0.574**	NA	**0.595**	**0.539**	**1.343**
Turbidity	NTUs	NA				**35.4**	**6.95**	NA	**8.98**	**12.8**	**38.4**
Depth to water	ft TOC	NA				**49.45**	**17.91**	NA	**45.6**	**18.02**	**44.45**

D = Deep well
J = Estimated value
mg/L = milligrams per liter
MCL = Maximum contaminant level from May 2016 EPA RSL Table.
* = Secondary MCL
mmhos/com = milli mhos per centimeter
Bold indicates detected results.
Dark gray shading indicates screening level exceedance for VOCs.
- = No natural attenuation criteria

mV = millivolts
NS = Not Sampled
NTU = Nephelometric Turbidity Unit
S = Shallow well
U = Compound was not detected
ug/L = micrograms per liter
NA = Not available

** - Equals points assignment for determining favorable conditions for biodegradation
0-5 = Inadequate
6-14 = Limited Evidence
15-20 = Adequate Evidence
>20 = Strong Evidence
Light gray shading indicates Evidence for biodegradation

Table 3-16
Groundwater Sample Results (Collected March 2017)
Remedial Investigation, Former Forbes Atlas S-5 Missile Site
Lyon County, Kansas

			Sample ID:	Natural Attenuation	Natural Attenuation	MW-04S-08	MW-04D-08	MW-05D-08	MW-06S-08	MW-06S-18	MW-06D-08
			Lab ID:	Screening	Screening	HS17031470-02	HS17031414-01, HS17031470-01	HS17031470-03	HS17031470-08	HS17031470-09	HS17031470-07
			Date Collected:	(Wiedemier)	(Wiedemier)	3/28/2017	3/27/2017	3/28/2017	3/28/2017	3/28/2017	3/28/2017
		Screening Level		Favorable	Points**					Duplicate	
Analyte	Units	Federal MCL		Concentration		Result	Result	Result	Result	Result	Result
Cis-1,2-Dichloroethene	ug/L	70		Daughter	2	0.5 U	0.5 U	0.5 U	**2.9**	**2.5**	0.5 U
Trichloroethene	ug/L	5		Released	0	0.5 U	0.5 U	0.5 U	**28**	**29**	**0.83 J**
Vinyl Chloride	ug/L	2		Daughter	2	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Natural Attenuation Parameters											
Alkalinity as CaCO3	mg/L	NA		2 times background	1	**335**	**310**	**483**	**399**	**395**	**362**
Alkalinity, Bicarbonate (As CaCO3)	mg/L	NA		-	-	**335**	**310**	**483**	**399**	**395**	**362**
Alkalinity, Carbonate (As CaCO3)	mg/L	NA		-	-	5 U	5 U	5 U	5 U	5 U	5 U
Alkalinity, Hydroxide (As CaCO3)	mg/L	NA		-	-	5 U	5 U	5 U	5 U	5 U	5 U
Bromide	mg/L	NA		-	-	0.05 UJ	**0.475 J**	**0.54 J**	0.05 UJ	0.05 UJ	0.05 UJ
Chloride *	mg/L	250		2 times background	2	**7.47**	**62.5**	**83.3**	**2.92**	**2.46**	**20.8**
Ethane	ug/L	NA		>10/>100 ug/L	2.0/3.0	0.361 U	0.361 U	0.361 U	0.361 U	0.361 U	**1.11**
Ethene	ug/L	NA		>10/>100 ug/L	2.0/3.0	0.337 U	**3.55**	0.337 U	0.337 U	0.337 U	**2.209**
Fluoride *	mg/L	4		-	-	**0.458 J**	**1.38**	**1.31 J**	**0.375 J**	**0.361 J**	**1.17 J**
Methane	ug/L	NA		>100/1,000 ug/L	2.0/3.0	**0.894**	**9.22**	**2.09**	0.193 U	**0.277 J**	**11.1**
Nitrate as N	mg/L	10		<1 mg/L	2	0.05 U	0.05 U	0.05 U	**0.504**	**0.661**	0.05 U
Nitrate/Nitrite	mg/L	10		-	-	0.05 U	0.1 U	0.05 U	**0.504**	**0.661**	0.05 U
Nitrite as N	mg/L	1		-	-	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
Phosphorus	mg/L	NA		-	-	**0.538**	**0.815 J**	**4.3**	0.1 U	0.1 U	**0.816**
Sulfate *	mg/L	250		<20 mg/L	2	**28.9**	**334**	**557**	**40.4**	**42.1**	**170**
Sulfide	mg/L	NA		>1 mg/L	3	1 U	**1.04**	**1.64**	1 U	1 U	**3.24**
pH *	SU	6.5 to 8.5		5<pH<9	0	**7.13**	**6.97**	**7.2**	**6.96**	NA	**6.92**
Temperature	℃	NA		>20 C	1	**13.14**	**13.61**	**13.31**	**14.06**	NA	**14.68**
Oxidation-Reduction Potential	mV	NA		< 50 mv/<-100 mv	1.0/2.0	**-51.6**	**-81.7**	**-99.8**	**8.8**	NA	**-107.6**
Dissolved Oxygen	mg/L	NA		<0.5 />1 mg/L	3.0/-3.0	**3.32**	**0.92**	**6.02**	**3.35**	NA	**1.84**
Ferrous iron	mg/L	0.3 for total iron		>1 mg/L	3	**0.4**	**1.1**	**0.5**	**0.1**	NA	**0.8**
Natural Biodegradation Scoring						**0**	**9**	**4**	**2**	NA	**4**
Other Parameters											
Conductivity	mmhos/cm	NA				**0.45**	**0.988**	**1.582**	**0.544**	NA	**0.744**
Turbidity	NTUs	NA				**302**	**43.8**	**55.8**	**32.2**	NA	**20.4**
Depth to water	ft TOC	NA				**31.41**	**54.5**	**52.9**	**9.63**	NA	**29.78**

D = Deep well
J = Estimated value
mg/L = milligrams per liter
MCL = Maximum contaminant level from May 2016 EPA RSL Table.
* = Secondary MCL
mmhos/com = milli mhos per centimeter
Bold indicates detected results.
Dark gray shading indicates screening level exceedance for VOCs.
- = No natural attenuation criteria

mV = millivolts
NS = Not Sampled
NTU = Nephelometric Turbidity Unit
S = Shallow well
U = Compound was not detected
ug/L = micrograms per liter
NA = Not available

** - Equals points assignment for determining favorable conditions for biodegradation
0-5 = Inadequate
6-14 = Limited Evidence
15-20 = Adequate Evidence
>20 = Strong Evidence
Light gray shading indicates Evidence for biodegradation

Table 3-16
Groundwater Sample Results (Collected March 2017)
Remedial Investigation, Former Forbes Atlas S-5 Missile Site
Lyon County, Kansas

		Sample ID:	Natural Attenuation	Natural Attenuation	MW-07S-08	MW-08S-04	MW-09S-04	MW-10S-04	MW-11S-04	MW-12S-04	MW-13S-04
		Lab ID:	Screening	Screening	HS17031646-03	HS17031611-04	HS17031611-01	HS17031611-02	HS17031646-04	HS17031646-02	HS17031470-05
		Date Collected:	(Wiedemier)	(Wiedemier)	3/30/2017	3/29/2017	3/29/2017	3/29/2017	3/30/2017	3/30/2017	3/28/2017
Analyte	Units	Screening Level Federal MCL	Favorable Concentration	Points**	Result	Result	Result	Result	Result	Result	Result
Cis-1,2-Dichloroethene	ug/L	70	Daughter	2	**0.71 J**	0.5 U	0.5 U	0.5 U	**26**	0.5 U	**6.7**
Trichloroethene	ug/L	5	Released	0	**8.5**	0.5 U	0.5 U	**0.33 J**	**61**	**1.6**	**64**
Vinyl Chloride	ug/L	2	Daughter	2	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Natural Attenuation Parameters											
Alkalinity as CaCO3	mg/L	NA	2 times background	1	**357**	**196.5**	**363**	**453**	**525**	**656**	**367**
Alkalinity, Bicarbonate (As CaCO3)	mg/L	NA	-	-	**357**	**196.5**	**363**	**453**	**525**	**656**	**367**
Alkalinity, Carbonate (As CaCO3)	mg/L	NA	-	-	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Alkalinity, Hydroxide (As CaCO3)	mg/L	NA	-	-	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Bromide	mg/L	NA	-	-	0.05 U	0.05 U	**0.414**	**0.414**	**0.514**	**1.17**	0.05 UJ
Chloride *	mg/L	250	2 times background	2	**2.68**	**4.34**	**6.43**	**1.31**	**5.83**	**33.1**	**2.88**
Ethane	ug/L	NA	>10/>100 ug/L	2.0/3.0	0.361 U	0.361 U	0.361 U	**0.352 J**	0.361 U	0.361 U	0.361 U
Ethene	ug/L	NA	>10/>100 ug/L	2.0/3.0	0.337 U	0.337 U	0.337 U	0.337 U	0.337 U	0.337 U	0.337 U
Fluoride *	mg/L	4	-	-	**0.36**	**0.392**	**0.444**	**0.492**	**0.222**	**0.431**	**0.328** J
Methane	ug/L	NA	>100/1,000 ug/L	2.0/3.0	**5.12**	**7.49**	**0.521**	**0.383 J**	**0.925**	**0.607**	0.5 U
Nitrate as N	mg/L	10	<1 mg/L	2	**0.224**	0.05 U	**0.263 J**	0.05 U	0.05 U	**0.779**	**0.546**
Nitrate/Nitrite	mg/L	10	-	-	**0.224**	0.05 U	**0.263 J**	0.05 U	0.05 U	**0.779**	**0.546**
Nitrite as N	mg/L	1	-	-	0.05 U	0.05 U	0.05 UJ	0.05 U	0.05 U	0.05 U	0.05 U
Phosphorus	mg/L	NA	-	-	0.1 U	0.1 U	0.1 UJ	0.1 U	0.1 U	0.1 U	0.1 U
Sulfate *	mg/L	250	<20 mg/L	2	0.5 U	**10.3**	**38.3**	**16.5**	**55.1**	**62.8**	**17.3**
Sulfide	mg/L	NA	>1 mg/L	3	1 U	1 U	1 U	1 U	**1.96**	**1.36**	**1.44**
pH *	SU	6.5 to 8.5	5<pH<9	0	**6.98**	**7.31**	**7.34**	**7.03**	**6.87**	**7.02**	**7.15**
Temperature	°C	NA	>20 C	1	**12.95**	**13.74**	**11.21**	**11.69**	**13.91**	**13.64**	**13.36**
Oxidation-Reduction Potential	mV	NA	< 50 mv/<-100 mv	1.0/2.0	**-7.4**	**22.9**	**121.8**	**130.3**	**109.1**	**130.2**	**64**
Dissolved Oxygen	mg/L	NA	<0.5 />1 mg/L	3.0/-3.0	**0.93**	**1.27**	**6.73**	**2.68**	**3.02**	**3.63**	**3.84**
Ferrous iron	mg/L	0.3 for total iron	>1 mg/L	3	**0.1**	**0.1**	0	**0.1**	**0.1**	**0.1**	**0.1**
Natural Biodegradation Scoring					**7**	**2**	**-1**	**1**	**4**	**2**	**6**
Other Parameters											
Conductivity	mmhos/cm	NA			**0.466**	**0.268**	**0.473**	**0.525**	**0.709**	**0.933**	**0.473**
Turbidity	NTUs	NA			**139**	**30.8**	**17**	**31.4**	**65.4**	**153**	**36.8**
Depth to water	ft TOC	NA			**20.39**	**12.1**	**12.45**	**14.5**	**13.17**	**20.79**	**12.86**

D = Deep well
J = Estimated value
mg/L = milligrams per liter
MCL = Maximum contaminant level from May 2016 EPA RSL Table.
* = Secondary MCL
mmhos/com = milli mhos per centimeter
Bold indicates detected results.
Dark gray shading indicates screening level exceedance for VOCs.
- = No natural attenuation criteria

mV = millivolts
NS = Not Sampled
NTU = Nephelometric Turbidity Unit
S = Shallow well
U = Compound was not detected
ug/L = micrograms per liter
NA = Not available

** - Equals points assignment for determining favorable conditions for biodegradation
0-5 = Inadequate
6-14 = Limited Evidence
15-20 = Adequate Evidence
>20 = Strong Evidence
Light gray shading indicates Evidence for biodegradation

APPENDIX B

Cost Estimates of Remedial Alternatives

Alternative 2 – Long-Term Monitoring

Description of Alternative 2 – Long-Term Monitoring (LTM) and contingent Alternate Water Supply (AWS)

Alternative 2 consists of the following assumptions, which are for cost estimating purposes only and does not necessarily reflect final design parameters.

- The cost estimate lasts for 100 years, the assumed reasonable timeframe for this costing exercise. SourceDK modeling estimates 200 years to reach the PRG. The cost estimate includes 2 years for remedial design and remedial action construction and 98 years of LTM monitoring.

- The seventeen (17) existing monitoring wells along with three new monitoring wells (total of 20 wells) will be part of the groundwater sampling network. Additional wells will be installed offsite if the property owner agrees to right-of-entry.

- The first three years of sampling will be semi-annual, with the sampling rounds to be conducted using passive diffusion bag samplers for VOCs and down-hole probes to obtain field parameters. Starting in year 4, groundwater sampling frequency will be reduced to annually.

- Alternative includes connecting a future on-Site residence to an alternate water supply (Lyon County Rural Water District 1). Estimated costs include installing a service lateral to the water main, connecting the service lateral to the water main, installation of a water meter, design costs, project management costs, and construction completion report. This cost was assumed to occur during year 10, as an alternate water supply is not currently required.

- Five-year reviews will be conducted every five years.

Table B-1: Present Value Cost for Forbes S-5 Feasibility Study
Alternative 2 - Long-Term Monitoring

Fiscal Year	Year	Remedial Design ($)	Remedial Action Construction ($)	Monitoring Costs ($)	5-Year Review Costs ($)	Total Costs ($)	Discount with R at 0.6%	Total Present Value Cost ($)
2020	1	$ 63,613	$ -	$ -	$ -	$ 63,613	1.000	$ 63,613
2021	2	$ -	$ 36,650	$ -	$ -	$ 36,650	0.994	$ 36,431
2022	3	$ -	$ -	$ 68,858	$ -	$ 68,858	0.988	$ 68,039
2023	4	$ -	$ -	$ 60,055	$ -	$ 60,055	0.982	$ 58,987
2024	5	$ -	$ -	$ 60,055	$ 47,753	$ 107,808	0.976	$ 105,259
2025	6	$ -	$ -	$ 27,003	$ -	$ 27,003	0.971	$ 26,207
2026	7	$ -	$ -	$ 27,003	$ -	$ 27,003	0.965	$ 26,051
2027	8	$ -	$ -	$ 27,003	$ -	$ 27,003	0.959	$ 25,896
2028	9	$ -	$ -	$ 27,003	$ -	$ 27,003	0.953	$ 25,741
2029	10	$ -	$ 207,900	$ 27,003	$ 47,753	$ 282,656	0.948	$ 267,841
2030	11	$ -	$ -	$ 27,003	$ -	$ 27,003	0.942	$ 25,435
2031	12	$ -	$ -	$ 27,003	$ -	$ 27,003	0.936	$ 25,283
2032	13	$ -	$ -	$ 27,003	$ -	$ 27,003	0.931	$ 25,133
2033	14	$ -	$ -	$ 27,003	$ -	$ 27,003	0.925	$ 24,983
2034	15	$ -	$ -	$ 27,003	$ 47,753	$ 74,756	0.920	$ 68,750
2035	16	$ -	$ -	$ 27,003	$ -	$ 27,003	0.914	$ 24,686
2036	17	$ -	$ -	$ 27,003	$ -	$ 27,003	0.909	$ 24,538
2037	18	$ -	$ -	$ 27,003	$ -	$ 27,003	0.903	$ 24,392
2038	19	$ -	$ -	$ 27,003	$ -	$ 27,003	0.898	$ 24,246
2039	20	$ -	$ -	$ 27,003	$ 47,753	$ 74,756	0.893	$ 66,724
2040	21	$ -	$ -	$ 27,003	$ -	$ 27,003	0.887	$ 23,958
2041	22	$ -	$ -	$ 27,003	$ -	$ 27,003	0.882	$ 23,815
2042	23	$ -	$ -	$ 27,003	$ -	$ 27,003	0.877	$ 23,673
2043	24	$ -	$ -	$ 27,003	$ -	$ 27,003	0.871	$ 23,532
2044	25	$ -	$ -	$ 27,003	$ 47,753	$ 74,756	0.866	$ 64,758
2045	26	$ -	$ -	$ 27,003	$ -	$ 27,003	0.861	$ 23,252
2046	27	$ -	$ -	$ 27,003	$ -	$ 27,003	0.856	$ 23,113
2047	28	$ -	$ -	$ 27,003	$ -	$ 27,003	0.851	$ 22,976
2048	29	$ -	$ -	$ 27,003	$ -	$ 27,003	0.846	$ 22,839
2049	30	$ -	$ -	$ 27,003	$ 47,753	$ 74,756	0.841	$ 62,850
2050	31	$ -	$ -	$ 27,003	$ -	$ 27,003	0.836	$ 22,567
2051	32	$ -	$ -	$ 27,003	$ -	$ 27,003	0.831	$ 22,432
2052	33	$ -	$ -	$ 27,003	$ -	$ 27,003	0.826	$ 22,299
2053	34	$ -	$ -	$ 27,003	$ -	$ 27,003	0.821	$ 22,166
2054	35	$ -	$ -	$ 27,003	$ 47,753	$ 74,756	0.816	$ 60,998
2055	36	$ -	$ -	$ 27,003	$ -	$ 27,003	0.811	$ 21,902
2056	37	$ -	$ -	$ 27,003	$ -	$ 27,003	0.806	$ 21,771
2057	38	$ -	$ -	$ 27,003	$ -	$ 27,003	0.801	$ 21,641
2058	39	$ -	$ -	$ 27,003	$ -	$ 27,003	0.797	$ 21,512
2059	40	$ -	$ -	$ 27,003	$ 47,753	$ 74,756	0.792	$ 59,200
2060	41	$ -	$ -	$ 27,003	$ -	$ 27,003	0.787	$ 21,257
2061	42	$ -	$ -	$ 27,003	$ -	$ 27,003	0.782	$ 21,130
2062	43	$ -	$ -	$ 27,003	$ -	$ 27,003	0.778	$ 21,004
2063	44	$ -	$ -	$ 27,003	$ -	$ 27,003	0.773	$ 20,878
2064	45	$ -	$ -	$ 27,003	$ 47,753	$ 74,756	0.769	$ 57,456
2065	46	$ -	$ -	$ 27,003	$ -	$ 27,003	0.764	$ 20,630
2066	47	$ -	$ -	$ 27,003	$ -	$ 27,003	0.759	$ 20,507
2067	48	$ -	$ -	$ 27,003	$ -	$ 27,003	0.755	$ 20,385
2068	49	$ -	$ -	$ 27,003	$ -	$ 27,003	0.750	$ 20,263
2069	50	$ -	$ -	$ 27,003	$ 47,753	$ 74,756	0.746	$ 55,763
2070	51	$ -	$ -	$ 27,003	$ -	$ 27,003	0.741	$ 20,022
2071	52	$ -	$ -	$ 27,003	$ -	$ 27,003	0.737	$ 19,903
2072	53	$ -	$ -	$ 27,003	$ -	$ 27,003	0.733	$ 19,784
2073	54	$ -	$ -	$ 27,003	$ -	$ 27,003	0.728	$ 19,666
2074	55	$ -	$ -	$ 27,003	$ 47,753	$ 74,756	0.724	$ 54,120
2075	56	$ -	$ -	$ 27,003	$ -	$ 27,003	0.720	$ 19,432
2076	57	$ -	$ -	$ 27,003	$ -	$ 27,003	0.715	$ 19,316
2077	58	$ -	$ -	$ 27,003	$ -	$ 27,003	0.711	$ 19,201
2078	59	$ -	$ -	$ 27,003	$ -	$ 27,003	0.707	$ 19,087

Table B-1: Present Value Cost for Forbes S-5 Feasibility Study
Alternative 2 - Long-Term Monitoring

Fiscal Year	Year	Remedial Design ($)	Remedial Action Construction ($)	Monitoring Costs ($)	5-Year Review Costs ($)	Total Costs ($)	Discount with R at 0.6%	Total Present Value Cost ($)
2079	60	$ -	$ -	$ 27,003	$ 47,753	$ 74,756	0.703	$ 52,525
2080	61	$ -	$ -	$ 27,003	$ -	$ 27,003	0.698	$ 18,860
2081	62	$ -	$ -	$ 27,003	$ -	$ 27,003	0.694	$ 18,747
2082	63	$ -	$ -	$ 27,003	$ -	$ 27,003	0.690	$ 18,635
2083	64	$ -	$ -	$ 27,003	$ -	$ 27,003	0.686	$ 18,524
2084	65	$ -	$ -	$ 27,003	$ 47,753	$ 74,756	0.682	$ 50,977
2085	66	$ -	$ -	$ 27,003	$ -	$ 27,003	0.678	$ 18,304
2086	67	$ -	$ -	$ 27,003	$ -	$ 27,003	0.674	$ 18,195
2087	68	$ -	$ -	$ 27,003	$ -	$ 27,003	0.670	$ 18,086
2088	69	$ -	$ -	$ 27,003	$ -	$ 27,003	0.666	$ 17,978
2089	70	$ -	$ -	$ 27,003	$ 47,753	$ 74,756	0.662	$ 49,475
2090	71	$ -	$ -	$ 27,003	$ -	$ 27,003	0.658	$ 17,765
2091	72	$ -	$ -	$ 27,003	$ -	$ 27,003	0.654	$ 17,659
2092	73	$ -	$ -	$ 27,003	$ -	$ 27,003	0.650	$ 17,553
2093	74	$ -	$ -	$ 27,003	$ -	$ 27,003	0.646	$ 17,449
2094	75	$ -	$ -	$ 27,003	$ 47,753	$ 74,756	0.642	$ 48,017
2095	76	$ -	$ -	$ 27,003	$ -	$ 27,003	0.638	$ 17,241
2096	77	$ -	$ -	$ 27,003	$ -	$ 27,003	0.635	$ 17,138
2097	78	$ -	$ -	$ 27,003	$ -	$ 27,003	0.631	$ 17,036
2098	79	$ -	$ -	$ 27,003	$ -	$ 27,003	0.627	$ 16,934
2099	80	$ -	$ -	$ 27,003	$ 47,753	$ 74,756	0.623	$ 46,602
2100	81	$ -	$ -	$ 27,003	$ -	$ 27,003	0.620	$ 16,733
2101	82	$ -	$ -	$ 27,003	$ -	$ 27,003	0.616	$ 16,633
2102	83	$ -	$ -	$ 27,003	$ -	$ 27,003	0.612	$ 16,534
2103	84	$ -	$ -	$ 27,003	$ -	$ 27,003	0.609	$ 16,435
2104	85	$ -	$ -	$ 27,003	$ 47,753	$ 74,756	0.605	$ 45,229
2105	86	$ -	$ -	$ 27,003	$ -	$ 27,003	0.601	$ 16,240
2106	87	$ -	$ -	$ 27,003	$ -	$ 27,003	0.598	$ 16,143
2107	88	$ -	$ -	$ 27,003	$ -	$ 27,003	0.594	$ 16,047
2108	89	$ -	$ -	$ 27,003	$ -	$ 27,003	0.591	$ 15,951
2109	90	$ -	$ -	$ 27,003	$ 47,753	$ 74,756	0.587	$ 43,896
2110	91	$ -	$ -	$ 27,003	$ -	$ 27,003	0.584	$ 15,761
2111	92	$ -	$ -	$ 27,003	$ -	$ 27,003	0.580	$ 15,667
2112	93	$ -	$ -	$ 27,003	$ -	$ 27,003	0.577	$ 15,574
2113	94	$ -	$ -	$ 27,003	$ -	$ 27,003	0.573	$ 15,481
2114	95	$ -	$ -	$ 27,003	$ 47,753	$ 74,756	0.570	$ 42,603
2115	96	$ -	$ -	$ 27,003	$ -	$ 27,003	0.566	$ 15,297
2111	97	$ -	$ -	$ 27,003	$ -	$ 27,003	0.563	$ 15,206
2112	98	$ -	$ -	$ 27,003	$ -	$ 27,003	0.560	$ 15,115
2113	99	$ -	$ -	$ 27,003	$ -	$ 27,003	0.556	$ 15,025
2113	100	$ -	$ -	$ 27,003	$ 47,753	$ 74,756	0.553	$ 41,347
	Total	$ 63,600	$ 244,600	$ 2,754,300	$ 955,100	$ 4,017,500		**$ 3,099,900**

Notes:

Totals are rounded to the nearest $100

Discount Equation =1/(1+R)^(n-1)

R= Discount Rate, currently at 0.6% for 2018; n= year

-Discount Rate is taken from the 30-year Real Discount Rates for the 2017 Appendix C of OMB Circular No. A-94.

-Source DK model has a remedial timeframe greater than 100 years. Reasonable timeframe of 100 years used.

-Assume that the Five-Year Review cost in 2111 will be used to write a "Close-Out Report" instead of a Five-Year Review.

Contingent alternate water supply costs included in Year 10.

Estimate Documentation Report - Layout 1

Software:

RACER Version: RACER® Version 11.5.99.0
Database Location: C:\Users\g5edegep\Desktop\B07KS0204_01_24.mdb

Folder:

Folder Name: NWK 2018 CTC Estimates

FUDS Property:

ID: B07KS0204
Name: Forbes AFB Atlas S-05
Category: None

Location
State / Country: KANSAS
City: KANSAS STATE AVERAGE

Location Modifier	Default	User	Reason for changes
	0.960	0.960	

Options
Database: Modified System Costs
Cost Database Date: 2019
Report Option: Fiscal

Description

Forbes AFB Atlas Missile Site S-05 Property Description:

Contamination and Source: VOC solvents potentially from missile maintenance operations are the main focus of environmental investigation at the site.

This Atlas E (coffin type) site is located near Bushong, Kansas (20 miles northwest of Emporia, KS, and was one of nine missile atlas sites that were circled around Forbes AFB in Topeka, KS. Used primarily between 1960-1963 before being deactivated.

In 1990-91, O'Brien and Gere (for USACE) performed a limited investigation (confirmation study) to provide a preliminary determination of the presence or absence of chemical contamination which may have resulted from past DOD activities at the site. Two monitoring wells installed, shallow soil samples for metals, SVOCs, and VOCs were taken. TCE, trans-1,2-DCE detected.

In 1990's Right of Entry (ROE) to the property was denied and no further investigation were conducted until 2006 when ROE was once again granted by different owner. In 2007, Tetra Tech conducted an environmental investigation at the property. TCE, and cis-1,2-DCE

Estimate Documentation Report - Layout 1

detected in groundwater. In 2017 Remedial Investigation was completed.

Location Modifier:
Geographic Information: Bushong, Lyon County, Kansas, 66833.
Latitude: 38.68694444
Longitude: -96.30333333

Assume KANSAS STATE AVERAGE for location cost modifier.

Estimate Documentation Report - Layout 1

Project:

ID: 02
Name: Alternative 2 - Long Term GW Monitoring
Type: HTRW

Media/Waste Type

Primary: Groundwater
Secondary: N/A

Contaminant

Primary: Volatile Organic Compounds (VOCs)
Secondary: None

Phase Names

Pre-Study	☐	
Study	☑	**Safety Level:** D
Design	☑	**Safety Level:** E
Removal/Interim Action	☐	
Remedial Action	☑	**Safety Level:** D
Operations & Maintenance	☑	**Safety Level:** D
Long Term Monitoring	☐	
Site Closeout	☐	

In the RACER Preferences the default value for the Safety Level is established. This sets the default value for the safety level for each technology model based on the type of work being completed. Note: RACER Technologies that safety level is not appropriate to change from the default are hard-coded to estimate costs without a safety level productivity factor, which is Safety Level E.

Documentation

Description: Forbes AFB Atlas Missile Site S-05 Project: The cost included are to estimate capital and long term cost of the alternatives included in the feasibility study report. These Alternatives include GW Monitoring and In-Situ Bioremediation. See Section 6.2.2 for Groundwater Monitoring Alternative details and Appendix B Costing Summary for assumptions.

Support Team: Project Geologist Chuck Williams 816-389-3575
Project Engineer Jason L'Ecuyer 816-389-3908

References: May 2018 Remedial Investigation Reprot.

Estimator Information

Estimator Name: Jason L'Ecuyer
Estimator Title: Process Engineer
Agency/Org./Office: USACE/CENWK/ED-EG
Business Address: Bolling Federal Building Suite 439
601 E. 12th St.
Kansas City, MO 64106
Telephone Number: 816-389-3908
Email Address: jason.r.lecuyer@usace.army.mil
Estimate Prepared Date: 01/24/2019

Estimator Signature: _____ **Date:** _____

Estimate Documentation Report - Layout 1

Reviewer Information

Reviewer Name:
Reviewer Title:
Agency/Org./Office:
Business Address:
Telephone Number:
Email Address:
Date Reviewed: 01/24/2019

Reviewer Signature: _____ **Date:** _____

Estimate Costs:

Phase Names	Marked-Up Cost
RD (LTM Work Plans)	$63,613
RA-C (Monitoring Well Installation)	$36,650
RA-O (FY22-24 Monitoring Costs & 5YRs)	$523,237
RA-O (Monitoring FY25-FY100)	$810,088
Total Cost:	$1,433,588
Total Project Cost:	$1,433,588

Phase Documentation:

Phase Type: Design
Phase Name: RD (LTM Work Plans)
Description: Remedial Design Phase to estimate costs for developing a long-term monitoring work plan to install three additional groundwater monitoring wells in the RA-C phase and to conduct scheduled long-term monitoring for VOCs during the subsequent RA-O phase. Assume the RD-Detail Technology used for the estimate.

In accordance with ER 1110-3-1301, dated 30 Dec 2016, Contingencies shall be applied to each phase total as described in the EPA Guidance "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study." For RD phase, a 0% contingency is recommended. The scope of work estimated in the RD phase is relatively defined for the FUDS program and there is no field work associated with this phase. Therefore the contingency for the RD phase is 0%.

Start Date: October, 2019
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Estimate Documentation Report - Layout 1

Phase Markup Template: FUDS RD 0% Continency

Technology Markups	Markup	% Prime	% Sub.
Remedial Design	Yes	100	0

Total Marked-up Cost: $63,613.16

Technologies:

Technology Name: **Remedial Design (#1)**

User Name: **Remedial Design**

Description	Default	User	UOM
System Definition			
Required Parameters			
Project Approach		Ex Situ Removal - Performance-Based On-site Treatment or Disposal	n/a
Complexity		Low	n/a
Project Planning		Yes	n/a
Treatability & Other Studies		No	n/a
Preliminary Design (30%)		No	n/a
Intermediate Design (60%)		Yes	n/a
Prefinal Design (90%)		Yes	n/a
Final Design (100%)		Yes	n/a
Bid Documents		Yes	n/a
Site Distance		125	MI
Level of RD Detail		Narrow	n/a
Project Planning			
Required Parameters			
Site Visit		Yes	n/a
RD Work Plan		Yes	n/a
Data Review		Yes	n/a
Public Meetings		Yes	n/a
Intermediate Design			
Required Parameters			
Revised Basis of Design Report		Yes	n/a
Intermediate Plans & Specifications		Yes	n/a
VE Report		Yes	n/a

Estimate Documentation Report - Layout 1

Technology Name: **Remedial Design (#1)**

User Name: **Remedial Design**

Description	Default	User	UOM
Prefinal Design			
Required Parameters			
Prefinal Plans & Specifications		Yes	n/a
Construction QA Plan		Yes	n/a
Final Design			
Required Parameters			
Final Plans & Specifications		Yes	n/a
Final Report		Yes	n/a
Public Meetings		Yes	n/a
Post Design Fact Sheet		Yes	n/a
Bid Documents			
Required Parameters			
Prepare Bid Documents		Yes	n/a
Issue Invitations for Bids/Request Proposals		Yes	n/a
Contractor Bid Evaluation/Selection Support		Yes	n/a

Comments: Remedial Design Notes - Assume for the System Definition Tab that Remediation approach is Ex-Situ Removal, Performance Based On-Site Treatment, low site complexity, narrow level of RD detail, and 125 miles one way to the site. Tasks to be completed include: Project Planning, 60. 90, and 100% drafts, bid documents. Assume all tasks selected in secondary tabs.

Technology: Remedial Design

Element: Project Planning

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
33010104	Sample collection, vehicle mileage charge, car or van	125.00	MI	0.00	0.00	0.00	0.26	$32.40	No
33220102	Project Manager	16.00	HR	0.00	186.12	0.00	0.00	$2,977.97	No
33220103	Office Manager	3.00	HR	0.00	153.98	0.00	0.00	$461.93	No
33220105	Project Engineer	3.00	HR	0.00	157.80	0.00	0.00	$473.39	No
33220106	Staff Engineer	20.00	HR	0.00	162.52	0.00	0.00	$3,250.42	No
33220109	Staff Scientist	50.00	HR	0.00	138.76	0.00	0.00	$6,937.91	No
33220110	QA/QC Officer	20.00	HR	0.00	127.38	0.00	0.00	$2,547.68	No
33220111	Certified Industrial Hygienist	2.00	HR	0.00	168.61	0.00	0.00	$337.22	No
33220112	Field Technician	11.00	HR	0.00	88.62	0.00	0.00	$974.78	No
33220113	Secretarial/ Administrative	6.00	HR	0.00	96.01	0.00	0.00	$576.07	No
33220114	Word Processing/Clerical	17.00	HR	0.00	87.28	0.00	0.00	$1,483.78	No
33220115	Draftsman/CADD	3.00	HR	0.00	101.73	0.00	0.00	$305.18	No

Estimate Documentation Report - Layout 1

Technology: Remedial Design

33240101	Other Direct Costs	1.00	LS	74.47	0.00	0.00	0.00	$74.47	No

Total Element Cost: $20,433.20

Element: Intermediate Design

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	2.00	HR	0.00	186.12	0.00	0.00	$372.25	No
33220105	Project Engineer	3.00	HR	0.00	157.80	0.00	0.00	$473.39	No
33220106	Staff Engineer	15.00	HR	0.00	162.52	0.00	0.00	$2,437.81	No
33220110	QA/QC Officer	3.00	HR	0.00	127.38	0.00	0.00	$382.15	No
33220113	Secretarial/ Administrative	1.00	HR	0.00	96.01	0.00	0.00	$96.01	No
33220114	Word Processing/Clerical	2.00	HR	0.00	87.28	0.00	0.00	$174.56	No
33220115	Draftsman/CADD	5.00	HR	0.00	101.73	0.00	0.00	$508.63	No
33240101	Other Direct Costs	1.00	LS	8.14	0.00	0.00	0.00	$8.14	No

Total Element Cost: $4,452.94

Element: Prefinal Design

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	3.00	HR	0.00	186.12	0.00	0.00	$558.37	No
33220103	Office Manager	7.00	HR	0.00	153.98	0.00	0.00	$1,077.84	No
33220105	Project Engineer	5.00	HR	0.00	157.80	0.00	0.00	$788.98	No
33220106	Staff Engineer	25.00	HR	0.00	162.52	0.00	0.00	$4,063.02	No
33220109	Staff Scientist	35.00	HR	0.00	138.76	0.00	0.00	$4,856.54	No
33220110	QA/QC Officer	5.00	HR	0.00	127.38	0.00	0.00	$636.92	No
33220111	Certified Industrial Hygienist	10.00	HR	0.00	168.61	0.00	0.00	$1,686.08	No
33220113	Secretarial/ Administrative	3.00	HR	0.00	96.01	0.00	0.00	$288.04	No
33220114	Word Processing/Clerical	23.00	HR	0.00	87.28	0.00	0.00	$2,007.47	No
33220115	Draftsman/CADD	6.00	HR	0.00	101.73	0.00	0.00	$610.35	No
33240101	Other Direct Costs	1.00	LS	45.54	0.00	0.00	0.00	$45.54	No

Total Element Cost: $16,619.15

Element: Final Design

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	9.00	HR	0.00	186.12	0.00	0.00	$1,675.11	No
33220103	Office Manager	7.00	HR	0.00	153.98	0.00	0.00	$1,077.84	No

Estimate Documentation Report - Layout 1

Technology: Remedial Design

33220105	Project Engineer	5.00	HR	0.00	157.80	0.00	0.00	$788.98	No
33220106	Staff Engineer	27.00	HR	0.00	162.52	0.00	0.00	$4,388.06	No
33220109	Staff Scientist	35.00	HR	0.00	138.76	0.00	0.00	$4,856.54	No
33220110	QA/QC Officer	5.00	HR	0.00	127.38	0.00	0.00	$636.92	No
33220111	Certified Industrial Hygienist	10.00	HR	0.00	168.61	0.00	0.00	$1,686.08	No
33220113	Secretarial/ Administrative	3.00	HR	0.00	96.01	0.00	0.00	$288.04	No
33220114	Word Processing/Clerical	23.00	HR	0.00	87.28	0.00	0.00	$2,007.47	No
33220115	Draftsman/CADD	6.00	HR	0.00	101.73	0.00	0.00	$610.35	No
33240101	Other Direct Costs	1.00	LS	49.50	0.00	0.00	0.00	$49.50	No

Total Element Cost: $18,064.89

Element: Bid Documents

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	3.00	HR	0.00	186.12	0.00	0.00	$558.37	No
33220103	Office Manager	4.00	HR	0.00	153.98	0.00	0.00	$615.91	No
33220105	Project Engineer	3.00	HR	0.00	157.80	0.00	0.00	$473.39	No
33220106	Staff Engineer	3.00	HR	0.00	162.52	0.00	0.00	$487.56	No
33220109	Staff Scientist	2.00	HR	0.00	138.76	0.00	0.00	$277.52	No
33220110	QA/QC Officer	2.00	HR	0.00	127.38	0.00	0.00	$254.77	No
33220111	Certified Industrial Hygienist	1.00	HR	0.00	168.61	0.00	0.00	$168.61	No
33220113	Secretarial/ Administrative	7.00	HR	0.00	96.01	0.00	0.00	$672.08	No
33220114	Word Processing/Clerical	6.00	HR	0.00	87.28	0.00	0.00	$523.69	No
33240101	Other Direct Costs	1.00	LS	11.08	0.00	0.00	0.00	$11.08	No

Total Element Cost: $4,042.97

Total Tech Cost: $63,613.16

Cost Over Time Summary

Element	Year(s)	Cost per Year	Total Cost
General	2020	$63,613.16	$63,613.16

Total Marked Up Tech Cost: $63,613.16

Phase Documentation:

Estimate Documentation Report - Layout 1

Phase Type: Remedial Action
Phase Name: RA-C (Monitoring Well Installation)
Description: Remedial Action - Construction will consist of setting up the monitoring well network. There are 17 existing monitoring wells. Assume three more shall be installed during this phase. See Appendix B Costing Details for all assumptions.

In accordance with ER 1110-3-1301, dated 30 Dec 2016, Contingencies shall be applied to each phase total as described in the EPA Guidance "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study." When estimating remedial action construction phase where the study phases are not all complete, there is a greater level of risk associated with the phase. Exhibit 5-6 in the EPA Guidance shows various contingences per technology. By taking the average of each technology contingency range and then average in all of the technology contingency together the average contingency is 15% for RA-C phase.

Note that FUDS Program Manager Dave Nelson does not believe installing monitoring wells constitutes enough work for an entire RA-C phase so this phase is being renamed/reassigned to the RA-O phase. See attached Email note "FW_CTCs still needing work (Nelson 12Mar2018). pdf"

Approach: Ex Situ
Start Date: October, 2020
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Phase Markup Template: FUDS V8 - All Phases Except PCO

Technology Markups	Markup	% Prime	% Sub.
Groundwater Monitoring Well	Yes	100	0
Professional Labor Management	No	0	100
Residual Waste Management	Yes	100	0

Total Marked-up Cost: $36,649.90

Technologies:

Technology Name: **Groundwater Monitoring Well (#1)**
User Name: **Groundwater Monitoring Well**

Description	Default	User	UOM
System Definition			
Required Parameters			
Number of Aquifers		One	n/a
Include Guard Posts		Yes	n/a
Depth to Groundwater to Aquifer One		35	FT

Estimate Documentation Report - Layout 1

Technology Name: **Groundwater Monitoring Well (#1)**

User Name: **Groundwater Monitoring Well**

Description	Default	User	UOM
System Definition			
Required Parameters			
Number of Wells to Aquifer One		3	EA
Safety Level		D	n/a
Aquifer One			
Required Parameters			
Aquifer One: Average Well Depth		40	LF
Aquifer One: Formation Type		Unconsolidated	n/a
Aquifer One: Drilling Method		Air Rotary	n/a
Aquifer One: Well Diameter		2 Inch	n/a
Aquifer One: Well Construction Material		PVC Schedule 40	n/a
Aquifer One: Split Spoon Sample Collection		No	n/a
Aquifer One: Average Number of Soil Samples per Well		0	EA
Aquifer One: Soil Analytical Template		None	n/a

Comments: Groundwater Monitoring Well Technology Notes:

Assume one aquifer, depth to groundwater 35 ft, bgs, 3 wells to be installed with guard posts, average well depth of 40 ft, unconsolidated formation, well drilled by air rotary methods, 2 in. diameter, schedule 40 PVC construction, safety level d.

Technology: Groundwater Monitoring Well

Element: Aquifer 1

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
33020303	Organic Vapor Analyzer Rental, per Day	2.00	DAY	0.00	0.00	0.00	53.88	$107.76	No
33170808	Decontaminate Rig, Augers, Screen (Rental Equipment)	2.00	DAY	65.35	898.47	0.00	0.00	$1,927.63	No
33220112	Field Technician	32.00	HR	0.00	124.28	0.00	0.00	$3,976.92	No
33230101	2" PVC, Schedule 40, Well Casing	90.00	LF	4.98	7.59	6.34	0.00	$1,701.13	No
33230201	2" PVC, Schedule 40, Well Screen	30.00	LF	5.79	7.59	6.34	0.00	$591.36	No
33230301	2" PVC, Well Plug	3.00	EA	15.90	22.74	18.99	0.00	$172.88	No
33231146	Air Rotary, 6" Dia Borehole (Unconsolidated), Depth <= 100 ft	123.00	LF	0.00	33.85	37.57	0.00	$8,785.11	No
33231401	2" Screen, Filter Pack	36.00	LF	8.69	5.85	4.88	0.00	$698.99	No
33231811	2" Well, Portland Cement Grout	81.00	LF	9.74	0.00	0.00	0.00	$789.27	No

Estimate Documentation Report - Layout 1

Technology: Groundwater Monitoring Well

33232101	2" Well, Bentonite Seal	3.00	EA	24.48	151.23	126.26	0.00	$905.93	No

Total Element Cost: $19,656.99

Element: General Aquifers

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
33010101	Mobilize/DeMobilize Drilling Rig & Crew	1.00	LS	0.00	2,274.44	1,512.07	0.00	$3,786.51	No
33231178	Move Rig/Equipment Around Site	2.00	EA	149.34	326.95	217.36	0.00	$1,387.31	No
33231182	DOT steel drums, 55 gal., open, 17C	6.00	EA	142.94	0.00	0.00	0.00	$857.61	No
33231504	Surface Pad, Concrete, 2' x 2' x 4"	3.00	EA	89.33	25.58	1.74	0.00	$349.96	No
33232301	5' Guard Posts, Cast Iron, Concrete Fill	12.00	EA	86.79	162.85	0.07	0.00	$2,996.46	No

Total Element Cost: $9,377.86

Total Tech Cost: $29,034.85

Cost Over Time Summary

Element	Year(s)	Cost per Year	Total Cost
General	2021	$29,034.85	$29,034.85

Total Marked Up Tech Cost: $29,034.85

Technology Name: **Residual Waste Management (#1)**

User Name: **Residual Waste Management**

Description	Default	User	UOM
System Definition			
Required Parameters			
Safety Level		D	n/a
Non-Rad Disposal			
Required Parameters			
Waste Type/ Condition		Non-Hazardous Drums	n/a
Total Quantity		6	Units
Units		Drums	-
Stabilization		No	n/a
Transportation Type		Truck	n/a
Distance 1		125	MI
Distance 2		0	MI

Comments: Residual Waste Management technology used to estimate costs for any IDW created by the groundwater monitoring well installation. Assumed 125 miles one-way to the site, IDW is non-hazardous waste and will be transported by truck in its existing container.

Estimate Documentation Report - Layout 1

Technology: Residual Waste Management
Element:

Year(s)	Cost per Year
2021	$1,481.06

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
33190103	Load Drums on Disposal Vehicle	6.00	EA	0.00	8.57	2.80	0.00	$68.22	No
33190204	Transport 55 Gallon Drums of Hazardous Waste, Max 80 drums (per Mile)	125.00	MI	0.00	0.00	0.00	2.32	$289.51	No
33190317	Waste Stream Evaluation Fee, Not Including 50% Rebate on 1st Shipment	1.00	EA	0.00	0.00	0.00	68.23	$68.23	No
33197205	Landfill Nonhazardous Solid Waste, 55 Gallon Drum	6.00	EA	0.00	0.00	0.00	175.85	$1,055.10	No

Total Element Cost: $1,481.06

Total Tech Cost: $1,481.06

Cost Over Time Summary

Element	Year(s)	Cost per Year	Total Cost
General	2021	$1,481.06	$1,481.06

Total Marked Up Tech Cost: $1,481.06

Technology Name: **Professional Labor Management (#1)**

User Name: **Professional Labor Management**

Description	Default	User	UOM
System Definition			
Required Parameters			
Markedup Construction Cost ($)		30516.00	$
Percentage	20.10	20.10	%
Dollar Amount		6134.00	$

Comments: Professional Labor Management costs for conducting management of groundwater monitoring well installation and disposal of IDW waste. Assumed default % to calculate this technology.

Technology: Professional Labor Management
Element:

Year(s)	Cost per Year
2021	$6,134.00

Estimate Documentation Report - Layout 1

Technology: Professional Labor Management

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
33220149	Lump Sum Percentage Labor Cost	1.00	LS	0.00	6,134.00	0.00	0.00	$6,134.00	No

Total Element Cost: $6,134.00

Total Tech Cost: $6,134.00

Cost Over Time Summary

Element	Year(s)	Cost per Year	Total Cost
General	2021	$6,134.00	$6,134.00

Total Marked Up Tech Cost: $6,134.00

Phase Documentation:

Phase Type: Operations & Maintenance

Phase Name: RA-O (FY22-24 Monitoring Costs & 5YRs)

Description: RA-O phase to include long-term VOC monitoring of groundwater. Monitoring Technology - Assume at least 79 years of monitoring 20 wells (17 existing, 3 new wells from RA-O) at the site for VOCs only. The 79 years duration of RA-O phase is based on SourceDK a remediation timeframe estimation model. First 3 years to be sem-annual by low-flow sampling methods, followed by annual sampling by passive diffusion bag sampling.
Residual Waste Management - for disposal of IDW from monitoring events.
Five-Year Reviews are to be conducted five years after the signing of the DD to evaluate the effectiveness of the remedy.

In accordance with ER 1110-3-1301, dated 30 Dec 2016, Contingencies shall be applied to each phase total as described in the EPA Guidance "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study." There is a low level of risk estimating the RA-O phase prior to the FS being complete. During this phase the remedy is operating to obtain response complete. A 10% contingency should be used to account for this associated risk. Per the EPA Guidance 10% is the lowest range for contingency.

Start Date: October, 2021

Labor Rate Group: System Labor Rate

Analysis Rate Group: System Analysis Rate

Phase Markup Template: FUDS V8 - All Phases Except PCOA

Technology Markups	Markup	% Prime	% Sub.
MONITORING Sem-Annual FY22-24	Yes	100	0
Five-Year Review	Yes	100	0
Residual Waste Management	Yes	100	0

Estimate Documentation Report - Layout 1

Total Marked-up Cost: $523,237.12

Technologies:

Technology Name: **Residual Waste Management (#1)**

User Name: **Residual Waste Management**

Description	Default	User	UOM
System Definition			
Required Parameters			
Safety Level		D	n/a
Non-Rad Disposal			
Required Parameters			
Waste Type/ Condition		Non-Hazardous Bulk Liquid	n/a
Total Quantity		5016	Units
Units		GAL	-
Stabilization		No	n/a
Transportation Type		Truck	n/a
Distance 1		125	MI
Distance 2		0	MI

Comments: Residual Waste Management Notes:

Assume non-hazardous purge water, to be transported 125 miles in bulk container by Truck.

Technology: Residual Waste Management

Element:

Year(s)	Cost per Year
2022	$8,802.65

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
33190101	Liquid Loading Into 5,000 Gallon Bulk Tank Truck	2.00	EA	0.00	786.94	411.79	0.00	$2,397.47	No
33190108	Tanker Pumping Equipment to Load Liquid	2.00	HR	0.00	0.00	0.00	36.08	$72.16	No
33190207	Transport Bulk Liquid/Sludge Hazardous Waste, Maximum 5,000 Gallon (per Mile)	250.00	MI	0.00	0.00	0.00	3.48	$870.33	No

Estimate Documentation Report - Layout 1

Technology: Residual Waste Management

33190317	Waste Stream Evaluation Fee, Not Including 50% Rebate on 1st Shipment	1.00	EA	0.00	0.00	0.00	65.26	$65.26	No
33197274	Commercial RCRA landfills, regional outline, liquid, non-hazardous	5,016.00	GAL	0.00	0.00	0.00	1.08	$5,397.43	No

Total Element Cost: $8,802.65

Total Tech Cost: $8,802.65

Cost Over Time Summary

Element	Year(s)	Cost per Year	Total Cost
General	2022	$8,802.65	$8,802.65

Total Marked Up Tech Cost: $8,802.65

Technology Name: **Monitoring (#1)**

User Name: **MONITORING Sem-Annual FY22-24**

Description	Default	User	UOM
System Definition			
Required Parameters			
Model Name		Monitoring	n/a
Groundwater		Yes	n/a
Surface Soil		No	n/a
Surface Water		No	n/a
Subsurface Soil		No	n/a
Sediment		No	n/a
Soil Gas		No	n/a
Air		No	n/a
Site Distance (One-way)		125	MI
Safety Level		D	n/a
Groundwater			
Required Parameters			
Average Sample Depth		40	FT
Samples per Event (First Year)		20	EA
Samples per Event (Out Years)		20	EA
Number of Events (First Year)		2	EA
Number of Events (Out Years)		2	EA
Number of Years (Out Years)		2	EA
Secondary Parameters			
Primary Analytical Template	System Water - VOCs	System Water - VOCs	n/a
Secondary Analytical Template	None	None	n/a
Turnaround Time	Standard (21 Days)	Standard (21 Days)	n/a

Estimate Documentation Report - Layout 1

Technology Name: **Monitoring (#1)**

User Name: **MONITORING Sem-Annual FY22-24**

Description	Default	User	UOM
Groundwater			
Secondary Parameters			
Data Package/QC	Stage 1	Stage 1	n/a
Sampling Method	Existing Wells - Low Flow Pump	Existing Wells - Low Flow Pump	n/a
Number of Wells/Day	8	6	EA
Contain Purge Water	Yes	Yes	n/a
QA/QC			
Secondary Parameters			
Split Samples	1:10	1:10	EA
Field Duplicate Samples	1:10	1:10	EA
Rinse Blanks (per Round)	1	1	EA
Trip Blanks (per Day)	1	1	EA
Matrix Spikes/Matrix Spike Duplicates	1:20	1:20	EA
Data Management			
Secondary Parameters			
Monitoring Plan	Standard	None	n/a
Lab Data Review	Stage 1	Stage 1	n/a
Submit Data Electronically	Yes	Yes	n/a
Monitoring Reports	Abbreviated	Abbreviated	n/a

Comments: Monitoring Technology Notes:

Assume this covers VOC monitoring for the first three years of the RA-O phase. Semi-Annual (twice a year) using low-flow sampling for VOCs. 20 Monitoring wells to be sampled along with default QA/QC samples. 125 miles one-way travel to the site. Assume in Data Mgmt tab that the Monitoring Plan is already costed in the RD Phase so "None" was selected. All other selections are defaults.

Technology: MONITORING Sem-Annual FY22-24

Element: Groundwater

Year(s)	Cost per Year
2022 - 2024	$37,946.99

NOTE: With the exception of the Data Management cost, total yearly cost shown matches the total element cost shown when the frequencies (number of samples and number of events) are similar for Year 1 and the out years. When a Comprehensive, Standard, or Abbreviated Monitoring Plan is included in the estimate, the Data Management cost shown for Year 1 will differ from the associated costs shown for the rest of the project duration, as it includes cost associated with the Monitoring Plan. Please reference the Monitoring, Cost Over Time & the Estimate Documentation Report help topic for details on how the Monitoring Plan cost is calculated. The help topic also addresses how the out year costs are calculated when frequencies (number of samples and number of events) differ between Year 1 and the out years.

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override

Estimate Documentation Report - Layout 1

Technology: MONITORING Sem-Annual FY22-24

33020401	Disposable Materials per Sample	59.00	EA	12.30	0.00	0.00	0.00	$725.43	No
33020402	Decontamination Materials per Sample	59.00	EA	28.09	0.00	0.00	0.00	$1,657.19	No
33020561	Lysimeter accessories, nylon tubing, 1/4" OD	1,625.00	LF	0.68	0.00	0.00	0.00	$1,105.71	No
33021509	Monitor well sampling equipment, rental, water quality testing parameter device rental	2.00	WK	0.00	0.00	0.00	388.22	$776.45	No
33021618	Testing, purgeable organics (624, 8260)	59.00	EA	0.00	0.00	0.00	194.95	$11,502.27	No
33022124	Testing, RCRA evaluations, EP toxicity analysis, metals (6010,7470)	1.00	EA	0.00	0.00	0.00	142.42	$142.42	No
33220102	Project Manager	10.00	HR	0.00	249.68	0.00	0.00	$2,496.78	No
33220112	Field Technician	163.00	HR	0.00	118.88	0.00	0.00	$19,376.69	No
33230614	Peristaltic Pump, Weekly Rental	2.00	WK	0.00	0.00	0.00	124.69	$249.39	No

Total First Year Element Cost: $38,032.31

Element: Data Management

Year(s)	Cost per Year
2022 - 2024	$12,168.69

NOTE: With the exception of the Data Management cost, total yearly cost shown matches the total element cost shown when the frequencies (number of samples and number of events) are similar for Year 1 and the out years. When a Comprehensive, Standard, or Abbreviated Monitoring Plan is included in the estimate, the Data Management cost shown for Year 1 will differ from the associated costs shown for the rest of the project duration, as it includes cost associated with the Monitoring Plan. Please reference the Monitoring, Cost Over Time & the Estimate Documentation Report help topic for details on how the Monitoring Plan cost is calculated. The help topic also addresses how the out year costs are calculated when frequencies (number of samples and number of events) differ between Year 1 and the out years.

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	8.00	HR	0.00	249.68	0.00	0.00	$1,997.42	No
33220108	Project Scientist	34.00	HR	0.00	230.48	0.00	0.00	$7,836.32	No
33220110	QA/QC Officer	4.00	HR	0.00	170.88	0.00	0.00	$683.52	No
33220112	Field Technician	4.00	HR	0.00	118.88	0.00	0.00	$475.50	No
33220114	Word Processing/Clerical	4.00	HR	0.00	117.08	0.00	0.00	$468.34	No
33220115	Draftsman/CADD	4.00	HR	0.00	136.46	0.00	0.00	$545.85	No
33240101	Other Direct Costs	1.00	LS	0.00	161.73	0.00	0.00	$161.73	No

Total First Year Element Cost: $12,168.69

Estimate Documentation Report - Layout 1

Technology: MONITORING Sem-Annual FY22-24

Element: General Monitoring

Year(s)	Cost per Year
2022 - 2024	$9,939.66

NOTE: With the exception of the Data Management cost, total yearly cost shown matches the total element cost shown when the frequencies (number of samples and number of events) are similar for Year 1 and the out years. When a Comprehensive, Standard, or Abbreviated Monitoring Plan is included in the estimate, the Data Management cost shown for Year 1 will differ from the associated costs shown for the rest of the project duration, as it includes cost associated with the Monitoring Plan. Please reference the Monitoring, Cost Over Time & the Estimate Documentation Report help topic for details on how the Monitoring Plan cost is calculated. The help topic also addresses how the out year costs are calculated when frequencies (number of samples and number of events) differ between Year 1 and the out years.

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
33010104	Sample collection, vehicle mileage charge, car or van	710.00	MI	0.00	0.00	0.00	0.26	$184.03	No
33010202	Per Diem (per person)	14.00	DAY	0.00	0.00	0.00	178.50	$2,499.00	No
33022043	Overnight delivery service, 51 to 70 lb packages	240.00	LB	0.00	0.00	0.00	8.00	$1,920.17	No
33220112	Field Technician	45.00	HR	0.00	118.88	0.00	0.00	$5,349.39	No

Total First Year Element Cost: $9,952.59

Total First Year Tech Cost: $60,153.59

Cost Over Time Summary

Element	Year(s)	Cost per Year	Total Cost
Groundwater	2022 - 2024	$37,946.99	$113,840.97
Data Management	2022 - 2024	$12,168.69	$36,506.07
General Monitoring	2022 - 2024	$9,939.66	$29,818.98

Total Marked Up Tech Cost: $180,166.02

Technology Name: **Five-Year Review (#1)**

User Name: **Five-Year Review**

Description	Default	User	UOM
System Definition			
Required Parameters			
Site Complexity		Moderate	n/a
Document Review		Yes	n/a
Interviews		Yes	n/a
Site Inspection		Yes	n/a
Report		Yes	n/a
Travel		Yes	n/a

Estimate Documentation Report - Layout 1

Technology Name: **Five-Year Review (#1)**

User Name: **Five-Year Review**

Description	Default	User	UOM
System Definition			
Required Parameters			
Rebound Study		No	n/a
Start Month		October	n/a
No. Reviews		7	EA
Start Year		2023	n/a
Safety Level		D	n/a
Document Review			
Required Parameters			
5-Year Review Check List		Yes	n/a
Record of Decision		Yes	n/a
Remedial Action Design & Construction		Yes	n/a
Close-Out Report		Yes	n/a
Operations & Maintenance Manuals & Reports		No	n/a
Consent Decree or Settlement Records		No	n/a
Groundwater Monitoring & Reports		Yes	n/a
Remedial Action Required		Yes	n/a
Previous 5-Year Review Reports		Yes	n/a
Interviews			
Required Parameters			
Current and Previous Staff Management		Yes	n/a
Community Groups		No	n/a
State Contacts		Yes	n/a
Local Government Contacts		Yes	n/a
Operations & Maintenance Contractors		Yes	n/a
PRPs		No	n/a
Remedial Design Consultant		Yes	n/a
Site Inspection			
Required Parameters			
General Site Inspection		Yes	n/a
Containment System Inspection		No	n/a
Monitoring Systems Inspection		Yes	n/a
Treatment Systems Inspection		No	n/a
Regulatory Compliance		Yes	n/a
Site Visit Documentation (Photos, Diagrams, etc.)		Yes	n/a
Report			
Required Parameters			
Introduction		Yes	n/a
Remedial Objectives		Yes	n/a
ARARs Review		Yes	n/a
Summary of Site Visit		Yes	n/a

Estimate Documentation Report - Layout 1

Technology Name: **Five-Year Review (#1)**

User Name: **Five-Year Review**

Description	Default	User	UOM
Report			
Required Parameters			
Areas of Non Compliance		Yes	n/a
Technology Recommendations		Yes	n/a
Statement of Protectiveness		Yes	n/a
Next Review		Yes	n/a
Implementation Requirements		Yes	n/a
Travel			
Required Parameters			
Number of Travelers		2	EA
Number of Days		2	EA
Air Fare Ticket Price		0.00	$
Need a rental car?		Yes	n/a

Comments: Five-Year Review Notes:

Assume moderate site complexity and the first review to take place in FY24, five years after Decision Document, 16 reviews over the modeled in the first 79 years. Tasks to include Document Review, Interview, Site Inspections, Report, and Travel. For Document Review, assume "Consent Decree" and "O&M Manuals and Reports" are not selected as these documents may not be conducted for this project. Assume no PRPs interviewed on this project. There will be no containment or treatment systems to inspect so these are not selected. Assume 2 people to travel 2 days to the site using rental car.

Technology: Five-Year Review

Element: Document Review

Year(s)	Cost per Year
2024	$11,147.21
2025 - 2028	$0.00
2029	$11,147.21
2030 - 2033	$0.00
2034	$11,147.21
2035 - 2038	$0.00
2039	$11,147.21
2040 - 2043	$0.00
2044	$11,147.21
2045 - 2048	$0.00
2049	$11,147.21
2050 - 2053	$0.00
2054	$11,147.21

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override

Estimate Documentation Report - Layout 1

Technology: Five-Year Review

33220102	Project Manager	12.00	HR	0.00	249.68	0.00	0.00	$2,996.13	No
33220105	Project Engineer	12.00	HR	0.00	211.68	0.00	0.00	$2,540.12	No
33220108	Project Scientist	9.00	HR	0.00	230.48	0.00	0.00	$2,074.32	No
33220109	Staff Scientist	19.00	HR	0.00	186.14	0.00	0.00	$3,536.64	No

Total First Year Element Cost: $11,147.21

Element: Interviews

Year(s)	Cost per Year
2024	$2,746.46
2025 - 2028	$0.00
2029	$2,746.46
2030 - 2033	$0.00
2034	$2,746.46
2035 - 2038	$0.00
2039	$2,746.46
2040 - 2043	$0.00
2044	$2,746.46
2045 - 2048	$0.00
2049	$2,746.46
2050 - 2053	$0.00
2054	$2,746.46

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	11.00	HR	0.00	249.68	0.00	0.00	$2,746.46	No

Total First Year Element Cost: $2,746.46

Element: Site Inspection

Year(s)	Cost per Year
2024	$8,383.78
2025 - 2028	$0.00
2029	$8,383.78
2030 - 2033	$0.00
2034	$8,383.78
2035 - 2038	$0.00
2039	$8,383.78
2040 - 2043	$0.00
2044	$8,383.78
2045 - 2048	$0.00
2049	$8,383.78
2050 - 2053	$0.00
2054	$8,383.78

Estimate Documentation Report - Layout 1

Technology: Five-Year Review

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	6.00	HR	0.00	249.68	0.00	0.00	$1,498.07	No
33220105	Project Engineer	10.00	HR	0.00	211.68	0.00	0.00	$2,116.76	No
33220108	Project Scientist	11.00	HR	0.00	230.48	0.00	0.00	$2,535.28	No
33220109	Staff Scientist	12.00	HR	0.00	186.14	0.00	0.00	$2,233.67	No

Total First Year Element Cost: $8,383.78

Element: Report

Year(s)	Cost per Year
2024	$24,627.05
2025 - 2028	$0.00
2029	$24,627.05
2030 - 2033	$0.00
2034	$24,627.05
2035 - 2038	$0.00
2039	$24,627.05
2040 - 2043	$0.00
2044	$24,627.05
2045 - 2048	$0.00
2049	$24,627.05
2050 - 2053	$0.00
2054	$24,627.05

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	249.68	0.00	0.00	$2,996.13	No
33220105	Project Engineer	31.00	HR	0.00	211.68	0.00	0.00	$6,561.97	No
33220108	Project Scientist	25.00	HR	0.00	230.48	0.00	0.00	$5,762.00	No
33220109	Staff Scientist	50.00	HR	0.00	186.14	0.00	0.00	$9,306.95	No

Total First Year Element Cost: $24,627.05

Element: Travel

Year(s)	Cost per Year
2024	$848.14
2025 - 2028	$0.00
2029	$848.14
2030 - 2033	$0.00
2034	$848.14
2035 - 2038	$0.00
2039	$848.14

Estimate Documentation Report - Layout 1

Technology: Five-Year Review

2040 - 2043	$0.00
2044	$848.14
2045 - 2048	$0.00
2049	$848.14
2050 - 2053	$0.00
2054	$848.14

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	2.00	DAY	0.00	0.00	0.00	67.52	$135.05	No
33010202	Per Diem (per person)	4.00	DAY	0.00	0.00	0.00	178.50	$714.00	No
33041101	Airfare	2.00	LS	0.00	0.00	0.00	0.00	$0.00	No

Total First Year Element Cost: $849.05

Total First Year Tech Cost: $47,753.55

Cost Over Time Summary

Element	Year(s)	Cost per Year	Total Cost
Document Review	2024	$11,147.21	$11,147.21
Document Review	2029	$11,147.21	$11,147.21
Document Review	2034	$11,147.21	$11,147.21
Document Review	2039	$11,147.21	$11,147.21
Document Review	2044	$11,147.21	$11,147.21
Document Review	2049	$11,147.21	$11,147.21
Document Review	2054	$11,147.21	$11,147.21
Interviews	2024	$2,746.46	$2,746.46
Interviews	2029	$2,746.46	$2,746.46
Interviews	2034	$2,746.46	$2,746.46
Interviews	2039	$2,746.46	$2,746.46
Interviews	2044	$2,746.46	$2,746.46
Interviews	2049	$2,746.46	$2,746.46
Interviews	2054	$2,746.46	$2,746.46
Site Inspection	2024	$8,383.78	$8,383.78
Site Inspection	2029	$8,383.78	$8,383.78
Site Inspection	2034	$8,383.78	$8,383.78
Site Inspection	2039	$8,383.78	$8,383.78
Site Inspection	2044	$8,383.78	$8,383.78
Site Inspection	2049	$8,383.78	$8,383.78
Site Inspection	2054	$8,383.78	$8,383.78
Report	2024	$24,627.05	$24,627.05
Report	2029	$24,627.05	$24,627.05
Report	2034	$24,627.05	$24,627.05
Report	2039	$24,627.05	$24,627.05

Estimate Documentation Report - Layout 1

Report	2044	$24,627.05	$24,627.05
Report	2049	$24,627.05	$24,627.05
Report	2054	$24,627.05	$24,627.05
Travel	2024	$848.14	$848.14
Travel	2029	$848.14	$848.14
Travel	2034	$848.14	$848.14
Travel	2039	$848.14	$848.14
Travel	2044	$848.14	$848.14
Travel	2049	$848.14	$848.14
Travel	2054	$848.14	$848.14

Total Marked Up Tech Cost: $334,268.48

Phase Documentation:

Phase Type: Operations & Maintenance
Phase Name: RA-O (Monitoring FY25-FY100)
Description: Monitoring Technology - Annual sampling of 20 wells for VOCs from FY25-FY100

10% Contingency for RA-O phase (per EPA guidance for low level risk on RA-O phase).

Start Date: October, 2024
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Phase Markup Template: FUDS V8 - All Phases Except PCOA

Technology Markups	Markup	% Prime	% Sub.
MONITORING FY25-FY100	Yes	100	0

Total Marked-up Cost: $810,088.05

Technologies:

Technology Name: **Monitoring (#1)**
User Name: **MONITORING FY25-FY100**

Description	Default	User	UOM
System Definition			
Required Parameters			
Model Name		Monitoring	n/a

Estimate Documentation Report - Layout 1

Technology Name: **Monitoring (#1)**

User Name: **MONITORING FY25-FY100**

Description	Default	User	UOM
System Definition			
Required Parameters			
Groundwater		Yes	n/a
Surface Soil		No	n/a
Surface Water		No	n/a
Subsurface Soil		No	n/a
Sediment		No	n/a
Soil Gas		No	n/a
Air		No	n/a
Site Distance (One-way)		125	MI
Safety Level		D	n/a
Groundwater			
Required Parameters			
Average Sample Depth		40	FT
Samples per Event (First Year)		20	EA
Samples per Event (Out Years)		20	EA
Number of Events (First Year)		1	EA
Number of Events (Out Years)		1	EA
Number of Years (Out Years)		29	EA
Secondary Parameters			
Primary Analytical Template	System Water - VOCs	System Water - VOCs	n/a
Secondary Analytical Template	None	None	n/a
Turnaround Time	Standard (21 Days)	Standard (21 Days)	n/a
Data Package/QC	Stage 1	Stage 1	n/a
Sampling Method	Existing Wells - Low Flow Pump	Existing Wells - Passive Diffusion Samplers	n/a
Number of Wells/Day	12	10	EA
QA/QC			
Secondary Parameters			
Split Samples	1:10	1:10	EA
Field Duplicate Samples	1:10	1:10	EA
Rinse Blanks (per Round)	1	1	EA
Trip Blanks (per Day)	1	1	EA
Matrix Spikes/Matrix Spike Duplicates	1:20	1:20	EA
Data Management			
Secondary Parameters			
Monitoring Plan	Standard	None	n/a
Lab Data Review	Stage 1	Stage 1	n/a
Submit Data Electronically	Yes	Yes	n/a
Monitoring Reports	Abbreviated	Abbreviated	n/a

Comments: Monitoring FY25-FY100 Notes:

Estimate Documentation Report - Layout 1

Assume this will project monitoring costs for the rest of the standard 79 year RA-O estimate from FY25-FY100. Assume Annual sampling by passive diffusion bags for VOCs. Assume 125 miles one way to the site and that in the Data Mgmt tab, the Monitoring Plan is set to "None" as this was already costed in the RD phase.

Technology: MONITORING FY25-FY100

Element: Groundwater

Year(s)	Cost per Year
2025 - 2054	$14,533.06

NOTE: With the exception of the Data Management cost, total yearly cost shown matches the total element cost shown when the frequencies (number of samples and number of events) are similar for Year 1 and the out years. When a Comprehensive, Standard, or Abbreviated Monitoring Plan is included in the estimate, the Data Management cost shown for Year 1 will differ from the associated costs shown for the rest of the project duration, as it includes cost associated with the Monitoring Plan. Please reference the Monitoring, Cost Over Time & the Estimate Documentation Report help topic for details on how the Monitoring Plan cost is calculated. The help topic also addresses how the out year costs are calculated when frequencies (number of samples and number of events) differ between Year 1 and the out years.

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
33020401	Disposable Materials per Sample	28.00	EA	12.30	0.00	0.00	0.00	$344.27	No
33020402	Decontamination Materials per Sample	28.00	EA	28.09	0.00	0.00	0.00	$786.46	No
33020581	Passive Diffusion Samplers, 24" length	20.00	EA	45.10	0.00	0.00	0.00	$901.98	No
33021509	Monitor well sampling equipment, rental, water quality testing parameter device rental	1.00	WK	0.00	0.00	0.00	388.22	$388.22	No
33021618	Testing, purgeable organics (624, 8260)	28.00	EA	0.00	0.00	0.00	194.95	$5,458.70	No
33220102	Project Manager	3.00	HR	0.00	249.68	0.00	0.00	$749.03	No
33220112	Field Technician	50.00	HR	0.00	118.88	0.00	0.00	$5,943.77	No

Total First Year Element Cost: $14,572.44

Element: Data Management

Year(s)	Cost per Year
2025 - 2054	$8,225.52

NOTE: With the exception of the Data Management cost, total yearly cost shown matches the total element cost shown when the frequencies (number of samples and number of events) are similar for Year 1 and the out years. When a Comprehensive, Standard, or Abbreviated Monitoring Plan is included in the estimate, the Data Management cost shown for Year 1 will differ from the associated costs shown for the rest of the project duration, as it includes cost associated with the Monitoring Plan. Please reference the Monitoring, Cost Over Time & the Estimate Documentation Report help topic for details on how the Monitoring Plan cost is calculated. The help topic also addresses how the out year costs are calculated when frequencies (number of samples and number of events) differ between Year 1 and the out years.

Estimate Documentation Report - Layout 1

Technology: MONITORING FY25-FY100

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	6.00	HR	0.00	249.68	0.00	0.00	$1,498.07	No
33220108	Project Scientist	24.00	HR	0.00	230.48	0.00	0.00	$5,531.52	No
33220110	QA/QC Officer	2.00	HR	0.00	170.88	0.00	0.00	$341.76	No
33220112	Field Technician	2.00	HR	0.00	118.88	0.00	0.00	$237.75	No
33220114	Word Processing/Clerical	2.00	HR	0.00	117.08	0.00	0.00	$234.17	No
33220115	Draftsman/CADD	2.00	HR	0.00	136.46	0.00	0.00	$272.92	No
33240101	Other Direct Costs	1.00	LS	0.00	109.32	0.00	0.00	$109.32	No

Total First Year Element Cost: $8,225.52

Element: General Monitoring

Year(s)	Cost per Year
2025 - 2054	$4,244.35

NOTE: With the exception of the Data Management cost, total yearly cost shown matches the total element cost shown when the frequencies (number of samples and number of events) are similar for Year 1 and the out years. When a Comprehensive, Standard, or Abbreviated Monitoring Plan is included in the estimate, the Data Management cost shown for Year 1 will differ from the associated costs shown for the rest of the project duration, as it includes cost associated with the Monitoring Plan. Please reference the Monitoring, Cost Over Time & the Estimate Documentation Report help topic for details on how the Monitoring Plan cost is calculated. The help topic also addresses how the out year costs are calculated when frequencies (number of samples and number of events) differ between Year 1 and the out years.

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
33010104	Sample collection, vehicle mileage charge, car or van	310.00	MI	0.00	0.00	0.00	0.26	$80.35	No
33010202	Per Diem (per person)	4.00	DAY	0.00	0.00	0.00	178.50	$714.00	No
33022043	Overnight delivery service, 51 to 70 lb packages	120.00	LB	0.00	0.00	0.00	8.00	$960.08	No
33220112	Field Technician	21.00	HR	0.00	118.88	0.00	0.00	$2,496.38	No

Total First Year Element Cost: $4,250.82

Total First Year Tech Cost: $27,048.77

Cost Over Time Summary

Element	Year(s)	Cost per Year	Total Cost
Groundwater	2025 - 2054	$14,533.06	$435,991.80
Data Management	2025 - 2054	$8,225.52	$246,765.60
General Monitoring	2025 - 2054	$4,244.35	$127,330.50

Total Marked Up Tech Cost: $810,087.90

Cost Over Time Report (With Markups)

Folder: NWK 2018 CTC Estimates
FUDS Property Name: Forbes AFB Atlas S-05
FUDS Property ID: B07KS0204
Project Name: Alternative 2 - Long Term GW Monitoring
Project Type: HTRW
Project ID: 02

Location: KANSAS STATE AVERAGE, KS
Report Option: Fiscal

Estimator

Name: Grace Philpy
Title: Process Engineer
Agency/Org./Office: USACE/CENWK/ED-EG
Business Address: Bolling Federal Building Suite 439
601 E. 12th St.
Kansas City, MO 64106
Phone: 816-389-3908
Email: grace.philpy@usace.army.mil

Prepared Date: 3/12/2019 0:00

Phase	Phase Name	Fiscal Year 1 2020	Fiscal Year 2 2021	Fiscal Year 3 2022	Fiscal Year 4 2023	Fiscal Year 5 2024	Fiscal Year 6 2025	Fiscal Year 7 2026	Fiscal Year 8 2027	Fiscal Year 9 2028
Design	RD (LTM Work Plans)	$63,613								
Remedial Action	RA-C (Monitoring Well Installation)		$36,650							
Operations & Maintenance	RA-O (FY22-24 Monitoring Costs & 5YRs)			$68,858	$60,055	$107,808	$0	$0	$0	$0
Operations & Maintenance	RA-O (Monitoring FY25-FY100)						$27,003	$27,003	$27,003	$27,003
Total		$63,613	$36,650	$68,858	$60,055	$107,808	$27,003	$27,003	$27,003	$27,003

Fiscal Year 10 2029	Fiscal Year 11 2030	Fiscal Year 12 2031	Fiscal Year 13 2032	Fiscal Year 14 2033	Fiscal Year 15 2034	Fiscal Year 16 2035	Fiscal Year 17 2036	Fiscal Year 18 2037	Fiscal Year 19 2038	Fiscal Year 20 2039	Fiscal Year 21 2040	Fiscal Year 22 2041	Fiscal Year 23 2042
$47,753	$0	$0	$0	$0	$47,753	$0	$0	$0	$0	$47,753	$0	$0	$0
$27,003	$27,003	$27,003	$27,003	$27,003	$27,003	$27,003	$27,003	$27,003	$27,003	$27,003	$27,003	$27,003	$27,003
$74,756	$27,003	$27,003	$27,003	$27,003	$74,756	$27,003	$27,003	$27,003	$27,003	$74,756	$27,003	$27,003	$27,003

Fiscal Year 24 2043	Fiscal Year 25 2044	Fiscal Year 26 2045	Fiscal Year 27 2046	Fiscal Year 28 2047	Fiscal Year 29 2048	Fiscal Year 30 2049	Fiscal Year 31 2050	Fiscal Year 32 2051	Fiscal Year 33 2052	Fiscal Year 34 2053	Fiscal Year 35 2054	Total	Phase
												$63,613	Design
												$36,650	Remedial Action
$0	$47,753	$0	$0	$0	$0	$47,753	$0	$0	$0	$0	$47,753	$523,237	Operations & Maintenance
$27,003	$27,003	$27,003	$27,003	$27,003	$27,003	$27,003	$27,003	$27,003	$27,003	$27,003	$27,003	$810,088	Operations & Maintenance
$27,003	$74,756	$27,003	$27,003	$27,003	$27,003	$74,756	$27,003	$27,003	$27,003	$27,003	$74,756	$1,433,588	**Total**

Alternate Water Supply Costs
Forbes S-5 Feasibility Study

Task	Unit Cost	Unit	Quantity	Estimated Cost
Draft and Final Construction Work Plans	$12,000	LS	1	$12,000
Field Work, construction from Rural Water District to future residence	$20	feet	7920	$158,400
Field Work, water meter and installation	$2,500	LS	1	$2,500
Draft and Final Construction Completion Report	$8,000	LS	1	$8,000
Project Management Costs	$27,000	LS	1	$27,000
AWS Total Cost				$207,900

Notes:
Estimated distance from Rural Water to Residence based Lyon County Rural Water District 1 boundary to the South of the property. An additional 0.25 miles was added to account for piping to the residence on the property, resulting in a total of 1.5 miles of piping.

Linear feet of water connection piping based upon similar project using 4" 200 Class PVC piping, 20 ft gasketed sections from a 10" water main.

Reporting and project management costs based upon similar projects' work plans and construction completion report for rural water connection.

Alternative 3 – In-Situ Treatment with Groundwater Monitoring

Alternative 3 – In-Situ Treatment with Groundwater Monitoring

Description of Alternative 3 – In-Situ Treatment, Long-Term Monitoring (LTM), and contingent Alternative Water Supply (AWS)

Alternative 3 consists of the following assumptions, which are for cost estimating purposes only and does not necessarily reflect final design parameters:

- Cost estimate lasts until 2034. The cost estimate includes 2 years for remedial design and remedial action construction and 40 years for monitoring.

- In-situ remediation by ISCO or EAB will be performed in two separate area where TCE concentrations exceed 50µg/L, one near MW-13S and the other near MW02s and MW-11S. The total area to be treated approximately 60,000 square feet, where the impacted groundwater is approximately 20 feet bgs and approximately 10 feet in thickness.

- Assumed 3 injection rounds spaced 2 years apart. Injection costing is based upon 15 ft radius of influence and approximately 70 injection wells.

- Prior to full-scale implementation, a pilot study will be conducted to confirm injections are feasible onsite and if so, provide expected radius of influence for each injection well.

- The seventeen (17) existing monitoring wells along with three new monitoring wells (total of 20 wells) will be part of the groundwater sampling network. Additional wells will be installed offsite if the property owner agrees to right-of-entry.

- The first three years of sampling will be semi-annual, with the sampling rounds to be conducted using passive diffusion bag samplers for VOCs and down-hole probes to obtain field parameters. Starting in year 4, groundwater sampling frequency will be reduced to annually.

- Alternative includes connecting a future on-Site residence to an alternate water supply (Lyon County Rural Water District 1). Estimated costs include installing a service lateral to the water main, connecting the service lateral to the water main, installation of a water meter, design costs, project management costs, and construction completion report. This cost was assumed to occur during year 10, as an alternate water supply is not currently required.

- Five-year reviews will be conducted every five years.

Table B-2: Present Value Cost for Forbes S-5 Feasibility Study
Alternative 3 - In-Situ Injection Treatment

Fiscal Year	Year	Remedial Design ($)	Remedial Action Construction ($)	Injection Events	Monitoring Costs ($)	5-Year Review Costs ($)	Total Costs ($)	Discount with R at 0.6%	Total Present Value Cost ($)
2020	1	$ 119,608	$ -	$ -	$ -	$ -	$ 119,608	1.000	$ 119,608
2021	2	$ -	$ 2,000,516	$ -	$ 36,650	$ -	$ 2,037,166	0.994	$ 2,025,016
2022	3	$ -	$ -	$ -	$ 71,970	$ -	$ 71,970	0.988	$ 71,114
2023	4	$ -	$ -	$ 287,673	$ 60,055	$ -	$ 347,728	0.982	$ 341,544
2024	5	$ -	$ -	$ -	$ 56,194	$ 47,753	$ 103,947	0.976	$ 101,489
2025	6	$ -	$ -		$ 27,003	$ -	$ 27,003	0.971	$ 26,207
2026	7	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.965	$ 26,051
2027	8	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.959	$ 25,896
2028	9	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.953	$ 25,741
2029	10	$ -	$ 207,900	$ -	$ 27,003	$ 47,753	$ 282,656	0.948	$ 267,840
2030	11	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.942	$ 25,435
2031	12	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.936	$ 25,283
2032	13	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.931	$ 25,133
2033	14	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.925	$ 24,983
2034	15	$ -	$ -	$ -	$ 27,003	$ 47,753	$ 74,756	0.920	$ 68,750
2035	16	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.914	$ 24,686
2036	17	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.909	$ 24,538
2037	18	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.903	$ 24,392
2038	19	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.898	$ 24,246
2039	20	$ -	$ -	$ -	$ 27,003	$ 47,753	$ 74,756	0.893	$ 66,724
2040	21	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.887	$ 23,958
2041	22	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.882	$ 23,815
2042	23	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.877	$ 23,673
2043	24	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.871	$ 23,532
2044	25	$ -	$ -	$ -	$ 27,003	$ 47,753	$ 74,756	0.866	$ 64,758
2045	26	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.861	$ 23,252
2046	27	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.856	$ 23,113
2047	28	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.851	$ 22,976
2048	29	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.846	$ 22,839
2049	30	$ -	$ -	$ -	$ 27,003	$ 47,753	$ 74,756	0.841	$ 62,850
2050	31	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.836	$ 22,567
2051	32	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.831	$ 22,432
2052	33	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.826	$ 22,299
2053	34	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.821	$ 22,166
2054	35	$ -	$ -	$ -	$ 27,003	$ 47,753	$ 74,756	0.816	$ 60,998
2055	36	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.811	$ 21,902
2056	37	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.806	$ 21,771
2057	38	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.801	$ 21,641
2058	39	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.797	$ 21,512
2059	40	$ -	$ -	$ -	$ 27,003	$ 47,753	$ 74,756	0.792	$ 59,200
2060	41	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.787	$ 21,257
2061	42	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.782	$ 21,130
2062	43	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.778	$ 21,004
2063	44	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.773	$ 20,878
2064	45	$ -	$ -	$ -	$ 27,003	$ 47,753	$ 74,756	0.769	$ 57,456
2065	46	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.764	$ 20,630
2066	47	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.759	$ 20,507
2067	48	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.755	$ 20,385
2068	49	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.750	$ 20,263
2069	50	$ -	$ -	$ -	$ 27,003	$ 47,753	$ 74,756	0.746	$ 55,763
2070	51	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.741	$ 20,022
2071	52	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.737	$ 19,903
2072	53	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.733	$ 19,784
2073	54	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.728	$ 19,666
2074	55	$ -	$ -	$ -	$ 27,003	$ 47,753	$ 74,756	0.724	$ 54,120
2075	56	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.720	$ 19,432
2076	57	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.715	$ 19,316
2077	58	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.711	$ 19,201
2078	59	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.707	$ 19,087
2079	60	$ -	$ -	$ -	$ 27,003	$ 47,753	$ 74,756	0.703	$ 52,525
2080	61	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.698	$ 18,860
2081	62	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.694	$ 18,747
2082	63	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.690	$ 18,635
2083	64	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.686	$ 18,524
2084	65	$ -	$ -	$ -	$ 27,003	$ 47,753	$ 74,756	0.682	$ 50,977

Table B-2: Present Value Cost for Forbes S-5 Feasibility Study
Alternative 3 - In-Situ Injection Treatment

2085	66	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.678	$ 18,304
2086	67	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.674	$ 18,195
2087	68	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.670	$ 18,086
2088	69	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.666	$ 17,978
2089	70	$ -	$ -	$ -	$ 27,003	$ 47,753	$ 74,756	0.662	$ 49,475
2090	71	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.658	$ 17,765
2091	72	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.654	$ 17,659
2092	73	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.650	$ 17,553
2093	74	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.646	$ 17,449
2094	75	$ -	$ -	$ -	$ 27,003	$ 47,753	$ 74,756	0.642	$ 48,017
2095	76	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.638	$ 17,241
2096	77	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.635	$ 17,138
2097	78	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.631	$ 17,036
2098	79	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.627	$ 16,934
2099	80	$ -	$ -	$ -	$ 27,003	$ 47,753	$ 74,756	0.623	$ 46,602
2100	81	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.620	$ 16,733
2101	82	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.616	$ 16,633
2102	83	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.612	$ 16,534
2103	84	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.609	$ 16,435
2104	85	$ -	$ -	$ -	$ 27,003	$ 47,753	$ 74,756	0.605	$ 45,229
2105	86	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.601	$ 16,240
2106	87	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.598	$ 16,143
2107	88	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.594	$ 16,047
2108	89	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.591	$ 15,951
2109	90	$ -	$ -	$ -	$ 27,003	$ 47,753	$ 74,756	0.587	$ 43,896
2110	91	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.584	$ 15,761
2111	92	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.580	$ 15,667
2112	93	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.577	$ 15,574
2113	94	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.573	$ 15,481
2114	95	$ -	$ -	$ -	$ 27,003	$ 47,753	$ 74,756	0.570	$ 42,603
2115	96	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.566	$ 15,297
2111	97	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.563	$ 15,206
2112	98	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.560	$ 15,115
2113	99	$ -	$ -	$ -	$ 27,003	$ -	$ 27,003	0.556	$ 15,025
2113	100	$ -	$ -	$ -	$ 27,003	$ 47,753	$ 74,756	0.553	$ 41,347
	Total	$ 119,600	$ 2,208,400	$ 287,700	$ 2,790,200	$ 955,100	$ 6,360,900		**$ 5,426,400**

Notes:

Totals are rounded to the nearest $100

Discount Equation =1/(1+R)^(n-1)

R= Discount Rate, currently at 0.6% for 2018; n= year

-Discount Rate is taken from the 30-year Real Discount Rates for the 2017 Appendix C of OMB Circular No. A-94.

-Source DK model has a remedial timeframe of 100 years after injections. Reasonable timeframe of 100 years selected for project costs.

Contingent alternate water supply costs included in Year 10.

Estimate Documentation Report - Layout 1

Software:

RACER Version: RACER® Version 11.5.99.0
Database Location: C:\Users\g5edegep\Desktop\B07KS0204_01_24.mdb

Folder:

Folder Name: NWK 2018 CTC Estimates

FUDS Property:

ID: B07KS0204
Name: Forbes AFB Atlas S-05
Category: None

Location
State / Country: KANSAS
City: KANSAS STATE AVERAGE

Location Modifier	Default	User	Reason for changes
	0.960	0.960	

Options
Database: Modified System Costs
Cost Database Date: 2019
Report Option: Fiscal

Description

Forbes AFB Atlas Missile Site S-05 Property Description:

Contamination and Source: VOC solvents potentially from missile maintenance operations are the main focus of environmental investigation at the site.

This Atlas E (coffin type) site is located near Bushong, Kansas (20 miles northwest of Emporia, KS, and was one of nine missile atlas sites that were circled around Forbes AFB in Topeka, KS. Used primarily between 1960-1963 before being deactivated.

In 1990-91, O'Brien and Gere (for USACE) performed a limited investigation (confirmation study) to provide a preliminary determination of the presence or absence of chemical contamination which may have resulted from past DOD activities at the site. Two monitoring wells installed, shallow soil samples for metals, SVOCs, and VOCs were taken. TCE, trans-1,2-DCE detected.

In 1990's Right of Entry (ROE) to the property was denied and no further investigation were conducted until 2006 when ROE was once again granted by different owner. In 2007, Tetra Tech conducted an environmental investigation at the property. TCE, and cis-1,2-DCE

Estimate Documentation Report - Layout 1

detected in groundwater. In 2017 Remedial Investigation was completed.

Location Modifier:
Geographic Information: Bushong, Lyon County, Kansas, 66833.
Latitude: 38.68694444
Longitude: -96.30333333

Assume KANSAS STATE AVERAGE for location cost modifier.

Estimate Documentation Report - Layout 1

Project:

ID: 03
Name: Alternative 3 - In-Situ Injections
Type: HTRW

Media/Waste Type

Primary: Groundwater
Secondary: N/A

Contaminant

Primary: Volatile Organic Compounds (VOCs)
Secondary: None

Phase Names

Pre-Study	☐	
Study	☑	**Safety Level:** D
Design	☑	**Safety Level:** E
Removal/Interim Action	☐	
Remedial Action	☑	**Safety Level:** D
Operations & Maintenance	☑	**Safety Level:** D
Long Term Monitoring	☐	
Site Closeout	☐	

In the RACER Preferences the default value for the Safety Level is established. This sets the default value for the safety level for each technology model based on the type of work being completed. Note: RACER Technologies that safety level is not appropriate to change from the default are hard-coded to estimate costs without a safety level productivity factor, which is Safety Level E.

Documentation

Description: Forbes AFB Atlas Missile Site S-05 Project: The cost include are to estimate the estimated capital and long term cost of the alternatives included in the feasibility study report. This Alternative is for Alternative 3 In-Situ Treatment with MNA 75% mass removal.See section 6.2.3 for Alternative 3 details.

Support Team: Project Geologist Chuck Williams 816-389-3575
Project Engineer Jason L'Ecuyer 816-389-3908

References: May 2018 Remedial Investigation Reprot.

Estimator Information

Estimator Name: Jason L'Ecuyer
Estimator Title: Process Engineer
Agency/Org./Office: USACE/CENWK/ED-EG
Business Address: Bolling Federal Building Suite 439
601 E. 12th St.
Kansas City, MO 64106
Telephone Number: 816-389-3908
Email Address: jason.r.lecuyer@usace.army.mil
Estimate Prepared Date: 01/24/2019

Estimator Signature: _____ **Date:** _____

Estimate Documentation Report - Layout 1

Reviewer Information

Reviewer Name:
Reviewer Title:
Agency/Org./Office:
Business Address:
Telephone Number:
Email Address:
Date Reviewed: 01/24/2019

Reviewer Signature: _____ **Date:** _____

Estimate Costs:

Phase Names	Marked-Up Cost
RD (Work Plans)	$119,608
RA-C (Monitoring Well Installation)	$36,650
RA-C - In-Situ Treatment	$2,000,516
RA-O (FY22-26 Monitoring Costs & 5YRs)	$646,460
Re-Injection (1 event)	$287,673
Total Cost:	$3,090,907

Total Project Cost: $3,090,907

Phase Documentation:

Phase Type: Design
Phase Name: RD (Work Plans)
Description: Remedial Design Phase to estimate costs for developing an In-Situ design for in-situ treatment of TCE concentrations greater than 50ug/L and to install three additional groundwater monitoring wells in the RA-C phase and to conduct scheduled long-term monitoring for VOCs during the subsequent RA-O phase. Assume the RD-Detail Technology used for the estimate.

In accordance with ER 1110-3-1301, dated 30 Dec 2016, Contingencies shall be applied to each phase total as described in the EPA Guidance "A Guide to Developing and Documenting Cost Estimates during the Feasibility Study." For RD phase, a 0% contingency is recommended. The scope of work estimated in the RD phase is relatively defined for the FUDS program and there is no field work associated with this phase. Therefore the contingency for the RD phase is 0%.

Start Date: October, 2019
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Estimate Documentation Report - Layout 1

Phase Markup Template: FUDS RD 0% Continency

Technology Markups	Markup	% Prime	% Sub.
Remedial Design	Yes	100	0

Total Marked-up Cost: $119,608.01

Technologies:

Technology Name: **Remedial Design (#2)**

User Name: **Remedial Design**

Description	Default	User	UOM
System Definition			
Required Parameters			
Project Approach		Ex Situ Removal - Performance-Based On-site Treatment or Disposal	n/a
Complexity		Moderately Low	n/a
Project Planning		Yes	n/a
Treatability & Other Studies		No	n/a
Preliminary Design (30%)		Yes	n/a
Intermediate Design (60%)		Yes	n/a
Prefinal Design (90%)		Yes	n/a
Final Design (100%)		Yes	n/a
Bid Documents		Yes	n/a
Site Distance		125	MI
Level of RD Detail		Narrow	n/a
Project Planning			
Required Parameters			
Site Visit		Yes	n/a
RD Work Plan		Yes	n/a
Data Review		Yes	n/a
Public Meetings		Yes	n/a
Preliminary Design			
Required Parameters			
Design Criteria Memorandum		Yes	n/a
Basis of Design Report		Yes	n/a
Preliminary Plans & Specifications		Yes	n/a
VE Screening Report		No	n/a

Estimate Documentation Report - Layout 1

Technology Name: **Remedial Design (#2)**

User Name: **Remedial Design**

Description	Default	User	UOM
Preliminary Design			
Required Parameters			
Public Meetings		No	n/a
Intermediate Design			
Required Parameters			
Revised Basis of Design Report		Yes	n/a
Intermediate Plans & Specifications		Yes	n/a
VE Report		Yes	n/a
Prefinal Design			
Required Parameters			
Prefinal Plans & Specifications		Yes	n/a
Construction QA Plan		Yes	n/a
Final Design			
Required Parameters			
Final Plans & Specifications		Yes	n/a
Final Report		Yes	n/a
Public Meetings		Yes	n/a
Post Design Fact Sheet		Yes	n/a
Bid Documents			
Required Parameters			
Prepare Bid Documents		Yes	n/a
Issue Invitations for Bids/Request Proposals		Yes	n/a
Contractor Bid Evaluation/Selection Support		Yes	n/a

Comments: Remedial Design Notes - Assume for the System Definition Tab that Remediation approach is Ex-Situ Removal, Performance Based On-Site Treatment, low site complexity, narrow level of RD detail, and 125 miles one way to the site. Tasks to be completed include: Project Planning, 60. 90, and 100% drafts, bid documents. Assume all tasks selected in secondary tabs.

Technology: Remedial Design

Element: Project Planning

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
33010104	Sample collection, vehicle mileage charge, car or van	125.00	MI	0.00	0.00	0.00	0.26	$32.40	No
33220102	Project Manager	23.00	HR	0.00	186.12	0.00	0.00	$4,280.84	No
33220103	Office Manager	4.00	HR	0.00	153.98	0.00	0.00	$615.91	No
33220105	Project Engineer	5.00	HR	0.00	157.80	0.00	0.00	$788.98	No
33220106	Staff Engineer	30.00	HR	0.00	162.52	0.00	0.00	$4,875.63	No
33220109	Staff Scientist	75.00	HR	0.00	138.76	0.00	0.00	$10,406.87	No
33220110	QA/QC Officer	29.00	HR	0.00	127.38	0.00	0.00	$3,694.14	No

Estimate Documentation Report - Layout 1

Technology: Remedial Design

33220111	Certified Industrial Hygienist	3.00	HR	0.00	168.61	0.00	0.00	$505.83	No
33220112	Field Technician	16.00	HR	0.00	88.62	0.00	0.00	$1,417.86	No
33220113	Secretarial/ Administrative	8.00	HR	0.00	96.01	0.00	0.00	$768.10	No
33220114	Word Processing/Clerical	25.00	HR	0.00	87.28	0.00	0.00	$2,182.03	No
33220115	Draftsman/CADD	4.00	HR	0.00	101.73	0.00	0.00	$406.90	No
33240101	Other Direct Costs	1.00	LS	164.56	0.00	0.00	0.00	$164.56	No

Total Element Cost: $30,140.03

Element: Preliminary Design

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	6.00	HR	0.00	186.12	0.00	0.00	$1,116.74	No
33220103	Office Manager	6.00	HR	0.00	153.98	0.00	0.00	$923.86	No
33220105	Project Engineer	25.00	HR	0.00	157.80	0.00	0.00	$3,944.88	No
33220106	Staff Engineer	51.00	HR	0.00	162.52	0.00	0.00	$8,288.57	No
33220109	Staff Scientist	42.00	HR	0.00	138.76	0.00	0.00	$5,827.84	No
33220110	QA/QC Officer	9.00	HR	0.00	127.38	0.00	0.00	$1,146.46	No
33220113	Secretarial/ Administrative	4.00	HR	0.00	96.01	0.00	0.00	$384.05	No
33220114	Word Processing/Clerical	26.00	HR	0.00	87.28	0.00	0.00	$2,269.31	No
33220115	Draftsman/CADD	13.00	HR	0.00	101.73	0.00	0.00	$1,322.43	No
33240101	Other Direct Costs	1.00	LS	69.31	0.00	0.00	0.00	$69.31	No

Total Element Cost: $25,293.45

Element: Intermediate Design

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	3.00	HR	0.00	186.12	0.00	0.00	$558.37	No
33220105	Project Engineer	5.00	HR	0.00	157.80	0.00	0.00	$788.98	No
33220106	Staff Engineer	23.00	HR	0.00	162.52	0.00	0.00	$3,737.98	No
33220110	QA/QC Officer	4.00	HR	0.00	127.38	0.00	0.00	$509.54	No
33220113	Secretarial/ Administrative	2.00	HR	0.00	96.01	0.00	0.00	$192.02	No
33220114	Word Processing/Clerical	3.00	HR	0.00	87.28	0.00	0.00	$261.84	No
33220115	Draftsman/CADD	7.00	HR	0.00	101.73	0.00	0.00	$712.08	No
33240101	Other Direct Costs	1.00	LS	18.58	0.00	0.00	0.00	$18.58	No

Total Element Cost: $6,779.39

Estimate Documentation Report - Layout 1

Element: Prefinal Design

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	5.00	HR	0.00	186.12	0.00	0.00	$930.62	No
33220103	Office Manager	10.00	HR	0.00	153.98	0.00	0.00	$1,539.77	No
33220105	Project Engineer	8.00	HR	0.00	157.80	0.00	0.00	$1,262.36	No
33220106	Staff Engineer	37.00	HR	0.00	162.52	0.00	0.00	$6,013.27	No
33220109	Staff Scientist	52.00	HR	0.00	138.76	0.00	0.00	$7,215.43	No
33220110	QA/QC Officer	7.00	HR	0.00	127.38	0.00	0.00	$891.69	No
33220111	Certified Industrial Hygienist	15.00	HR	0.00	168.61	0.00	0.00	$2,529.13	No
33220113	Secretarial/ Administrative	5.00	HR	0.00	96.01	0.00	0.00	$480.06	No
33220114	Word Processing/Clerical	34.00	HR	0.00	87.28	0.00	0.00	$2,967.56	No
33220115	Draftsman/CADD	9.00	HR	0.00	101.73	0.00	0.00	$915.53	No
33240101	Other Direct Costs	1.00	LS	101.99	0.00	0.00	0.00	$101.99	No

Total Element Cost: $24,847.41

Element: Final Design

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	13.00	HR	0.00	186.12	0.00	0.00	$2,419.60	No
33220103	Office Manager	10.00	HR	0.00	153.98	0.00	0.00	$1,539.77	No
33220105	Project Engineer	8.00	HR	0.00	157.80	0.00	0.00	$1,262.36	No
33220106	Staff Engineer	40.00	HR	0.00	162.52	0.00	0.00	$6,500.84	No
33220109	Staff Scientist	52.00	HR	0.00	138.76	0.00	0.00	$7,215.43	No
33220110	QA/QC Officer	7.00	HR	0.00	127.38	0.00	0.00	$891.69	No
33220111	Certified Industrial Hygienist	15.00	HR	0.00	168.61	0.00	0.00	$2,529.13	No
33220113	Secretarial/ Administrative	5.00	HR	0.00	96.01	0.00	0.00	$480.06	No
33220114	Word Processing/Clerical	34.00	HR	0.00	87.28	0.00	0.00	$2,967.56	No
33220115	Draftsman/CADD	9.00	HR	0.00	101.73	0.00	0.00	$915.53	No
33240101	Other Direct Costs	1.00	LS	110.14	0.00	0.00	0.00	$110.14	No

Total Element Cost: $26,832.11

Element: Bid Documents

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	4.00	HR	0.00	186.12	0.00	0.00	$744.49	No

Estimate Documentation Report - Layout 1

Technology: Remedial Design

33220103	Office Manager	6.00	HR	0.00	153.98	0.00	0.00	$923.86	No
33220105	Project Engineer	4.00	HR	0.00	157.80	0.00	0.00	$631.18	No
33220106	Staff Engineer	4.00	HR	0.00	162.52	0.00	0.00	$650.08	No
33220109	Staff Scientist	2.00	HR	0.00	138.76	0.00	0.00	$277.52	No
33220110	QA/QC Officer	3.00	HR	0.00	127.38	0.00	0.00	$382.15	No
33220111	Certified Industrial Hygienist	2.00	HR	0.00	168.61	0.00	0.00	$337.22	No
33220113	Secretarial/ Administrative	10.00	HR	0.00	96.01	0.00	0.00	$960.12	No
33220114	Word Processing/Clerical	9.00	HR	0.00	87.28	0.00	0.00	$785.53	No
33240101	Other Direct Costs	1.00	LS	23.46	0.00	0.00	0.00	$23.46	No

Total Element Cost: $5,715.62

Total Tech Cost: $119,608.01

Cost Over Time Summary

Element	Year(s)	Cost per Year	Total Cost
General	2020	$119,608.01	$119,608.01

Total Marked Up Tech Cost: $119,608.01

Phase Documentation:

Phase Type: Remedial Action
Phase Name: RA-C (Monitoring Well Installation)
Description: Remedial Action - Construction will consist of setting up the monitoring well network. There are 17 existing monitoring wells. Assume three more shall be installed during this phase.

In accordance with ER 1110-3-1301, dated 30 Dec 2016, Contingencies shall be applied to each phase total as described in the EPA Guidance "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study." When estimating remedial action construction phase where the study phases are not all complete, there is a greater level of risk associated with the phase. Exhibit 5-6 in the EPA Guidance shows various contingences per technology. By taking the average of each technology contingency range and then average in all of the technology contingency together the average contingency is 15% for RA-C phase.

Note that FUDS Program Manager Dave Nelson does not believe installing monitoring wells constitutes enough work for an entire RA-C phase so this phase is being renamed/reassigned to the RA-O phase. See attached Email note "FW_CTCs still needing work (Nelson 12Mar2018). pdf"

Approach: Ex Situ
Start Date: October, 2020
Labor Rate Group: System Labor Rate

Estimate Documentation Report - Layout 1

Analysis Rate Group: System Analysis Rate

Phase Markup Template: FUDS V8 - All Phases Except PCO

Technology Markups	Markup	% Prime	% Sub.
Groundwater Monitoring Well	Yes	100	0
Professional Labor Management	No	0	100
Residual Waste Management	Yes	100	0

Total Marked-up Cost: $36,649.90

Technologies:

Technology Name: **Residual Waste Management (#2)**

User Name: **Residual Waste Management**

Description	Default	User	UOM
System Definition			
Required Parameters			
Safety Level		D	n/a
Non-Rad Disposal			
Required Parameters			
Waste Type/ Condition		Non-Hazardous Drums	n/a
Total Quantity		6	Units
Units		Drums	-
Stabilization		No	n/a
Transportation Type		Truck	n/a
Distance 1		125	MI
Distance 2		0	MI

Comments: Residual Waste Management technology used to estimate costs for any IDW created by the groundwater monitoring well installation. Assumed 125 miles one-way to the site, IDW is non-hazardous waste and will be transported by truck in its existing container.

Technology: Residual Waste Management

Element:

Year(s)	Cost per Year
2021	$1,481.06

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
33190103	Load Drums on Disposal Vehicle	6.00	EA	0.00	8.57	2.80	0.00	$68.22	No

Estimate Documentation Report - Layout 1

Technology: Residual Waste Management

33190204	Transport 55 Gallon Drums of Hazardous Waste, Max 80 drums (per Mile)	125.00	MI	0.00	0.00	0.00	2.32	$289.51	No
33190317	Waste Stream Evaluation Fee, Not Including 50% Rebate on 1st Shipment	1.00	EA	0.00	0.00	0.00	68.23	$68.23	No
33197205	Landfill Nonhazardous Solid Waste, 55 Gallon Drum	6.00	EA	0.00	0.00	0.00	175.85	$1,055.10	No

Total Element Cost: $1,481.06

Total Tech Cost: $1,481.06

Cost Over Time Summary

Element	Year(s)	Cost per Year	Total Cost
General	2021	$1,481.06	$1,481.06

Total Marked Up Tech Cost: $1,481.06

Technology Name: **Groundwater Monitoring Well (#2)**

User Name: **Groundwater Monitoring Well**

Description	Default	User	UOM
System Definition			
Required Parameters			
Number of Aquifers		One	n/a
Include Guard Posts		Yes	n/a
Depth to Groundwater to Aquifer One		35	FT
Number of Wells to Aquifer One		3	EA
Safety Level		D	n/a
Aquifer One			
Required Parameters			
Aquifer One: Average Well Depth		40	LF
Aquifer One: Formation Type		Unconsolidated	n/a
Aquifer One: Drilling Method		Air Rotary	n/a
Aquifer One: Well Diameter		2 Inch	n/a
Aquifer One: Well Construction Material		PVC Schedule 40	n/a
Aquifer One: Split Spoon Sample Collection		No	n/a
Aquifer One: Average Number of Soil Samples per Well		0	EA
Aquifer One: Soil Analytical Template		None	n/a

Comments: Groundwater Monitoring Well Technology Notes:

Assume one aquifer, depth to groundwater 35 ft, bgs, 3 wells to be installed with guard posts, average well depth of 40 ft, unconsolidated formation, well drilled by air rotary methods, 2 in.

Estimate Documentation Report - Layout 1

diameter, schedule 40 PVC construction, safety level d.

Technology: Groundwater Monitoring Well

Element: Aquifer 1

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
33020303	Organic Vapor Analyzer Rental, per Day	2.00	DAY	0.00	0.00	0.00	53.88	$107.76	No
33170808	Decontaminate Rig, Augers, Screen (Rental Equipment)	2.00	DAY	65.35	898.47	0.00	0.00	$1,927.63	No
33220112	Field Technician	32.00	HR	0.00	124.28	0.00	0.00	$3,976.92	No
33230101	2" PVC, Schedule 40, Well Casing	90.00	LF	4.98	7.59	6.34	0.00	$1,701.13	No
33230201	2" PVC, Schedule 40, Well Screen	30.00	LF	5.79	7.59	6.34	0.00	$591.36	No
33230301	2" PVC, Well Plug	3.00	EA	15.90	22.74	18.99	0.00	$172.88	No
33231146	Air Rotary, 6" Dia Borehole (Unconsolidated), Depth <= 100 ft	123.00	LF	0.00	33.85	37.57	0.00	$8,785.11	No
33231401	2" Screen, Filter Pack	36.00	LF	8.69	5.85	4.88	0.00	$698.99	No
33231811	2" Well, Portland Cement Grout	81.00	LF	9.74	0.00	0.00	0.00	$789.27	No
33232101	2" Well, Bentonite Seal	3.00	EA	24.48	151.23	126.26	0.00	$905.93	No

Total Element Cost: $19,656.99

Element: General Aquifers

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
33010101	Mobilize/DeMobilize Drilling Rig & Crew	1.00	LS	0.00	2,274.44	1,512.07	0.00	$3,786.51	No
33231178	Move Rig/Equipment Around Site	2.00	EA	149.34	326.95	217.36	0.00	$1,387.31	No
33231182	DOT steel drums, 55 gal., open, 17C	6.00	EA	142.94	0.00	0.00	0.00	$857.61	No
33231504	Surface Pad, Concrete, 2' x 2' x 4"	3.00	EA	89.33	25.58	1.74	0.00	$349.96	No
33232301	5' Guard Posts, Cast Iron, Concrete Fill	12.00	EA	86.79	162.85	0.07	0.00	$2,996.46	No

Total Element Cost: $9,377.86

Total Tech Cost: $29,034.85

Cost Over Time Summary

Element	Year(s)	Cost per Year	Total Cost
General	2021	$29,034.85	$29,034.85

Estimate Documentation Report - Layout 1

Total Marked Up Tech Cost: $29,034.85

Technology Name: **Professional Labor Management (#2)**

User Name: **Professional Labor Management**

Description	Default	User	UOM
System Definition			
Required Parameters			
Markedup Construction Cost ($)		30516.00	$
Percentage	20.10	20.10	%
Dollar Amount		6134.00	$

Comments: Professional Labor Management costs for conducting management of groundwater monitoring well installation and disposal of IDW waste. Assumed default % to calculate this technology.

Technology: Professional Labor Management

Element:

Year(s)	Cost per Year
2021	$6,134.00

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
33220149	Lump Sum Percentage Labor Cost	1.00	LS	0.00	6,134.00	0.00	0.00	$6,134.00	No

Total Element Cost: $6,134.00

Total Tech Cost: $6,134.00

Cost Over Time Summary

Element	Year(s)	Cost per Year	Total Cost
General	2021	$6,134.00	$6,134.00

Total Marked Up Tech Cost: $6,134.00

Phase Documentation:

Phase Type: Remedial Action

Phase Name: RA-C - In-Situ Treatment

Description: Remedial Action - Construction - In-situ remediation by ISCO or EAB will be performed in two separate area where TCE concentrations exceed 50ug/L, one near MW-13S and the other near MW02s and MW-11S. The total area to be treated approximately 60,000 square feet approximately 10 feet in thickness, approximately 20 feet bgs.

Approach: In Situ

Start Date: October, 2020

Labor Rate Group: System Labor Rate

Estimate Documentation Report - Layout 1

Analysis Rate Group: System Analysis Rate

Phase Markup Template: FUDS V8 - All Phases Except PCO

Technology Markups	Markup	% Prime	% Sub.
In Situ Biodegradation	Yes	100	0
Professional Labor Management	No	0	100
Residual Waste Management	Yes	100	0

Total Marked-up Cost: $2,000,516.14

Technologies:

Technology Name: **In Situ Biodegradation (#1)**

User Name: **In Situ Biodegradation**

Description	Default	User	UOM
System Definition			
Required Parameters			
Media of Concern		Groundwater	n/a
Soil Type		Silt/Silty-Clay Mixture	n/a
Type of Biodegradation		Anaerobic	n/a
Remedial Configuration		Entire Plume	n/a
Contaminant Concentration		Low	n/a
Treatment Area Length		300	FT
Treatment Area Width		200	FT
Depth to Top of Aquifer		20	FT
Aquifer Thickness		10	FT
Formation		Consolidated	n/a
Treatability Test		Yes	n/a
Install Monitoring Technology		Yes	n/a
Safety Level		E	n/a
Anaerobic			
Secondary Parameters			
Treatment Area	60000	60000	SF
Substrate Selection	Vegetable Oil	Vegetable Oil	n/a
Bioaugmentation	0	0	L
Nutrient	561	561	LB
Substrate Delivery Method	Injection Wells	Injection Wells	n/a
Number of Delivery Points	240	70	EA
Substrate Application Rate / Delivery Point	10.00	3.00	%
Number of Applications for First Year	1	1	EA

Estimate Documentation Report - Layout 1

Technology Name: **In Situ Biodegradation (#1)**

User Name: **In Situ Biodegradation**

Description	Default	User	UOM
Anaerobic			
Secondary Parameters			
Outyears for O&M Only	1	1	Years
Number of Bench-scale Tests	1	0	EA
Cost per Bench-scale Test	0.00	0.00	$
Number of Pilot-scale Tests	1	1	EA
Cost per Pilot-scale Test	50000.00	100000.00	$
Injection Well			
Secondary Parameters			
Drilling Method	Air Rotary	Air Rotary	n/a
Screen Length per Well	10	10	FT
Substrate Mixing System Type	Batch Mixing	Batch Mixing	n/a
Average Length of Piping, per Well	100	100	FT

Comments: In-situ remediation by ISCO or EAB will be performed in two separate area where TCE concentrations exceed 50ug/L, one near MW-13S and the other near MW02s and MW-11S. The total area to be treated approximately 60,000 square feet approximately 10 feet in thickness. Assumed 2 injection rounds 2 years apart. Molasses was assumed to the amendment that will be used for this alternative (soluble, able to treat larger area). This amendment selection may change during remedial design.

Technology: In Situ Biodegradation
Element:

Year(s)	Cost per Year
2021	$1,814,654.01

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
19010207	Polyvinyl chloride pressure pipe, 4", class 200, SDR 21, includes trenching to 3' deep	7,000.00	LF	4.22	17.24	6.85	0.00	$198,140.78	No
19040401	Wastewater holding tanks, above ground, ss, DOT approved, monthly rental, 550 gal	1.00	MO	0.00	0.00	0.00	555.86	$555.86	No
33020537	Water level indicators, water level chart recorder, battery operated	70.00	EA	1,720.52	0.00	0.00	0.00	$120,436.24	No
33021511	Recycle Flow Meter, 3/4 HP Unit	70.00	EA	496.30	0.00	0.00	0.00	$34,741.22	No
33119951	Biological treatment, bionutrients, 50 lb bag	12.00	EA	312.01	0.00	0.00	0.00	$3,744.11	No
33190340	Non Haz Drummed Site Waste - Load,	105.00	EA	0.00	0.00	0.00	317.63	$33,351.57	No

Estimate Documentation Report - Layout 1

Technology: In Situ Biodegradation

	Transp, & Landfill Disp (55-Gal Drums)								
33220105	Project Engineer	84.00	HR	0.00	181.46	0.00	0.00	$15,243.00	No
33220112	Field Technician	560.00	HR	0.00	101.91	0.00	0.00	$57,068.84	No
33230112	4" PVC, Schedule 80, Well Casing	1,400.00	LF	17.80	9.33	9.50	0.00	$51,278.05	No
33230212	4" PVC, Schedule 80, Well Screen	700.00	LF	25.31	9.33	9.50	0.00	$30,896.53	No
33230302	4" PVC, Well Plug	70.00	EA	31.40	20.73	21.09	0.00	$5,125.49	No
33231128	Air Rotary, 8" Dia Borehole (Consolidated), Depth <= 100 ft	2,100.00	LF	0.00	55.50	75.16	0.00	$274,386.18	No
33231178	Move Rig/Equipment Around Site	69.00	EA	149.34	268.10	217.36	0.00	$43,801.54	No
33231180	Mobilization/Demobilization, Drill Equipment or Trencher, Crew	1.00	EA	649.33	1,165.65	945.04	0.00	$2,760.02	No
33231187	Load Supplies/Equipment	1.00	LS	389.60	699.39	567.03	0.00	$1,656.01	No
33231402	4" Screen, Filter Pack	910.00	LF	14.99	8.29	8.44	0.00	$28,859.53	No
33231502	Surface Pad, Concrete, 4' x 4' x 4"	1.00	EA	138.96	32.62	2.71	0.00	$174.30	No
33231812	4" Well, Portland Cement Grout	1,190.00	LF	14.03	0.00	0.00	0.00	$16,694.32	No
33232102	4" Well, Bentonite Seal	70.00	EA	349.07	186.51	189.89	0.00	$50,782.40	No
33240103	Pilot Scale Test	1.00	LS	172,327.50	0.00	0.00	0.00	$172,327.50	No
33270114	2" PVC, Schedule 40, 90 Degree, Elbow	70.00	EA	5.01	51.12	0.00	0.00	$3,929.23	No
33270404	Valves, iron body, silent check, bronze trim, compact wafer type, for 125 or 150 lb. flanges, 4"	70.00	EA	405.31	372.11	0.00	0.00	$54,419.81	No
33290103	50 GPM Centrifugal Pump, 100' Head, 3 HP, Includes TEFC Motor	70.00	EA	7,527.27	979.26	0.00	0.00	$595,456.46	No
33330184	Emulsified Vegetable Oil Bioremediation Substrate	5,079.97	LB	3.71	0.00	0.00	0.00	$18,825.00	No

Total Element Cost: $1,814,654.01

Total Tech Cost: $1,814,654.01

Cost Over Time Summary

Element	Year(s)	Cost per Year	Total Cost
General	2021	$1,814,654.01	$1,814,654.01

Estimate Documentation Report - Layout 1

Total Marked Up Tech Cost: $1,814,654.01

Technology Name: **Professional Labor Management (#1)**

User Name: **Professional Labor Management**

Description	Default	User	UOM
System Definition			
Required Parameters			
Markedup Construction Cost ($)		1818651.00	$
Percentage	16.50	10.00	%
Dollar Amount		181865.00	$

Comments:

Technology: Professional Labor Management
Element:

Year(s)	Cost per Year
2021	$181,865.00

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
33220149	Lump Sum Percentage Labor Cost	1.00	LS	0.00	181,865.00	0.00	0.00	$181,865.00	No

Total Element Cost: $181,865.00

Total Tech Cost: $181,865.00

Cost Over Time Summary

Element	Year(s)	Cost per Year	Total Cost
General	2021	$181,865.00	$181,865.00

Total Marked Up Tech Cost: $181,865.00

Technology Name: **Residual Waste Management (#1)**

User Name: **Residual Waste Management**

Description	Default	User	UOM
System Definition			
Required Parameters			
Safety Level		D	n/a
Non-Rad Disposal			
Required Parameters			
Waste Type/ Condition		Non-Hazardous Bulk Solid	n/a
Total Quantity		72	Units

Estimate Documentation Report - Layout 1

Technology Name: **Residual Waste Management (#1)**

User Name: **Residual Waste Management**

Description	Default	User	UOM
Non-Rad Disposal			
Required Parameters			
Units		CY	-
Stabilization		No	n/a
Transportation Type		Truck	n/a
Distance 1		50	MI
Distance 2		0	MI

Comments:

Technology: Residual Waste Management
Element:

Year(s)	Cost per Year
2021	$3,997.13

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
33190102	Bulk Solid Waste Loading Into Disposal Vehicle or Bulk Disposal Container	72.00	BCY	1.72	1.92	0.61	0.00	$305.95	No
33190205	Transport Bulk Solid Hazardous Waste, Maximum 20 CY (per Mile)	200.00	MI	0.00	0.00	0.00	2.45	$489.69	No
33190317	Waste Stream Evaluation Fee, Not Including 50% Rebate on 1st Shipment	1.00	EA	0.00	0.00	0.00	68.23	$68.23	No
33190807	32 Ft. Dump Truck, 6 Mil Liner, disposable	4.00	EA	46.49	0.00	0.00	0.00	$185.95	No
33197270	Landfill Nonhazardous Solid Bulk Waste by CY	72.00	CY	0.00	0.00	0.00	40.94	$2,947.33	No

Total Element Cost: $3,997.13

Total Tech Cost: $3,997.13

Cost Over Time Summary

Element	Year(s)	Cost per Year	Total Cost
General	2021	$3,997.13	$3,997.13

Total Marked Up Tech Cost: $3,997.13

Estimate Documentation Report - Layout 1

Phase Documentation:

Phase Type: Operations & Maintenance
Phase Name: RA-O (FY22-26 Monitoring Costs & 5YRs)
Description: RA-O phase to include long-term VOC monitoring of groundwater. Monitoring Technology - Assume at least 59 years and 39 years of monitoring 20 wells (17 existing, 3 new wells from RA-O) at the site for VOCs only. The 61 years and 41 years duration of RA-O phase is based on SourceDK a remediation timeframe estimation model. First 5 years to be semi-annual by low-flow sampling methods, followed by annual sampling by passive diffusion bag sampling. Residual Waste Management - for disposal of IDW from monitoring events. Five-Year Reviews are to be conducted five years after the signing of the DD to evaluate the effectiveness of the remedy.

In accordance with ER 1110-3-1301, dated 30 Dec 2016, Contingencies shall be applied to each phase total as described in the EPA Guidance "A Guide to Developing and Documenting Cost Estimates during the Feasibility Study." There is a low level of risk estimating the RA-O phase prior to the FS being complete. During this phase the remedy is operating to obtain response complete. A 10% contingency should be used to account for this associated risk. Per the EPA Guidance 10% is the lowest range for contingency.

Start Date: October, 2021
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Phase Markup Template: FUDS V8 - All Phases Except PCOA

Technology Markups	Markup	% Prime	% Sub.
MONITORING Sem-Annual FY22-24	Yes	100	0
Five-Year Review	Yes	100	0
Residual Waste Management	Yes	100	0

Total Marked-up Cost: $646,459.97

Technologies:

Technology Name: **Monitoring (#2)**
User Name: **MONITORING Sem-Annual FY22-24**

Description	Default	User	UOM
System Definition			
Required Parameters			
Model Name		Monitoring	n/a

Estimate Documentation Report - Layout 1

Technology Name: **Monitoring (#2)**

User Name: **MONITORING Sem-Annual FY22-24**

Description	Default	User	UOM
System Definition			
Required Parameters			
Groundwater		Yes	n/a
Surface Soil		No	n/a
Surface Water		No	n/a
Subsurface Soil		No	n/a
Sediment		No	n/a
Soil Gas		No	n/a
Air		No	n/a
Site Distance (One-way)		125	MI
Safety Level		D	n/a
Groundwater			
Required Parameters			
Average Sample Depth		40	FT
Samples per Event (First Year)		20	EA
Samples per Event (Out Years)		20	EA
Number of Events (First Year)		2	EA
Number of Events (Out Years)		2	EA
Number of Years (Out Years)		4	EA
Secondary Parameters			
Primary Analytical Template	System Water - VOCs	System Water - VOCs	n/a
Secondary Analytical Template	None	None	n/a
Turnaround Time	Standard (21 Days)	Standard (21 Days)	n/a
Data Package/QC	Stage 1	Stage 1	n/a
Sampling Method	Existing Wells - Low Flow Pump	Existing Wells - Low Flow Pump	n/a
Number of Wells/Day	8	6	EA
Contain Purge Water	Yes	Yes	n/a
QA/QC			
Secondary Parameters			
Split Samples	1:10	1:10	EA
Field Duplicate Samples	1:10	1:10	EA
Rinse Blanks (per Round)	1	1	EA
Trip Blanks (per Day)	1	1	EA
Matrix Spikes/Matrix Spike Duplicates	1:20	1:20	EA
Data Management			
Secondary Parameters			
Monitoring Plan	Standard	None	n/a
Lab Data Review	Stage 1	Stage 1	n/a
Submit Data Electronically	Yes	Yes	n/a
Monitoring Reports	Abbreviated	Abbreviated	n/a

Estimate Documentation Report - Layout 1

Comments: Monitoring Technology Notes:

Assume this covers VOC monitoring for the first three years of the RA-O phase. Semi-Annual (twice a year) using low-flow sampling for VOCs. 20 Monitoring wells to be sampled along with default QA/QC samples. 125 miles one-way travel to the site. Assume in Data Mgmt tab that the Monitoring Plan is already costed in the RD Phase so "None" was selected. All other selections are defaults.

Technology: MONITORING Sem-Annual FY22-24

Element: Groundwater

Year(s)	Cost per Year
2022 - 2026	$37,946.99

NOTE: With the exception of the Data Management cost, total yearly cost shown matches the total element cost shown when the frequencies (number of samples and number of events) are similar for Year 1 and the out years. When a Comprehensive, Standard, or Abbreviated Monitoring Plan is included in the estimate, the Data Management cost shown for Year 1 will differ from the associated costs shown for the rest of the project duration, as it includes cost associated with the Monitoring Plan. Please reference the Monitoring, Cost Over Time & the Estimate Documentation Report help topic for details on how the Monitoring Plan cost is calculated. The help topic also addresses how the out year costs are calculated when frequencies (number of samples and number of events) differ between Year 1 and the out years.

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
33020401	Disposable Materials per Sample	59.00	EA	12.30	0.00	0.00	0.00	$725.43	No
33020402	Decontamination Materials per Sample	59.00	EA	28.09	0.00	0.00	0.00	$1,657.19	No
33020561	Lysimeter accessories, nylon tubing, 1/4" OD	1,625.00	LF	0.68	0.00	0.00	0.00	$1,105.71	No
33021509	Monitor well sampling equipment, rental, water quality testing parameter device rental	2.00	WK	0.00	0.00	0.00	388.22	$776.45	No
33021618	Testing, purgeable organics (624, 8260)	59.00	EA	0.00	0.00	0.00	194.95	$11,502.27	No
33022124	Testing, RCRA evaluations, EP toxicity analysis, metals (6010,7470)	1.00	EA	0.00	0.00	0.00	142.42	$142.42	No
33220102	Project Manager	10.00	HR	0.00	249.68	0.00	0.00	$2,496.78	No
33220112	Field Technician	163.00	HR	0.00	118.88	0.00	0.00	$19,376.69	No
33230614	Peristaltic Pump, Weekly Rental	2.00	WK	0.00	0.00	0.00	124.69	$249.39	No

Total First Year Element Cost: $38,032.31

Element: Data Management

Estimate Documentation Report - Layout 1

Technology: MONITORING Sem-Annual FY22-24

Year(s)	Cost per Year
2022 - 2026	$12,168.69

NOTE: With the exception of the Data Management cost, total yearly cost shown matches the total element cost shown when the frequencies (number of samples and number of events) are similar for Year 1 and the out years. When a Comprehensive, Standard, or Abbreviated Monitoring Plan is included in the estimate, the Data Management cost shown for Year 1 will differ from the associated costs shown for the rest of the project duration, as it includes cost associated with the Monitoring Plan. Please reference the Monitoring, Cost Over Time & the Estimate Documentation Report help topic for details on how the Monitoring Plan cost is calculated. The help topic also addresses how the out year costs are calculated when frequencies (number of samples and number of events) differ between Year 1 and the out years.

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	8.00	HR	0.00	249.68	0.00	0.00	$1,997.42	No
33220108	Project Scientist	34.00	HR	0.00	230.48	0.00	0.00	$7,836.32	No
33220110	QA/QC Officer	4.00	HR	0.00	170.88	0.00	0.00	$683.52	No
33220112	Field Technician	4.00	HR	0.00	118.88	0.00	0.00	$475.50	No
33220114	Word Processing/Clerical	4.00	HR	0.00	117.08	0.00	0.00	$468.34	No
33220115	Draftsman/CADD	4.00	HR	0.00	136.46	0.00	0.00	$545.85	No
33240101	Other Direct Costs	1.00	LS	0.00	161.73	0.00	0.00	$161.73	No

Total First Year Element Cost: $12,168.69

Element: General Monitoring

Year(s)	Cost per Year
2022 - 2026	$9,939.66

NOTE: With the exception of the Data Management cost, total yearly cost shown matches the total element cost shown when the frequencies (number of samples and number of events) are similar for Year 1 and the out years. When a Comprehensive, Standard, or Abbreviated Monitoring Plan is included in the estimate, the Data Management cost shown for Year 1 will differ from the associated costs shown for the rest of the project duration, as it includes cost associated with the Monitoring Plan. Please reference the Monitoring, Cost Over Time & the Estimate Documentation Report help topic for details on how the Monitoring Plan cost is calculated. The help topic also addresses how the out year costs are calculated when frequencies (number of samples and number of events) differ between Year 1 and the out years.

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
33010104	Sample collection, vehicle mileage charge, car or van	710.00	MI	0.00	0.00	0.00	0.26	$184.03	No
33010202	Per Diem (per person)	14.00	DAY	0.00	0.00	0.00	178.50	$2,499.00	No
33022043	Overnight delivery service, 51 to 70 lb packages	240.00	LB	0.00	0.00	0.00	8.00	$1,920.17	No
33220112	Field Technician	45.00	HR	0.00	118.88	0.00	0.00	$5,349.39	No

Total First Year Element Cost: $9,952.59

Estimate Documentation Report - Layout 1

Total First Year Tech Cost: $60,153.59

Cost Over Time Summary

Element	Year(s)	Cost per Year	Total Cost
Groundwater	2022 - 2026	$37,946.99	$189,734.95
Data Management	2022 - 2026	$12,168.69	$60,843.45
General Monitoring	2022 - 2026	$9,939.66	$49,698.30

Total Marked Up Tech Cost: $300,276.70

Technology Name: **Five-Year Review (#4)**

User Name: **Five-Year Review**

Description	Default	User	UOM
System Definition			
Required Parameters			
Site Complexity		Moderate	n/a
Document Review		Yes	n/a
Interviews		Yes	n/a
Site Inspection		Yes	n/a
Report		Yes	n/a
Travel		Yes	n/a
Rebound Study		No	n/a
Start Month		October	n/a
No. Reviews		7	EA
Start Year		2023	n/a
Safety Level		D	n/a
Document Review			
Required Parameters			
5-Year Review Check List		Yes	n/a
Record of Decision		Yes	n/a
Remedial Action Design & Construction		Yes	n/a
Close-Out Report		Yes	n/a
Operations & Maintenance Manuals & Reports		No	n/a
Consent Decree or Settlement Records		No	n/a
Groundwater Monitoring & Reports		Yes	n/a
Remedial Action Required		Yes	n/a
Previous 5-Year Review Reports		Yes	n/a
Interviews			
Required Parameters			
Current and Previous Staff Management		Yes	n/a
Community Groups		No	n/a
State Contacts		Yes	n/a
Local Government Contacts		Yes	n/a
Operations & Maintenance Contractors		Yes	n/a

Estimate Documentation Report - Layout 1

Technology Name: **Five-Year Review (#4)**

User Name: **Five-Year Review**

Description	Default	User	UOM
Interviews			
Required Parameters			
PRPs		No	n/a
Remedial Design Consultant		Yes	n/a
Site Inspection			
Required Parameters			
General Site Inspection		Yes	n/a
Containment System Inspection		No	n/a
Monitoring Systems Inspection		Yes	n/a
Treatment Systems Inspection		No	n/a
Regulatory Compliance		Yes	n/a
Site Visit Documentation (Photos, Diagrams, etc.)		Yes	n/a
Report			
Required Parameters			
Introduction		Yes	n/a
Remedial Objectives		Yes	n/a
ARARs Review		Yes	n/a
Summary of Site Visit		Yes	n/a
Areas of Non Compliance		Yes	n/a
Technology Recommendations		Yes	n/a
Statement of Protectiveness		Yes	n/a
Next Review		Yes	n/a
Implementation Requirements		Yes	n/a
Travel			
Required Parameters			
Number of Travelers		2	EA
Number of Days		2	EA
Air Fare Ticket Price		0.00	$
Need a rental car?		Yes	n/a

Comments: Five-Year Review Notes:

Assume low site complexity and the first review to take place in FY24, five years after Decision Document, 16 reviews over the modeled in the first 79 years. Tasks to include Document Review, Interview, Site Inspections, Report, and Travel. For Document Review, assume "Consent Decree" and "O&M Manuals and Reports" are not selected as these documents may not be conducted for this project. Assume no PRPs interviewed on this project. There will be no containment or treatment systems to inspect so these are not selected. Assume 2 people to travel 2 days to the site using rental car.

Technology: Five-Year Review

Element: Document Review

Year(s)	Cost per Year

Estimate Documentation Report - Layout 1

Technology: Five-Year Review

Year(s)	Cost per Year
2024	$11,147.21
2025 - 2028	$0.00
2029	$11,147.21
2030 - 2033	$0.00
2034	$11,147.21
2035 - 2038	$0.00
2039	$11,147.21
2040 - 2043	$0.00
2044	$11,147.21
2045 - 2048	$0.00
2049	$11,147.21
2050 - 2053	$0.00
2054	$11,147.21

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	249.68	0.00	0.00	$2,996.13	No
33220105	Project Engineer	12.00	HR	0.00	211.68	0.00	0.00	$2,540.12	No
33220108	Project Scientist	9.00	HR	0.00	230.48	0.00	0.00	$2,074.32	No
33220109	Staff Scientist	19.00	HR	0.00	186.14	0.00	0.00	$3,536.64	No

Total First Year Element Cost: $11,147.21

Element: Interviews

Year(s)	Cost per Year
2024	$2,746.46
2025 - 2028	$0.00
2029	$2,746.46
2030 - 2033	$0.00
2034	$2,746.46
2035 - 2038	$0.00
2039	$2,746.46
2040 - 2043	$0.00
2044	$2,746.46
2045 - 2048	$0.00
2049	$2,746.46
2050 - 2053	$0.00
2054	$2,746.46

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	11.00	HR	0.00	249.68	0.00	0.00	$2,746.46	No

Total First Year Element Cost: $2,746.46

Estimate Documentation Report - Layout 1

Technology: Five-Year Review

Element: Site Inspection

Year(s)	Cost per Year
2024	$8,383.78
2025 - 2028	$0.00
2029	$8,383.78
2030 - 2033	$0.00
2034	$8,383.78
2035 - 2038	$0.00
2039	$8,383.78
2040 - 2043	$0.00
2044	$8,383.78
2045 - 2048	$0.00
2049	$8,383.78
2050 - 2053	$0.00
2054	$8,383.78

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	6.00	HR	0.00	249.68	0.00	0.00	$1,498.07	No
33220105	Project Engineer	10.00	HR	0.00	211.68	0.00	0.00	$2,116.76	No
33220108	Project Scientist	11.00	HR	0.00	230.48	0.00	0.00	$2,535.28	No
33220109	Staff Scientist	12.00	HR	0.00	186.14	0.00	0.00	$2,233.67	No

Total First Year Element Cost: $8,383.78

Element: Report

Year(s)	Cost per Year
2024	$24,627.05
2025 - 2028	$0.00
2029	$24,627.05
2030 - 2033	$0.00
2034	$24,627.05
2035 - 2038	$0.00
2039	$24,627.05
2040 - 2043	$0.00
2044	$24,627.05
2045 - 2048	$0.00
2049	$24,627.05
2050 - 2053	$0.00
2054	$24,627.05

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	249.68	0.00	0.00	$2,996.13	No

Estimate Documentation Report - Layout 1

Technology: Five-Year Review

33220105	Project Engineer	31.00	HR	0.00	211.68	0.00	0.00	$6,561.97	No
33220108	Project Scientist	25.00	HR	0.00	230.48	0.00	0.00	$5,762.00	No
33220109	Staff Scientist	50.00	HR	0.00	186.14	0.00	0.00	$9,306.95	No

Total First Year Element Cost: $24,627.05

Element: Travel

Year(s)	Cost per Year
2024	$848.14
2025 - 2028	$0.00
2029	$848.14
2030 - 2033	$0.00
2034	$848.14
2035 - 2038	$0.00
2039	$848.14
2040 - 2043	$0.00
2044	$848.14
2045 - 2048	$0.00
2049	$848.14
2050 - 2053	$0.00
2054	$848.14

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	2.00	DAY	0.00	0.00	0.00	67.52	$135.05	No
33010202	Per Diem (per person)	4.00	DAY	0.00	0.00	0.00	178.50	$714.00	No
33041101	Airfare	2.00	LS	0.00	0.00	0.00	0.00	$0.00	No

Total First Year Element Cost: $849.05

Total First Year Tech Cost: $47,753.55

Cost Over Time Summary

Element	Year(s)	Cost per Year	Total Cost
Document Review	2024	$11,147.21	$11,147.21
Document Review	2029	$11,147.21	$11,147.21
Document Review	2034	$11,147.21	$11,147.21
Document Review	2039	$11,147.21	$11,147.21
Document Review	2044	$11,147.21	$11,147.21
Document Review	2049	$11,147.21	$11,147.21
Document Review	2054	$11,147.21	$11,147.21
Interviews	2024	$2,746.46	$2,746.46
Interviews	2029	$2,746.46	$2,746.46

Estimate Documentation Report - Layout 1

Interviews	2034	$2,746.46	$2,746.46
Interviews	2039	$2,746.46	$2,746.46
Interviews	2044	$2,746.46	$2,746.46
Interviews	2049	$2,746.46	$2,746.46
Interviews	2054	$2,746.46	$2,746.46
Site Inspection	2024	$8,383.78	$8,383.78
Site Inspection	2029	$8,383.78	$8,383.78
Site Inspection	2034	$8,383.78	$8,383.78
Site Inspection	2039	$8,383.78	$8,383.78
Site Inspection	2044	$8,383.78	$8,383.78
Site Inspection	2049	$8,383.78	$8,383.78
Site Inspection	2054	$8,383.78	$8,383.78
Report	2024	$24,627.05	$24,627.05
Report	2029	$24,627.05	$24,627.05
Report	2034	$24,627.05	$24,627.05
Report	2039	$24,627.05	$24,627.05
Report	2044	$24,627.05	$24,627.05
Report	2049	$24,627.05	$24,627.05
Report	2054	$24,627.05	$24,627.05
Travel	2024	$848.14	$848.14
Travel	2029	$848.14	$848.14
Travel	2034	$848.14	$848.14
Travel	2039	$848.14	$848.14
Travel	2044	$848.14	$848.14
Travel	2049	$848.14	$848.14
Travel	2054	$848.14	$848.14
	Total Marked Up Tech Cost:		$334,268.48

Technology Name: **Residual Waste Management (#2)**

User Name: **Residual Waste Management**

Description	Default	User	UOM
System Definition			
Required Parameters			
Safety Level		D	n/a
Non-Rad Disposal			
Required Parameters			
Waste Type/ Condition		Non-Hazardous Bulk Liquid	n/a
Total Quantity		8360	Units
Units		GAL	-
Stabilization		No	n/a
Transportation Type		Truck	n/a
Distance 1		50	MI
Distance 2		0	MI

Estimate Documentation Report - Layout 1

Comments: Residual Waste Management Notes:

Assume non-hazardous purge water, to be transported 125 miles in bulk container by Truck.

Technology: Residual Waste Management
Element:

Year(s)	Cost per Year
2022	$11,914.82

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
33190101	Liquid Loading Into 5,000 Gallon Bulk Tank Truck	2.00	EA	0.00	786.94	411.79	0.00	$2,397.47	No
33190108	Tanker Pumping Equipment to Load Liquid	3.00	HR	0.00	0.00	0.00	36.08	$108.24	No
33190207	Transport Bulk Liquid/Sludge Hazardous Waste, Maximum 5,000 Gallon (per Mile)	100.00	MI	0.00	0.00	0.00	3.48	$348.13	No
33190317	Waste Stream Evaluation Fee, Not Including 50% Rebate on 1st Shipment	1.00	EA	0.00	0.00	0.00	65.26	$65.26	No
33197274	Commercial RCRA landfills, regional outline, liquid, non-hazardous	8,360.00	GAL	0.00	0.00	0.00	1.08	$8,995.72	No

Total Element Cost: $11,914.82

Total Tech Cost: $11,914.82

Cost Over Time Summary

Element	Year(s)	Cost per Year	Total Cost
General	2022	$11,914.82	$11,914.82

Total Marked Up Tech Cost: $11,914.82

Phase Documentation:

Phase Type: Operations & Maintenance
Phase Name: Re-Injection (1 event)
Description: Re-injection with existing infrastructure

Start Date: October, 2021
Labor Rate Group: System Labor Rate

Estimate Documentation Report - Layout 1

Analysis Rate Group: System Analysis Rate

Phase Markup Template: FUDS V8 - All Phases Except PCO

Technology Markups	Markup	% Prime	% Sub.
Operations and Maintenance	Yes	100	0

Total Marked-up Cost: $287,672.65

Technologies:

Technology Name: **Operations and Maintenance (#1)**

User Name: **Operations and Maintenance**

Description	Default	User	UOM
ISZ - In Situ Biodegradation			
Wizard Parameters			
Aquifer Thickness		10	FT
Depth to Top of Aquifer		20	FT
Number of Applications for First Year		1	EA
Number of Delivery Points		70	EA
Substrate Application Rate / Delivery Point		3.00	%
Substrate Delivery Method		Injection Wells	n/a
Substrate Selection		Vegetable Oil	n/a
Labor			
Secondary Parameters			
Operations Labor: Type	Exclude from Estimate	Exclude from Estimate	n/a
Professional Labor: Type	Exclude from Estimate	Exclude from Estimate	n/a
Analytical			
Secondary Parameters			
Wastewater/Effluent: Sampling Frequency	Exclude from Estimate	Exclude from Estimate	n/a
Wastewater/Effluent: Primary Analytical Template	None	None	n/a
Wastewater/Effluent: Secondary Analytical Template	None	None	n/a
Air Emissions: Sampling Frequency	Exclude from Estimate	Exclude from Estimate	n/a
Air Emissions: Primary Analytical Template	None	None	n/a
Air Emissions: Secondary Analytical Template	None	None	n/a
Solid Wastes: Sampling Frequency	Exclude from Estimate	Exclude from Estimate	n/a
Solid Wastes: Primary Analytical Template	None	None	n/a
Solid Wastes: Secondary Analytical Template	None	None	n/a
Heating Requirements			
Secondary Parameters			
Air Streams: Flow Rate	0	0	CFM

Estimate Documentation Report - Layout 1

Technology Name: **Operations and Maintenance (#1)**

User Name: **Operations and Maintenance**

Description	Default	User	UOM
Heating Requirements			
Secondary Parameters			
Air Streams: Temperature Difference	0	0	F
Air Streams: Months per Year	0	0	Month
Water Streams: Flow Rate	0	0	CFM
Water Streams: Temperature Difference	0	0	F
Water Streams: Months per Year	0	0	Month
Facility: Area	0	0	SF
Facility: Temperature Difference	0	0	F
Facility: Months per Year	0	0	Month

Comments:

Technology: Operations and Maintenance

Element: In Situ Biodegradation

Year(s)	Cost per Year
2022	$287,672.65

Assembly	Description	QTY	UOM	Mat Cost	Lab Cost	Eqp Cost	Sub Bid Cost	Extended Cost	Cost Override
33010109	Truck, 2 Axle, Highway, 21,700 GVW, 4 x 2, 2 Axle	70.00	DAY	0.00	0.00	502.39	0.00	$35,167.38	No
33190149	Truck Driver, Light	560.00	HR	0.00	103.40	0.00	0.00	$57,902.04	No
33220105	Project Engineer	129.00	HR	0.00	221.30	0.00	0.00	$28,547.44	No
33220112	Field Technician	854.00	HR	0.00	124.28	0.00	0.00	$106,134.13	No
33330184	Emulsified Vegetable Oil Bioremediation Substrate	16,170.00	LB	3.71	0.00	0.00	0.00	$59,921.66	No

Total First Year Element Cost: $287,672.65

Total First Year Tech Cost: $287,672.65

Cost Over Time Summary

Element	Year(s)	Cost per Year	Total Cost
In Situ Biodegradation	2022	$287,672.65	$287,672.65

Total Marked Up Tech Cost: $287,672.65

Cost Over Time Report (With Markups)

Folder: NWK 2018 CTC Estimates
FUDS Property Name: Forbes AFB Atlas S-05
FUDS Property ID: B07KS0204
Project Name: Alternative 3 - In-Situ Injections
Project Type: HTRW
Project ID: 03

Location: KANSAS STATE AVERAGE, KS
Report Option: Fiscal

Estimator

Name: Grace Philpy
Title: Process Engineer
Agency/Org./Office: USACE/CENWK/ED-EG
Business Address: Bolling Federal Building Suite 439
601 E. 12th St.
Kansas City, MO 64106
Phone: 816-389-3908
Email: grace.philpy@usace.army.mil

Prepared Date: 3/12/2019 0:00

Phase	Phase Name	Fiscal Year 1 2020	Fiscal Year 2 2021	Fiscal Year 3 2022	Fiscal Year 4 2023	Fiscal Year 5 2024	Fiscal Year 6 2025	Fiscal Year 7 2026	Fiscal Year 8 2027	Fiscal Year 9 2028
Design	RD (Work Plans)	$119,608								
Remedial Action	RA-C (Monitoring Well Installation)		$36,650							
Remedial Action	RA-C - In-Situ Treatment		$2,000,516							
Operations & Maintenance	RA-O (FY22-26 Monitoring Costs & 5YRs)			$71,970	$60,055	$107,808	$60,055	$60,055	$0	$0
Operations & Maintenance	Re-Injection (1 event)			$287,673						
Total		$119,608	$2,037,166	$359,643	$60,055	$107,808	$60,055	$60,055	$0	$0

Fiscal Year 10 2029	Fiscal Year 11 2030	Fiscal Year 12 2031	Fiscal Year 13 2032	Fiscal Year 14 2033	Fiscal Year 15 2034	Fiscal Year 16 2035	Fiscal Year 17 2036	Fiscal Year 18 2037	Fiscal Year 19 2038	Fiscal Year 20 2039	Fiscal Year 21 2040	Fiscal Year 22 2041	Fiscal Year 23 2042
$47,753	$0	$0	$0	$0	$47,753	$0	$0	$0	$0	$47,753	$0	$0	$0
$47,753	$0	$0	$0	$0	$47,753	$0	$0	$0	$0	$47,753	$0	$0	$0

Fiscal Year 24 2043	Fiscal Year 25 2044	Fiscal Year 26 2045	Fiscal Year 27 2046	Fiscal Year 28 2047	Fiscal Year 29 2048	Fiscal Year 30 2049	Fiscal Year 31 2050	Fiscal Year 32 2051	Fiscal Year 33 2052	Fiscal Year 34 2053	Fiscal Year 35 2054	Total	Phase
												$119,608	Design
												$36,650	Remedial Action
												$2,000,516	Remedial Action
$0	$47,753	$0	$0	$0	$0	$47,753	$0	$0	$0	$0	$47,753	$646,460	Operations & Maintenance
												$287,673	Operations & Maintenance
$0	$47,753	$0	$0	$0	$0	$47,753	$0	$0	$0	$0	$47,753	$3,090,907	**Total**

Alternate Water Supply Costs
Forbes S-5 Feasibility Study

Task	Unit Cost	Unit	Quantity	Estimated Cost
Draft and Final Construction Work Plans	$12,000	LS	1	$12,000
Field Work, construction from Rural Water District to future residence	$20	feet	7920	$158,400
Field Work, water meter and installation	$2,500	LS	1	$2,500
Draft and Final Construction Completion Report	$8,000	LS	1	$8,000
Project Management Costs	$27,000	LS	1	$27,000
AWS Total Cost				$207,900

Notes:
Estimated distance from Rural Water to Residence based Lyon County Rural Water District 1 boundary to the South of the property. An additional 0.25 miles was added to account for piping to the residence on the property, resulting in a total of 1.5 miles of piping.

Linear feet of water connection piping based upon similar project using 4" 200 Class PVC piping, 20 ft gasketed sections from a 10" water main.

Reporting and project management costs based upon similar projects' work plans and construction completion report for rural water connection.

APPENDIX C

Input Parameters for SourceDK for Estimating Time to Reach Remedial Action Objectives

Appendix C: Input Parameters for SourceDK for Estimating Time to Reach Remedial Action Objectives for Former Forbes S-5 Feasibility Study

Background

SourceDK Remediation Timeframe Decision Support System (SourceDK) was developed for the U.S. Air Force Center for Engineering and Environment to assess remedial time frames for remedial alternatives 2 and 3. The software uses both TCE groundwater concentrations and soil mass to predict groundwater concentrations under future scenarios. Groundwater gradient and hydraulic conductivity are used to assess effects of the groundwater flow regime on TCE concentrations. A biodegradation rate constant can be added to estimate biodegradation effects on groundwater concentrations. SourceDK was used to model groundwater concentrations over time during long-term monitoring (alternative 2) and following in-situ treatment (alternative 3). For alternative 3, a remediation goal of 20 µg/L (75% reduction in groundwater concentrations at MW-02), was selected as the starting point for the long-term monitoring analysis. The rationale for each input selection is outlined below.

Hydrogeology

The hydraulic conductivity used for SourceDK screening (1.5×10^{-4}cm/s) and gradient (0.014 feet/feet) were selected from RI median values for the shallow Schroyer Limestone member. During the RI, water levels were collected from each shallow and deep monitoring well on a quarterly basis for two years. Depth to water for the shallow bedrock wells generally ranged from 11 to 29 feet bgs. The horizontal hydraulic gradients for the shallow monitoring wells screened in the Schroyer Limestone Member ranged from a maximum of 0.026 feet/feet to a minimum of 0.002 feet/feet, with water flowing from south to north. Analysis of slug test data for the shallow bedrock wells during the RI resulted in hydraulic conductivity values ranging from 1.7×10^{-5} to 5.6×10^{-4} cm/s. The estimated linear groundwater velocities for the shallow monitoring wells screened in the Schroyer Limestone Member ranged from a maximum of 91.59 feet/year to a minimum of 0.29 feet/year. The linear groundwater velocity calculated for the SourceDK model assumptions was 4.4 feet/year.

Source Characteristics

Groundwater concentration data entered for the source characteristics inputs for Alternative 2 was the average of RI data from MW-02 and MW-07 with an assumed distribution of 300 feet long by 200 feet wide, 10 feet thick. MW-02 and MW-07 were selected to be representative of the highest TCE concentration area. For Alternative 3, the same area and aquifer thickness were used, but the starting groundwater concentration was reduced to 20 µg/L.

Degradation

Source decay is applied using soil concentration data and an assumed biodegradation rate constant. Soil TCE concentration from the depths with the greatest TCE concentration SB-01 and SB-07 were averaged for the soil "source" mass for Alternative 2, resulting in a concentration of 142 µg/kg. For Alternative 3, the soil concentration was reduced by 75% to account for in-situ treatment, resulting in a soil concentration of 35.5 µg/kg. Reference TCE degradation rates cited in the SourceDK manual range from 0.04 to 0.18 $year^{-1}$ with 0.11 being the mid-range value (Mace, 1997; McNab et al., 1999; and McNab, 2001). The mid-range rate was assumed for both Alternative 2 and 3.

Appendix C: Input Parameters for SourceDK for
Estimating Time to Reach Remedial Action Objectives
Former Forbes Atlas S-5 Missile Site
Lyon County, Kansas

	Hydraulic Conductivity (cm/s)	Hydraulic Gradient (feet/feet)	Calculated Darcy Velocity (ft/year)	Average Source GW Concentration (µg/L)	Average Soil Concentration (mg/kg)	Source Length (feet)	Source Width (feet)	Thickness (feet)	Biodegradation Rate Constant (per year)	SourceDK Ouptut: Mid-Range Estimated Time to Reach ROAs (years)	Costed Duration (years)
Alternative 2: Long-Term Monitoring	1.50E-04	0.014	2.173	82	142	300	200	10	0.11	209	100
Alternative 3: 75% Mass Removal from In-Situ Treatment	1.50E-04	0.014	2.173	20	35.5	300	200	10	0.11	106	100

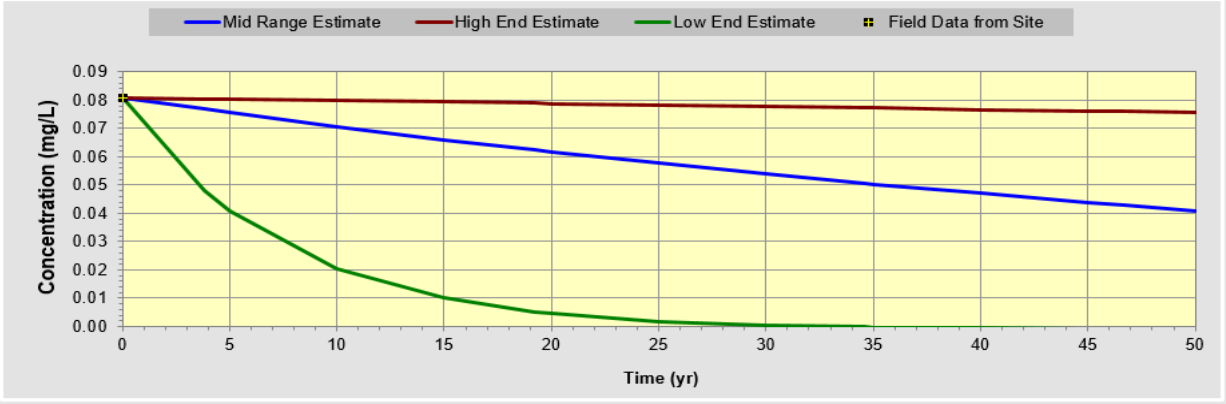
Notes:

1. Default soil bulk density of 2.265 kg/L used in defining total mass for all scenarios.
2. Analysis of slug test data for the shallow bedrock wells during the RI resulted in hydraulic conductivity values ranging from 1.7 E-5 to 5.6 E-4 centimeters per second (cm/sec). The median of the RI shallow hydraulic
3. The horizontal hydraulic gradients for the shallow monitoring wells screened in the Schroyer Limestone Member ranged from a maximum of 0.026 ft/ft to a minimum of 0.002 ft/ft. The midpoint of this range (0.014 ft/ft)
4. Darcy velocity calculated from hydraulic conductivity and gradient.
5. Groundwater concentrations used are from MW-02 during the RI.
6. Soil concentration is the average of the highest TCE concentrations measured at soil borings SB-01 and SB-07.
7. Source length, width, and thickness are the approximate dimensions of the area with groundwater above 10x the MCL (50µg/L).
8. Biodegradation rate constant used is the mid-range value for TCE degradation provided in the SourceDK manual. TCE degradation rates cited were 0.04 to 0.18 yr^{-1} (Mace, 1997; McNab et al., 1999; and McNab, 2001).
9. Reasonable timeframe determined to be 100 years. Limited FS cost assumptions to 100 years.

Appendix C: Input Parameters for SourceDK for
SourceDK Output for Alternative 2
Estimating Time to Reach Remedial Action Objectives
Former Forbes Atlas S-5 Missile Site
Lyon County, Kansas

Time (yr)

TYPE OF MODEL	0.00	3.85	5.00	10.00	15.00	19.23	20.00	25.00	30.00	34.62	35.00	40.00	45.00	46.67	50.00
Model Conc. (mg/L)	0.082	0.078	0.077	0.072	0.067	0.063	0.063	0.059	0.055	0.052	0.051	0.048	0.045	0.044	0.042
Actual Conc. (mg/L)	0.082														
Mass Discharge (kg/yr)	1.9E-02	1.9E-02	1.8E-02	1.7E-02	1.6E-02	1.5E-02	1.5E-02	1.4E-02	1.3E-02	1.2E-02	1.2E-02	1.1E-02	1.1E-02	1.0E-02	1.0E-02



1. Display Concentration Vs. Time Chart
   or
   Display Source Mass Vs. Time Chart

2. Number of Years Over Which to Plot Graph: 50 (yr)
   (Press "Calculate Current Sheet" button after changing value.)

Log ⟷ Linear

Concentration/Time Mini-Calculator

Time: 60 (yr) →
- 0.076 (mg/L) High End Conc Estimate
- 0.037 (mg/L) Mid Range Conc Estimate
- 0.000 (mg/L) Low End Conc Estimate

Concentration: 0.005 (mg/L) →
- >500 (yr) High End Time Estimate
- 209 (yr) Mid Range Time Estimate
- 21 (yr) Low End Time Estimate

Return To Input
Calculate Current Sheet
HELP

SourceDK — Remediation Timeframe Decision Support System
Air Force Center for Engineering and Environment — Version 2.0

TIER 2 Box Model

Site Location and I.D.: Forbes S-5
Constituent of Interest: TCE

1. HYDROGEOLOGY

Darcy Velocity	V_d	4.35E+00	(ft/yr)
	or		
Hydraulic Conductivity	K	1.5E-04	cm/sec
Hydraulic Gradient	i	0.014	(ft/ft)

Calculate Vd

2. SOURCE CHARACTERISTICS

Key Assumption: Source Represented as Box Model

Average Source Groundwater Concentration at Time = 0	C_{gwo}	0.082	mg/L
Source Length	S_l	300	(ft)
Source Width	S_w	200	(ft)
Source Thickness	S_t	10	(ft)
Enter Value for Specific Discharge or Press "Calculate Q" Button	Q	8.4E+03	(ft^3/yr)

Calculate Q

3. SOURCE DECAY CONSTANT

- Enter Directly — k_s (1/yr)
  or
- Calculate Source Decay Constant Using Sections 3A and 3B — k_s 1.3E-02 (1/yr)

3A. SOURCE MASS

Source Mass at Time = 0 — M_o 5.5E+00 (kg)

Select Method for Calculating Source Mass

- Method 1: Enter Source Mass Directly
  or
- Method 2: Simple Volume X Concentration Calculation
  or
- Method 3: Detailed Volume X Concentration Calculation
  or
- Method 4: Estimated From NAPL Relationships

Print Method 2

3B. SOURCE ZONE BIODEGRADATION

- No Biodegradation

or

Assume Biodegradation Occurs in "Box" in Dissolved Phase Only

- Select Method 1:
  Biodegradation Rate Constant — lambda 0.11 (per yr)

or

- Select Method 2:
  Biodegradation Rate Derived From Electron Acceptor By-Product Data.
  (Applies Only to Petroleum Hydrocarbon Sites)

a) Biodegradation Capacity	BC		(mg/L)
or			
Delta Oxygen	DO		(mg/L)
Delta Nitrate	NO_3		(mg/L)
Observed Ferrous Iron	Fe^{2+}		(mg/L)
Delta Sulfate	SO_4		(mg/L)
Observed Methane	CH_4		(mg/L)
and			
b) Percentage of Biodegradation Capacity Applied to This Constituent			(%)

4. TIME FOR OUTPUT

a) Number of Years Over Which to Plot Data: 50 (yr) (Required)
b) Time in Years at Which Decay Starts: (yr) (Optional)

5. UNCERTAINTY RANGE FOR MASS ESTIMATE

± Factor of 10

6. FIELD DATA FOR COMPARISON

Year From Time = 0 (yr)	0	5	10	15	20	25	30	35	40	45		
Concentration (mg/L)	0.082											

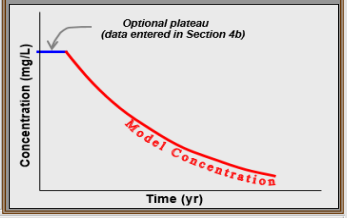
7. CHOOSE OUTPUT TO VIEW

Show Graph | Return to Main Screen | New Site/Clear Screen | Paste Example Data Set | HELP

Data Input Instructions:

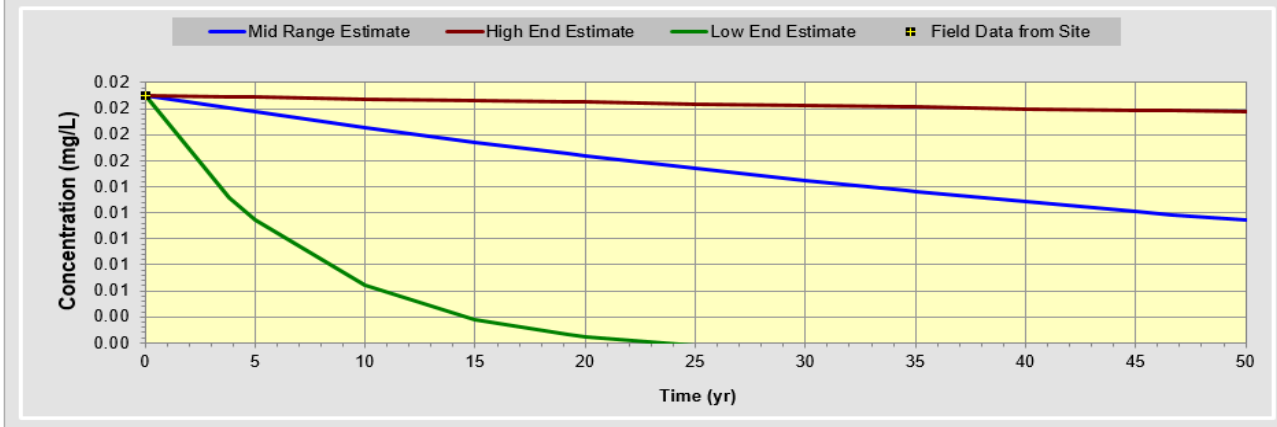
115 → 1. Enter value directly ... or
115 → 2. Calculate by filling in blue cells. Press Enter, then press the "Calculate" button.
115 → 3. Value calculated by model. (Do not enter any data.)

SourceDK OUTPUT SHOWS THIS:



Appendix C: Input Parameters for SourceDK for
SourceDK Output for Alternative 3
Estimating Time to Reach Remedial Action Objectives after Injections
Former Forbes Atlas S-5 Missile Site
Lyon County, Kansas

TYPE OF MODEL	Time (yr) 0.00	3.85	5.00	10.00	15.00	19.23	20.00	25.00	30.00	34.62	35.00	40.00	45.00	46.67	50.00
Model Conc. (mg/L)	0.020	0.019	0.019	0.018	0.016	0.016	0.015	0.014	0.014	0.013	0.013	0.012	0.011	0.011	0.010
Actual Conc. (mg/L)	0.020														
Mass Discharge (kg/yr)	4.8E-03	4.5E-03	4.5E-03	4.2E-03	3.9E-03	3.7E-03	3.7E-03	3.4E-03	3.2E-03	3.0E-03	3.0E-03	2.8E-03	2.6E-03	2.6E-03	2.5E-03



1. Display Concentration Vs. Time Chart
or
Display Source Mass Vs. Time Chart

2. Number of Years Over Which to Plot Graph 50 (yr)
(Press "Calculate Current Sheet" button after changing value.)

Log Linear

Concentration/Time Mini-Calculator

60 (yr) Time →
0.018 (mg/L) High End Conc Estimate
0.009 (mg/L) Mid Range Conc Estimate
0.000 (mg/L) Low End Conc Estimate

0.005 (mg/L) Concentration →
>500 (yr) High End Time Estimate
106 (yr) Mid Range Time Estimate
11 (yr) Low End Time Estimate

Return To Input
Calculate Current Sheet
HELP

SourceDK
Remediation Timeframe Decision Support System
Air Force Center for Engineering and Environment
Version 2.0

TIER 2 Box Model

Site Location and I.D.: Forbes S-5
Constituent of Interest: TCE

1. HYDROGEOLOGY
Darcy Velocity V_d 4.35E+00 (ft/yr)
or
Hydraulic Conductivity K 1.5E-04 cm/sec
Hydraulic Gradient i 0.014 (ft/ft)
Calculate Vd

2. SOURCE CHARACTERISTICS


Key Assumption:
Source Represented as Box Model

Average Source Groundwater Concentration at Time = 0 C_{gwo} 0.02 mg/L
Source Length S_l 300 (ft)
Source Width S_w 200 (ft)
Source Thickness S_t 10 (ft)

Enter Value for Specific Discharge or Press "Calculate Q" Button Q 8.4E+03 (ft^3/yr)
Calculate Q

3. SOURCE DECAY CONSTANT
Enter Directly k_s (1/yr)
or
Calculate Source Decay Constant Using Sections 3A and 3B k_s 1.3E-02 (1/yr)

3A. SOURCE MASS
Source Mass at Time = 0 M_o 1.4E+00 (kg)
Select Method for Calculating Source Mass
Method 1: Enter Source Mass Directly
or
Method 2: Simple Volume X Concentration Calculation
or
Method 3: Detailed Volume X Concentration Calculation
or
Method 4: Estimated From NAPL Relationships
Print Method 2

3B. SOURCE ZONE BIODEGRADATION
No Biodegradation
or
Assume Biodegradation Occurs in "Box" in Dissolved Phase Only
Select Method 1:
Biodegradation Rate Constant lambda 0.11 (per yr)
or
Select Method 2:
Biodegradation Rate Derived From Electron Acceptor By-Product Data.
(Applies Only to Petroleum Hydrocarbon Sites)
a) Biodegradation Capacity BC (mg/L)
or
Delta Oxygen DO (mg/L)
Delta Nitrate NO_3 (mg/L)
Observed Ferrous Iron Fe^{2+} (mg/L)
Delta Sulfate SO_4 (mg/L)
Observed Methane CH_4 (mg/L)
and
b) Percentage of Biodegradation Capacity Applied to This Constituent (%)

4. TIME FOR OUTPUT
a) Number of Years Over Which to Plot Data 50 (yr) (Required)
b) Time in Years at Which Decay Starts (yr) (Optional)

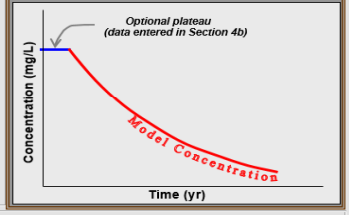
5. UNCERTAINTY RANGE FOR MASS ESTIMATE
± Factor of 10

6. FIELD DATA FOR COMPARISON

Year From Time = 0 (yr)	0	5	10	15	20	25	30	35	40	45		
Concentration (mg/L)	0.02											

7. CHOOSE OUTPUT TO VIEW
Show Graph | Return to Main Screen | New Site/Clear Screen | Paste Example Data Set | HELP

Data Input Instructions:
115 → 1. Enter value directly ... or
115 → 2. Calculate by filling in blue cells. Press Enter, then press the "Calculate" button.
115 → 3. Value calculated by model. (Do not enter any data.)

SourceDK OUTPUT SHOWS THIS:


APPENDIX D

Representative Safety Data Sheets for In-Situ Remediation Amendments

SAFETY DATA SHEET
Klozur® SP

SDS # : 7775-27-1-12
Revision date: 2018-07-13
Format: NA
Version 1.04

1. PRODUCT AND COMPANY IDENTIFICATION

Product Identifier

Product Name Klozur® SP

CAS-No 7775-27-1

Synonyms Sodium Persulfate; Sodium Peroxydisulfate; Disodium Peroxydisulfate; Peroxydisulfuric acid, disodium salt; Peroxydisulfuric acid, sodium salt.

Alternate Commercial Name Klozur® Persulfate

Recommended use of the chemical and restrictions on use

Recommended Use: In situ and ex situ chemical oxidation of contaminants and compounds of concern for environmental remediation applications

Restrictions on Use No uses to be advised against were identified.

Manufacturer/Supplier

PeroxyChem LLC
2005 Market Street
Suite 3200
Philadelphia, PA 19103
Phone: +1 267/ 422-2400 (General Information)
E-Mail: sdsinfo@peroxychem.com

Emergency telephone numbers

For leak, fire, spill or accident emergencies, call:
1 800 / 424 9300 (CHEMTREC - U.S.A.)
1 703 / 527 3887 (CHEMTREC - Collect - All Other Countries)
1 303/ 389-1409 (Medical - U.S. - Call Collect)

2. HAZARDS IDENTIFICATION

Classification

OSHA Regulatory Status
This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200)

Acute toxicity - Oral	Category 4
Skin corrosion/irritation	Category 2
Serious eye damage/eye irritation	Category 2B
Respiratory sensitization	Category 1
Skin sensitization	Category 1
Specific target organ toxicity (single exposure)	Category 3
Oxidizing Solids	Category 3

GHS Label elements, including precautionary statements

EMERGENCY OVERVIEW

Danger

Hazard Statements
H334 - May cause allergy or asthma symptoms or breathing difficulties if inhaled
H335 - May cause respiratory irritation
H319 - Causes serious eye irritation
H315 - Causes skin irritation
H317 - May cause an allergic skin reaction
H302 - Harmful if swallowed
H272 - May intensify fire; oxidizer

Precautionary Statements - Prevention
P261 - Avoid breathing dust/ fume/ gas/ mist/ vapors/ spray
P285 - In case of inadequate ventilation wear respiratory protection
P271 - Use only outdoors or in a well-ventilated area
P280 - Wear protective gloves/ protective clothing
P264 - Wash face, hands and any exposed skin thoroughly after handling
P210 - Keep away from heat/sparks/open flames/hot surfaces. - No smoking
P220 - Keep/Store away from clothing/combustible materials
P221 - Take any precaution to avoid mixing with combustibles

Precautionary Statements - Response
P305 + P351 + P338 - IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing
P337 + P313 - If eye irritation persists: Get medical advice/ attention
P302 + P352 - IF ON SKIN: Wash with plenty of water.
P333 + P313 - If skin irritation or rash occurs: Get medical advice/ attention
P362 - Take off contaminated clothing and wash before reuse
P304 + P340 - IF INHALED: Remove person to fresh air and keep comfortable for breathing
P342 + P311 - If experiencing respiratory symptoms: Call a POISON CENTER or doctor
P301 + P312 - IF SWALLOWED: Call a POISON CENTER or doctor if you feel unwell
P330 - Rinse mouth
P370 + P378 - In case of fire: Use water for extinction

Precautionary Statements - Storage
P403 + P233 - Store in a well-ventilated place. Keep container tightly closed

Hazards not otherwise classified (HNOC)
No hazards not otherwise classified were identified.

Other Information
Risk of decomposition by heat or by contact with incompatible materials

Unknown acute toxicity
0% of the mixture consists of ingredient(s) of unknown toxicity

3. COMPOSITION/INFORMATION ON INGREDIENTS

Formula Na2O8S2

Chemical name	CAS-No	Weight %
Sodium Persulfate	7775-27-1	> 99
Sodium sulfate	7757-82-6	< 2

4. FIRST AID MEASURES

General Advice May produce an allergic reaction.

Eye Contact Rinse thoroughly with plenty of water for at least 15 minutes, lifting lower and upper eyelids intermittently. Consult a physician. If symptoms persist, call a physician.

Skin Contact Wash off immediately with soap and plenty of water while removing all contaminated clothes and shoes. Get medical attention if irritation develops and persists.

Inhalation Remove from exposure, lie down. If breathing is irregular or stopped, administer artificial respiration. Call a physician immediately.

Ingestion Do NOT induce vomiting. Call a physician or poison control center immediately. Rinse mouth. Drink 1 or 2 glasses of water.

Most important symptoms and effects, both acute and delayed Itching; Redness; Coughing and/ or wheezing.

Indication of immediate medical attention and special treatment needed, if necessary Treat symptomatically

5. FIRE-FIGHTING MEASURES

Suitable Extinguishing Media Water. Cool containers with flooding quantities of water until well after fire is out.

Unsuitable extinguishing media Do not use carbon dioxide or other gas filled fire extinguishers; they will have little effect on decomposing persulfate.

Specific Hazards Arising from the Chemical Decomposes under fire conditions to release oxygen that intensifies the fire.

Flammable properties Contact with combustible material may cause fire

Explosion data
Sensitivity to Mechanical Impact Not sensitive.
Sensitivity to Static Discharge Not sensitive.

Protective equipment and precautions for firefighters As in any fire, wear self-contained breathing apparatus pressure-demand, MSHA/NIOSH (approved or equivalent) and full protective gear.

6. ACCIDENTAL RELEASE MEASURES

Personal Precautions Keep off any unprotected persons. Avoid contact with the skin and the eyes. Avoid breathing dust. Wear personal protective equipment.

Other Never add other substances or combustible waste to product residues.

Environmental Precautions Prevent material from entering into soil, ditches, sewers, waterways, and/or groundwater. See Section 12, Ecological Information for more detailed information.

Methods for Containment Vacuum, shovel or pump waste into a drum and label contents for disposal. Avoid dust formation. Store in closed container.

Methods for cleaning up Clean up spill area and treat as special waste. Dispose of waste as indicated in Section 13.

7. HANDLING AND STORAGE

Handling Wear personal protective equipment. Use only in area provided with appropriate exhaust ventilation. Avoid dust formation. Handle product only in closed system or provide appropriate exhaust ventilation at machinery. Avoid contact with skin and eyes. Avoid breathing dust. Remove and wash contaminated clothing before re-use. Reference to other sections.

Storage Keep containers tightly closed in a dry, cool and well-ventilated place. Keep away from heat. Do not store near combustible materials. Avoid contamination of opened product. Keep away from food, drink and animal feedingstuffs. Avoid formation and deposition of dust.

Incompatible products Acids, Alkalis, Halides, Combustible materials, Organic material, Reducing agents. Acids, alkalis, halides (fluorides, chlorides, bromides), combustible materials, reducing agents and organic compounds.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Control parameters

Exposure Guidelines .

Chemical name	ACGIH TLV	OSHA PEL	NIOSH	Mexico
Sodium Persulfate 7775-27-1	TWA: 0.1 mg/m³	-	-	-
Chemical name	**British Columbia**	**Quebec**	**Ontario TWAEV**	**Alberta**
Sodium Persulfate 7775-27-1	TWA: 0.1 mg/m³	-	TWA: 0.1 mg/m³	TWA: 0.1 mg/m³

Appropriate engineering controls

Engineering measures Provide local exhaust or general ventilation adequate to maintain exposures below permissable exposure limits.

Individual protection measures, such as personal protective equipment

Eye/Face Protection Eye protection recommended. Chemical goggles consistent with EN 166 or equivalent.

Skin and Body Protection Wear long-sleeved shirt, long pants, socks, and shoes.

Hand Protection Protective gloves: Neoprene gloves, Polyvinylchloride, Natural Rubber.

Respiratory Protection If exposure limits are exceeded or irritation is experienced, NIOSH/MSHA approved respiratory protection should be worn: particulate filtering facepiece respirators.

Hygiene measures Keep away from food, drink and animal feeding stuffs. Do not eat, drink or smoke when using this product. Wash hands before breaks and after shifts. Keep work clothes separate, remove contaminated clothing - launder after open handling of product.

General information Protective engineering solutions should be implemented and in use before personal protective equipment is considered.

9. PHYSICAL AND CHEMICAL PROPERTIES

Information on basic physical and chemical properties

Appearance	Crystalline solid
Physical State	Solid
Color	White
Odor	odorless
Odor threshold	Not applicable
pH	6.0 (1% solution)
Melting point/freezing point	180 °C (Decomposes)
Boiling Point/Range	Decomposes upon heating
Flash point	Not flammable
Evaporation Rate	No information available
Flammability (solid, gas)	Not flammable
Flammability Limit in Air	Not applicable
Upper flammability limit:	No information available
Lower flammability limit:	No information available
Vapor pressure	6.07E-30 mm Hg at 25ºC
Vapor density	No information available
Density	2.59 g/cm³ (crystal density)
Specific gravity	No information available
Water solubility	42 % @ 25 °C
Solubility in other solvents	No information available
Partition coefficient	No information available (inorganic)
Autoignition temperature	No evidence of combustion up to 600°C No evidence of combustion up to 600 °C
Decomposition temperature	> 100 °C (assume)
Viscosity, kinematic	No information available (Solid)
Viscosity, dynamic	No information available
Explosive properties	Not explosive
Oxidizing properties	oxidizer
Molecular weight	238.1
VOC content (%)	Not applicable
Bulk density	1.12 g/cm³ (loose)

10. STABILITY AND REACTIVITY

Reactivity None under normal use condtions. Oxidizer. Contact with other material may cause fire.

Chemical Stability Stable.

Possibility of Hazardous Reactions None under normal processing.

Hazardous polymerization Hazardous polymerization does not occur.

Conditions to avoid Heat. Moisture.

Incompatible materials Acids, alkalis, halides (fluorides, chlorides, bromides), combustible materials, reducing agents and organic compounds. . Acids, Alkalis, Halides, Combustible materials, Organic material, Reducing agents.

Hazardous Decomposition Products Oxygen which supports combustion.

11. TOXICOLOGICAL INFORMATION

Product Information

Unknown acute toxicity 0% of the mixture consists of ingredient(s) of unknown toxicity

LD50 Oral	Sodium Persulfate: 895 mg/kg (rat)
LD50 Dermal	Sodium Persulfate: > 10 g/kg
LC50 Inhalation	Sodium Persulfate: >5.10 mg/L (4h) (rat)

Serious eye damage/eye irritation Irritating to eyes.
Skin corrosion/irritation Minimally irritating.

Sensitization Sodium Persulfate:. May cause sensitization by inhalation and skin contact.

Component Information

Chemical name	LD50 Oral	LD50 Dermal	LC50 Inhalation	NOAEL Oral Value
Sodium Persulfate (7775-27-1)	895 mg/kg (Rat)	> 10000 mg/kg (Rabbit)	> 21.6 mg/L (Rat) 4 h	
Sodium sulfate (7757-82-6)	> 10000 mg/kg (Rat)			

Information on toxicological effects

Symptoms Symptoms of allergic reaction may include rash, itching, swelling and trouble breathing.

Delayed and immediate effects as well as chronic effects from short and long-term exposure

Irritation Irritating to eyes, respiratory system and skin.
corrosivity None.

Carcinogenicity Contains no ingredient listed as a carcinogen.

Mutagenicity Did not show mutagenic effects in animal experiments

Neurological effects Not neurotoxic

Reproductive toxicity This product is not recognized as reprotox by Research Agencies.
Developmental toxicity None known.
Teratogenicity Not teratogenic in animal studies.

STOT - single exposure May cause respiratory irritation.
STOT - repeated exposure Not classified.

Target organ effects Eyes, Lungs.

Aspiration hazard No information available.

12. ECOLOGICAL INFORMATION

Ecotoxicity

Ecotoxicity effects

Sodium Persulfate (7775-27-1)				
Active Ingredient(s)	Duration	Species	Value	Units
Sodium Persulfate	96 h LC50	Rainbow trout	163	mg/L
Sodium Persulfate	48 h LC50	Daphnia magna	133	mg/L
Sodium Persulfate	96 h LC50	Grass shrimp	519	mg/L
Sodium Persulfate	72 h EC50	Algae Selenastrum capricornutum	116	mg/L

Persistence and degradability Biodegradability does not pertain to inorganic substances.

Bioaccumulation Does not bioaccumulate.

Mobility Dissociates into ions.

Other Adverse Effects None known.

13. DISPOSAL CONSIDERATIONS

Waste disposal methods This material, as supplied, is a hazardous waste according to federal regulations (40 CFR 261). It must undergo special treatment, e.g. at suitable disposal site, to comply with local regulations.

Contaminated Packaging Empty remaining contents. Dispose of in accordance with local regulations.

14. TRANSPORT INFORMATION

DOT

UN/ID no UN 1505
Proper Shipping Name SODIUM PERSULFATE
Hazard class 5.1
Packing Group III

TDG

UN/ID no UN 1505
Proper Shipping Name SODIUM PERSULFATE
Hazard class 5.1
Packing Group III

MEX

UN/ID no UN 1505
Proper Shipping Name SODIUM PERSULFATE
Hazard class 5.1
Packing Group III

ICAO

UN/ID no UN 1505
Proper Shipping Name SODIUM PERSULFATE
Hazard class 5.1
Packing Group III

ICAO/IATA

UN/ID no UN 1505
Proper Shipping Name SODIUM PERSULFATE
Hazard class 5.1

Packing Group III

IMDG/IMO

UN/ID no	UN 1505
Proper Shipping Name	SODIUM PERSULFATE
Hazard class	5.1
Packing Group	III

ADR/RID

UN/ID no	UN 1505
Proper Shipping Name	SODIUM PERSULFATE
Hazard class	5.1
Packing Group	III

ADN

Proper Shipping Name	SODIUM PERSULFATE
Hazard class	5.1
Packing Group	III

15. REGULATORY INFORMATION

U.S. Federal Regulations

SARA 313
Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA). This product does not contain any chemicals which are subject to the reporting requirements of the Act and Title 40 of the Code of Federal Regulations, Part 372

SARA 311/312 Hazard Categories
This product is not subject to reporting under the Emergency Planning and Community Right-to-Know rule.

Clean Water Act
This product does not contain any substances regulated as pollutants pursuant to the Clean Water Act (40 CFR 122.21 and 40 CFR 122.42)

CERCLA/EPCRA
This material, as supplied, does not contain any substances regulated as hazardous substances under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) (40 CFR 302) or the Superfund Amendments and Reauthorization Act (SARA) (40 CFR 355). There may be specific reporting requirements at the local, regional, or state level pertaining to releases of this material

US State Regulations

U.S. State Right-to-Know Regulations
This product contains the following substances regulated under state Right-to-Know laws:

Chemical name	Massachusetts	New Jersey	Pennsylvania	Illinois	Rhode Island
Sodium Persulfate		X			
Sodium sulfate	X		X		

California Proposition 65
This product does not contain any Proposition 65 chemicals

CANADA

Environmental Emergencies
This product contains no substances listed under Canada's Environmental Emergency regulations.

Canadian National Pollutant Release Inventory

This product contains no substances reportable under Canada's National Pollutant Release Inventory regulations.

International Inventories

Component	TSCA (United States)	DSL (Canada)	EINECS/ELINCS (Europe)	ENCS (Japan)	China (IECSC)	KECL (Korea)	PICCS (Philippines)	AICS (Australia)	NZIoC (New Zealand)
Sodium Persulfate 7775-27-1 (> 99)	X	X	X	X	X	X	X	X	X
Sodium sulfate 7757-82-6 (< 2)	X	X	X	X	X	X	X	X	X

Mexico

Mexico - Grade Slight risk, Grade 1

16. OTHER INFORMATION

NFPA	**Health Hazards** 1	**Flammability** 0	**Stability** 1	**Special Hazards** OX
HMIS	**Health Hazards** 1	**Flammability** 0	**Physical hazard** 1	**Special precautions** J

NFPA/HMIS Ratings Legend Special Hazards: OX = Oxidizer
Protection=J (Safety goggles, gloves, apron, combination dust and vapor respirator)

Revision date: 2018-07-13
Revision note SDS sections updated: 3.
Issuing Date: 2017-03-17

Disclaimer

PeroxyChem believes that the information and recommendations contained herein (including data and statements) are accurate as of the date hereof. NO WARRANTY OF FITNESS FOR ANY PARTICULAR PURPOSE, WARRANTY OF MERCHANTABILITY OR ANY OTHER WARRANTY, EXPRESSED OR IMPLIED, IS MADE CONCERNING THE INFORMATION PROVIDED HEREIN. The information provided herein relates only to the specified product designated and may not be applicable where such product is used in combination with any other materials or in any process. Further, since the conditions and methods of use are beyond the control of PeroxyChem, PeroxyChem expressly disclaims any and all liability as to any results obtained or arising from any use of the products or reliance on such information.

Prepared By:

PeroxyChem

End of Safety Data Sheet

LINK TO:
QRS™-SL
Product Sheet

60% Sodium Lactate "*Injection Ready*" QRS™-SL Substrate Package
SAFETY DATA SHEET

Effective Date: 06/28/14

1. Product Identification

Synonyms:	Quick Release Substrate (QRS™-SL); Sodium Lactate; Propanoic acid, 2-Hydroxy Monosodium salt; L-Lactic Acid, Sodium Salt
Recommended Use:	Treatment of groundwater contaminated with chlorinated solvents and other anaerobically degradable compounds.
Supplier:	Terra Systems, Inc. 130 Hickman Road, Suite 1 Claymont, Delaware 19703 Telephone (302) 798-9553 Fax (302) 798-9554 www.terrasystems.net

2. Hazards Identification

Emergency Overview	
Caution:	May cause eye irritation.
Health Rating:	1 - Slight
Flammability Rating:	0 - None
Reactivity Rating:	0 - None
Contact Rating:	1 - Slight
Protective Equipment:	Goggles; Proper Gloves
Storage Color Code:	Orange (General Storage)
Potential Health Effects	
Inhalation:	Not expected to be a health hazard
Ingestion:	Not expected to be a health hazard via ingestion
Skin Contact:	No adverse effects expected
Eye Contact:	May cause irritation, possible reddening
Chronic Exposure:	No information found
Aggravation of Pre-existing Conditions:	No information found

3. Composition/Information on Ingredients

Ingredient	CAS#	Percent	Hazardous
Sodium Lactate	72-17-3	60	Yes
Water	7732-18-5	40	No

4. First Aid Measures

Inhalation: Not expected to require first aid measures. Remove to fresh air. Get medical attention for any breathing difficulty.

Ingestion: If large amounts were swallowed, give water to drink and get medical advice.

Skin Contact: Not expected to require first aid measures. Wash exposed area with soap and water. Get medical advice if irritation develops.

Eye Contact: Immediately flush eyes with plenty of water for at least 15 minutes, lifting upper and lower eyelids occasionally. Get medical attention if irritation persists.

5. Fire Fighting Measures

Fire: Flash point: 110 C (230 F). Not considered to be a fire hazard.

Explosion: Not considered to be an explosion hazard.

Fire Extinguishing Media: Use any means suitable for extinguishing surrounding fire.

Special Information: In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full face piece operated in the pressure demand or other positive pressure mode.

6. Accidental Release Measures

Clean-up personnel may require protective clothing. Absorb in sand, paper towels, “Oil Dry”, or other inert material. Scoop up and containerize for disposal. Flush trace residues to sewer with soap and water. Containerized waste may be sent to an approved waste disposal facility.

7. Handling and Storage

Keep in a tightly closed container, stored in a cool, dry, ventilated area. Protect against physical damage. Avoid long storage times. Containers of this material may be hazardous when empty since they do retain product residues (vapors, liquid). Observe all warnings and precautions listed for the product.

8. Exposure Controls/Personal Protection

Airborne Exposure Limits:	None established.
Ventilation System:	Not expected to require any special ventilation.
Personal Respirators (NIOSH Approved):	Not expected to require personal respirator usage.
Skin Protection:	Wear protective gloves and clean body-covering clothing.
Eye Protection:	Use chemical safety goggles and/or a full face shield where splashing is possible. Provide readily accessible eye wash stations and safety showers.
Slips, Trips, and Falls:	Material is slippery when spilled. Clean up with sand, paper towels, or other inert material.

9. Physical and Chemical Properties

Appearance:	Colorless to yellow liquid.
Odor:	Odorless
Solubility:	100% soluble in water.
Specific Gravity (water=1):	1.32. (11.01 pounds per gallon)
pH:	6.5-8.5
% Volatiles by volume @ 21C (70F):	No information found.
Boiling Point:	110 C (230 F)
Melting Point:	17 C (63 F)
Flash Point (F):	No information found
Autoignition Temperature:	No information found
Decomposition Temperature:	No information found.
Vapor Density (Air=1):	0.7
Vapor Pressure (mm Hg):	14 @ 20 C (68 F)
Evaporation Rate (BuAc=1):	No information found
Viscosity @23 C (73 F):	100 centipoises
Partition Coefficient (octanol/water):	No information found

10. Stability and Reactivity

Stability:	Stable under ordinary conditions of use and storage.
Reactivity:	Not reactive under ordinary conditions.
Hazardous Decomposition Products:	Carbon dioxide and carbon monoxide may form when heated to decomposition.
Hazardous Polymerization:	Will not occur.
Incompatibilities:	Strong oxidizers, acids.
Conditions to Avoid:	Incompatibles. Isolate from heat and open flame.

11. Toxicological Information

Oral rat LD50: 2000 mg/Kg. Irritation Data for Sodium Lactate: (Std Draize, rabbit, eye): 100 mg - mild.

--------\Cancer Lists\----------

Ingredient	---NTP Carcinogen--- Known	Anticipated	IARC Category
Sodium Lactate (72-17-3)	No	No	None
Water (7732-18-5)	No	No	None

12. Ecological Information

Environmental Fate: Mobile with water and readily biodegradable

Environmental Toxicity: Ecological injuries are not known or expected under normal use; (No effect on Daphnia @ 10g/L)

Degradability: This product is completely biodegradable under both aerobic and anaerobic conditions.

Soil Mobility: This compound will move with groundwater until the adsorbed onto the soil. Degradation products may be mobile.

Bioaccumulation Potential: No information found.

13. Disposal Considerations

Whatever cannot be saved for recovery or recycling should be managed in an appropriate and approved waste disposal facility. Processing, use or contamination of this product may change the waste management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and local requirements.

14. Transport Information

Not regulated.

Terra Systems, Inc.
130 Hickman Road, Suite 1, Claymont, Delaware 19703
Contact: Michael Free, VP, Sales and Marketing
Office: 302-798-9553; Cell: 484-889-2214 Email: mfree@terrasystems.net

15. Regulatory Information

--------\Chemical Inventory Status - Part 1\----------

Ingredient	TSCA	EC	Japan	Australia
Sodium Lactate (72-17-3)	Yes	Yes	Yes	Yes
Water (7732-18-5)	Yes	Yes	Yes	Yes

--------\Chemical Inventory Status - Part 2\----------

Ingredient	Korea	--Canada-- DSL	NDSL	Phil.
Sodium Lactate (72-17-3)	Yes	Yes	No	Yes
Water (7732-18-5)	Yes	Yes	No	Yes

--------\Federal, State & International Regulations - Part 1\----------

Ingredient	-SARA 302- RQ	TPQ	------SARA 313------ List	Chemical Catg.
Sodium Lactate (72-17-3)	No	No	No	No
Water (7732-18-5)	No	No	No	No

--------\Federal, State & International Regulations - Part 2\----------

Ingredient	-RCRA- CERCLA	-TSCA- 261.33	8(d)
Sodium Lactate (72-17-3)	No	No	No
Water (7732-18-5)	No	No	No

Chemical Weapons Convention: No TSCA 12(b): No CDTA: No
SARA 311/312: Acute: Yes Chronic: No Fire: No Pressure: No
Reactivity: No (Mixture / Liquid)

16. Other Information

NFPA Ratings: Health: **1** Flammability: **0** Reactivity: **0**

Date Prepared: March 28, 2014

Revision Information: SDS Section(s) changed since last revision of document include: None.

Disclaimer: Terra Systems, Inc. provides the information contained herein in good faith but makes no representation as to its comprehensiveness or accuracy. This document is intended only as a guide to the appropriate precautionary handling of the

material by a properly trained person using this product. Individuals receiving the information must exercise their independent judgment in determining its appropriateness for a particular purpose. TERRA SYSTEMS, INC. MAKES NO REPRESENTATIONS OR WARRANTIES, EITHER EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION ANY WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE WITH RESPECT TO THE INFORMATION SET FORTH HEREIN OR THE PRODUCT TO WHICH THE INFORMATION REFERS. ACCORDINGLY, TERRA SYSTEMS, INC. WILL NOT BE RESPONSIBLE FOR DAMAGES RESULTING FROM USE OF OR RELIANCE UPON THIS INFORMATION.

Prepared by: Terra Systems, Inc.
Phone Number: (302) 798-9553 (U.S.A.)

Terra Systems, Inc.
130 Hickman Road, Suite 1, Claymont, Delaware 19703
Contact: Michael Free, VP, Sales and Marketing
Office: 302-798-9553; Cell: 484-889-2214 Email: mfree@terrasystems.net

EOS Remediation, LLC

EOS 100

SAFETY DATA SHEET

Section 1: Identification	
Product Name:	**EOS 100**
Chemical Description:	Mixture; vegetable oil-based
Manufacturer:	EOS Remediation PO Box 14266 Research Triangle Park, NC 27709 (P): 919-873-2204
Recommended Use:	Groundwater Bioremediation (environmental applications)
Restricted Use:	Not for human consumption
24-Hour Emergency Contact:	ChemTel: United States (P): 800-255-3924 ChemTel: International (P): 813-248-0585

Section 2: Hazard(s) Identification	
Hazard Classification:	Irritant (eye and skin)
Signal Word:	Warning
Hazard Statement(s):	Potential eye and skin irritant.
Pictograms:	
Precautionary Statement(s):	Not for human consumption. Protect from freezing. Do not store near excessive heat or oxidizers. Avoid contact with eyes and skin. Wear protective gloves and eye protection.

Section 3: Composition/Information on Ingredients		
Common Name(s)	**CAS NO.**	**% by Weight**
Soybean Oil	8001-22-7	85
Emulsifiers Trade Secret[1,2]	Proprietary	10
Additives Trade Secret[1,2]	Proprietary	5

1 – The precise composition of this product is proprietary information. A more complete disclosure will be provided to a physician in the event of a medical emergency.
2 – The soluble substrates and emulsifiers are generally recognized as safe.

Section 4: First-Aid Measures	
Routes of Exposure	**Emergency First-Aid Procedures**
Inhalation	Remove to fresh air.
Eye Contact	Flush with water for 15 minutes; if irritation persists see a physician.
Dermal	Wash with mild soap and water.

Ingestion	Product is non-toxic. If nausea occurs, induce vomiting and seek medical attention.

Section 5: Fire-Fighting Measures	
Extinguishing Media:	CO_2, foam, dry chemical Note: Water, fog and foam may cause frothing and spattering.
Special Fire Fighting Procedures:	Wear self-contained breathing apparatus and chemical resistant clothing. Use water spray to cool fire exposed containers.
Fire Hazard(s):	Burning will cause oxides of carbon.

Section 6: Accidental Release Measures	
Personal Precautions:	Avoid contact with eyes and skin. Do not consume.
Emergency Procedures:	N/A
Methods & Materials used for Containment:	Compatible granular absorbent
Cleanup Procedures:	Spread compatible granular absorbent over spill area and sweep using broom and pan; dispose in appropriate receptacle. Clean area with water.

Section 7: Handling and Storage	
Safe Handing & Storage:	Do not store near excessive heat or oxidizers.
Other Precautions:	Consumption of food and beverages should be prevented in work area where product is being used. After handling product, always wash hands and face thoroughly with soap and water before eating, drinking, or smoking.

Section 8: Exposure Controls/Personal Protection		
Exposure Limits		
OSHA PEL:	Vegetable Oil Mist	15 mg/m^3 (total) 5 mg/m^3 (respirable)
ACGIH TLV:	NE	NE
NIOSH REL:	Vegetable Oil Mist	10 mg/m^3 (total) 5 mg/m^3 (respirable)
Personal Protective Measures		
Respiratory Protection:	Not normally required. P95 respirator if aerosols might be generated.	
Hand Protection:	Protective gloves are recommended	
Eye Protection:	Recommended	
Engineering Measures:	Local exhaust ventilation if aerosols are generated	
Hygiene Measures:	Wash promptly with soap & water if skin becomes irritated from contact.	
Other Protection:	Wear appropriate clothing to prevent skin contact.	

NE – Not Established

Section 9: Physical and Chemical Properties			
Appearance:	Pale Yellow	Explosive Limits:	NE
Odor:	Vegetable Oil	Vapor Pressure:	NE
Odor Threshold:	NE	Vapor Density:	Heavier than air
pH:	NE	Relative Density:	0.92-0.93
Melting Point/Freezing Point:	Liquid at room temperature	Solubility:	Easily soluble & dispersible
Boiling Point:	N/A	Partition coefficient:	NE
Flash Point:	>600°F (316°C)	Auto-ignition Temperature:	NE
Evaporation Rate:	NE	Decomposition Temperature:	N/A
Flammability (solid, gas):	NE	Viscosity:	50 cP

NE – Not Established
N/A – Non-Applicable

Section 10: Stability and Reactivity	
Stability:	Stable
Incompatibility:	Strong acids and oxidizers
Hazardous Decomposition Products:	Thermal decomposition may produce oxides of carbon
Hazardous Reactions/Polymerization:	Will not occur
Conditions to Avoid:	None known

Section 11: Toxicological Information		
Likely Routes of Exposure:		Ingestion, dermal and eye contact
Signs and Symptoms of Exposure:		None known
Health Hazards		
	Acute:	Potential eye and skin irritant
	Chronic:	None known
Carcinogenicity		
	NTP:	No
	IARC:	No
	OSHA:	No

Section 12: Ecological Information (non-mandatory)
There is no data on the ecotoxicity of this product.

Section 13: Disposal Considerations (non-mandatory)	
Waste Disposal Methods:	Dispose of according to Federal and local regulations for non-hazardous

	waste.

Section 14: Transport Information (non-mandatory)
The product is not covered by international regulation on the transport of dangerous goods.
No transport warning required.

Section 15: Regulatory Information (non-mandatory)
N/A

Section 16: Other Information	
Date of Preparation:	29 May 2014
Last Modified Date:	27 June 2019
The information contained herein is based on available data and is believed to be correct. However, EOS Remediation, LLC makes no warranty, expressed or implied, regarding the accuracy of this data or the results to be obtained thereof. This information and product are furnished on the condition that the person receiving them shall make his/her own determination as to the suitability of the product for his/her particular purpose.	

EOS Remediation, LLC

EOSZVI

SAFETY DATA SHEET

Section 1: Identification	
Product Name:	**EOS ZVI**
Chemical Description:	Mixture; micro-iron powder in vegetable oil
Manufacturer:	EOS Remediation PO Box 14266 Research Triangle Park NC, 27709 (P): 919-873-2204
Recommended Use:	Groundwater Bioremediation (environmental applications)
Restricted Use:	Not for human consumption
24-Hour Emergency Contact:	ChemTel: United States (P): 800-255-3924 ChemTel: International (P): 813-248-0585

Section 2: Hazard(s) Identification	
Hazard Classification:	Irritant (eye and skin)
Signal Word:	Warning
Hazard Statement(s):	Potential eye and skin irritant.
Pictograms:	
Precautionary Statement(s):	Not for human consumption. Protect from freezing. Do not store near excessive heat or oxidizers. Avoid contact with eyes and skin. Wear protective gloves and eye protection.

Section 3: Composition/Information on Ingredients		
Common Name(s)	**CAS NO.**	**% by Weight**
Soybean Oil	8001-22-7	40 - 45
Emulsifiers Trade Secret[1,2]	Proprietary	5 - 10
Stabilizers Trade Secret[1,2]	Proprietary	1 - 5
Micro-Iron powder	7439-89-6	45 - 55

1 – The precise composition of this product is proprietary information. A more complete disclosure will be provided to a physician in the event of a medical emergency.
2 – The soluble substrates and emulsifiers are generally recognized as safe.

Section 4: First-Aid Measures	
Routes of Exposure	**Emergency First-Aid Procedures**
Inhalation	Remove to fresh air.
Eye Contact	Flush with water for 15 minutes; if irritation persists see a physician.
Dermal	Wash with mild soap and water.
Ingestion	Product is non-toxic. If nausea occurs, induce vomiting and seek medical attention.

Section 5: Fire-Fighting Measures	
Extinguishing Media:	CO_2, foam, dry chemical Note: Water, fog and foam may cause frothing and spattering.
Special Fire Fighting Procedures:	Wear self-contained breathing apparatus and chemical resistant clothing. Use water spray to cool fire exposed containers.
Fire Hazard(s):	Burning will cause oxides of carbon.

Section 6: Accidental Release Measures	
Personal Precautions:	Avoid contact with eyes and skin. Do not consume.
Emergency Procedures:	N/A
Methods & Materials used for Containment:	Compatible granular absorbent
Cleanup Procedures:	Spread compatible granular absorbent over spill area and sweep using broom and pan; dispose in appropriate receptacle. Clean area with water.

Section 7: Handling and Storage	
Safe Handing & Storage:	Do not store near excessive heat (> 150°C) or oxidizers.
Other Precautions:	Consumption of food and beverages should be prevented in work area where product is being used. After handling product, always wash hands and face thoroughly with soap and water before eating, drinking, or smoking.

Section 8: Exposure Controls/Personal Protection		
Exposure Limits		
OSHA PEL:	Vegetable Oil Mist	15 mg/m^3 (total) 5 mg/m^3 (respirable)
ACGIH TLV:	NE	NE
NIOSH REL:	Vegetable Oil Mist	10 mg/m^3 (total) 5 mg/m^3 (respirable)
Personal Protective Measures		
Respiratory Protection:	Not normally required. P95 respirator if aerosols might be generated.	

Hand Protection:	Protective gloves are recommended
Eye Protection:	Recommended
Engineering Measures:	Local exhaust ventilation if aerosols are generated
Hygiene Measures:	Wash promptly with soap & water if skin becomes irritated from contact.
Other Protection:	Wear appropriate clothing to prevent skin contact.

NE – Not Established

Section 9: Physical and Chemical Properties			
Appearance:	Black	Explosive Limits:	NE
Odor:	Vegetable Oil	Vapor Pressure:	NE
Odor Threshold:	NE	Vapor Density:	Heavier than air
pH:	NE	Relative Density:	1.5 – 1.7
Melting Point/Freezing Point:	Liquid at room temperature	Solubility:	Easily soluble & dispersible
Boiling Point:	N/A	Partition coefficient:	NE
Flash Point:	>600°F (316°C)	Auto-ignition Temperature:	NE
Evaporation Rate:	NE	Decomposition Temperature:	N/A
Flammability (solid, gas):	NE	Viscosity:	2350 cP

NE – Not Established

N/A – Non-Applicable

Section 10: Stability and Reactivity	
Stability:	Stable
Incompatibility:	Strong acids and oxidizers
Hazardous Decomposition Products:	Thermal decomposition may produce oxides of carbon
Hazardous Reactions/Polymerization:	Will not occur
Conditions to Avoid:	Do not expose to temperatures above 150°C

Section 11: Toxicological Information		
Likely Routes of Exposure:		Ingestion, dermal and eye contact
Signs and Symptoms of Exposure:		None known
Health Hazards		
	Acute:	Potential eye and skin irritant
	Chronic:	None known
Carcinogenicity		
	NTP:	No
	IARC:	No
	OSHA:	No

Section 12: Ecological Information (non-mandatory)
There is no data on the ecotoxicity of this product.

Section 13: Disposal Considerations (non-mandatory)	
Waste Disposal Methods:	Dispose of according to Federal and local regulations for non-hazardous waste.

Section 14: Transport Information (non-mandatory)
The product is not covered by international regulation on the transport of dangerous goods.
No transport warning required.

Section 15: Regulatory Information (non-mandatory)
N/A

Section 16: Other Information	
Date of Preparation:	2 June 2016
Last Modified Date:	12 August 2019
The information contained herein is based on available data and is believed to be correct. However, EOS Remediation, LLC makes no warranty, expressed or implied, regarding the accuracy of this data or the results to be obtained thereof. This information and product are furnished on the condition that the person receiving them shall make his/her own determination as to the suitability of the product for his/her particular purpose.	