Review Comments for the
Revised Draft Final SWMU 13 Corrective Measures Study Work Plan and Report
Tooele Army Depot – South Area
Dated February 2016

No.	Page	Section, Paragraph	Comment	Response
Name, Organization: Dave Larsen, Utah DSHW, March 8, 2016				
Responses to State comments on the CMS Work Plan and Report				
1			Notwithstanding the information in Section 3.3.6.1 about sample reanalysis, the information in Section 3.3.6 about agent breakdown products (ABPs) and the information in Figures L.1 and L.4 showing chloroform and TCE plumes outside the main release area, the responses to Division comments five and six indicate additional dissolved groundwater related work will not be needed. The Division does not concur with this response and suggests the need for additional wells or borings to define the dissolved plumes and contamination in the deeper groundwater system. In addition, the presence of contamination in the deeper groundwater seems to verify a hydraulic connection between the shallow and deep systems. These issues will need to be addressed in detail sometime during the corrective action process and as needed to create a natural attenuation and post-closure monitoring plan. Please modify appropriate sections of the CMS Work Plan and Report as needed and indicate when these issues will be addressed.	While the Rust 1997 RFI did not completely define the area impacted by several non-fuel spill related VOCs in groundwater, sufficient information has been collected to select a corrective measure for the fuel-impacted area and the recommended corrective measures will address remediation of all contaminants within the fuel-impacted area. It is acknowledged that non-fuel constituents were identified in groundwater during the CMS data gap investigation outside of the fuel release area. While delineating the lateral extent of chloroform and TCE is not part of a CMS, these constituents will be monitored in groundwater as part of the long term monitoring (LTM) program (see Response to Comment #15) following the CMI and will be addressed in a natural attenuation and LTM work plan. Monitoring results will be tracked, and trend analyses will be conducted to ensure compliance with the *Principle of Non-degradation* (UAC R315-101-3). Please note that ABPs in groundwater have not been detected above the tapwater RSLs and, therefore, LTM and/or remediation is not required. Note that the SVOCs detected in the deep well during the initial (2014) sampling event were at concentrations below

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				their respective MCLs and RSL. Sampling of the deep well on March 31, 2016 confirms that the SVOCs detected remain at concentrations below RSLs and MCLs. Sections 3.1.4.4 Groundwater Sampling and 3.3.6.1 Deep Monitoring Well (S13-CAM-DW1) have been revised to describe the sampling conducted in March/April 2016 and the results of the samples analyses. Additionally, this well has been surveyed and the vertical groundwater gradient has been evaluated (see Response to Comment #2 below). Also note that for the purposes of completing the CMS, sufficient information has been collected to select a corrective measure and following implementation of the corrective measure, this well will be included in the post corrective measures monitoring program. If monitoring shows impacts to groundwater above risk-based thresholds, the corrective measure will be revisited and modified, as required.
2			Groundwater elevation data for S13-CAM-DW1 was not included in Table 3-1 as indicated in the response to comment seven. The hydrasleeve sample log indicates a static water depth of 13.64 feet, but does provide information needed to calculate a groundwater elevation for comparison with co-located well S-CAM-2 as requested in the original comment. Please add this information to Table 3-1 and add an evaluation of vertical groundwater gradients based on this information.	S13-CAM-DW1 has been surveyed and groundwater elevation data has been added to Table 3.1. An evaluation of vertical gradients comparing S-CAM-2 to well S-CAM-DW1 has been included in the report as Section 3.4.6., using water levels measured in S-CAM-2 and S13-CAM-DW1 on 5/6/2016.
3			Regarding TEADS response to Division comment eight, the intent of the Division cross sections was to define the extent of contaminated soil and determining	Low concentrations of fuel constituents (including naphthalene) are present in stained areas outside the LNAPL pool. Section 3.3.5.3 has been added to the CMS

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			if this soil represents a source of ongoing releases to groundwater. The Division generally concurs with the recommended corrective action alternatives. However, please provide a response about the need for removal of sources of groundwater contamination in soil outside the light non-aqueous phase liquid (LNAPL) plume as shown in Figure 3.10 to meet Corrective Action Objective (CAO) 2. For example, will naphthalene contamination in the soil outside the LNAPL area continue to release naphthalene to the shallow groundwater (DAF-20 naphthalene groundwater protection value is 0.01 mg/kg)?	indicating that fuel constituents are present in soil outside of the LNAPL pool at concentrations exceeding the 20 times the USEPA soil (to groundwater) screening levels (SSLs). Evidence collected indicates that these constituents are attenuating naturally and they do not pose a risk to further degradation of groundwater. Although soil sampling locations in the stained areas do not allow a direct comparison of hydrocarbon constituents concentrations through time, constituent concentrations in soil are assumed to be in equilibrium with those in co-located groundwater. A comparison of groundwater concentrations of naphthalene and other constituents from the Rust 1997 RFI sampling to those measured in the 2014 sampling show that the concentrations are decreasing. Table M-2 (see Appendix M) summarizing this information has been be added to the CMS Report. Additionally, the presence of methane in soil gas at explosive levels in the center of the plume supports biodegradation. Lastly, the biodegradation of petroleum in soils in groundwater is well known phenomenon. USEPA's 2015 *Technical Guide For Addressing Petroleum Vapor Intrusion At Leaking Underground Storage Tank Sites* provides an extensive list of references on the aerobic and anaerobic biodegradation of petroleum hydrocarbons on pages 14-15 of their guidance document. As described above in Response to Comment #1, the natural attenuation of constituents in groundwater will be monitored and tracked during the post-closure LTM period to ensure compliance with UAC R315-101-3. If

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				monitoring shows impacts to groundwater above risk-based thresholds or noncompliance with the *Principle of Non-degradation* (UAC R315-101-3), the corrective measure will be revisited and modified as required. Natural attenuation of these hydrocarbon constituents will remove them. As there are no schedule demands that will drive the corrective action timeframe, there is no need for excavation or another active corrective measure at this time. Note, that as groundwater LTM will be sufficient to demonstrate compliance with the *Principle of Non-degradation* (UAC R315-101-3), the previously proposed soil monitoring program will not be required, and has been removed from Sections 8.2.2 and 8.2.4.
CMS Work Plan and Report Comments				
4			Case studies are referenced in Section 9.2 and 10, but specific information is not provided and the Division does not see any references specifically related to excavation trenches. Please provide a review of specific case studies with site conditions similar to SWMU 13 and copies of these studies documenting successful use of the preferred alternative/Extraction Trenches at petroleum related sites.	Appendix N has been added to the report providing case studies reviewed and considered in the development of the preferred alternative "Extraction Trenches."
5			Text in Section 3.3.6 indicates a low frequency of detection of MPA in CAMDS closure soil samples. What was the frequency of detection of DIMP and IMPA in CAMDS soil samples? Text also indicates an MPA detect in well S-76-91 in 2010, but this well was not sampled in 2014. It has been the Division's experience that MPA is the most commonly detected	Please see Response to Comment #1

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			and most widespread of the ABPs (wells S-76-91 and S-78-91 lie within the TCE plume shown in Figure L.1). It appears sampling for ABPs including MPA will be needed as part of long term monitoring. Please modify text as needed.	
6			Please modify CAO 2 on page 4-2 as needed and address the need for removal of soil in areas outside the LNAPL plume as needed to prevent further degradation of the groundwater (see comment 3 above).	Please see Response to Comment #3.
7			In Section 4.0 on page 4-1 and in Section 5.1 please clarify collection of the Rust data before closure of CAMDS, completion of the Rust risk assessment before the final nature and extent investigation, and indicate the Rust risk assessment did not follow the TEADS Risk Assumption Document (RAD) or adequately address all the requirements of R315-101 of the Utah Administrative Code.	Text has been added to the 3rd paragraph of Section 4.0 indicating that the Rust (1997) data used in the HHRA, ERA, and CMS was collected prior to the closure of CAMDS, and the risk assessments were completed prior to the final nature and extent investigation, and did not follow the TEAD-S Risk Assumptions Document (RAD) (AQS 2014), or adequately address the requirements of R315-101 of the UAC. Text has been added to Section 5.1 indicating that the Rust (1997) data used in human health and ecological risk assessments was collected prior to the closure of CAMDS, and final nature and extent investigation, and did not follow the TEAD-S RAD (AQS 2014), or adequately address the requirements of R315-101 of the UAC.
8			The text on page 4-1 indicates current conditions are the same since the Rust investigation. However, significant new information about groundwater contamination, soil gas and current contaminant	Text has been added to the 4th paragraph of Section 4.0 indicating that additional information regarding current groundwater, soil gas, and soil contaminant concentrations were collected during the CMS Data Gap Investigation to

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			concentrations were collected during the data gap investigation and this information was needed to complete an adequate risk assessment and the CMS Report. Please revise the text as needed.	complete an adequate risk assessment and CMS Report.
9			Exposure to methane may be possible during construction and operation of the remedial alternative. Please add a CAO as needed on page 4-2 and modify the text on page 8-16 under "Safety".	CAO #5 on Page 4-2 has been modified to include implementation of appropriate mitigation measures to prevent on-site worker exposure to methane vapors during construction and operation and maintenance of the corrective action alternative. The 2nd sentence of Section 8.2.4.1, Technical Evaluation, Safety has been revised to read "*Onsite workers may be exposed to diesel fuel, fuel constituents, and methane vapors during construction, operation, and maintenance activities if appropriate precautionary measures are not implemented and maintained.*"
10			In Table 6.1 for "Institutional Controls" and "Groundwater Monitoring" under "Effectiveness," it seems groundwater monitoring can detect future changes in contaminant concentrations in groundwater and determine if natural attenuation occurs etc. Please delete 'none" under "Effectiveness" and add text as needed. CAO related decisions will be made based on monitoring data.	Table 6.1 for "Institutional Controls" and "Groundwater Monitoring" under "Effectiveness," has been revised to indicate prevention of future degradation of groundwater by detecting changes in contaminant concentrations.
11			Extraction as a technology in Table 6.1 does not appear to include areas outside the LNALP body or address CAO 2 for these areas. Please include these areas (see response to state comment 3 above).	Please see Response to Comment #3.

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12			Please add "Unsaturated" in the "Enhanced Aerobic Biodegradation" row under the "Phase Change" in Table 6.1. In addition, monitoring and other activities may be needed and may be considered a "technology" related to natural attenuation (e.g., *Sweeney and Ririe, 2014, Temperature as a Tool to Evaluate Aerobic Biodegradation in Hydrocarbon Contaminated Soil, Groundwater Monitoring & Remediation, 34. no 3: 41-50*.) Monitored natural attenuation (MNA) and monitoring in general are not "walk away" remedies/alternatives.	Enhanced Aerobic Biodegradation has been revised to show applicability to the Saturated and Unsaturated Zones in Table 6.1 under "Phase Change". Comment noted.
13			Table 6.1 lists "Applicable Geology (Fine/Coarse)" as one of the technology effectiveness criteria and this appears to be the main criteria for rejecting a technology. Section 7.1 barely mentions site conditions with not detail or reference to geology, boring logs or other information in the report. The Division generally concurs that geology is the main criteria for technology selection and that the shallow soils at SWMU 13 are generally clayey and fine-grained with poor transmissivity. However, please provide additional detail justifying rejection of nine of twenty remedial options. One exception is Bioslurping/Enhanced Fluid Recovery, which works in fine-grained soil, but has high costs (rejected due to cost?). Please note the public will have the opportunity to comment on the SWMU 13 CMS	Section 7.1 has been revised to include a discussion on site conditions which limit the effectiveness of a number of the technologies considered. Appendix H (Corrective Measures Technologies Screening) has been revised to include additional justification for the rejection of those technologies identified in Table 6.1 that were not considered in the development of corrective measures alternatives in Section 7.

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			Work Plan and Report, so it needs to clearly explain why technologies or groups of technologies won't satisfy the CAOs.	
14			Table 6.1 lists "hydraulic control required" as a disadvantage of the Extraction Trench technology, and rejects all other technologies requiring hydraulic control. Hydraulic control works best in sediments with a certain transmissivity, and these types of sediment are not present at SWMU 13 for certain technologies, but Extraction Trench qualifies as the recommended corrective action technology. Please provide more information about hydraulic control as related to Extraction Trenches (not addressed in Section 8.2.4). If success of this technology depends on hydraulic control by water flooding it may be effective, as significant mounding can occur in fine sediments. If drawdown is needed hydraulic control may not be effective (see comment 1 above).	Hydraulic control may enhance the effectiveness of LNAPL removal from the collection trenches, but is not necessary. Additionally, hydraulic control was not the sole reason for rejection of other technologies.
15			In Section 7.3.4, please add additional groundwater monitoring parameters as needed based on the plume maps in the Appendix. All contaminants need to be tracked and natural attenuation needs to be quantified. A sufficient data base is also needed to determine if contaminant concentrations are increasing, decreasing etc. For example, a significant increase in contaminant concentrations may occur immediately after corrective action begins and it will take time to determine if CAOs are being met. This comment applies to all five alternatives evaluated in Section 7.	Sections 7.3.1 through 7.3.5 have been revised to indicate that "petroleum constituents and other VOCs" will be monitored using USEPA Method 8260 (full scan). Sections 8.2.1 through 8.2.5 have been revised to indicate that groundwater monitoring will be conducted to monitor LNAPL levels, TPH-DRO, petroleum constituents and other VOC concentrations.

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16			Section 7.3.4 and 8.2.4 indicate soil monitoring and collection of boring data for five years. The Division understands monitoring time and number of samples become part of the cost estimate, but justification for monitoring times and number of samples should be proposed in the CMI and post-closure plan.	As noted in the comment, monitoring time frames specified in Sections 7.3.4 and 8.2.4 were derived for estimating purposes. Actual monitoring time frames will be proposed in the CMI and post-closure plan. Text has been added to the last paragraph in Section 7.3 indicating that "*Estimated time frames for monitoring included in Alternative 1 through 5 were assumed for cost estimating purposes.*" Sections 8.2.1 through 8.2.5 have been revised to state that corrective action and monitoring time frames were assumed for cost estimating purposes. Additionally, the soil monitoring program proposed for Alternatives 2 and 4, along with the associated number of samples and time frame has been eliminated, as it will be difficult to determine if decreasing concentrations in soil are the result of biodegradation or leaching to groundwater. Text in Section 8.2.2 and 8.2.4 has been revised accordingly.
17			Please add a bullet to Section 7.3.4 describing management of excavated trench soil. Although it is assumed the trench system will be in the subsurface (perforated pipe and collection sump), will excavated contaminated soil need to be stockpiled and land-farmed, sent off site, etc.? Section 8.2.4 indicates construction of 500 feet of trench.	Unstained soil will be excavated from the trenches and stockpiled on site for reuse as backfill. Stained and saturated soil excavated will be transported off-site for treatment/disposal. Section 7.3.4 has been revised to provide clarification regarding the management of excavated trench soil.

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18			In Section 8.24 indicate covering of the pipe with excavated overburden following pipe and sump construction.	As indicated in Response to Comment #17 unstained soil will be used as backfill and stained soil will be transported off-site for treatment/disposal. The saturated zone within the trench will be backfilled with granular material to allow the collection of free product and direct it to one of the collection sumps. No piping will be installed in the trench. Stockpiled overburden will be used as backfill on top of the granular material. If additional backfill is required it will be imported from a TEAD-S borrow area. Section 8.2.4 has been revised to provide clarification regarding the construction of the extraction trenches.
19			Figure 8.4 shows the extent of product, product flow direction and the location of three trenches and indicates these trenches will be used to capture all the free product. However, it appears approximately 1/8 of the free product shown downgradient of the southern-most trench cannot be captured by this system. If this diagram addresses cost estimation no changes are needed, but the CMI/engineering design will need to address this issue.	Figure 8.4 provides only a conceptual design used primarily for developing a cost estimate for Alternative 4. The actual design and placement of the trenches will be developed in the CMI/engineering design. Text has been added to Section 8.2 indicating that *“Conceptual designs for each of the alternatives evaluated in this Section are provided as Figures 8.1 through 8.5. These conceptual designs were developed to assist in developing cost estimates for each alternative. The actual design of the corrective measures alternative selected will be developed as part of the corrective measures implementation/engineering design.”*
20			Section 8.2.4 indicates pipe installation at 15 feet below ground surface, 3.5 years of product collection etc. Justification (cross sections etc.) for this depth, time and other related details will be needed in the	Horizontal piping will not be used for the collection of LNAPL, rather LNAPL will be collected in the granular material placed within the saturated zone of each trench, which will be approximately 15 feet deep. A vertical pipe

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			CMI/engineering design. Details related to MNA are also needed the CMI. The CMS includes no detail about MNA.	will then extend from the surface into the granular material to collect LNAPL at each collection sump (which are schematically illustrated in Figure 8.4). Trench depth, location, and remedial time-frames were assumed as part of a conceptual design for cost estimating. Design details will be included in the CMI/engineering design. Please see Response to Comment #19. MNA is a component of all alternatives, and is implied through the proposed monitoring program. Sections 7.3.1 through 7.3.5 have been revised to indicate that MNA is a component of each alternative. Sections 8.2.1 through 8.2.5 have been revised to include the implementation of a MNA/groundwater monitoring program.
21			Please modify Section 8.3 following review of state comment 3 as needed.	Please see Response to Comment #3.

2nd REVISED DRAFT FINAL SOLID WASTE MANAGEMENT UNIT 13 CORRECTIVE MEASURES STUDY WORK PLAN, REPORT, AND STATEMENT OF BASIS

TOOELE ARMY DEPOT - SOUTH AREA
STOCKTON, UTAH

Contract Number: W912DY-09-D-0062
Delivery Order: CM03

Prepared for:
Tooele Army Depot - South Area,
U.S. Army Corps of Engineers,
Sacramento District,
and U.S. Army Environmental Command

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May 2016

2nd REVISED DRAFT FINAL SOLID WASTE MANAGEMENT UNIT 13 CORRECTIVE MEASURES STUDY WORK PLAN, REPORT, AND STATEMENT OF BASIS

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LIST OF APPENDICES

ACRONYMS AND ABBREVIATIONS

°F	Degrees Fahrenheit
<	Less Than
>	More Than
%	Percent
ABP	Agent Breakdown Product
AMPA	Alkyl Methylphosphonic Acid
amsl	Above Mean Sea Level
AST	Aboveground Storage Tank
ASTM	American Society for Testing Materials
BDA	Brine Drying Area
bgs	Below Ground Surface
BIF	Bulk Items Facility
Ca	Calcium
CAO	Corrective Action Objective
CAMDS	Chemical Agent Munitions Disposal System
CAP	Corrective Action Program
CASRN	Chemical Abstract Services Registry Number
CBDCOM	Chemical and Biological Defense Command
CCV	Continuing Calibration Verification
Cl	Chlorine
CMS	Corrective Measures Study
CPT	Cone Penetration Test
DAF	Dilution Attenuation Factor
DCD	Deseret Chemical Depot
DIMP	Diisopropylmethylphosphonate
DoD	Department of Defense
DOT	Department of Transportation
DRO	Diesel Range Organic
DVR	Data Validation Report
DWMRC	Division of Waste Management and Radiation Control
DWR	Division of Water Rights
ECC	Explosive Containment Cubicle
EcoSSL	Ecological Soil Screening Level
ELAP	Environmental Laboratory Accreditation Program
ERA	Ecological Risk Assessment
ETF	Equipment Test Facility

ACRONYMNS AND ABBREVIATIONS (CONTINUED)

FID	Flame Ionization Detector
FIR	Food Ingestion Rate
ft	Foot/Feet
g/ml	Grams per Milliliter
gal/day	Gallons per Day
H5N95	A 5% Hydrogen/95% Nitrogen Gas Mixture
Hg	Mercury
HHRA	Human Health Risk Assessment
ICV	Initial Calibration Verification
IMPA	Isopropyl Methylphosphonic Acid
IOC	Industrial Operations Command
Kg	Kilograms
LC	Liquid Chromatography
LCS	Laboratory Control Sample
LNAPL	Light Non-Aqueous Phase Liquid
LOD	Limit of Detection
LOQ	Limit of Quantitation
LTM	Long-Term Monitoring
µg/L	Micrograms per Liter
µg/m3	Micrograms per Cubic Meter
MCL	Maximum Contaminant Level
Mg	Magnesium
mg/kg	Milligrams per Kilogram
mg/L	Milligrams per Liter
ml/min	Milliliters per Minute
MNA	Monitored Natural Attenuation
MPA	Methylphosphonic Acid
MS	Mass Spectrometry
MS	Matrix Spike
MSD	Matrix Spike Duplicate
O&M	Operation and Maintenance
OD	Outside Diameter
ORC	Oxygen Releasing Compound
PAH	Polycyclic Aromatic Hydrocarbon
PAL	Project Action Limit
ppm	Parts per Million

ACRONYMNS AND ABBREVIATIONS (CONTINUED)

PTFE	Polytetrafluoroethylene
PVC	Polyvinyl Chloride
QA	Quality Assurance
QAPjP (or QAPP)	Quality Assurance Project Plan
QC	Quality Control
RAD	Risk Assumptions Document
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
RSL	Regional Screening Level
SDG	Sample Delivery Group
SOB	Statement of Basis
SOP	Standard Operating Procedure
SS	Soil Sample
SSL	Soil-to-Groundwater Screening Level
SVOC	Semi-Volatile Organic Compound
SWMU	Solid Waste Management Unit
TDG	Thiodiglycol
TDS	Total Dissolved Solids
TEAD	Tooele Army Depot
TEAD-S	Tooele Army Depot – South
TIC	Tentatively Identified Compounds
TOCDF	Tooele Chemical Agent Disposal Facility
TPH	Total Petroleum Hydrocarbons
TRV	Toxicity Reference Value
UAC	Utah Administrative Code
UDEQ	Utah Department of Environmental Quality
U.S.	United States
USACE	United States Army Corps of Engineers
USCS	Unified Soil Classification System
USEPA	United States Environmental Protection Agency
VISL	Vapor Intrusion Screening Level
VMP	Vapor Monitoring Point
VOC	Volatile Organic Compound
WUB	West Utilities Building

SECTION 1.0
INTRODUCTION

1.1 PROJECT AUTHORIZATION

Parsons has been contracted by the United States Army Corps of Engineers (USACE) Sacramento District, under contract number W912DY-09-D-0062, Delivery Order CM03, to provide environmental services for Tooele Army Depot-South (TEAD-S) at Solid Waste Management Unit (SWMU) 13. This report has been prepared by Parsons in support of an updated Corrective Measures Study (CMS) required under the terms of this contract. This document has been prepared to meet the requirements of Utah Administrative Code (UAC) R315-101-4 and the conditions of Module V of the TEAD-S Resource Conservation and Recovery Act (RCRA) Part B Permit. The Utah Department of Environmental Quality (UDEQ), Division of Waste Management and Radiation Control (DWMRC) is the regulatory authority for all RCRA environmental restoration activities at TEAD-S.

1.2 PURPOSE

The purpose of this document is to specify how the CMS was conducted, to screen applicable technologies, develop corrective measures alternatives, evaluate and compare alternatives, and recommend corrective measures for mitigation of unacceptable risks and hazards through management, containment, treatment, or removal, based on the site-specific objectives established for SWMU 13.

1.3 SCOPE

Following the technology screening process, technologies that were determined to be applicable to SWMU 13 were then assembled into corrective measures alternatives. Note that alternatives typically include one or more technologies. A detailed evaluation of the assembled alternatives and comparison of the alternatives in relation to the screening criteria specified in Module V of the TEAD-S RCRA Part B Permit was conducted, and a preferred alternative is recommended. Site characterization activities that have preceded this document were used to develop the approaches described herein.

1.4 REPORT ORGANIZATION

This CMS work plan and report is organized into the following eleven sections, including this introduction:

SECTION 2.0 BACKGROUND INFORMATION – Provides a summary of background information related to TEAD-S, SWMU 13, and previous investigations conducted at the site.

SECTION 3.0 CMS DATA GAP INVESTIGATION AND RESULTS – Presents the results of the SWMU 13 CMS Data Gap Investigation conducted in 2014 to evaluate current conditions at SWMU 13.

SECTION 4.0 CORRECTIVE ACTION OBJECTIVES – Presents the Corrective Action Objectives (CAOs) developed for SWMU 13.

SECTION 5.0 CMS APPROACH – Provides the approach used for technology screening and assembly of corrective measures alternatives to be evaluated.

SECTION 6.0 SCREENING OF CORRECTIVE MEASURES TECHNOLOGIES – Provides a detailed screening of technologies and identifies those to be retained for development of corrective measures alternatives.

SECTION 7.0 ASSEMBLY OF CORRECTIVE MEASURES ALTERNATIVES – Assembles retained technologies into corrective measures alternatives to be evaluated.

SECTION 8.0 EVALUATION OF RETAINED CORRECTIVE MEASURES ALTERNATIVES – Provides a detailed analysis of the assembled corrective measures alternatives and comparison of the alternatives against the screening criteria specified in the TEAD-S RCRA Part B Permit.

SECTION 9.0 STATEMENT OF BASIS – Presents the preferred corrective measures alternative for the SWMU 13 fuel spill.

SECTION 10.0 DATA AND INFORMATION SOURCES – Presents a list of existing data acquired during the RCRA Facility Investigation (RFI) and Data Gap Investigation that was considered.

SECTION 11.0 REFERENCES – Provides the references used.

SECTION 2.0
BACKGROUND INFORMATION

2.1 FACILITY DESCRIPTION

TEAD-S, formerly known as Deseret Chemical Depot (DCD), is located in Tooele County, Utah, approximately 35 miles southwest of Salt Lake City. The facility encompasses 19,364 acres in the northern portion of Rush Valley (Figure 2.1). Most of the facility is located on the east side of Rush Valley on gently southwestward-sloping alluvial fans adjacent to the Oquirrh Mountains (Parsons 2013a).

Initial construction on DCD began in July 1942 and was completed in January 1943. DCD was constructed to provide storage and maintenance services for chemical munitions. In 1955, the depot was placed under the command of Tooele Army Depot (TEAD), renamed the Deseret Depot Activity, and underwent a major expansion. In 1962, the Deseret Depot Activity became TEAD-S (DCD 2009, Rust 1997). In October 1996, the installation was officially transferred from the Industrial Operations Command (IOC) to the Chemical and Biological Defense Command (CBDCOM), and the installation was renamed the DCD.

The primary mission of DCD was to store, renovate, and dispose of a wide array of chemical munitions. Prior to the start of chemical demilitarization activities, the installation stored 44-percent of the total United States (U.S.) original stockpile of lethal chemical agents. This stockpile consisted of two major types of chemical agents: blister agents (including mustard gas) and nerve agents. From the 1940s through the late 1970s, chemical weapons were demilitarized (after the explosive components were deactivated) and disposed of by burning and burial. The Tooele Chemical Agent Disposal Facility (TOCDF) was constructed from 1989 to 1993 for the destruction of chemical munitions by incineration. Subsequent testing of the facility occurred from 1993 to 1996. Destruction of chemical munitions at the TOCDF began in 1996 and continued until January 2012, at which time the last chemical munitions at the installation were safely destroyed.

The primary mission of storing and demilitarizing chemical munitions has been completed. As such, facilities at the installation related to demilitarization have been closed, the entire 19,364 acres has been transferred to TEAD, and the installation has been renamed TEAD-S.

2.2 SITE DESCRIPTION

SWMU 13 is located within the southwestern quadrant of TEAD-S (Figure 2.2). It includes the former Chemical Agent Munitions Disposal System (CAMDS) within a ten acre fenced area. The CAMDS facility operated from 1979 to 2005 to develop and demonstrate methods for chemical munitions handling, demilitarizing chemical munitions, waste incineration, and treating wastes from the demilitarization process. When operational, CAMDS consisted of incinerators, munitions handling areas, waste handling areas, chemical storage areas, hazardous waste storage areas, laboratories, control rooms, maintenance facilities, and support buildings (Rust 1997, URS 2002, Parsons 2013a).

Upon completion of the CAMDS mission in 2005, operations ceased, the facility was decommissioned and all facilities were demolished. The closure of CAMDS has been approved by the Utah DWMRC with respect to past chemical releases (URS 2012), with the exception of the remnants of a historical fuel spill and minor releases of chlorinated solvents. The historic fuel spill was the result of a leak in an underground diesel fuel line that occurred sometime between 1980 and 1985 in the vicinity of three aboveground storage tanks (ASTs) near the western perimeter of CAMDS (Figure 2.3). The leak went undetected for an unknown period of time and up to 38,000 gallons of fuel may have been released (Rust 1997). As part of the closure verification, URS (2012) collected soil and sump-water samples that were analyzed for metals, explosives, volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), chemical agents, and agent breakdown products (ABPs) based on the history of individual facilities and their potential for contamination.

2.3 PHYSICAL CHARACTERISTICS

2.3.1 Topography

TEAD-S is located in northeastern Rush Valley. The surface topography of TEAD-S is generally flat with a gradual and gentle slope toward the west-southwest. SWMU 13 is located in the south-western portion of the installation and lies at an elevation of approximately 5,050 ft above mean sea level (amsl).

2.3.2 Climate

The climate of Rush Valley is semi-arid with four well defined seasons. The area is noted for plentiful sunshine, low relative humidity, and light precipitation. Minimum temperatures between December and February can drop below 10°F. In the summer, maximum daytime temperatures frequently exceed 90°F. Night-time temperatures decrease considerably as colder air subsides from the surrounding mountain slopes into Rush Valley. Prevailing winds at TEAD-S are from the southeast, with occasional winds from the north-northwest. Average annual precipitation ranges from approximately 12 inches in the basin areas of Rush Valley to greater than 40 inches in the surrounding mountains. The majority of precipitation occurs as snowfall during the winter and early spring, and the least precipitation occurs during the hot summer months of July and August (Gardner and Kirby 2011, Parsons 2013a).

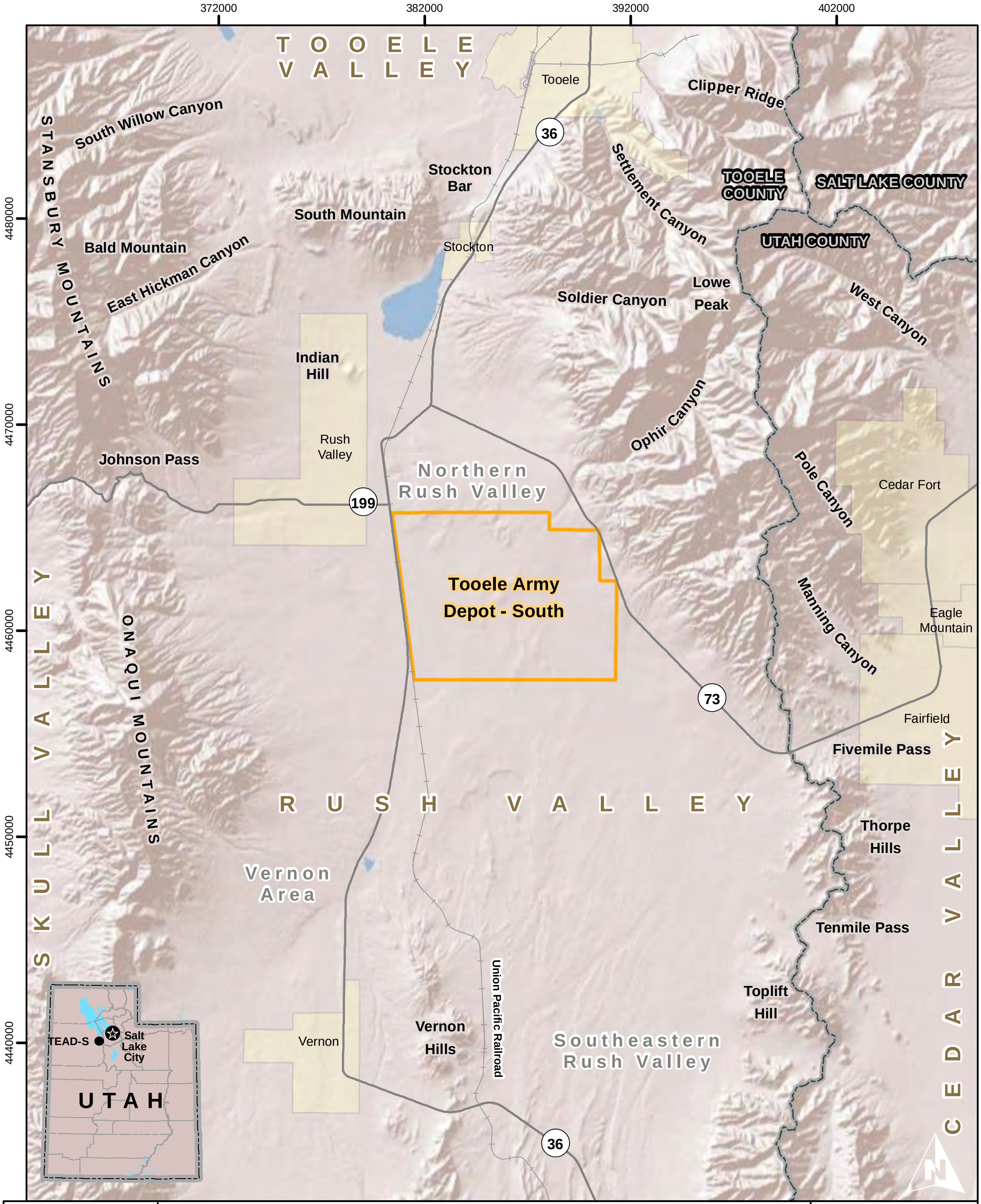

Figure 2.1

TEAD-S Location

Legend

▭ Tooele Army Depot - South

Imagery: Bing Map Aerials, (c) 2010 Microsoft Corporation and its data suppliers.
Boundary: Deseret Chemical Depot

Miles
0 2 4

Projection & Grid Coordinates:
WGS84, UTM Zone 12N

PARSONS

Date:	3/9/2015
Prepared:	RGS
Checked:	JF
Revision:	3

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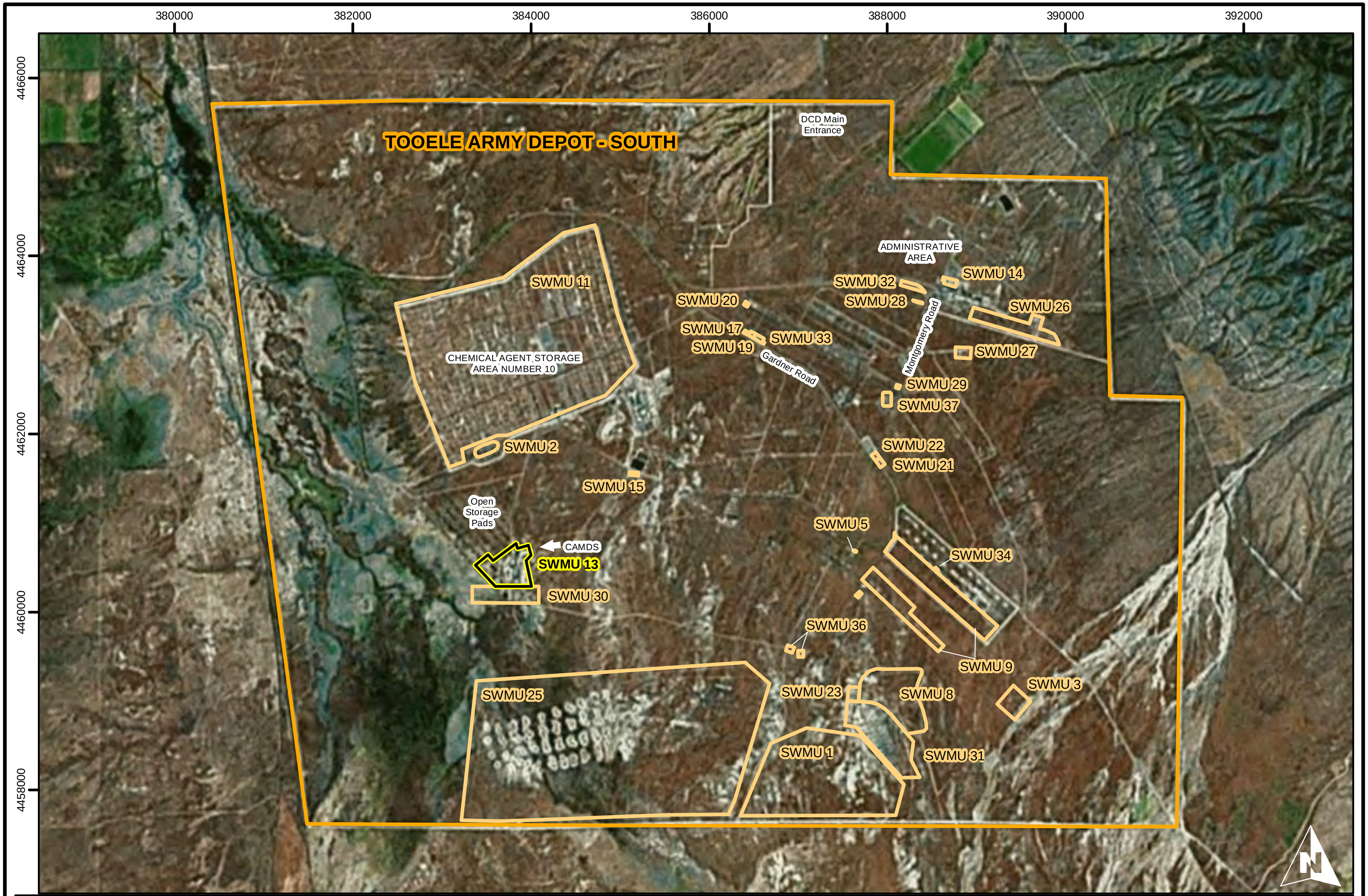

Figure 2.2

SWMU 13 Location

Legend

☐ SWMU 13

☐ SWMU Boundary

☐ Tooele Army Depot - South

Imagery: ESRI (c) 2013
SWMUs, Wells: Deseret Chemical Depot

Miles
0 0.5 1

Projection & Grid Cooridnates:
WGS84, UTM Zone 12N

PARSONS

Date:	3/9/2015
Prepared:	RGS
Checked:	DS
Revision:	1

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Figure 2.3

General Location of Fuel Oil Piping and ASTs

Legend

● Monitoring Well

● Monitoring Well - Abandoned

— Fuel Oil Piping

🟥 SWMU Boundary

NOTE:
ETF = Equipment Test Facility (ETF Sump)

Imagery: ESRI (c) 2013
Boundary, SWMUs, Wells: Deseret Chemical Depot

Feet
0 150 300

Projection & Grid Coorindates:
NAD83 StatePlane Utah Central

PARSONS

Date:	3/11/2015
Prepared:	RGS
Checked:	JF
Revision:	6

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2.3.3 Ecology

TEAD-S is located in Rush Valley and is considered a high-altitude desert. The vegetative community consists mainly of plant species that are adapted to low precipitation, high evaporation rates, and generally alkaline and saline soils. Vegetation at TEAD-S consists mainly of sagebrush, rabbit-brush, saltbush, and grasses (native and invasive varieties). The lack of precipitation during the summer months limits plant life to these drought resistant or drought tolerant species (DCD 2009, AQS 2015).

The developed area at SWMU 13 primarily consists of the gravel roads, building foundations, and concrete/asphalt covered areas. The site has been subject to significant disturbance in the past as a result of the construction, operations, and subsequent closure and demolition of the CAMDS facility. Outside of the developed area, the vegetation consists of 5 vegetation types: 1) bunchgrasses/annual forbs, 2) saltbush, 3) rabbit-brush/big sagebrush/greasewood, 4) alkali pan with salt blight, and 5) greasewood (Rust 1997).

Over 100 species of wildlife have been observed at TEAD-S. Birds are the most diverse vertebrates at TEAD-S, with about 105 bird species known. A total of 39 mammal species have been observed on TEAD-S. Eight reptile species potentially occur at TEAD-S (Tetra Tech 2015).

Although there are surface water bodies and wetlands at TEAD-S, none are located within SWMUs 13 and 30 (Tetra Tech 2015).

Only two federally listed species are expected to occur within Tooele County (Tetra Tech 2015):

- Yellow-billed cuckoo (*Coccyzus americanus*), threatened
- Ute Ladies'-tresses (*Spiranthes diluvialis*), threatened

The following state sensitive species have been known to occur within Tooele County and, therefore, may occur at TEAD-S (AQS 2015):

- Ferruginous hawk (*Buteo regalis*)
- Townsend's big-eared bat (*Corynorhinus townsendii*)
- Long-billed curlew (*Numenius americanus*)
- Burrowing owl (*Athene cunicularia*)
- Greater sage grouse (*Centrocercus urophasianus*)
- Bald eagle (*Haliaeetus leucocephalus*)
- Lyrate mountainsnail (*Oreohelix haydeni*)

2.3.4 Geologic Setting

Rush Valley is part of the Great Basin section of the Basin and Range Physiographic Province. The mountains that surround Rush Valley are folded and faulted blocks of predominantly sedimentary rocks; igneous and metamorphic rocks are also present. The topographic relief is largely the result of extensional movement along normal fault systems, which generally trend northward (Kleinfelder 1999). Rush Valley is comprised of a number of small horsts and grabens, common features associated with normal faulting in extensional tectonic regions. TEAD-S is situated on a structural feature known as the Mid-Valley Horst, which runs north-south near the center of TEAD-S. The TEAD-S facility is underlain by basin-fill sediments derived from alluvial and lacustrine processes. Sediment deposits across TEAD-S range from silty gravels/gravelly silts in the Ophir Creek alluvial fan deposits near the northeastern Depot boundary, to fine-grained silty clays with fine sand seams in lacustrine sediments that underlie the western and southwestern portions of the facility. Between these two regions lies a transition zone of alluvial gravels and sands interbedded with clay-rich lacustrine deposits (Kleinfelder 1999).

Subsurface conditions beneath SWMU 13 are predominantly sediments that were deposited by Lake Bonneville. Surface materials at SWMU 13 consist of fill and areas disturbed by re-grading and placement of imported granular fill that were used to support the development of the former CAMDS facility. Outside the developed area, surface materials are quaternary lacustrine deposits of the Bonneville Lake cycle. Soil types are generally fine-grained sands, silts, and clays. Subsurface materials beneath SWMU 13 are broken into two general subgroups with shallower younger alluvium being 15 to 45 ft thick overlying older denser terrestrial deposits. The shallower subgroup is “laterally discontinuous, interbedded fine to coarse calcareous sands and gravels, interbedded with silts and clays.” Below the upper subgroup, the generally finer-grained materials are “hard dense, stiff, calcareous clays and silts” (Parsons 2013a).

2.3.5 Hydrogeologic Setting

Groundwater at TEAD-S is part of the regional flow system within Rush Valley. The groundwater underlying TEAD-S is recharged by intermittent streams and subsurface flow coming from the Oquirrh Mountains northeast of the facility (Parsons 2013a). Groundwater flow at TEAD-S is influenced by the presence of a notable groundwater divide that crosses the facility from the northeast to the southwest. North of this divide, groundwater flow is generally to the west toward discharge points near the center of Rush Valley. South of the divide, groundwater is directed southeastward toward Cedar Valley (Gardner and Kirby 2011, Parsons 2013a). Shallow groundwater at TEAD-S generally occurs under unconfined conditions, although semi-confined and confined conditions exist in localized areas. Depth to groundwater beneath TEAD-S ranges from greater than 200 ft below ground surface (bgs) at sites closer to the recharge areas in the northeast, to less than 10 ft bgs near discharge areas located along the TEAD-S western boundary (Parsons 2013a). As indicated on Figure 2.6 in the Final Hydrogeological Assessment Report (Parsons 2013a) and Parsons (2014) water level measurements in 2014, there is little gradient in the vicinity of SWMU 13. SWMU 13 lies on the west side of the regional groundwater divide and groundwater flows to the southeast (Parsons 2013a, 2014). The average depth to groundwater at SWMU 13 and the surrounding area, measured during February 2014, was 12 ft bgs (Parsons 2014).

2.4 REGULATORY BACKGROUND

The TEAD-S RCRA Part B Permit has specific conditions requiring TEAD-S to conduct investigations and corrective actions (if required) at SWMUs and other management units where hazardous waste was generated, stored, handled or disposed of. All environmental investigations, corrective actions, and site closures at TEAD-S are performed under a corrective action program (CAP) and must be conducted in accordance with State and Federal regulations, and the TEAD-S RCRA Part B Permit. The UDEQ DWMRC is the regulatory authority for all RCRA environmental activities at TEAD-S.

As required by Module V of the TEAD-S RCRA Part B Permit, the U.S. Army is conducting corrective action under RCRA to address chemically impacted soil and groundwater at SWMU 13 that resulted from the release of approximately 38,000 gallons of diesel fuel at the site. RFIs and CMSs have been on-going at TEAD-S since 1990. A CMS for SWMU 13 was completed in 2002 (URS 2002), based on the results of the Phase II RFI (Rust 1997), which identified unacceptable risks/hazards for hypothetical residents but no unacceptable risks to onsite Depot workers under the anticipated future use of the site, as Depot workers are not exposed to subsurface soil or groundwater. However, the total petroleum hydrocarbon (TPH) concentrations detected at the site exceeded the cleanup standards for the State of Utah of 5,000 mg/kg for diesel-related TPH in soil and free product was detected in SWMU 13 monitoring wells during groundwater sampling. The original CMS (URS 2002), selected bio-venting, oil-skimming, and institutional controls as the corrective measure for diesel fuel in soil and groundwater. During the design phase, it was determined that the selected corrective measures could not be accomplished in an economical manner due to the lithology and depth to groundwater at the site.

In order to achieve site closure, the CMS for SWMU 13 is being updated. The process for updating the CMS included the collection of current soil, soil gas, and groundwater data, as specified in SWMU 13 CMS Data Gap Work Plan (Parsons 2014). This CMS work plan and report presents the data collected by Parsons in 2014, develops and evaluates potential corrective measures alternatives, and recommends a preferred corrective measures alternative.

2.5 PREVIOUS INVESTIGATIONS

Section 2.1 of the SWMU 13 CMS Data Gap Work Plan and SWMU 30 Phase II RFI Addendum Work Plan (Parsons 2014) summarized previous environmental investigations at SWMU 13 and their findings. These investigations included:

- Installation Assessment – 1979
- Installation Environmental Assessment – 1982
- Exploratory Survey – 1982
- Preliminary Assessment/Site Investigation – 1988
- Phase I RFI – 1990
- Remedial Investigation – 1991
- Phase II RFI – 1997
- Decision Document – 2001
- Corrective Measures Study – 2002
- Product Thickness Monitoring – 2009
- CAMDS Closure Verification Sampling – 2012
- Base-wide Groundwater Monitoring – 1999 through 2011

In addition to these investigations, additional data was collected in accordance with the SWMU 13 CMS Data Gap Work Plan (Parsons 2014) to evaluate current site conditions at SWMU 13 and to support an updated CMS. Results of the CMS data gap investigation are provided in Section 3.0 of this report.

SECTION 3.0
CMS DATA GAP INVESTIGATION AND RESULTS

3.1 INVESTIGATION ACTIVITIES

The objectives of the SWMU 13 data gap investigation were to collect current soil, groundwater, and soil gas data. Once collected, the data was used to estimate the area of contamination, volume of free product, the cost for various corrective measures alternatives for residual fuel and VOC contamination, and to ensure that corrective measures alternatives address compliance with the CAOs indentified in Section 4.0. Sampling and other field activities were conducted in accordance with the approved work plan for this project (Parsons 2013b, 2014).

It should be noted that Utah Tier 1 screening levels for risk based corrective action of petroleum related sites were used as project action limits (PALs) for TPH-DRO. However, they were used only as a guideline for defining the extent of TPH-DRO contamination in soil and groundwater and were not considered in the evaluation or selection of corrective measures. The evaluation and selection of corrective measures are based on UAC R315-101 requirements as they relate to petroleum constituents released on the site.

This section provides a summary of the field activities conducted and the results of the investigation to define current soil, soil gas, and groundwater contamination associated with SWMU 13. The following investigation activities were conducted:

- An initial round of monitoring well inspections, groundwater elevation measurements, and free product thickness measurements in 35 existing monitoring wells.
- Collection of five active soil gas samples from five ft bgs.
- Direct push soil borings:
  - Nine borings with one surface and two subsurface samples collected from each boring.
  - Fifteen additional borings (two of which were also installed to support the SWMU 30 RFI) for visual analysis and screening. Cores were logged and screened with a flame ionization detector (FID).
- Collection of groundwater samples:
  - Eight samples from direct-push borings.
  - Twelve samples from previously existing and one new monitoring well.
- Three bail-down (i.e., free product recovery) tests.

3.1.1 Initial Well Inspection and Measurements

The initial investigative activity at SWMU 13 was an evaluation of the monitoring well network. A separate work plan memorandum for this inspection and measurement task was prepared and approved by the UDEQ before the field program began (Parson 2013b). There were several objectives for this initial task. Each well was first inspected to evaluate its viability for use in subsequent monitoring and CMS evaluations. As described below, several wells were repaired and redeveloped during subsequent field tasks. Depth to groundwater data (see Table 3.1) was collected to confirm groundwater elevation, gradient, and flow direction. Additionally, free product thickness was measured to evaluate whether the thickness and distribution of the Light Non-Aqueous Phase Liquid (LNAPL) from the diesel fuel spill had changed since it was first reported in 1991 (Rust 1997).

Fieldwork associated with this task was conducted during February 2014. Both the work plan and the results of the initial well inspection and measurement tasks were reported previously in the SWMU 13 CMS Data Gap Work Plan and SWMU 30 Phase II RFI Addendum Work Plan (Parsons 2014). For completeness, the results are also included in this section.

3.1.2 Soil Gas Sampling

A total of five active soil gas samples were collected in September 2014 from the temporary vapor monitoring points (VMPs) shown on Figure 3.1. Soil gas data were collected for comparison to previous RFI data (Rust 1997) to evaluate changes and determine whether the corrective action alternatives proposed here need to account for vapor intrusion. Field measurements for methane, carbon dioxide, and oxygen were also taken to provide an indication of the biodegradation of fuel hydrocarbons. Soil gas samples and field measurements were collected from four locations (13-SG-01 through 13-SG-04) where the highest VOC concentrations were detected during the Rust (1997) Phase II RFI. Additionally, one soil gas sample and field measurements for biodegradation indicators were collected at one location (13-SG-05) as close as could be determined to the historic Equipment Test Facility (ETF) Explosive Containment Cubicle (ECC) sump, where VOCs were detected during the closure of CAMDS (URS 2012).

Each VMP was installed in accordance with the process detailed in *Standard Operating Procedure (SOP) 02 Near-Surface Soil Gas Sampling* of the project work plan and Quality Assurance Project Plan (QAPjP) (Parsons 2014). A direct push drill rig was used to construct each VMP at a depth of five ft bgs. A soil vapor sampling implant, connected to polytetrafluoroethylene (PTFE) tubing was used for each monitoring point. The annulus around the implant was backfilled with a sand pack to 3 inches above the probe screen. A clay seal composed of hydrated bentonite was placed from the top of the sand pack upwards to the ground surface. Each VMP was allowed to equilibrate for at least 24 hour prior to leak testing and sampling.

TABLE 3.1
WATER LEVEL MEASUREMENT DATA - FEBRUARY 2014
TOOELE ARMY DEPOT - SOUTH

							Screened Interval				Parsons Field Data										
	Measurement	TOC Elevation[1]	Casing Stickup Length[2]	Ground Surface Elevation[2,3]	Casing Diameter	Constructed Well Depth	Top	Bottom	Top	Bottom	Depth to Product		Depth to Water			Freshwater Equivalent Head	Well Depth	Temp	Density	Density	Salinity
Well ID	Date	(ft amsl)	(ft)	(ft amsl)	(in)	(ft bgs)	(ft bgs)	(ft bgs)	(ft amsl)	(ft amsl)	(ft TOC)	(ft bgs)	(ft TOC)	(ft amsl)	(ft bgs)	(ft amsl)	(ft TOC)	(°C)	(kg/m^3)	(g/m^3)	(ppt)
S-1-82	2/3/2014	5039.59	1.25	5038.34	4	20.50	10.30	20.30	5028.04	5018.04	-	-	9.29	5030.30	8.04	5030.3	22.51	9.41	1000.70	1.0007	1.20
S-25-88	2/18/2014	5043.03	-0.31	5043.34	4	19.50	9.50	19.50	5033.84	5023.84	-	-	11.51	5031.52	11.82	-	18.08	-	-	-	-
S-26-88	2/18/2014	5043.33	-0.08	5043.41	4	19.00	9.00	19.00	5034.41	5024.41	-	-	11.12	5032.21	11.20	-	18.95	-	-	-	-
S-27-88	2/5/2014	5042.68	-0.25	5042.93	4	20.00	10.00	20.00	5032.93	5022.93	-	-	2.15	5040.53	2.40	-	5.42	[4]	[4]	[4]	[4]
S-28-88	2/4/2014	5044.96	1.52	5043.44	4	15.00	5.00	15.00	5038.44	5028.44	13.68	12.16	14.29	5030.67	12.77	-	20.10	[5]	[5]	[5]	[5]
S-29-88	2/4/2014	5042.68	1.42	5041.26	4	16.00	6.00	16.00	5035.26	5025.26	-	-	11.85	5030.83	10.43	5030.8	20.26	10.87	1002.17	1.0022	3.27
S-30-88	2/4/2014	5041.56	1.58	5039.98	4	16.00	5.40	15.40	5034.58	5024.58	-	-	10.72	5030.84	9.14	5030.8	20.03	10.32	1003.25	1.0033	4.59
S-54-90	2/4/2014	5054.01	1.94	5052.07	4	27.50	17.50	27.50	5034.57	5024.57	-	-	20.44	5033.57	18.50	5033.6	30.56	11.79	1011.30	1.0113	15.34
S-55-90	2/5/2014	5045.75	0.52	5045.23	4	18.00	8.00	18.00	5037.23	5027.23	-	-	12.39	5033.36	11.87	5033.4	20.89	12.26	1011.68	1.0117	15.94
S-56-90	2/4/2014	5056.06	1.52	5054.54	4	49.00	39.00	49.00	5015.54	5005.54	-	-	22.87	5033.19	21.35	5033.6	51.08	11.41	1019.55	1.0196	26.21
S-57-90	2/3/2014	5041.15	2.13	5039.02	4	17.00	7.00	17.00	5032.02	5022.02	-	-	12.10	5029.05	9.97	5029.1	19.90	10.16	1012.42	1.0124	16.52
S-58-90	2/3/2014	5039.73	1.88	5037.85	4	14.00	4.00	14.00	5033.85	5023.85	-	-	8.63	5031.10	6.75	5031.1	14.15	8.09	1005.91	1.0059	7.75
S-59-90	2/3/2014	5038.90	1.98	5036.92	4	15.00	5.00	15.00	5031.92	5021.92	-	-	7.90	5031.00	5.92	5031.0	17.87	8.40	1004.43	1.0044	5.88
S-60-90	2/3/2014	5038.09	1.33	5036.76	4	17.00	7.00	17.00	5029.76	5019.76	-	-	7.35	5030.74	6.02	5030.8	19.85	8.09	1003.56	1.0036	4.73
S-76-91	2/4/2014	5042.90	1.21	5041.69	4	23.40	8.00	23.00	5033.69	5018.69	-	-	11.45	5031.45	10.24	5031.5	25.44	10.63	1001.56	1.0016	2.45
S-77-91	2/3/2014	5038.05	1.08	5036.97	4	18.40	8.00	18.00	5028.97	5018.97	-	-	7.77	5030.28	6.69	5030.3	20.43	9.18	1004.38	1.0044	5.90
S-78-91	2/4/2014	5042.38	1.23	5041.15	4	23.10	7.70	22.70	5033.45	5018.45	-	-	11.03	5031.35	9.80	5031.4	24.95	11.25	1003.01	1.0030	4.41
S-79-91	2/3/2014	5039.10	1.15	5037.95	4	17.40	7.00	17.00	5030.95	5020.95	-	-	6.91	5032.19	5.76	5032.2	19.04	8.83	1003.67	1.0037	4.94
S-80-91	2/3/2014	5045.35	1.71	5043.64	4	23.00	7.65	22.65	5035.99	5020.99	-	-	13.97	5031.38	12.26	5031.4	25.51	10.88	1002.07	1.0021	3.14
S-81-91	2/4/2014	5044.87	1.29	5043.58	4	23.00	7.65	22.65	5035.93	5020.93	-	-	13.41	5031.46	12.12	5031.5	25.37	11.11	1002.37	1.0024	3.56
S-82-91	2/4/2014	5044.40	1.42	5042.98	4	23.40	13.00	23.00	5029.98	5019.98	-	-	13.06	5031.34	11.64	5031.3	25.64	13.09	1001.42	1.0014	2.65
S-83-91	2/4/2014	5041.89	0.94	5040.95	4	23.80	13.50	23.50	5027.45	5017.45	-	-	11.10	5030.79	10.16	5030.8	25.48	10.11	1003.13	1.0031	4.40
S-84-91	2/3/2014	5040.15	0.98	5039.17	4	26.50	5.35	25.35	5033.82	5013.82	-	-	9.11	5031.04	8.13	5031.1	28.24	10.63	1007.46	1.0075	10.10
S-85-91	2/3/2014	5037.99	1.46	5036.53	4	22.00	6.65	21.65	5029.88	5014.88	-	-	7.03	5030.96	5.57	5031.0	24.03	8.33	1003.59	1.0036	4.79
S-86-91	2/4/2014	5049.90	1.27	5048.63	4	17.00	11.65	16.65	5036.98	5031.98	-	-	Dry	-	-	-	18.72	-	-	-	-
S-87-91	2/5/2014	5045.29	-0.33	5045.62	4	17.40	7.00	17.00	5038.62	5028.62	-	-	-	-	-	-	-	-	-	-	-
S-91-91	2/4/2014	5040.47	1.06	5039.41	4	24.10	3.70	23.70	5035.71	5015.71	-	-	9.87	5030.60	8.81	5030.6	19.97	8.82	1005.01	1.0050	6.67
S-92-91	2/3/2014	5045.43	1.06	5044.37	4	26.00	10.65	25.65	5033.72	5018.72	-	-	13.98	5031.45	12.92	5031.5	28.48	10.70	1002.48	1.0025	3.65
S-103-93	2/3/2014	5071.36	1.60	5069.76	4	49.40	40.10	49.40	5029.66	5020.36	-	-	38.46	5032.90	36.86	5033.0	52.11	11.35	1008.42	1.0084	11.48
S-104-93	2/3/2014	5072.15	1.85	5070.30	4	71.40	62.10	71.40	5008.20	4998.90	-	-	40.24	5031.91	38.39	5032.2	74.96	11.66	1008.61	1.0086	11.78
S-105-93	2/3/2014	5042.09	1.88	5040.21	4	17.40	8.10	17.40	5032.11	5022.81	-	-	11.00	5031.09	9.12	5031.1	20.37	9.64	1003.26	1.0033	4.51
1-106-93	2/3/2014	5044.48	1.79	5042.69	4	51.00	41.00	51.00	5001.69	4991.69	-	-	13.30	5031.18	11.51	5031.3	52.62	10.41	1002.44	1.0024	3.55
S-107-93	2/3/2014	5038.42	1.77	5036.65	4	48.75	38.75	48.75	4997.90	4987.90	-	-	6.51	5031.91	4.74	5032.0	52.77	10.19	1001.67	1.0017	2.54
S-CAM-1	2/5/2014	5043.41	-0.08	5043.49	2	22.00	5.60	21.60	5037.89	5021.89	11.95	12.03	13.47	5029.94	13.55	-	22.80	[5]	[5]	[5]	[5]
S-CAM-2	2/5/2014	5045.70	2.00	5043.70	2	23.00	5.50	23.50	5038.20	5020.20	14.19	12.19	15.02	5030.68	13.02	-	26.16	[5]	[5]	[5]	[5]
S-CAM-2	5/6/2016	5045.75[6]	2.00	5043.75	2	23.00	5.50	23.50	5038.25	5020.25	11.79	9.79	12.15	5033.60	10.15	-	-	-	-	-	-
S13-CAM-DW1	5/6/2016	5044.75[6]	2.57	5042.18	2	60.00	54.00	59.00	4988.18	4983.18	-	-	11.16	5033.59	8.59	-	-	-	-	-	-

Definitions:

amsl = above mean sea level (NAVD; 1988)
ft bgs = feet below ground surface
ft TOC = feet below top of casing

Notes:

1 - from JTS Professional Surveyors survey of wells at the site in 1998
2 - from Jacobs, 2011. Technical Memorandum Hydrogeologic Assessment, Draft Final. Deseret Chemical Depot Stockton, Utah. March.
3 - Calculated as the difference of the top of casing (TOC) elevation from the "TOC stick up" by Jacobs (2011)
4 - Total depth of well and water level much higher that expected. Suspect well is full of sediment. Water is black and smells of rotten eggs. No water quality parameters measured.
5 - Water quality parameters cannot be measured using a field meter in the presence of LNAPL
6 - from Ensign Engineering survey of wells at the site in May 2016

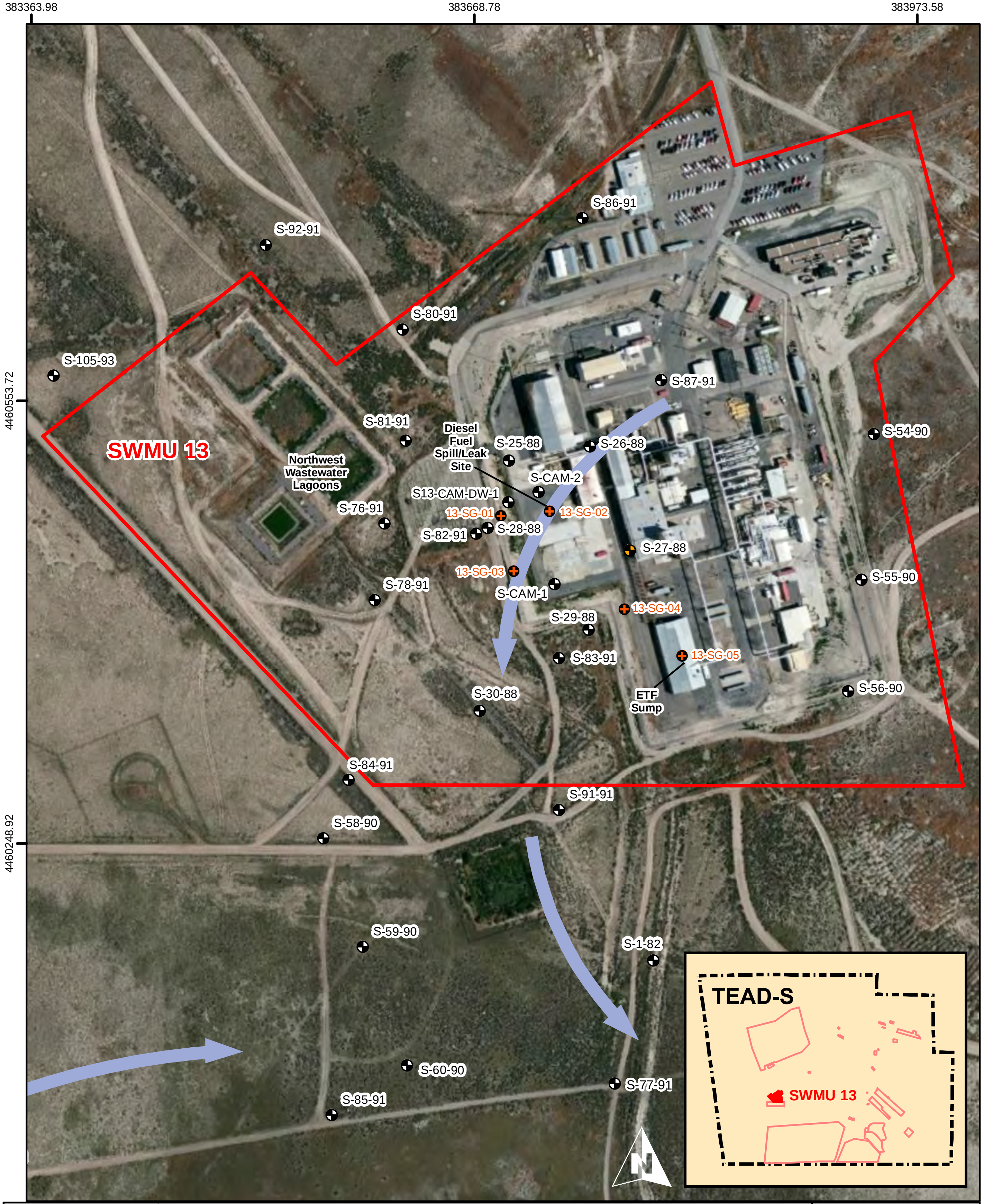

Figure 3.1

SWMU 13 Soil Gas Sampling Locations

Legend

- ⊕ Monitoring Well
- ⊕ Monitoring Well - Abandoned
- ✚ Soil Gas
- ➡ General Direction of Groundwater Movement (based on freshwater equivalent head)
- ▭ SWMU Boundary

NOTE: ETF = Equipment Test Facility (ETF Sump)

Imagery: ESRI (c) 2013 TPHC: Dames & Moore, 2002
Boundary, SWMUs, Wells: Deseret Chemical Depot
Sample Locations: Parsons

Feet
0 150 300

Projection & Grid Cooordinates:
NAD83 StatePlane Utah Central

PARSONS

Date:	3/11/2015
Prepared:	RGS
Checked:	JF
Revision:	6

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Prior to sampling, a static leak test of the sampling train was conducted to ensure no ambient air intruded into the soil gas stream during sample collection. Following the static leak test, each VMP was purged a minimum of five volumes to evacuate ambient air; during which time FID readings were also collected at regular intervals to assess stabilization of the vapor. Concurrently throughout the VMP purging process, a tracer gas test was performed to confirm no leaks were occurring through the grouted borehole into the VMP sampling train. A five-percent hydrogen, 95-percent nitrogen (H5N95) gas mixture was used as the tracer gas. The purging and sampling procedures, including descriptions of the static and leak tests, are detailed in SOP 02 *Near-Surface Soil Gas Sampling* (Parsons 2014).

Soil gas samples were collected in one-liter Summa® canisters. Samples were collected over a five minute interval using flow controllers calibrated to 200 milliliters per minute. Three to five inches mercury (Hg) of residual vacuum was maintained in each canister following sampling to ensure sample integrity during shipment to the laboratory. The soil gas samples were shipped to a subcontractor laboratory for analysis of VOCs by U.S. Environmental Protection Agency (USEPA) method TO-15.

Field measurements (including methane concentrations) and field conditions were recorded in the project field logs (Appendix B).

3.1.3 Soil Sampling

Twenty-two direct push soil borings were installed in September 2014 to evaluate the present day conditions of the diesel fuel contamination in soil. Nine initial borings, followed by 13 additional step-out borings were advanced at the locations shown on Figure 3.2. Of the initial nine borings, one (13-SS-02) was installed in the immediate vicinity of the former AST location, one (13-SS-05) was installed near the former West Utilities Building (WUB) boiler blowdown sump, and one (13-SS-09) was installed near the former ETF ECC sump. The remaining six initial borings (13-SS-01, 13-SS-03, 13-SS-04, 13-SS-06, 13-SS-07, and 13-SS-08) were placed to more closely define the extent of total petroleum hydrocarbon-diesel range organic (TPH-DRO) contamination. Placement of the 13 additional step-out borings (13-SS-01A, 13-SS-02A and B, 13-SS-03B, 13-SS-05A and B, 13-SS-06A, 13-SS-07A, 13-SS-09A, 13-SS-10, 13-SS-10B and C, and 13-SS-11) was determined by field observations such of stained soil or FID screening readings made during the installation of previous borings. Step-out borings were logged and screened with an FID to evaluate the maximum extent of petroleum contamination. Two additional borings (SS-30-01 and SS-30-02) that were sampled as part of the SWMU 30 Phase II RFI Addendum investigation were also logged and screened to supplement the observations made at SWMU 13.

Soil borings were completed using direct push drilling methods and sampling was performed in accordance with *SOP 01 Direct Push Soil Sampling* of the project work plan and QAPjP (Parsons 2014). The direct push rig collected continuous soil core in lengths of approximately four feet using macro-core open tube samplers. The field geologist logged each boring and collected samples as specified by the project work plan and QAPjP (Parsons 2014). The soil cores from each boring were field screened using an FID for VOCs and other fuel related contaminants. The purpose of the field screening was to identify specific subsurface soil intervals for sampling.

Samples for laboratory analysis were collected at the surface and at two subsurface intervals from the initial nine borings (13-SS-01 through 13-SS-09) that were advanced to a depth of approximately 15 ft bgs. Subsurface samples were biased towards depth intervals with elevated FID field screening readings and/or visible discoloration of soil. In the absence of signs of potential contamination, subsurface samples were collected at intervals of 3-5 ft and 8-10 ft bgs. All samples collected were shipped to a subcontractor laboratory for analysis of TPH-DRO by USEPA method 8015D. Additionally, subsurface samples were analyzed for VOCs by USEPA method 8260C.

Field measurements and observations were recorded in the project field logs (Appendix B). Detailed lithologic logs for the soil borings are provided in Appendix C.

3.1.4 Groundwater Sampling

Current groundwater impacts were evaluated through a combination of direct push (HydroPunch^{TM}) sampling and HydraSleeve^{TM} sampling of existing monitoring wells. The existing monitoring wells were evaluated, repaired, and redeveloped as necessary prior to sampling. Lastly, the direct push sampling and the existing monitoring wells all sampled a shallow aquifer at about 10 ft bgs. Therefore, to evaluate potential impacts to deeper groundwater, a monitoring well was installed in a water-bearing zone below the water table. Each of these activities are described below.

3.1.4.1 Direct Push Groundwater Sampling

Eight groundwater samples were collected in September 2014 using direct push (HydroPunch^{TM}) sampling methods to provide additional data points for evaluating current groundwater contamination. As shown on Figure 3.3, direct push groundwater samples were collected near monitoring well S-27-88 (which was damaged during CAMDS closure), as near as possible to the former ETF ECC sump, and at six additional locations to supplement groundwater sampling from the existing monitoring wells.

Direct push groundwater samples were collected using direct push drilling methods in accordance with *SOP 03 Direct Push Groundwater Sampling* of the project work plan and QAPjP (Parsons 2014). A direct push drill rig was used to advance the groundwater sampler to the desired sampling interval. Groundwater samples were obtained by inserting ¼ inch outside diameter (OD) polyethylene tube down the probe rod string into the sampling screen and pumping the water at a flow-rate of less than 100 milliliters/minute (ml/min) to the surface using a peristaltic pump. Once the groundwater sample was obtained, the borehole was backfilled with hydrated bentonite up to the ground surface.

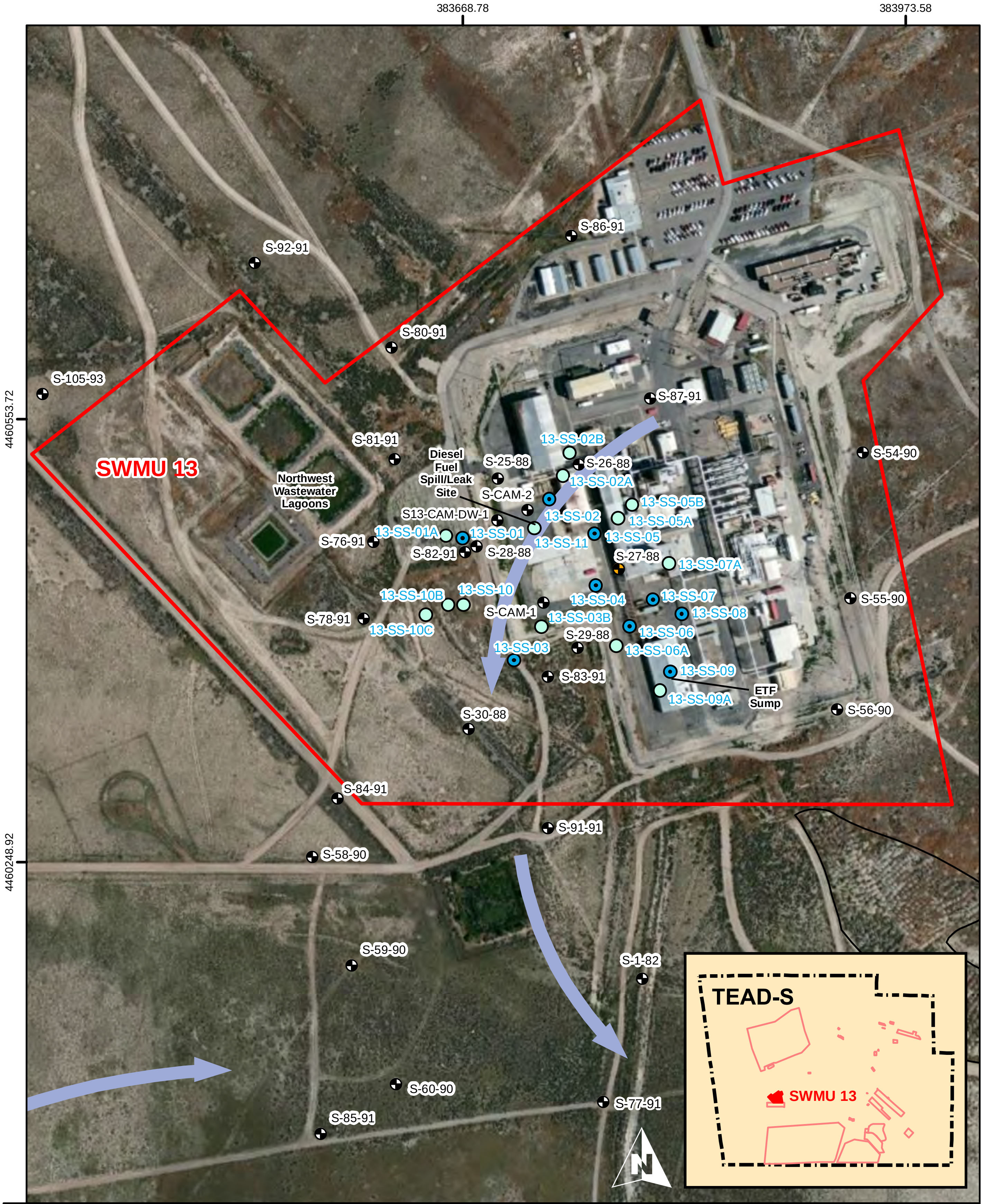

Figure 3.2

SWMU 13 Geoprobe and Soil Sample Locations

Legend

- ⊕ Monitoring Well
- ⊕ Monitoring Well - Abandoned
- ○ Geoprobe without Sample
- ◉ Geoprobe with Sample
- ➡ General Direction of Groundwater Movement (based on freshwater equivalent head)
- ▭ SWMU Boundary

NOTE: ETF = Equipment Test Facility

Imagery: ESRI (c) 2013 TPHC: Dames & Moore, 2002
Boundary, SWMUs, Wells: Deseret Chemical Depot
Sample Locations: Parsons

Feet
0 150 300

Projection & Grid Coorindates:
NAD83 StatePlane Utah Central

PARSONS

Date:	3/9/2015
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Checked:	JF
Revision:	6

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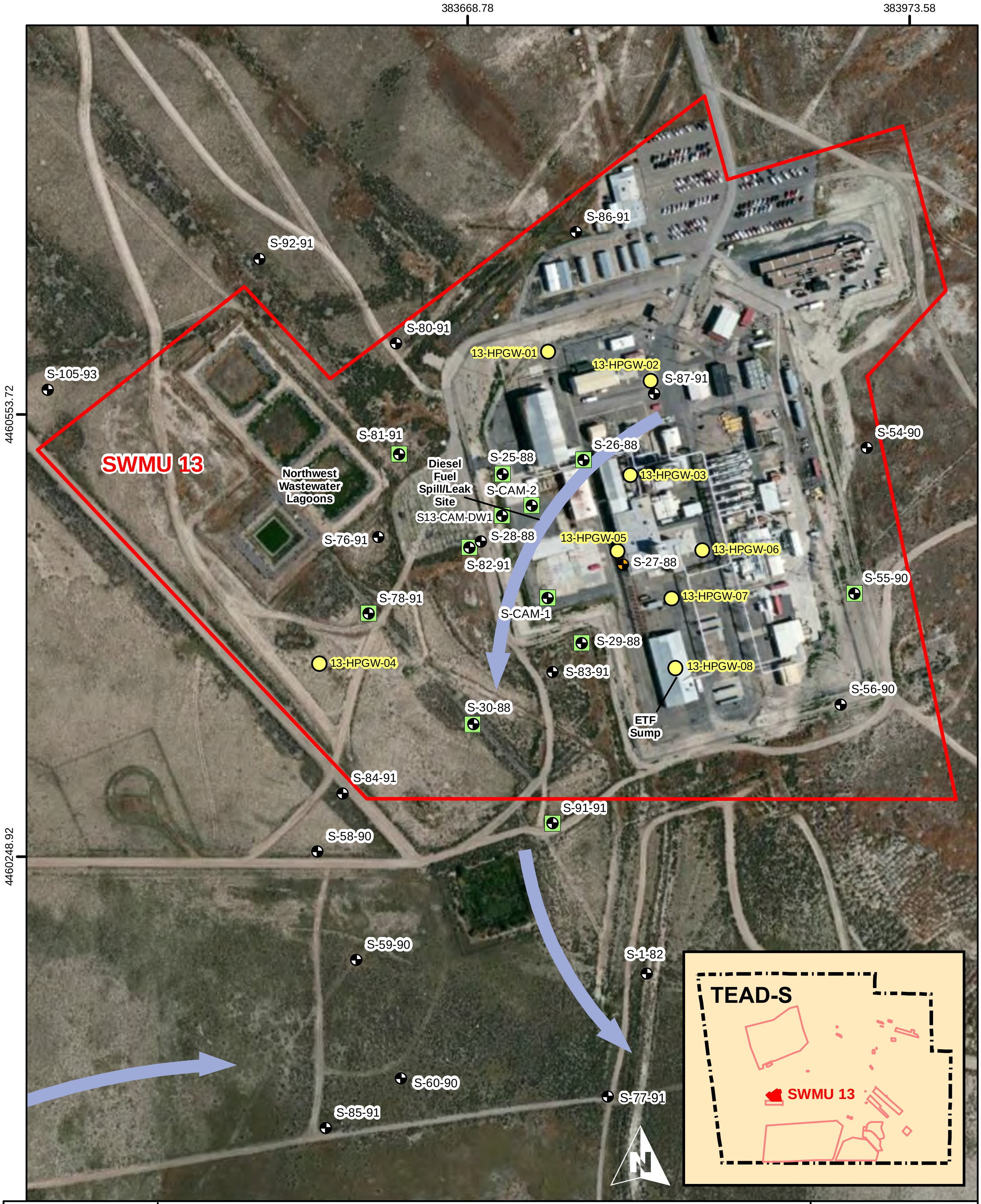

Figure 3.3

SWMU 13 Groundwater Sample Locations

Legend

- ⊕ Monitoring Well
- ⊕ Monitoring Well - Abandoned
- 🟩 Sampled
- ○ Hydropunch
- ➡ General Direction of Groundwater Movement (based on freshwater equivalent head)
- ▭ SWMU Boundary

Feet
0 150 300

Projection & Grid Cooridnates:
NAD83 StatePlane Utah Central

PARSONS

Date:	3/11/2015
Prepared:	RGS
Checked:	JF
Revision:	6

NOTE:
ETF = Equipment Test Facility (ETF Sump)

Imagery: ESRI (c) 2015
Boundary, SWMUs, Wells: Deseret Chemical Depot
Sample Locations: Parsons

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All groundwater samples were analyzed for VOCs using USEPA method 8260C and TPH-DRO using USEPA method 8015D. Additionally, four groundwater samples were analyzed for polycyclic aromatic hydrocarbons (PAHs) using USEPA method 8270D to support the evaluation of potential plant uptake. These samples were collected from direct push locations where TPH-DRO was suspected to be highest in groundwater (i.e., 13-HPGW-02, 13-HPGW-03, 13-HPGW-05, and 13-HPGW-07). Lastly, two direct push groundwater samples were analyzed for ABPs using method WS-LC-0004/8321M. Samples analyzed for ABPs were collected near former agent management areas; i.e., 13-HPGW-05, located adjacent to the former Bulk Items Facility (BIF), and the direct push location to the southwest of ECC #1 (i.e., 13-HPGW-03).

Field measurements and observations were recorded in the project field logs (Appendix B).

3.1.4.2 Monitoring Well Repair and Development

Prior to sampling the groundwater monitoring wells, all groundwater monitoring wells were inspected (Parsons 2013b) in February 2014 to determine whether they were intact and could be sampled as part of this investigation and future monitoring. All monitoring wells were found to be in good condition with the exception of S-CAM-1, S-25-88, S-26-88, S-27-88, and S-87-91. The conditions found and remedy at these wells, are as follows:

- S-CAM-1 was found to be unsuitable for sampling as the subsurface well box contained mud and debris. The well was upgraded to an aboveground completion and redeveloped prior to sampling.
- S-25-88 was found to be unsuitable for sampling as the subsurface well box contained mud and debris. The well was upgraded to an aboveground completion and redeveloped prior to sampling.
- S-87-91 was found to be unsuitable for sampling as the subsurface well box contained mud and debris, and a bailer was found lodged in the bottom of the well. Prior to sampling, the bailer was removed, the well was upgraded with an aboveground completion, and was redeveloped.
- S-26-88 appeared to have been damaged during the closure of CAMDS. The well casing and aboveground surface completion were repaired, and the well was redeveloped prior to sampling.
- S-27-88 also appeared to have been damaged during the closure of CAMDS. The well depth was measured at 5.42 ft bgs, even though the constructed depth was 20 ft bgs. Therefore, it was felt that the well was full of sediment and was not usable for the purposes of this study or future monitoring. S-27-88 was abandoned and removed from the monitoring well network.

Copies of the well redevelopment logs for monitoring wells S-CAM-1, S-25-88, S-87-91 and S-26-88 are provided in Appendix G.

3.1.4.3 Sampling of Existing Monitoring Wells

Groundwater samples were collected from the 12 existing monitoring wells shown on Figure 3.3 to characterize current groundwater conditions.

Groundwater samples were collected and sampling was performed in accordance with SOP 05 *Groundwater Sampling Using HydraSleeve™ Samplers* of the project work plan and QAPjP (Parsons 2014). Samplers were deployed by attaching a suspension line to the top and a weight to the bottom of the empty sampler and lowering it into the well. The upper end of the suspension line was attached to the well cap/casing to suspend the sampler at the desired depth until sampling was conducted. The samplers were placed in each well as close to the bottom of the well screen as possible. Monitoring wells were allowed to re-equilibrate for a minimum of 24 hours before samples were collected. To collect samples, the HydraSleeve™ sampler was activated by pulling the sampler upward at a constant rate of 1-2 feet per second, which allows the sampler check valve to open and allows water to flow into the sampler. In some cases, multiple HydraSleeve™ sampler deployments were required to achieve the required sample volume for multiple analytical suites, splits and quality assurance/quality control (QA/QC) samples. Each groundwater sample was transferred from the HydraSleeve™ sampler to the sample container using a discharge tube provided with the sampler to minimize aeration and agitation. All samples were transferred into the sample containers at a rate of 100 ml/min or less. The flow rate was controlled by raising or lowering the bottom of the sampler or pinching the discharge tube.

All groundwater samples were analyzed for VOCs using USEPA method 8260C and TPH-DRO using method 8015D. Additionally, six groundwater samples were analyzed for PAHs using USEPA method 8270D where it was anticipated that TPH-DRO concentrations were likely to be the highest (i.e., S-25-88, S-26-88, S-29-88, S-82-91, S-CAM-1, and S-CAM-2) to support the evaluation of potential plant uptake. Lastly, two groundwater samples collected from monitoring wells where ABPs have previously been detected (i.e., S-26-88, adjacent to the former Brine Drying Area (BDA), and S-78-91) were analyzed for ABPs using method WS-LC-0004/8321M.

Field measurements and observations were recorded in the project field logs (Appendix B). HydraSleeve™ sampling logs for existing monitoring wells are provided in Appendix D.

3.1.4.4 Installation and Sampling of Deep Monitoring Well

To determine if contaminants are present at depth, and to evaluate vertical hydraulic gradients, a new groundwater monitoring well was installed and completed as S13-CAM-DW1 near S-CAM-2, in the area where known LNAPL from diesel fuel storage ASTs is present (Figure 3.4). Monitoring well S13-CAM-DW1 was installed in a water bearing layer below those intervals previously sampled at SWMU 13. The Division of Water Rights (DWR) requires wells installed deeper than 30 ft bgs to be permitted.

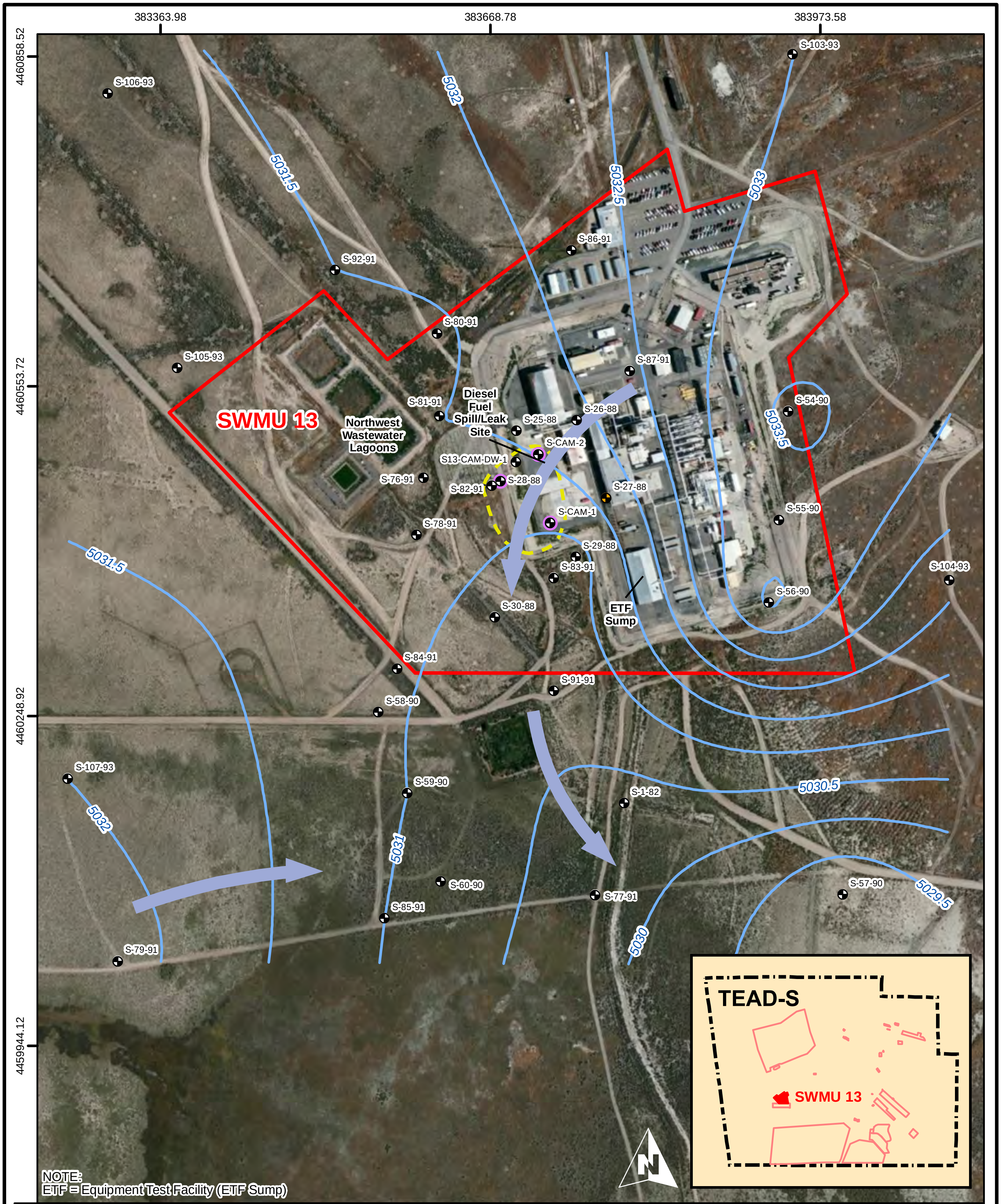

Figure 3.4

SWMU 13 Groundwater Elevation Surface and Flow Directions

Legend

●	Monitoring Well	➡	General Direction of Groundwater Movement (based on freshwater equivalent head)
●	Monitoring Well - Inoperable	▭	Extent of Free Product-Feb. 2014 (Parsons Well Inspection and Water Table Measurements)
●	Monitoring Well with Measurable LNAPL	🟥	SWMU Boundary
—	Groundwater Elevation Contour - February, 2014 0.5 ft. interval in ft. AMSL (above mean sea level)		

Imagery: ESRI (c) 2013
Groundwater Elevation Contour, Groundwater Flow: Parsons, 2014
Boundary, SWMUs, Wells: Deseret Chemical Depot

Feet
0 200 400

Projection & Grid Coorindates:
NAD83 StatePlane Utah Central

PARSONS

Date:	3/11/2015
Prepared:	RGS
Checked:	JF
Revision:	6

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Prior to commencement of drilling, an *Application for Non-Production Well Construction Permit* was submitted and approved by the DWR (Appendix E). Details of the drilling, installation, development, and sampling are discussed below.

Installation Summary

On October 30, 2014 a cone penetration test (CPT) was performed at the location where monitoring well S13-CAM-DW1 was to be installed. The CPT reached refusal at 64 ft bgs due to a very tight fine grained soil. Based on the CPT results, the deeper monitoring well was constructed to a depth of 60 ft bgs with a screened interval from 54-59 ft straddling a water bearing gravelly sand lens located at 55-57 ft bgs.

Drilling and construction of S13-CAM-DW1, including the surface completion was completed on November 3, 2014 in accordance with *SOP 09 Groundwater Monitoring Well Installation* of the project work plan (Parsons 2014).

The borehole for well S13-CAM-DW1 was advanced using hollow stem auger drilling techniques. A Parsons State of Utah-registered geologist was onsite continuously during the drilling in order to monitor hydrogeologic conditions, maintain a current geologic log, and determine when to terminate drilling. Drill core was logged by the Parsons geologist using American Society for Testing Materials (ASTM) Method D2488, which is used for unconsolidated geologic materials and based on the Unified Soil Classification System (USCS). A copy of the well driller's report, CPT report and detailed boring log are provided in Appendix F.

Well Construction Summary

The well construction diagram for S13-CAM-DW1 is shown in Figure 3.5. The well was cased using 2-inch OD, schedule 40 polyvinyl chloride (PVC) and was screened from 54-59 ft bgs using continuous 2-inch vee wrap screen with 0.01 inch slots. All joints were flush threaded with rubber o-rings. A sand filter pack (10-20 Colorado silica sand) was emplaced from the bottom of the boring to approximately two ft above the top of the screen (60-52) ft bgs. The sand pack interval was isolated from upper portions of the borehole with a five ft thick bentonite chip seal installed from 52-47 ft bgs. The bentonite chips were installed to prevent the upper portion of the borehole (bentonite grout) from infiltrating into the filter pack-well screen interval. The bentonite chips were slowly poured from the surface into the well annulus to minimize the risk of bridging. The bentonite chips were placed below the water table and were allowed to hydrate for 30 minutes prior to the placement of the bentonite grout.

Above the bentonite chip seal, bentonite grout was emplaced from 47-3 ft bgs. The grout slurry was pumped into the well annulus above the bentonite chips seal using a mixture of two bags of Puregold bentonite powder with 30 gallons of potable water, producing a slurry of 30%

solids. The bentonite grout was installed by using a tremmie pipe that was lowered into the borehole to just above the upper surface of the chip seal and withdrawn as the grout filled the borehole.

The aboveground completion was constructed in accordance with the procedures outlined in *SOP 09 Groundwater Monitoring Well Installation* of the project work plan (Parsons 2014). The PVC riser above the ground surface was enclosed in a protective steel casing with a locking lid. The protective steel casing was set approximately 2.5 ft above ground surface. A two-foot square, six-inch thick concrete pad was installed around the protective casing on the ground surface. The protective steel casing was centered within the pad, and oriented so that the sides of the pad are perpendicular to the four cardinal compass directions. Four steel bollards standing approximately three ft above the ground surface were positioned around the corners of the pad to protect it from vehicular traffic. The steel casing and bollards were painted to be consistent with the existing monitoring wells at the site.

Well Development

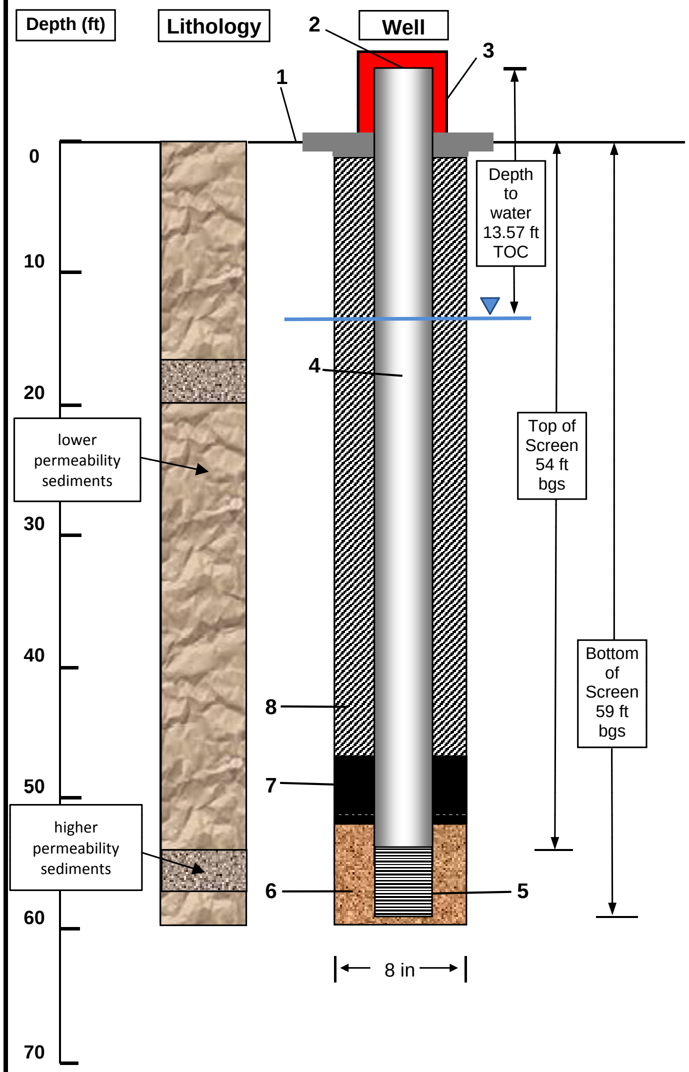
Well development was conducted by the Parsons geologist and a well development subcontractor on November 7, 2014. Development of the well was completed using a combination of surging, bailing and pumping procedures, in accordance with *SOP 10 Well Development* of the project work plan (Parsons 2014). Alternating bailing, surging and pumping methods were used to remove coarser suspended material (i.e., sand and silt) in the well and to establish hydraulic communication with the water-bearing intervals. The well was initially bailed using a 1.75-inch diameter, ten ft long stainless steel bailer and surged with a 1.5-inch steel surge block for approximately one hour. Approximately 23 gallons of water was removed during this period using the bailer. After allowing the well to recharge for approximately 30 minutes the well was pumped at a rate of 1.0 to 1.5 gallons per minute for approximately 1 ½ hours. During the pumping period, approximately 110 gallons of water were removed. Following this pumping period, well development activities were considered complete as all measured parameters were stable. A copy of the well development log is provided in Appendix F.

Groundwater Sampling

On November 12, 2014, five days after the installation and development of S13-CAM-DW1 was completed, a groundwater sample was collected using the same equipment and methods described above in Section 3.1.4.3. The groundwater sample from S13-CAM-DW1 was analyzed for VOCs using USEPA method 8260C, TPH-DRO using method 8015D, metals and cations using USEPA method 6020A/SW7470A, anions using USEPA method 300.0, and total dissolved solids using SM2540C. The HydraSleeve^{TM} sampling logs for S13-CAM-DW1 are provided in Appendix D. Monitoring well S13-CAM-DW1 was re-sampled on March 31 and April 1, 2016.

CONTRACTOR	Groundwater Monitoring Well S13-CAM-DW1	FIGURE
PARSONS	Installation Data Record	3.5

PROJECT : **Monitoring Well Installation, SWMU 13**
LOCATION : **Tooele County, Utah**
DRILLING SUBCONTRACTOR : **Conetec, Inc.**
DRILLER: **Terry Campbell**
DRILLING METHOD / EQUIPMENT: **Hollow Stem Auger / D-1 drilling rig**
HELPERS: **Brian Mercer, Shawn Steiner**
GROUNDWATER: **10.90 ft bgs** on 11/3/14
START: **10/30/2014**
END: **11/3/2014**
GEOLOGIST: **Chris Duncan, David Shank**



DRAWING NOT TO SCALE

1- Ground elevation at well :	approximately 5043.00 ft bgs
2- Measuring point elevation :	NA
3- Surface completion casing :	
a) type / dimensions	Steel Square - 8 x 8 - inch
b) height above ground	3 feet
c) length below ground	2 feet
d) type of sealant	Portland cement
e) protective bollards	Four / 3 feet above ground
4- Well casing :	
a) type / diameter	Schedule 40 PVC / 2 inch
b) height above ground	approximately 2.5 feet
c) length below ground	54 feet
d) type / quantity of sealant	see # 8
e) well centralizers	none
5- Well screen :	
a) type / diameter	Schedule 40 Vee-wrap PVC / 2 inch
b) slot size	0.010 inch
c) length / interval	5 feet / 54 to 59 feet bgs
d) sump	2 inches (2" end cap)
6- Well screen filter pack :	
a) type	10 - 20 Colorado Silica
b) quantity used	4.5 - 50 lb bags
c) method of placement	poured from surface
c) depth	7 feet / 52 to 60 ft bgs
7- Bentonite seal :	
a) type	Cetco 1/4 - inch tablets
b) quantity used	2 - 5 gallon buckets
c) method of placement	poured from surface
c) length / interval	5 feet / 47 to 52 feet bgs
8- Grout :	
a) type	Cetco Pure Gold bentonite powder
b) grout mix	50 lb bag / 14 gallons H2O (2.2 cubic feet)
c) method of placement	pumped through tremmie pipe
d) length / interval	44 feet / 3 to 47 feet bgs
e) quantity	8 - 50 lb bags

The sample collected on March 31, 2016 was analyzed for VOCs using USEPA method 8260C, SVOCs using USEPA method 8270D, and TDS using USEPA method SM2540C. The sample collected from monitoring well S13-CAM-DW1 on April 1, 2016 was analyzed for TPH-DRO using USEPA method 8015D and total metals using USEPA methods 6020A and 7470A.

3.1.5 Bail-Down (Free Product Recovery) Test

Though not specified in the project work plan (Parsons 2014), a bail-down (free product recovery) test was performed at monitoring wells S-28-88, S-CAM-1, and S-CAM-2. The free product recovery test was conducted to determine the general rate at which free product could be removed from existing wells. Initial depth-to-product and depth-to-water measurements were taken to determine product thicknesses prior to the tests. Free product was removed with a bailer and subsequent depth-to-product/depth-to-water measurements were made to record how quickly the product thickness recovered over time. Graphic presentations of the free product recovery test results are included in Appendix G.

3.2 DATA QUALITY SUMMARY

3.2.1 Data Usability

Data usability was evaluated using a multi-disciplinary team based on the data review, data quality requirements, and ultimate use of the data. Data usability was evaluated for the dataset as a whole, as well as for each sample and each preparation / analytical batch. This section identifies the data quality issues found and their impact on the usability of the data for making the project decisions outlined in the data quality objectives. Specific details regarding each sample delivery group (SDG) can be found in the associated Data Validation Report (DVR) prepared for each SDG, included in Appendix A.5 of this report. Sampling procedures and overall QC and quality assurance protocols are presented in the project QAPjP (Parsons 2014). Laboratory data reports are provided in Appendix A.6, which includes laboratory data reports for SWMU 13, along with data collected to support the SWMU 30 RFI addendum, as sampling at both SWMUs was conducted concurrently.

3.2.1.1 Volatile Organic Compounds

Quality issues found for the volatiles data included non-compliant Laboratory Control Sample (LCS), Matrix Spike/Matrix Spike Duplicate (MS/MSD), and surrogate recoveries, blank contamination, failing Initial Calibration Verification (ICV)/Continuing Calibration Verification (CCV) recoveries, field duplicate imprecision, and laboratory spiking errors.

No data qualifiers were applied for the LCS or MS/MSD recoveries as all non-compliant recoveries were high and the associated sample results were non-detect. Each of these issues had minimal impact on data usability. Most exceedances were minor, or indicated a high bias with all associated sample results non-detect. Data qualifiers were applied as detailed in the associated

DVRs and the SWMU 13 Master Data Verification Worksheet for the laboratory SDGs included in this data set. All data qualified as estimated was considered usable for the purposes of this project. All data points qualified as estimated were detections significantly below the project action limit (PAL) or were non-detect values with Limit of Detection (LOD) / Limit of Quantitation (LOQ) concentrations significantly lower than the PAL. Thus, no data quality issues for VOCs impacted data usability.

3.2.1.2 Diesel Range Organics

Quality issues found for the DRO data included non-compliant surrogate recoveries, blank contamination, and field duplicate imprecision. Each of these issues had minimal impact on data usability. Data qualifiers were applied as detailed in the associated DVRs and the SWMU 13 Master Data Verification Worksheet for the laboratory SDGs included in this data set. All data qualified as estimated was considered usable for the purposes of this project. All data points qualified as estimated were detections significantly below the PAL or were non-detect values with LOD/LOQ concentrations significantly lower than the PAL. Thus, no data quality issues for DRO impacted data usability.

3.2.1.3 Polycyclic Aromatic Hydrocarbons

Quality issues found for the PAH data included low recoveries for anthracene in one MS/MSD pair, non-compliant surrogate recoveries in one method blank and one MSD, and high field duplicate variability for 2-methylnapthalene, phenanthrene, and naphthalene. Each of these issues had minimal impact on data usability. Data qualifiers were applied as detailed in the associated DVRs and the SWMU 13 Master Data Verification Worksheet for the associated SDGs. All data qualified as estimated was considered usable for the purposes of this project. All data points qualified as estimated were detections significantly below the PAL or were non-detect values with LOD/LOQ concentrations significantly lower than the PAL. Thus, no data quality issues for PAHs impacted data usability.

3.2.1.4 Soil Gas

The soil gas data had minor quality issues with acetone contamination and field duplicate imprecision for acetone, 2-butanone, and toluene. The estimated values for these analytes did not impact data usability as the higher of the two field duplicate values was used for evaluation. In addition, the PALs for these analytes were significantly greater than (more than 230 times) the higher detected concentration. Therefore, all soil gas results were usable as qualified.

3.2.1.5 Agent Breakdown Products

It should be noted that although the QAPjP (Parsons 2014) specified USEPA Method 8321B for the analysis of ABPs, the method used by the analytical laboratory was USEPA Method 8321M (i.e., modified). This is consistent with the basewide QAPP (AQS 2012). USEPA Method 8321A/B is an organophosphorus pesticide analytical method and no analytical laboratories are Department of Defense (DoD) Environmental Laboratory Accreditation Program

(ELAP) certified for the analysis of ABPs via USEPA Method 8321A/B. However, the analytical laboratory used here (Test America) is DoD ELAP certified for the analysis of ABPs via their own proprietary SOP (i.e., WS-LC-004). As the laboratory's SOP follows the Liquid Chromatography/Double Mass Spectrometry (LC/MS/MS) protocols provided in USEPA Method 8321B, the method is referred to here as USEPA Method 8321M.

Quality issues found for the ABP data included non-compliant MS/MSD and surrogate spike recoveries and blank detections of thiodiglycol (TDG). TDG was not detected in any samples in this data set, so the blank detections did not impact data quality. Data qualifiers were applied as detailed in the associated DVRs and the SWMU 13 Master Data Verification Worksheet for the associated SDGs. All data qualified as estimated was considered usable for the purposes of this project. All data points qualified as estimated were detections significantly below the PAL or were non-detect values with LOD/LOQ concentrations significantly lower than the PAL. Thus, these data quality issues did not impact data usability.

One systematic data issue was demonstrated for ABPs. All MS/MSD recoveries for methylphosphonic acid (MPA) were zero (or near zero) percent. The high salt content in the matrix interferes with the detection of MPA in the site matrix. This has been observed over multiple years, SWMUs, contractors, and sampling events (e.g., Jacobs 2011), providing strong evidence that the matrix is the cause. All field sample results for MPA were qualified "R" as rejected due to the laboratory's inability to quantitate MPA in the project matrix. It should be noted that the MS/MSD was spiked at a concentration of 100 µg/L for MPA and the PAL for this compound is 940 µg/L. Therefore, while rejection of the MPA data was warranted, the absence of this compound in the sample data does provide some information regarding the analyte not being present at the site at levels sufficient to exceed the PAL.

3.2.1.6 Metals

One groundwater sample from S13-CSM-DW1 was analyzed for metals. Quality issues found for the metals data included non-compliant MSD recoveries and blank contamination. The high MSD recoveries were only one percent above criteria and thus did not warrant qualification. All metals detected in the field blanks were either non-detect in associated samples or sample concentrations were greater than five times the amount found in the associated field blanks. Therefore, data quality was not affected by the blank contamination. Thus, all metals data was usable for the purposes of this project.

3.2.1.7 Mercury

No quality issues found for the mercury data and all data was usable for the purposes of this project.

3.2.1.8 Cations

No quality issues found for the cation data and all data was usable for the purposes of this project.

3.2.1.9 Anions

No quality issues found for the anion data and all data was usable for the purposes of this project.

3.2.1.10 Total Dissolved Solids

No quality issues found for the total dissolved solids (TDS) data and all data was usable for the purposes of this project.

3.2.2 Data Usability Conclusions

In conclusion, the limitations on the dataset as a result of quality control issues were minor and did not impact the ability to make project decisions. Data qualifiers were applied to indicate estimated results, but all data (including data qualified as estimated) was usable for decision-making. The MPA data was qualified "R" for all field samples due to matrix interference. Although the data was rejected, the results do provide some usable information for the project.

3.3 INVESTIGATION RESULTS

3.3.1 Initial Well Inspection and Measurements

As described above, four of the existing monitoring wells at SWMU 13 were repaired and one was abandoned. Depth to water level measurements enabled generation of an updated groundwater surface elevation map and free-product thickness measurements confirmed the extent of LNAPL in the subsurface. Results of the water level measurements are presented in the Figure 3.4 that depicts the groundwater surface at SWMU 13. As described in the work plan memorandum for this task (Parsons 2013b), elevations were corrected for both salinity and free product thickness. Figure 3.4 also indicates the areal extent of the LNAPL at SWMU 13. Based on these measurements, LNAPL covers approximately 60,000 square feet.

3.3.2 Visibly Stained Soil and Elevated FID Screening Results

Of the 24 direct push soil borings at SWMU 13 (including two borings from SWMU 30), visibly stained soil was observed in 12 borings and FID readings greater than 0.0 parts per million (ppm) were measured at 17 locations. Visual observations of stained soil are illustrated in Figure 3.6. FID readings were measured at one ft intervals with the highest FID readings measured consistently within an interval of 9-13 ft bgs. The highest FID reading of 458 ppm was detected at 13 ft bgs in boring 13-SS-04. No stained soil and 0.0 ppm FID readings were noted in seven borings (13-SS-02B, 13-SS-03, 13-SS-05B, 13-SS-07A, 13-SS-09A, and 13-SS-10C). FID readings for the 24 borings are included in the field logs (Appendix B) and boring logs (Appendix C).

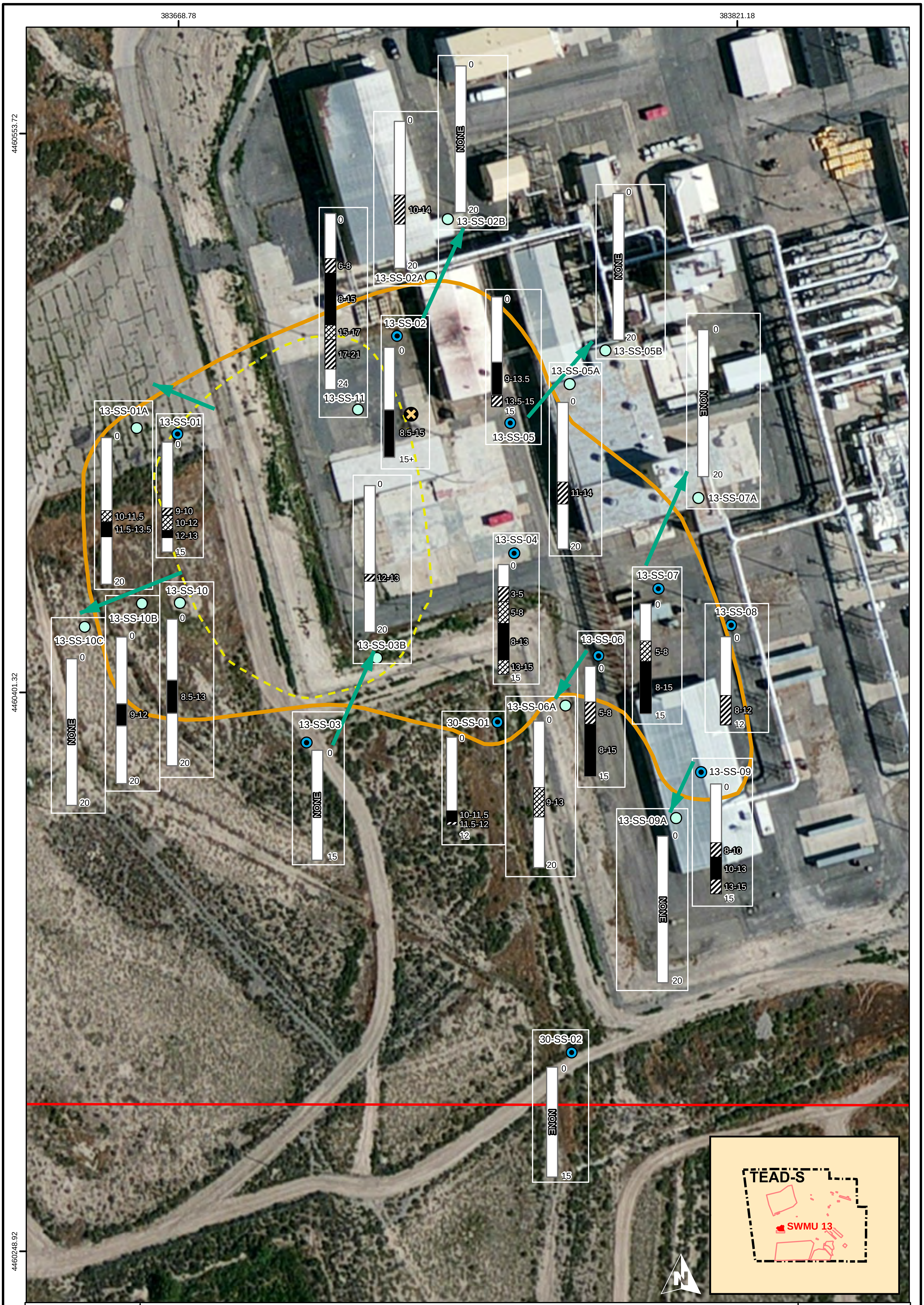


Figure 3.6
Soil Boring Observations and FID Readings

Legend

- ● Geoprobe without Sample
- ◉ Geoprobe with Sample
- ⊗ Former AST Location
- ▭ Stained Soil - Approximate
- ┅ Extent of Free Product-Feb. 2014
- ▭ SWMU Boundary
- → Direction of Step-Out Boring

Soil Boring with Measured Interval

- ▨ Slight Odor and No Staining
- ▩ Strong Odor and No Staining
- ■ Stained Soil with Strong Odor

NOTES:
ETF = Equipment Test Facility
Arrows indicate direction to step-out boring.

Imagery: ESRI (c) 2013 TPHC: Dames & Moore, 2002
Boundary, SWMUs, Wells: Deseret Chemical Depot
Proposed Samples: Parsons

Feet
0 40 80

Projection & Grid Coorindates:
NAD83 StatePlane Utah Central

PARSONS

Date:	4/29/2015
Prepared:	RGS
Checked:	DS
Revision:	1

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3.3.3 Soil Gas Sampling Results

As described above, five VMPs (13-SG-01 through 13-SG-05) were installed at five ft bgs at locations where the highest concentrations of VOCs were detected during the Phase II RFI (Rust 1997) and near the former location of the ETF ECC sump, where VOCs were detected during the closure of CAMDS. Although a total of 26 VOCs were detected in vapor samples at SWMU 13, only benzene, chloroform, and ethylbenzene were detected above the PALs. Benzene was detected above the PAL of 3.6 $\mu g/m^3$ at three locations. Chloroform was detected above the PAL of 1.2 $\mu g/m^3$ at two locations and ethylbenzene was detected above its PAL of 11 $\mu g/m^3$ at one location. Analytical results for VOCs detected in the soil gas samples are presented on Figure 3.7. A summary of soil gas analytical results is included in Appendix A.1.

3.3.4 Biodegradation Indicator Field Measurement Results

Field measurements for methane, carbon dioxide, and oxygen were recorded at VMPs 13-SG-01 through 13-SG-05 as an indicator of biodegradation of potential organic contaminants. Several measurements were recorded at each of the VMPs over a period of 15 to 22 minutes.

Methane readings ranged from 0.0 to 9.2%, carbon dioxide reading ranged from 2.8 to 13.2%, and oxygen readings ranged from 0.0 to 15.2%. Biodegradation indicator field measurement results are provided in the field logs (Appendix B) and are summarized below in Table 3.2.

TABLE 3.2
SWMU 13 METHANE SCREENING RESULTS

VMP	Methane (%)		Carbon Dioxide (%)		Oxygen (%)	
	Min	Max	Min	Max	Min	Max
13-SG-01	0.0	0.0	6.0	6.1	13.9	14.2
13-SG-02	8.2	9.2	13.0	13.2	0.0	0.1
13-SG-03	0.1	0.1	5.6	5.7	14.5	14.8
13-SG-04	0.1	0.1	5.6	5.7	12.3	12.4
13-SG-05	0.1	0.1	2.8	2.8	12.3	15.2

3.3.5 Soil Sampling Results

3.3.5.1 Surface Soil

Surface soil samples (13-SS-01A through 13-SS-09A) were collected from nine soil borings at SWMU 13. Each sample was analyzed TPH-DRO, which was detected in seven of the samples at concentrations ranging from 2.7 to 41.0 mg/kg. As shown in Figure 3.8, none of these results approach the PAL of 5,000 mg/kg established for the SWMU 13 corrective action.

TPH-DRO was not detected in surface soils samples collected from borings 13-SS-01A or 13-SS-06A. A summary of the soil analytical results is included in Appendix A.2.

3.3.5.2 Subsurface Soil

A total of 18 subsurface soil samples were collected from nine soil borings at SWMU 13. Nine of the samples (13-SS-01B through 13-SS-09B) were collected from intervals of 3-7 ft bgs and nine samples (13-SS-01C through 13-SS-09C) were collected from intervals of 8-15 ft bgs. All samples were analyzed for VOCs and TPH-DRO. A summary of the soil analytical results is included in Appendix A.2.

Detections in subsurface soil samples included TPH-DRO and several VOCs (Figure 3.8). TPH-DRO was detected in five samples collected from the 3-7 ft interval at concentrations ranging from 3.4 to 1,400 mg/kg. Eight samples collected from an interval of 8-15 ft contained TPH-DRO at concentrations ranging from 33 to 8,400 mg/kg. The only sample that exceeded the soil PAL of 5,000 mg/kg was 13-SS-02C at 12-14 ft bgs, where TPH-DRO was detected at 8,400 mg/kg. This sample location is near the main release from the two ASTs.

Of the VOCs detected, only naphthalene exceeded its PAL of 3.8 mg/kg at two locations. The highest concentration (29 mg/kg) was found in the same sample that contained TPH-DRO above the PAL; i.e., 13-SS-02C. The other location where naphthalene was detected above the PAL was in the area where the second release is suspected. At this location, naphthalene exceeded the PAL in the two subsurface samples; i.e., 6.4 mg/kg in 13-SS-07B at 9-11 ft bgs and 7.0 mg/kg in 13-SS-07C at 12-14 ft bgs.

3.3.5.3 Evaluation of Potential Groundwater Impacts

Compliance with UAC R315-101-3 (potential soil-to-groundwater impacts and the Principle of Non-Degradation) is achieved by evaluating the potential for chemicals detected in soil to impact groundwater in the future. The potential for future groundwater impacts for SWMU 13 were evaluated by comparing detected concentrations in soil to USEPA (2015) soil-to-groundwater screening levels (SSLs). Following the Risk Assumptions Document (AQS 2015), the SSLs were multiplied by a dilution attenuation factor (DAF) of 20.

As shown in Appendix M, Table M.1, with the exception of naphthalene, detected at 3-5 ft bgs at a concentration of 0.029 mg/kg at sample location 13-SS-09B, (see Figure 3.8), all concentrations exceeding the SSLs with a DAF of 20 are located within the smear zone or below the water table.

A comparison of groundwater concentrations of naphthalene and other constituents reported by Rust (1997) to those measured in 2014 show that the concentrations are generally decreasing (see Appendix M, Table M.2). Additionally, the presence of methane in soil gas at explosive levels in the center of the plume supports biodegradation (see Table 3.2).

13-SG-02 (5 ft bgs)
9/4/2014
1,3,5-Trimethylbenzene = 48 J
Benzene = 160
Cychlohexane = 1,100

13-SG-01 (5 ft bgs)
9/4/2014
1,2,4-Trimethylbenzene = 22 J
1,3,5-Trimethylbenzene = 32 J
2-Butanone = 61 J
Acetone = 760 J
Benzene = 13 J
Cychlohexane = 38 J

13-SG-03 (5 ft bgs)
9/4/2014
1,2,4-Trimethylbenzene = 23
1,3,5-Trimethylbenzene = 26
2-Butanone = 34 J
Acetone = 310 J
m,p-Xylene = 15 J
o-Xylene = 6.7 J
Toluene = 7.2 J

13-SG-03FD (5 ft bgs)
9/4/2014
1,2,4-Trimethylbenzene = 14 J
1,3,5-Trimethylbenzene = 16
2-Butanone = 100 J
Acetone = 1,400 J
m,p-Xylene = 14 J
Methylene Chloride = 5.9 J
o-Xylene = 5.9 J
Toluene = 15 J

13-SG-05 (5 ft bgs)
9/3/2014
1,1,1-Trichloroethane = 1.0
1,2,4-Trimethylbenzene = 2.0
1,3,5-Trimethylbenzene = 0.77 J
2-Butanone = 91
2-Hexanone = 18
4-Methyl-2-Pentanone = 2.0
Acetone = 1,200 J
Benzene = 1.9
Carbon Disulfide = 1.8 J
Carbon Tetrachloride = 1.1
Chloroethane = 0.51 J
Chloroform = 960
cis-1,2-Dichloroethene = 0.40 J
Dichlorodifluoromethane = 3.4
Ethylbenzene = 5.0
m,p-Xylene = 17
Methylene Chloride = 1.2
n-Propylbenzene = 0.42 J
o-Xylene = 6.2
Styrene = 0.77 J
Tetrachloroethene = 2.7
Toluene = 8.9 J
Trichloroethene = 1.1
Trichlorofluoromethane = 180

13-SG-04 (5 ft bgs)
9/3/2014
1,1,1-Trichloroethane = 0.73 J
1,2,4-Trimethylbenzene = 2.8
1,3,5-Trimethylbenzene = 1.3
2-Butanone = 180
2-Hexanone = 48
4-Methyl-2-Pentanone = 9.3
Acetone = 2,300 J
Benzene = 24
Carbon Disulfide = 17
Carbon Tetrachloride = 1.5
Chloroform = 50
cis-1,2-Dichloroethene = 0.54 J
Cumene = 0.75 J
Cyclohexane = 2.7
Dichlorodifluoromethane = 2.0
Ethylbenzene = 19
m,p-Xylene = 81
Methyl Tert-Butyl Ether = 0.45 J
Methylene Chloride = 0.89 J
n-Propylbenzene = 0.98
o-Xylene = 21
Styrene = 2.7
Tetrachloroethene = 18
Toluene = 160 J
Trichloroethene = 2.2
Trichlorofluoromethane = 9.2

Figure 3.7

SWMU 13 Soil Gas Sampling Results ($\mu g/m^3$)

Legend

- ● Monitoring Well
- ● Monitoring Well - Abandoned
- ● Soil Gas
- ➡ General Direction of Groundwater Movement (based on freshwater equivalent head)
- 🟥 SWMU Boundary

NOTES:
-Red highlighting = detected value exceeds the Preliminary Action Level
-ETF = Equipment Test Facility (ETF Sump)

Imagery: ESRI (c) 2015
Boundary, SWMUs, Wells: Deseret Chemical Depot
Sample Locations: Parsons

Feet
0 150 300

Projection & Grid Coordinates:
NAD83 StatePlane Utah Central

PARSONS

Date:	3/12/2015
Prepared:	RGS
Checked:	JF
Revision:	6

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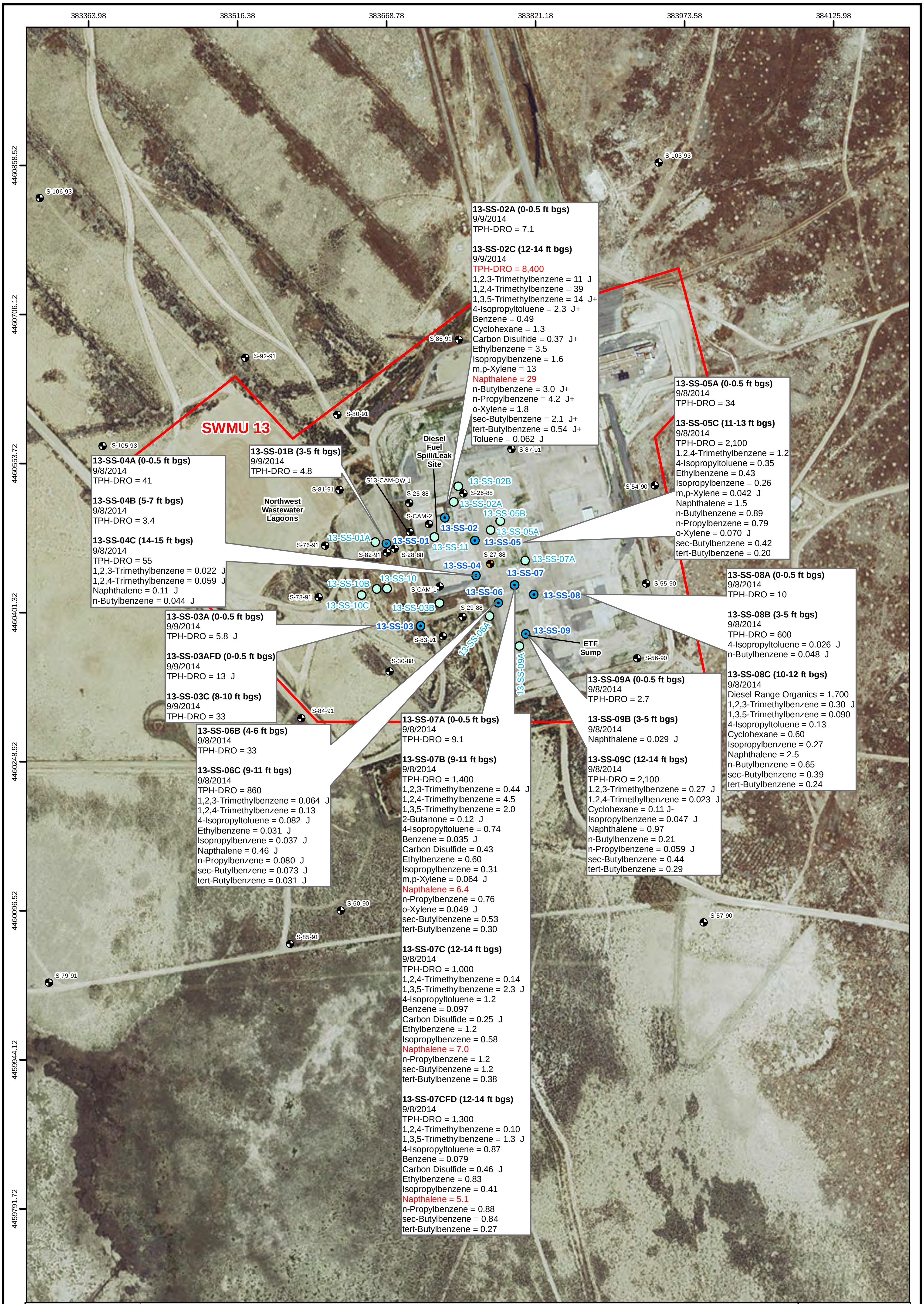

13-SS-02A (0-0.5 ft bgs)
9/9/2014
TPH-DRO = 7.1

13-SS-02C (12-14 ft bgs)
9/9/2014
TPH-DRO = 8,400
1,2,3-Trimethylbenzene = 11 J
1,2,4-Trimethylbenzene = 39
1,3,5-Trimethylbenzene = 14 J+
4-Isopropyltoluene = 2.3 J+
Benzene = 0.49
Cyclohexane = 1.3
Carbon Disulfide = 0.37 J+
Ethylbenzene = 3.5
Isopropylbenzene = 1.6
m,p-Xylene = 13
Napthalene = 29
n-Butylbenzene = 3.0 J+
n-Propylbenzene = 4.2 J+
o-Xylene = 1.8
sec-Butylbenzene = 2.1 J+
tert-Butylbenzene = 0.54 J+
Toluene = 0.062 J

13-SS-05A (0-0.5 ft bgs)
9/8/2014
TPH-DRO = 34

13-SS-05C (11-13 ft bgs)
9/8/2014
TPH-DRO = 2,100
1,2,4-Trimethylbenzene = 1.2
4-Isopropyltoluene = 0.35
Ethylbenzene = 0.43
Isopropylbenzene = 0.26
m,p-Xylene = 0.042 J
Naphthalene = 1.5
n-Butylbenzene = 0.89
n-Propylbenzene = 0.79
o-Xylene = 0.070 J
sec-Butylbenzene = 0.42
tert-Butylbenzene = 0.20

13-SS-04A (0-0.5 ft bgs)
9/8/2014
TPH-DRO = 41

13-SS-04B (5-7 ft bgs)
9/8/2014
TPH-DRO = 3.4

13-SS-04C (14-15 ft bgs)
9/8/2014
TPH-DRO = 55
1,2,3-Trimethylbenzene = 0.022 J
1,2,4-Trimethylbenzene = 0.059 J
Naphthalene = 0.11 J
n-Butylbenzene = 0.044 J

13-SS-01B (3-5 ft bgs)
9/9/2014
TPH-DRO = 4.8

13-SS-08A (0-0.5 ft bgs)
9/8/2014
TPH-DRO = 10

13-SS-08B (3-5 ft bgs)
9/8/2014
TPH-DRO = 600
4-Isopropyltoluene = 0.026 J
n-Butylbenzene = 0.048 J

13-SS-08C (10-12 ft bgs)
9/8/2014
Diesel Range Organics = 1,700
1,2,3-Trimethylbenzene = 0.30 J
1,3,5-Trimethylbenzene = 0.090
4-Isopropyltoluene = 0.13
Cyclohexane = 0.60
Isopropylbenzene = 0.27
Naphthalene = 2.5
n-Butylbenzene = 0.65
sec-Butylbenzene = 0.39
tert-Butylbenzene = 0.24

13-SS-03A (0-0.5 ft bgs)
9/9/2014
TPH-DRO = 5.8 J

13-SS-03AFD (0-0.5 ft bgs)
9/9/2014
TPH-DRO = 13 J

13-SS-03C (8-10 ft bgs)
9/9/2014
TPH-DRO = 33

13-SS-09A (0-0.5 ft bgs)
9/8/2014
TPH-DRO = 2.7

13-SS-09B (3-5 ft bgs)
9/8/2014
Naphthalene = 0.029 J

13-SS-09C (12-14 ft bgs)
9/8/2014
TPH-DRO = 2,100
1,2,3-Trimethylbenzene = 0.27 J
1,2,4-Trimethylbenzene = 0.023 J
Cyclohexane = 0.11 J-
Isopropylbenzene = 0.047 J
Naphthalene = 0.97
n-Butylbenzene = 0.21
n-Propylbenzene = 0.059 J
sec-Butylbenzene = 0.44
tert-Butylbenzene = 0.29

13-SS-06B (4-6 ft bgs)
9/8/2014
TPH-DRO = 33

13-SS-06C (9-11 ft bgs)
9/8/2014
TPH-DRO = 860
1,2,3-Trimethylbenzene = 0.064 J
1,2,4-Trimethylbenzene = 0.13
4-Isopropyltoluene = 0.082 J
Ethylbenzene = 0.031 J
Isopropylbenzene = 0.037 J
Napthalene = 0.46 J
n-Propylbenzene = 0.080 J
sec-Butylbenzene = 0.073 J
tert-Butylbenzene = 0.031 J

13-SS-07A (0-0.5 ft bgs)
9/8/2014
TPH-DRO = 9.1

13-SS-07B (9-11 ft bgs)
9/8/2014
TPH-DRO = 1,400
1,2,3-Trimethylbenzene = 0.44 J
1,2,4-Trimethylbenzene = 4.5
1,3,5-Trimethylbenzene = 2.0
2-Butanone = 0.12 J
4-Isopropyltoluene = 0.74
Benzene = 0.035 J
Carbon Disulfide = 0.43
Ethylbenzene = 0.60
Isopropylbenzene = 0.31
m,p-Xylene = 0.064 J
Napthalene = 6.4
n-Propylbenzene = 0.76
o-Xylene = 0.049 J
sec-Butylbenzene = 0.53
tert-Butylbenzene = 0.30

13-SS-07C (12-14 ft bgs)
9/8/2014
TPH-DRO = 1,000
1,2,4-Trimethylbenzene = 0.14
1,3,5-Trimethylbenzene = 2.3 J
4-Isopropyltoluene = 1.2
Benzene = 0.097
Carbon Disulfide = 0.25 J
Ethylbenzene = 1.2
Isopropylbenzene = 0.58
Napthalene = 7.0
n-Propylbenzene = 1.2
sec-Butylbenzene = 1.2
tert-Butylbenzene = 0.38

13-SS-07CFD (12-14 ft bgs)
9/8/2014
TPH-DRO = 1,300
1,2,4-Trimethylbenzene = 0.10
1,3,5-Trimethylbenzene = 1.3 J
4-Isopropyltoluene = 0.87
Benzene = 0.079
Carbon Disulfide = 0.46 J
Ethylbenzene = 0.83
Isopropylbenzene = 0.41
Napthalene = 5.1
n-Propylbenzene = 0.88
sec-Butylbenzene = 0.84
tert-Butylbenzene = 0.27

Figure 3.8
SWMU 13 Soil Sampling Results (mg/kg)

Legend

- Monitoring Well
- Monitoring Well - Abandoned
- Geoprobe without Sample
- Geoprobe with Sample
- 🟥 SWMU Boundary

Imagery: ESRI (c) 2015
Boundary, SWMUs, Wells: Deseret Chemical Depot
Sample Locations: Parsons

NOTES:
ETF = Equipment Test Facility
Red highlighting = detected value exceeds the Preliminary Action Level
ft bgs = Feet below ground surface
J = Analyte detected, estimated concentration.
J- = Analyte detected, estimated concentration with low bias.

Feet
0 150 300

Projection & Grid Cooridnates:
NAD83 StatePlane Utah Central

PARSONS

Date:	12/3/2015
Prepared:	RGS
Checked:	DS
Revision:	1

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Lastly, the biodegradation of petroleum in soils in groundwater is well known phenomenon. For example, USEPA's 2015 *Technical Guide for Addressing Petroleum Vapor Intrusion at Leaking Underground Storage Tank Sites (EPA 510-R-001)* provides an extensive list of references on the aerobic and anaerobic biodegradation of petroleum hydrocarbons on pages 14-15 of their guidance document. Therefore, the evidence collected indicates that these constituents are attenuating naturally and that they do not pose a risk to further degradation of groundwater.

3.3.6 Groundwater Sampling Results

Groundwater samples were collected from eight hydropunch locations and 12 monitoring wells. All samples were analyzed for TPH-DRO and VOCs. Four samples collected from selected hydropunch locations and six from selected monitoring wells were also analyzed for PAHs to support an evaluation of plant uptake of contaminants. Additionally, two hydropunch samples and two monitoring well samples collected near former chemical agent management areas were analyzed for ABPs. Groundwater analytical results are summarized in Appendix A.3.

Detections in groundwater included TPH-DRO, several VOCs, and PAHs at low concentrations (Figure 3.9). Isoconcentration maps showing the extent of contaminants detected at concentrations exceeding their respective PALs are provided in Appendix L. TPH-DRO was present at concentrations ranging from 130 to 110,000 µg/L, with samples from S-CAM-1 and S-CAM-2 exceeding the groundwater TPH-DRO PAL of 10,000 µg/L. VOCs (as measured by USEPA Method 8260C) were widely detected above their respective PALs in both hydropunch and monitoring well samples (Figure 3.9). With the exception of TCE and chloroform, all VOCs detected above PALs are common diesel fuel constituents; e.g., benzene, ethylbenzene, o-xylene, naphthalene, 1,2,3-trimethylbenzene, and 1,2,4-trimethylbenzene.

The PAHs (as measured by USEPA Method 8270D) 2-methylnaphthalene and naphthalene exceeded their respective PALs. As with the TPH-DRO and VOCs, the greatest PAH concentrations were present in wells S-CAM-1 and S-CAM-2 (Figure 3.9).

Although no ABPs were detected above PALs in either the hydropunch samples or the groundwater samples from monitoring wells, the ABPs diisopropylmethylphosphonate (DIMP) and isopropyl methylphosphonic acid (IMPA) were detected at S-78-91 at 3.9 and 260 µg/L, respectively. IMPA has previously been detected in S-78-91 in 2010 at 370 µg/L and in 2004 at 750 µg/L (Parsons 2013a).

All MPA groundwater results were R flagged due to zero percent recoveries in the MS/MSDs (see Section 3.2.1.5 and Appendix A). Since ions (including Ca, Cl, and Mg) in groundwater can result in severe interference in the detection of MPA and alkyl methylphosphonic acids (AMPAs) (Kataoka et al. 2000), the relatively high salinity in groundwater at SWMU 13 (see Table 3.4), are expected to lead to low recoveries for MPA and other AMPAs (i.e., ethylmethylphosphonic acid and IMPA). This has been observed over multiple years, SWMUs, contractors, and sampling events (e.g., Jacobs 2011) at TEAD-S, providing strong evidence that the matrix is the cause.

Although all groundwater MPA data were R qualified, MPA is unlikely to be a concern at SWMU 13. First, out of the 142 soil samples collected as part of CAMDS closure, MPA was only detected in 9 samples with a maximum detected concentration of 7 mg/kg (URS 2012), which is well below the residential Regional Screening Level (RSL) of 3,700 mg/kg.

The low concentrations of MPA detected during CAMDS closure suggests that there were no significant soil sources of MPA. Additionally, all potential MPA sources were removed as part of CAMDS closure. Thus, without a continuing source, groundwater concentrations of MPA at SWMU 13 would not be expected to increase over time. With that in mind, it should be noted that monitoring well S-78-91 has been sampled seven times from 1999 to 2010 for MPA and MPA was never detected even though the detection limits were generally below the tapwater RSL of 1,200 µg/L. Monitoring well S-76-91 was also sampled in 2005, 2008, and 2010 for MPA and was only detected in 2010 at 230 µg/L (Parsons 2013), which is well below the tapwater RSL. Altogether, this suggests that although MPA may be present in soil and groundwater at SWMU 13, the concentrations present are much less than the residential/tapwater RSLs and are unlikely to be of concern.

3.3.6.1 Deep Monitoring Well (S13-CAM-DW1)

To evaluate potential groundwater impacts below the water-table, a deeper monitoring well was installed in a water-bearing zone 55-57 ft bgs (see Section 3.1.4.4). A groundwater sample collected from S13-CAM-DW1 on November 12, 2014 was analyzed for TPH-DRO, VOCs, metals, TDS, and cations/anions. For comparative purposes, groundwater from the adjacent shallow well (i.e., S-CAM-2) was also analyzed for TDS and cations/anions. TPH-DRO was detected at 1,400 µg/L and the VOC 2-butanone at 0.99 µg/L, both below their respective PALs. Several metals were also detected, however only arsenic, cobalt, manganese, molybdenum and thallium exceeded their respective PALs. Arsenic was detected at 50 µg/L, which also exceeds the Maximum Contaminant Level (MCL) of 5 µg/L.

The chromatogram for the TPH-DRO detected in the groundwater sample from the deep monitoring well (S13-CAM-DW1) was atypical; i.e., several large individual peaks dwarfed all other peaks and altered the scale of the chromatogram such that identifying any fuel-type pattern in the smaller peaks was not feasible. At Parsons' request, the laboratory retrieved the extract used for the DRO analysis and screened it for SVOCs (including TICs) in an effort to identify the anomalous peaks. It should be noted that the SVOC screen was not included in the QAPjP and was not DOD QSM compliant as no quality control or surrogate spikes were performed as part of the analysis. Therefore, the SVOC data was obtained as an informal screening-level evaluation to determine whether re-sampling of this well using definitive methodologies is warranted. The SVOC data should be considered qualitative only as the concentrations reported are estimates and are only useful for comparing relative abundance.

S-CAM-2 11/12/2014
Method: 8015D
TPH-DRO = 49,000
Method: 8260C
1,2,3-Trimethylbenzene = 13
1,2,4-Trimethylbenzene = 42
1,3,5-Trimethylbenzene = 17
4-Isopropyltoluene = 2.6
Benzene = 3.4
Ethylbenzene = 5.6
Isopropylbenzene = 2.4
m,p-Xylene = 9.9
Naphthalene = 180
n-Propylbenzene = 5.0
o-Xylene = 11
sec-Butylbenzene = 1.8
tert-Butylbenzene = 2.2
Toluene = 0.82 J
Method: 8270D
2-Methylnaphthalene = 1,200
Acenaphthene = 57
Anthracene = 34
Fluorene = 64
Naphthalene = 180
Phenanthrene = 260
Pyrene = 7.3

S-26-88 11/12/2014
Method: 8015D
TPH-DRO = 5,200 J+
Method: 8260C
2-Butanone = 2.9 J
tert-Butylbenzene = 0.23 J
Method: 8270D
2-Methylnaphthalene = 0.45

S-25-88 11/12/2014
Method: 8015D
TPH-DRO = 580 J-

S-87-91 11/12/2014
Method: 8015D
TPH-DRO = 1,000 J-

13-HPGW-05 9/17/2014
Method: 8260C
Chloroform = 1.2
Trichlorofluoromethane = 2.6
Method: 8270D
2-Methylnaphthalene = 0.34 J
Acenaphthene = 0.097 J
Phenanthrene = 0.25 J

13-HPGW-03 9/17/2014
Method: 8015D
TPH-DRO = 230
Method: 8260C
Chloroform = 1.4
Trichlorofluoromethane = 1.9

13-HPGW-05FD 9/17/2014
Method: 8260C
Chloroform = 1.3
Trichlorofluoromethane = 3.0
Method: 8270D
2-Methylnaphthalene = 0.92 J
Acenaphthene = 0.23
Naphthalene = 0.63 J
Phenanthrene = 0.64 J

13-CAM-DW1 11/12/2014
Method: 8015D
TPH-DRO = 1,400 J-
Method: 8260C
2-Butanone = 0.99 J

S-82-91 11/12/2014
Method: 8260C
Methyl tert-butyl ether = 0.23 J
sec-Butylbenzene = 0.92 J
tert-Butylbenzene = 0.54 J
Method: 8270D
2-Methylnaphthalene = 0.39
Naphthalene = 0.22

S-55-90 11/12/2014
Method: 8015D
TPH-DRO = 410
Method: 8260C
Chloroform = 1.1

13-HPGW-06
Method: 8260C
9/17/2014
Chloroform = 0.50 J

S-55-90FD 11/12/2014
Method: 8015D
TPH-DRO = 130 J
Method: 8260C
1,2,3-Trimethylbenzene = 0.28 J
1,2,4-Trimethylbenzene = 0.39 J
Chloroform = 1.1

S-78-91 11/12/2014
Method: 8015D
TPH-DRO = 240 J-
Method: 8260C
1,2,4-Trimethylbenzene = 0.22 J
Chloroform = 0.57 J
Naphthalene = 1.3
Trichloroethene = 3.1
Method: 8321M
Diisopropylmethylphosphonate (DIMP) = 3.9 J
Isopropyl methylphosphonic acid (IMPA) = 260 J-

13-HPGW-04
9/18/2014
Trichloroethene - 0.86 J

13-HPGW-07 9/17/2014
Method: 8015D
TPH-DRO = 1,800 J-
Method: 8260C
1,2,3-Trimethylbenzene = 1.8
1,2,4-Trimethylbenzene = 0.76 J
1,3,5-Trimethylbenzene = 1.4
4-Isopropyltoluene = 2.4
Ethylbenzene = 0.95 J
Isopropylbenzene = 4.9
Naphthalene = 87
n-Butylbenzene = 1.6
n-Propylbenzene = 2.1
sec-Butylbenzene = 4.0
tert-Butylbenzene = 2.6
Method: 8270D
2-Methylnaphthalene = 41
Naphthalene = 29
Phenanthrene = 8.4

13-HPGW-08 9/17/2014
Method: 8015D
TPH-DRO = 1,300 J-
Method: 8260C
1,2,3-Trimethylbenzene = 0.73 J
Isopropylbenzene = 0.79 J
Naphthalene = 5.5
sec-Butylbenzene = 0.80 J
tert-Butylbenzene = 0.89 J

S-91-91 11/12/2014
Method: 8015D
TPH-DRO = 130 J
Method: 8260C
Naphthalene = 0.57 J

S-30-88 11/12/2014
Method: 8015D
TPH-DRO = 1,500
Method: 8260C
1,2,3-Trimethylbenzene = 0.47 J
1,2,4-Trimethylbenzene = 0.86 J
1,3,5-Trimethylbenzene = 0.25 J
m,p-Xylene = 0.59 J
Naphthalene = 9.2
o-Xylene = 0.35 J
tert-Butylbenzene = 0.51 J

S-CAM-1 11/12/2014
Method: 8015D
TPH-DRO = 110,000
Method: 8260C
1,2,3-Trimethylbenzene = 140
1,2,4-Trimethylbenzene = 280
1,3,5-Trimethylbenzene = 100
2-Butanone = 16
4-Isopropyltoluene = 7.3
Benzene = 15
Ethylbenzene = 64
Isopropylbenzene = 11
m,p-Xylene = 380
Methyl tert-butyl ether = 0.74 J
Naphthalene = 280
n-Propylbenzene = 20
o-Xylene = 220
tert-Butylbenzene = 2.0
Toluene = 38
Method: 8270D
2-Methylnaphthalene = 2,900
Anthracene = 68
Naphthalene = 730
Phenanthrene = 830
Pyrene = 25

S-29-88 11/12/2014
Method: 8015D
TPH-DRO = 900
Method: 8260C
sec-Butylbenzene = 0.41 J
tert-Butylbenzene = 0.49 J
Method: 8270D
2-Methylnaphthalene = 0.52
Naphthalene = 0.27

Figure 3.9 SWMU 13 Groundwater Sampling Results (ug/L)

Legend
- ◉ Monitoring Well
- ◉ Monitoring Well - Abandoned
- 🟩 Sampled
- ● Hydropunch
- ▭ SWMU Boundary

Imagery: ESRI (c) 2015
Boundary, SWMUs, Wells: Deseret Chemical Depot
Sample Locations: Parsons

NOTES:
ETF = Equipment Test Facility
Red highlighting = detected value exceeds the Preliminary Action Level
ft bgs = Feet below ground surface

Feet
0 150 300

Projection & Grid Coorindates:
NAD83 StatePlane Utah Central

PARSONS

Date:	4/29/2015
Prepared:	RGS
Checked:	DS
Revision:	1

X:\GISCADD\projects\TEAD_S_13_30\Mapfiles\CMS_Workplan\CMS13_hydropunch_results_11_17.mxd 4/29/2015

No formal data report was provided for the SVOC screen. The only information available is the raw data (i.e., quantitation report, chromatogram, and TIC report) for the specific sample screened. A copy of the raw data provided by the laboratory related to the SVOC screen is included in Appendix A.

The compounds identified in the TPH-DRO from S13-CAM-DW1 consisted of multiple petroleum constituents (i.e., the more mobile PAHs (i.e., fluoranthene, 1-methylnaphthalene, phenanthrene, and pyrene), the aliphatic octadecane, and carbazole (Dorbon et al. 1984)), as well as several phthalates (Table 3.3), which are believed to have been produced by the bacterial degradation of TPH (e.g., Hao et al. 2004, Harayama et al. 1999). The tentatively identified compounds (TICs) with greater than 70% fit (which are generally assumed to be positively identified) include multiple fatty acids, which are believed to have been produced by the bacterial degradation of TPH (i.e., tetradecanoic acid, 9-octadecenoic acid, n-hexadecanoic acid, and dodecanoic acid), some of the more mobile PAHs (i.e., 2-methyl-anthracene and 2-methyl-phenanthrene) that are found in petroleum, other petroleum constituents (i.e., norphytane (Hostettler et al. 2013), squalene, and eicosane), and 2-methyl-cyclopentanone (Table 3.3).

The analytical results for TDS and cations/anions show that groundwater quality decreases with depth (Table 3.4); i.e., based on salinity, shallow groundwater (i.e., S-CAM-2) is Class II and deeper groundwater (i.e., S13-CAM-DW1) is Class IV.

Based on the results of the November 2014 sampling event and informal screening-level evaluation of potential SVOCs in groundwater at S13-CAM-DW1, the well was re-sampled on March 31, 2016 and analyzed for SVOCs using USEPA method 8270D. Additionally the sample was analyzed for VOCs using USEPA method 8260C and TDS using method SM2540C. An additional sample was collected on April 1, 2016 which was analyzed for TPH-DRO using USEPA method 8015D and total metals using USEPA methods 6020A and 7470A.

TPH-DRO was detected at a concentration of 170 µg/L and the VOCs acetone and carbon disulfide were detected at concentrations of 3.3 µg/L and 1.9 µg/L respectively, all of which are less than their respective PALs. The SVOCs detected included bis(2-ethylhexyl)phthalate at 1.5 µg/L, butylbenzylphthalate at 0.83 µg/L, diethylphthalate at 0.48 µg/L, dimethylphthalate at 7.6 µg/L, and phenanthrene at 0.36 µg/L. As previously indicated, the phthalates are believed to have been produced by the bacterial degradation of TPH (e.g., Hao et al. 2004, Harayama et al. 1999). Phenanthrene, a hydrocarbon constituent, has been shown to produce phthalates through bacterial degradation (e.g., Harayama et al. 1999, Masakorala et al. 2013). Those SVOCs for which PALs have been established were detected at concentrations less than their respective PALs (see Table A.3). Several metals were detected in the groundwater sample collected on April 1, 2016 from S13-CAM-DW1 (see Table A.3), with only arsenic, manganese, and thallium detected at concentrations exceeding their respective PALs. As was shown by the 2014 TDS results (Table A.3) and confirmed by the March 31, 2016 TDS results (16,000 mg/L) (Table A.3), groundwater quality decreases with depth.

TABLE 3.3
ANALYSIS OF GROUNDWATER FROM S13-CAM-DW1 VIA USEPA METHOD 8270D

TOOELE ARMY DEPOT - SOUTH

Chemical	CASRN	Fit (%)	Concentration[1] (µg/L)	RSL (µg/L)	MCL (µg/L)
Identified Compounds					
TPH-diesel	-	-	1,400	-	-
bis(2-Ethylhexyl)phthalate	117-81-7	-	1.35	5.6	6
Carbazole	86-74-8	-	0.35	-	-
Diethyl phthalate	84-66-2	-	0.77	15,000	-
Dimethyl phthalate	131-11-3	-	36.9	-	-
Di-n-butyl phthalate	84-74-2	-	0.3	900	-
Fluoranthene	206-44-0	-	0.06	800	-
1-Methylnaphthalene	90-12-0	-	0.24	1.1	-
n-Octadecane	593-45-3	-	21.26	-	-
Phenanthrene	85-01-8	-	2.69	-	-
Pyrene	129-00-0	-	0.14	120	-
Tentatively Identified Compounds (TICs)					
Tetradecanoic acid	544-63-8	99	13.72	-	-
9-Octadecenoic acid	2027-47-6	99	78.1	-	-
Eicosane	112-95-8	98	11.43		
n-Hexadecanoic acid	57-10-3	98	113.14	-	-
Dodecanoic acid	143-07-7	97	6	-	-
Anthracene, 2-methyl-	613-12-7	97	3.09	-	-
Phenanthrene, 2-methyl-	2531-84-2	96	4.35	-	-
Cyclopentanone, 2-methyl-	1120-72-5	95	3.9	-	-
Squalene	7683-64-9	91	14.04		

Definitions:

CASRN - Chemical Abstract Services Registry Number

MCL - USEPA Maximum contaminant level

RSL - USEPA tapwater regional screening level (January 2015)

Notes: 1 - qualitative and are only useful for comparing relative abundance.

TABLE 3.4
CATIONS, ANIONS, AND TOTAL DISSOLVED SOLIDS IN GROUNDWATER AT SWMU 13 (mg/L)
TOOELE ARMY DEPOT - SOUTH

Analyte	S-CAM-2 (shallow)	S13-CAM-DW1 (deep)
Calcium	98	700
Iron	8.8	1.4
Magnesium	290	1,300
Sodium	660	4,500
Chloride	480	7,100
Nitrogen, nitrate-N	<0.025	<0.025
Sulfate	590	3,100
Total dissolved solids	2,800	17,000

3.4 CONTAMINATION ASSESSMENT

3.4.1 Measureable Free Product

In July 1991, the thickness of free product was measured in five monitoring wells (i.e., S-CAM-1, S-CAM-2, S-26-88, S-28-88, and S- 27-88), with thicknesses up to 0.52 ft (Rust 1997) (Table 3.5). Following those initial measurements, free product has consistently been measured in these same five monitoring wells on multiple dates.

TABLE 3.5
THICKNESS OF FREE PRODUCT (ft)
TOOELE ARMY DEPOT - SOUTH

	7/1991	5/2009	7/2010	2/2014
Well	(Rust 1997)	(SCEI 2009)	(Jacobs 2011)	(Parsons 2014)
S-CAM-1	0.49	2.44	0.84	1.52
S-CAM-2	0.52	1.79	0.90	0.93
S-26-88	0.16	1.05	-	-
S-27-88	<0.05	0.71	0.43	-
S-28-88	0.35	0.09	0.38	0.61

Due to the large degree of variability in free product measurements, the following discussion is based on a select group of representative measurements. By May 2009, free product appears to have reached a maximum thickness in these five wells, with thicknesses up to 2.44 ft (SCEI 2009). In July 2010, free product was measured in these five monitoring wells with a maximum thickness of 0.84 feet (Jacobs 2011), with diminished product thicknesses in three of the four other wells. Measurements taken as part of the CMS data gap investigation in February 2014 (Parsons 2014) confirmed reduced free product thickness in three of the five wells versus 2009 (Table 3.5).

Based on the data in Table 3.5, it appears that free product thickness may be diminishing with time in all wells, except potentially S-28-88. It should be noted that measuring LNAPL thickness is difficult and results may vary due to measurement equipment, methods, or changes in the underlying groundwater levels. However, it is more likely that the diminishing thickness is a result of the age of the fuel release, biodegradation by naturally occurring bacteria, volatilization, and dissolution into groundwater. For example, the 8-9% methane and 0-0.1% oxygen measured in soil gas at 13-SG-02 (Table 3.2) are good indicators of biodegradation. Nonetheless, the extent of LNAPL in groundwater appears to be limited at present to the vicinity of monitoring wells S-CAM-1, S-CAM-2, and S-28-88, representing an area of approximately 60,000 square feet (Figure 3.4).

3.4.2 Bail-Down (Free Product Recovery) Test

As described above, LNAPL is present in three monitoring wells at SWMU 13 (i.e., S-CAM-1, S-CAM-2, and S-28-88). To evaluate the true fuel hydrocarbon thickness and its general mobility, bail-down tests were performed in each of these wells. The results of the bail-down tests are plotted in Appendix G and suggest that the thickness of LNAPL ranges from a maximum of 0.7-feet in S-CAM-1 to minimum of 0.35-feet in well S-28-88. The area where LNAPL is present is estimated to occupy approximately 60,000 square feet (Figure 3.4).

The bail-down tests also indicate the potential for free product recovery at SWMU 13. Based on USEPA (1996) guidance, the initial free product recovery rate was calculated for S-CAM-1 (3.0 gal/day), S-CAM-2 (1.44 gal/day), and S-28-88 (6.6 gal/day) for skimming type operations. The rate of recovery depends on the design of the recovery system, the type and distribution of free product in the subsurface, and hydrogeological conditions. Expected recovery rates are used to design and size the recovery system. Usually, recovery rates decline after startup as the extractable free product in the adjacent soils is depleted.

3.4.3 Soil Contamination

Visibly stained soil and elevated FID readings (i.e., > 0.0 ppm) in soil borings were observed in intervals that generally extended above and below the water table several feet. The impacted interval is greatest (thickest) in the vicinity of the former AST and decreases with distance in each direction, except to the southeast. Impacted soil extends approximately 120-feet to the north, 350-feet to the southwest (the direction of groundwater flow), and 450-feet to the southeast (Figure 3.6).

The elongation toward the southeast is across the groundwater flow direction and supports the statement in the original RFI (Rust 1997) that there was a second release, south of the known spill at the ASTs. Based on review of the piping diagrams (Figure 2.3), it appears that there was a second release point along the fuel distribution pipeline southeast of monitoring well S-27-88. The vertical extent of visually impacted soil extends from approximately 8-15 feet bgs at several locations near the center of the impacted area (Figure 3.6). The stained soil depth intervals fit the original conceptual model of a large fuel hydrocarbon release that migrated laterally away from the release point(s) on the groundwater surface. Although visibly stained soil and elevated FID readings were found in many of the soil borings, no free product was observed in the soil cores. The combination of stained soil, the lack of free product, and the presence of methane in soil gas (see Table 3.2) indicates that LNAPL was once present in the stained intervals but has since degraded.

Only two analytes were detected at concentrations exceeding the PALs: TPH-DRO and naphthalene, both of which should be considered in remedy selection. TPH-DRO exceeded the PAL of 5,000 mg/kg in one sample collected near the former AST; i.e., 8,400 mg/kg in 13-SS-02 at 12-14 ft bgs. Naphthalene exceeded the PAL of 3.8 mg/kg at two locations; i.e., 29 mg/kg in 13-SS-02 at 12-14 ft bgs, 6.4 mg/kg in 13-SS-07 at 9-11 ft bgs, and 7.0 mg/kg (field duplicate of 5.1 mg/kg) in 13-SS-07 at 12-14 ft bgs. Thus, the area where exceedances of the PALs were detected is limited to the area immediately surrounding the locations of the two assumed releases (i.e., the former AST and the fuel distribution pipeline southeast of monitoring well S-27-88).

3.4.4 Soil Gas Contamination

Because potential risks from soil gas were not quantified in previous documents, Parsons added the following evaluation. Of the 26 VOCs detected in soil gas during the Parsons (2014) CMS data gap investigation, only benzene, chloroform, and ethylbenzene were detected at concentrations exceeding the PALs at 13-SG-01, 13-SG-02, 13-SG-04, and 13-SG-05 (Figure 3.7). VOC concentrations exceeding the PALs were detected near the former AST and in the general proximity of the fuel distribution pipeline southeast of monitoring well S-27-88. It should also be noted that several chemicals that were not detected in soil gas had detection limits greater than the PALs (see Appendix A.1) at soil gas VMPs 13-SG-01, 13-SG-02, and 13-SG-03, with the highest detection limits at 13-SG-02.

Following the TEAD-S Risk Assumptions Document (AQS 2015), those VOCs that exceeded the PALs (which are based on the USEPA vapor intrusion screening levels (VISLs)), or contributed to a cumulative risk greater than 1 x 10^{-6}, were further evaluated by calculating site-specific screening levels using the USEPA (2004) Johnson and Ettinger model. Separate screening levels were calculated for each VMP where VOCs were detected at concentrations greater than the PALs. Toxicity values for the USEPA (2004) Johnson and Ettinger model were taken from the USEPA (2015) Regional Screening Levels. The boring logs (Appendix C) from the nearest geoprobe borings were used to determine the predominant soil types for each soil gas VMP, as follows:

- 13-SG-01: the boring log for 13-SS-01 indicates that the soil type from 0-2.6 ft bgs is "silty gravel with sand" and the soil type from 2.6-10.6 ft bgs is "silt with sand." These were modeled as sand and silt loam, respectively.
- 13-SG-02: the boring log for 13-SS-11 indicates that the soil type from 0-5.5 ft bgs is "silty gravel with sand." This was modeled as sand.
- 13-SG-04: the boring log for 13-SS-06 indicates that the predominant soil type is "silt with sand." This was modeled as
- 13-SG-05: the boring log for 13-SS-09 indicates that the soil type from 0-5.5 ft bgs is "silty gravel with sand." This was modeled as sand.

Default USEPA (2004) soil, chemical, and building properties were used in the model along with default USEPA (2015) residential exposure parameters, with the exception that the air exchange rates were updated using the central tendency estimates from USEPA (2011). Since the USEPA (2004) version of the Johnson and Ettinger model does not account for the recommended Age Dependent Adjustment Factors (ADAFs) that are used to evaluate the residential cancer risks from the assumed inhalation of trichloroethene, this adjustment was applied by modifying the using the USEPA (2004) Johnson and Ettinger model to include the ADAF spreadsheets provided by USEPA (2016). The USEPA (2004) Johnson and Ettinger model spreadsheets for each VMP are provided in Appendix I.

Using a combination of the VISLs and site-specific soil gas screening levels calculated using the USEPA (2004) Johnson and Ettinger model, cumulative risks and hazards were estimated for all detected VOCs at each VMP using the following equations (AQS 2015):

$$Risk = \frac{C_{EPC}}{SL_c} \times TR$$

$$Hazard = \frac{C_{EPC}}{SL_{nc}} \times THQ$$

where:

C_{EPC} = VOC concentration in soil gas (µg/m^3)

SL_c = cancer-based USEPA VISL or site-specific screening level

SL_{nc} = noncancer-based USEPA VISL or site-specific screening level

THQ = Target hazard quotient (1.0)

TR = Target risk level (1 x 10^{-6})

Using the VISLs and site-specific soil gas screening levels calculated as described above, the cumulative residential risks and hazards from the assumed inhalation of VOCs that have migrated to indoor air from soil gas at 13-SG-01, 13-SG-02, and 13-SG-04 did not exceed the point of departure of 1 x 10^{-6} or the noncancer threshold value of 1 (see Tables 3.6 to 3.8). Therefore, the VOCs detected at concentrations greater than the PALs in soil gas at these locations do not represent contamination and do not need to be considered in remedy selection.

In contrast, the cumulative residential risk from the assumed inhalation of VOCs that have migrated to indoor air from soil gas at 13-SG-05 is approximately 1 x 10^{-5} (Table 3.9), which exceeds the threshold level of 1 x 10^{-6}. The only VOC that was detected at concentrations greater than the PALs at this sample location was chloroform, with a risk estimate of approximately 1 x 10^{-5}. Therefore, following the Risk Assumptions Document (AQS 2015), industrial worker risks were also estimated, using the same methods give above. The risk estimate from the assumed industrial worker inhalation of VOCs that have migrated to indoor air from soil gas at 13-SG-05 is approximately 3 x 10^{-6} (Table 3.10), with only the risks from chloroform being greater than 1 x 10^{-6}. The cumulative hazard estimates for residents and industrial workers were both below the noncancer threshold value of 1. Thus, the residential and industrial risks from chloroform in the vicinity of 13-SG-05 (i.e., the former ETF) should be considered during remedy selection.

If it is assumed that those chemicals with elevated detection limits in 13-SG-01 through 13-SG-03 were present at concentrations up to the method detection limit, the residential risk estimate[1] is approximately 6 x 10^{-6}, which is greater than the threshold level of 1 x 10^{-6}; however, the industrial worker risk estimate (4 x 10^{-7}) and hazard (0.003) are acceptable. Thus, the potential residential risks from the non-detected chemicals in 13-SG-01 through 13-SG-03 should be considered during remedy selection.

Field measurements for methane, carbon dioxide, and oxygen were recorded at all VMPs (Table 3.2) as an indicator of biodegradation of potential organic contaminants. The highest methane readings (8.2-9.2%) was measured at the same VMP (13-SG-02) as the highest carbon dioxide readings (13.0-13.2%) and lowest oxygen readings. (0.0-0.1%) This location is in the area of the former AST where LNAPL remains. The presence of both methane and carbon dioxide, and the lack of oxygen suggests that biodegradation of fuel hydrocarbons is occurring in the vicinity of the former AST (ITRC 2009b), although the lack of oxygen is limiting the degradation rate. Nonetheless, methane was measured in soil gas at up to 9.2%, which exceeds the lower explosive limit for methane of approximately 5%; therefore, there are potentially explosive levels of methane in soil gas at 13-SG-02 which should be considered during remedy selection. This appears to be limited to the immediate vicinity of 13-SG-02.

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[1] Modeled using the Johnson and Ettinger model and assuming soils were sand.

TABLE 3.6
RESIDENTIAL RISK ESTIMATES FOR VOCs DETECTED IN SOIL GAS AT 13-SG-01
TOOELE ARMY DEPOT - SOUTH

Chemical	Concentration ($\mu g/m^3$)	SL_c ($\mu g/m^3$)	SL_{nc} ($\mu g/m^3$)	Source	Risk	Hazard
Acetone	760	-	62,571	VISL	-	1.21E-02
Benzene	13	328	28,476		3.97E-08	4.57E-04
2-Butanone	61	-	52,143	VISL	-	1.17E-03
Cyclohexane	38	-	62,571	VISL	-	6.07E-04
1,2,4-Trimethylbenzene	22	-	73	VISL	-	3.01E-01
1,3,5-Trimethylbenzene	32	-	-	VISL	-	-
				Total	**4E-08**	**0.3**

Notes: 1 - see Appednix I.

Definitions:

SL_c = cancer-based residential soil gas screening level.

SL_{nc} = noncancer-based residential soil gas screening level.

VISL = USEPA Vapor Intrusion Screening Levels (VISLs) Version 3.3, based on May 2014 residential RSLs.

TABLE 3.7
RESIDENTIAL RISK ESTIMATES FOR VOCs DETECTED IN SOIL GAS AT 13-SG-02
TOOELE ARMY DEPOT - SOUTH

Chemical	Concentration ($\mu g/m^3$)	SL_c ($\mu g/m^3$)	SL_{nc} ($\mu g/m^3$)	Source	Risk	Hazard
Benzene	160	232	20,145	Calculated[1]	6.90E-07	7.94E-03
Cyclohexane	1,100	-	62,571	VISL	-	1.76E-02
1,3,5-Trimethylbenzene	48	-	-	VISL	-	-
				Total	**7E-07**	**0.03**

Notes: 1 - see Appednix I.

Definitions:

SL_c = cancer-based residential soil gas screening level.

SL_{nc} = noncancer-based residential soil gas screening level.

VISL = USEPA Vapor Intrusion Screening Levels (VISLs) Version 3.3, based on May 2014 residential RSLs.

TABLE 3.8
RESIDENTIAL RISK ESTIMATES FOR VOCs DETECTED IN SOIL GAS AT 13-SG-04
TOOELE ARMY DEPOT - SOUTH

Chemical	Concentration (µg/m^3)	SL$_c$ (µg/m^3)	SL$_{nc}$ (µg/m^3)	Source	Risk	Hazard
Acetone	2,300	-	323,286	VISL	-	7.11E-03
Benzene	24	412	35,793	Calculated[1]	5.83E-08	6.71E-04
2-Butanone	180	-	52,143	VISL	-	3.45E-03
Carbon disulfide	17	-	7,300	VISL	-	2.33E-03
Carbon tetrachloride	1.5	4.7	1,043	VISL	3.21E-07	1.44E-03
Chloroform	50	125	104,686	Calculated[1]	4.00E-07	4.78E-04
Cumene	0.75	-	4,171	VISL	-	1.80E-04
Cyclohexane	2.7	-	62,571	VISL	-	4.32E-05
Dichlorodifluoromethane	2	-	1,043	VISL	-	1.92E-03
cis-1,2-Dichloroethene	0.54	-	-	VISL	-	-
Ethylbenzene	19	1,436	1,333,808	Calculated[1]	1.32E-08	1.42E-05
2-Hexanone	48	-	313	VISL	-	1.53E-01
4-Methyl-2-pentanone	9.3	-	31,286	VISL	-	2.97E-04
Methyl tert-butyl ether	0.45	108	31,286	VISL	4.17E-09	1.44E-05
Methylene chloride	0.89	1,014	6,257	VISL	8.78E-10	1.42E-04
n-Propylbenzene	0.98	-	10,429	VISL	-	9.40E-05
Styrene	2.7	-	10,429	VISL	-	2.59E-04
Tetrachloroethene	18	108	417	VISL	1.67E-07	4.32E-02
Toluene	160	-	52,143	VISL	-	3.07E-03
1,1,1-Trichloroethane	0.73	-	52,143	VISL	-	1.40E-05
Trichloroethene	2.2	574	2,571	Calculated[1]	3.83E-09	8.56E-04
Trichlorofluoromethane	9.2	-	7,300	VISL	-	1.26E-03
1,2,4-Trimethylbenzene	2.8	-	73	VISL	-	3.84E-02
1,3,5-Trimethylbenzene	1.3	-	-	VISL	-	-
m,p-Xylene	81	-	1,043	VISL	-	7.77E-02
o-Xylene	21	-	1,043	VISL	-	2.01E-02
				Total	**1E-06**	**0.4**

Notes: 1 - see Appednix I.

Definitions:

SL$_c$ = cancer-based residential soil gas screening level.

SL$_{nc}$ = noncancer-based residential soil gas screening level.

VISL = USEPA Vapor Intrusion Screening Levels (VISLs) Version 3.3, based on May 2014 residential RSLs.

TABLE 3.9
RESIDENTIAL RISK ESTIMATES FOR VOCs DETECTED IN SOIL GAS AT 13-SG-05
TOOELE ARMY DEPOT - SOUTH

Chemical	Concentration ($\mu g/m^3$)	SL_c ($\mu g/m^3$)	SL_{nc} ($\mu g/m^3$)	Source	Risk	Hazard
Acetone	1,200	-	323,286	VISL	-	3.71E-03
Benzene	1.9	3.6	313	VISL	5.28E-07	6.07E-03
2-Butanone	91	-	52,143	VISL	-	1.75E-03
Carbon disulfide	1.8	-	7,300	VISL	-	2.47E-04
Carbon tetrachloride	1.1	4.7	1,043	VISL	2.35E-07	1.05E-03
Chloroethane	0.51	-	104,286	VISL	-	4.89E-06
Chloroform	960	73	61,438	Calculated[1]	1.31E-05	1.56E-02
Dichlorodifluoromethane	3.4	-	1,043	VISL	-	3.26E-03
cis-1,2-Dichloroethene	0.4	-	-	VISL	-	-
Ethylbenzene	5	11	10,429	VISL	4.45E-07	4.79E-04
2-Hexanone	18	-	313	VISL	-	5.75E-02
Methylene chloride	1.2	1,014	6,257	VISL	1.18E-09	1.92E-04
4-Methyl-2-pentanone	2	-	31,286	VISL	-	6.39E-05
n-Propylbenzene	0.42	-	10,429	VISL	-	4.03E-05
Styrene	0.77	-	10,429	VISL	-	7.38E-05
Tetrachloroethene	2.7	108	417	VISL	2.50E-08	6.47E-03
Toluene	8.9	-	52,143	VISL	-	1.71E-04
1,1,1-Trichloroethane	1	-	52,143	VISL	-	1.92E-05
Trichloroethene	1.1	4.8	21	VISL	2.30E-07	5.27E-02
Trichlorofluoromethane	180	-	7,300	VISL	-	2.47E-02
1,2,4-Trimethylbenzene	2	-	73	VISL	-	2.74E-02
1,3,5-Trimethylbenzene	0.77	-	-	VISL	-	-
m,p-Xylene	17	-	1,043	VISL	-	1.63E-02
o-Xylene	6.2	-	1,043	VISL	-	5.95E-03
				Total	**1E-05**	**0.2**

Notes: 1 - see Appednix I.

Definitions:

SL_c = cancer-based residential soil gas screening level.

SL_{nc} = noncancer-based residential soil gas screening level.

VISL = USEPA Vapor Intrusion Screening Levels (VISLs) Version 3.3, based on May 2014 residential RSLs.

TABLE 3.10
INDUSTRIAL WORKER RISK ESTIMATES FOR VOCs DETECTED IN SOIL GAS AT 13-SG-05
TOOELE ARMY DEPOT - SOUTH

Chemical	Concentration ($\mu g/m^3$)	SL_c ($\mu g/m^3$)	SL_{nc} ($\mu g/m^3$)	Source	Risk	Hazard
Acetone	1,200	-	1,357,800	VISL	-	8.84E-04
Benzene	1.9	16	1,314	VISL	1.21E-07	1.45E-03
2-Butanone	91	-	219,000	VISL	-	4.16E-04
Carbon disulfide	1.8	-	30,660	VISL	-	5.87E-05
Carbon tetrachloride	1.1	20	4,380	VISL	5.38E-08	2.51E-04
Chloroethane	0.51	-	438,000	VISL	-	1.16E-06
Chloroform	960	356	286,709	Calculated[1]	2.70E-06	3.35E-03
Dichlorodifluoromethane	3.4	-	4,380	VISL	-	7.76E-04
cis-1,2-Dichloroethene	0.4	-	-	VISL	-	-
Ethylbenzene	5	49	43,800	VISL	1.02E-07	1.14E-04
2-Hexanone	18	-	1,314	VISL	-	1.37E-02
Methylene chloride	1.2	12,264	26,280	VISL	9.78E-11	4.57E-05
4-Methyl-2-pentanone	2	-	131,400	VISL	-	1.52E-05
n-Propylbenzene	0.42	-	43,800	VISL	-	9.59E-06
Styrene	0.77	-	43,800	VISL	-	1.76E-05
Tetrachloroethene	2.7	472	1,752	VISL	5.72E-09	1.54E-03
Toluene	8.9	-	219,000	VISL	-	4.06E-05
1,1,1-Trichloroethane	1	-	219,000	VISL	-	4.57E-06
Trichloroethene	1.1	30	88	VISL	3.68E-08	1.26E-02
Trichlorofluoromethane	180	-	30,660	VISL	-	5.87E-03
1,2,4-Trimethylbenzene	2	-	307	VISL	-	6.52E-03
1,3,5-Trimethylbenzene	0.77	-	-	VISL	-	-
m,p-Xylene	17	-	4,380	VISL	-	3.88E-03
o-Xylene	6.2	-	4,380	VISL	-	1.42E-03
				Total	**3E-06**	**0.05**

Notes: 1 - see Appednix I.

Definitions:

SL_c = cancer-based residential soil gas screening level.

SL_{nc} = noncancer-based residential soil gas screening level.

VISL = USEPA Vapor Intrusion Screening Levels (VISLs) Version 3.3, based on May 2014 residential RSLs.

3.4.5 Groundwater Contamination

TPH-DRO exceeded the PAL of 10,000 µg/L in both S-CAM-1 and S-CAM-2, where it was detected at 110,000 and 49,000 µg/L, respectively. The high concentrations of TPH-DRO detected in groundwater samples from these monitoring wells are not unexpected as both wells contain measurable free product (Figure 3.4).

In these same two monitoring wells, multiple diesel fuel constituents were also detected above the PALs, including benzene, ethylbenzene, 2-methylnaphthalene, naphthalene, 1,2,3-trimethylbenzene, 1,2,4-trimethylbenzene, m,p-xylene, and o-xylene, all of which should be considered during remedy selection. Isoconcentration maps showing the extent of groundwater contaminants detected at concentrations exceeding their respective PALs are provided in Appendix L.

Outside of S-CAM-1 and S-CAM-2, naphthalene exceeded the PAL of 3.8 µg/L in 13-HPGW-05 (in the field duplicate only and via Method 8270 but not via Method 8260), 13-HPGW-07, 13-HPGW-08, S-29-88 (via Method 8270 but not via Method 8260), S-30-88, S-78-91, S-82-91 (via Method 8270 but not via Method 8260), and S-91-91 (Figures 3.9 and L.7). This is roughly the same distribution as visibly stained soils were observed (Figure 3.6), but extends further to the southwest (i.e., in the direction of groundwater flow) outside of the area of visibly stained soils to wells S-30-88, S-78-91 and S-91-91. 2-Methylnaphthelene also exceeded the PAL of 36 µg/L in 13-HPGW-07, which is next to the assumed release along the underground fuel pipeline (Figures 3.9 and L.10). Overall, TPH-DRO and diesel fuel constituents exceeded the PALs in an area similar (but larger to the southwest) in size and shape to the extent of visibly stained soils, with the highest concentrations centered on S-CAM-1 and S-CAM-2.

Chloroform was detected in groundwater above the PALs (but not the MCLs) in 13-HPGW-03, 13-HPGW-05, 13-HPGW-06, S-55-90, and S-78-91. Note that these locations run roughly east to west (Figures 3.9 and L.4) starting at S-55-90 and ending at S-78-91. This distribution does not follow the flow of groundwater (which is to the southwest). Note, however, that when detection limits have been low enough, chloroform has generally been detected in S-78-91. The historical data (Table 3.11) appear to indicate that chloroform concentrations have been decreasing in S-78-91 since it was first detected in 2002. With CAMDS closure (URS 2012), all known sources of chloroform have been removed.

Trichloroethene was detected in groundwater above the PALs (but not the MCLs) in two locations west of CAMDS; i.e., 13-HPGW-04 and S-78-91 (Figures 3.9 and L.1). These two sample locations are adjacent to each other, with the concentration in the upgradient sample (i.e., 3.1 µg/L at S-78-91) higher than the downgradient sample (i.e., 0.86 µg/L). Trichloroethene was not detected in the samples upgradient from S-78-91 (i.e., S-82-91 and S-CAM-2), suggesting that the area of groundwater contamination is limited in extent. Historically, trichloroethene has been detected at S-78-91 at about the same concentration and does not appear to be increasing in concentration (Table 3.11). With CAMDS closure (URS 2012), all known sources of trichloroethene have been removed. In the deep well (i.e., S13-CAM-DW1), the metals arsenic cobalt, manganese, molybdenum, and thallium were detected above the PALs. The presence of these metals is believed to be due to the high TDS (i.e., 17,000 mg/L) and not a release at the site.

TABLE 3.11
TRICHLOROETHENE AND CHLOROFORM IN S-78-91 (µg/L)
1999-2010 DATA FROM PARSONS (2013a)
TOOELE ARMY DEPOT - SOUTH

Date	Trichloroethene	Chloroform
12/1999	<4.0	<0.80
10/2000	3.4	<5.0
10/2001	3.0	<5.0
10/2002	3.0	10
10/2003	4.0	<5.0
10/2004	2.8	3.7
9/2005	3.0	<5.0
12/2006	3.9	2.1
11/2007	3.2	<0.93
11/2008	2.9	<1.1
7/2010	1.5	0.27
11/2014	3.1	0.57

Note that the only exceedance of the MCLs in shallow groundwater was at S-CAM-1, where benzene was detected at 15 µg/L (vs. MCL of 5 µg/L) (Table A.3). Thus, based on the MCLs, the extent of shallow groundwater contamination is very limited. Arsenic also exceeded the MCLs in the deep well (i.e., S13-CAM-DW1), however, this is believed to be correlated with high TDS (i.e., 17,000 mg/L).

3.4.6 Evaluation of Vertical Groundwater Gradient

Prior to determining the vertical gradient, the water level for S-CAM-2 was corrected to account for the different densities of the groundwater and free product layer. The water level was corrected as described in Appendix I of the Parsons (2014) "*SWMU 13 CMS Data Gap Work*

Plan and SWMU 30 Phase II RFI Addendum Work Plan," and Exhibits III.9 and III.10 of the USEPA (1996) guidance document *"How to Effectively Recover Free Product at Leaking Underground Storage Tank Sites."* The correction to the groundwater elevation was made using the following formula.

$$h_c = h_m + \left(H_0 \frac{\rho_o}{\rho_w}\right)$$

where:

h_c = hydraulic head corrected (ft amsl)
h_m = measured elevation of hydrocarbon-water interface (ft)
H_o = thickness of hydrocarbon layer (ft)
ρ_o = hydrocarbon density (g/ml)
ρ_w = water density (g/ml); assumed = 1.0

As the three aboveground storage tanks and underground piping that contributed to the approximately 38,000 gallon release contained heating oil to fuel boilers at the CAMDS facility, No. 2 or No. 4 heating oil would have been the most likely grade of fuel released. For the groundwater elevation correction of S-CAM-2, a density of 0.885 g/ml was used, which is the average density of No. 2 and No. 4 heating oil.

Using the above formula and water level measurements for S-CAM-2 measured 6 May 2016 (Table 3.1), a corrected groundwater elevation for S-CAM-2 of 5033.92 ft amsl (11.52 ft TOC or 9.82 ft bgs) was used in determining the vertical gradient between S-CAM-2 and S13-CAM-DW1.

To evaluate the potential for vertical migration of groundwater at SWMU 13, a vertical hydraulic gradient was calculated between the shallow (S-CAM-2) and deep (S13-CAM-DW1) screen intervals using the USEPA (2016) vertical gradient calculator. Input parameters to the USEPA (2016) vertical gradient calculator include the following for both the shallow (S-CAM-2) and deep (S13-CAM-DW1) monitoring wells.

- Ground surface elevation (ft amsl)
- Depth to well screen (ft bgs)
- Screen length (ft)
- Depth to water (ft bgs)

With the exception of the depth to groundwater for S-CAM-2, all input parameters were those shown on Table 3.1 from measurements obtained on 6 May, 2016. For S-CAM-2, depth to groundwater was derived as described above.

The calculated screen mid-point vertical gradient is a downward gradient of 0.008211 feet. Although this indicates that there is a slight downward gradient between wells S-CAM-2 and S13-CAM-DW1, it is felt that contamination found in deeper groundwater is the result of processes such as diffusion, and not from vertical groundwater movement. Output from the USEPA (2016) vertical gradient calculator is provided in Appendix O.

3.5 ESTIMATED VOLUME REQUIRING CORRECTIVE ACTION

At petroleum release sites, LNAPL is present in two states in soil. That part which is considered to be potentially recoverable (free phase) and that part which is immobile and bound to the matrix (soil at SWMU 13) into which it was released (residual phase). The later state will remain even after the recoverable portion is removed.

During the Parsons (2014) CMS data gap investigation, visible staining of soil representing the residual portion was observed in the geoprobe soil cores at depths ranging from 8-15 ft bgs with an average thickness of 4.33 ft over an area of approximately 178,000 square feet (Figures 3.6 and 3.10). Based on these numbers, approximately 28,546 cubic yards of soil at SMWU 13 has been impacted by the fuel spill.

Within the 178,000 square feet, free phase LNAPL was found in monitoring wells S-28-88, S-CAM-1, and S-CAM-2 at approximately 12 ft bgs over approximately 60,000 square feet (Figure 3.10). The thickness of LNAPL is these monitoring wells was measured in February 2014 during the SWMU 13 CMS data gap investigation (Parsons 2014) as 1.52 ft in S-CAM-1, 0.93 ft in S-CAM-2, and 0.62 ft in S-28-88.

Although the thickness of a layer of free phase LNAPL in a monitoring well can be accurately measured, it is usually larger (by up to a factor 4) than the thickness in the surrounding soil (USEPA 1996). This difference in thickness is the result of the capillary pressure within the monitoring well casing, and the changes in groundwater levels over time. Multiple methods are available to estimate the thickness/volume of free phase LNAPL in soil and are based on theoretical models, correlations between hydrocarbon thickness in wells, and specific oil volumes. The reliability of thickness/volume estimates is typically low, with accuracy within an order of magnitude. Even with substantial available data, thickness/volume estimates with an uncertainty of minus 50% to plus 100% are the best that can be expected (USEPA 1996).

Of the equations reviewed by USEPA (1996) to estimate LNAPL thickness in soil, the equation derived by de Pastrovich et al. (1979) uses known and measureable variables and is more accurate in finer grained soils (as are present at SWMU 13). Therefore, de Pastrovich et al.’s (1979) equation is used here to estimate is LNAPL thickness in soils and is as follows:

$$H_f = \frac{H_o\,(P_w - P_o)}{P_o}$$

H_f = Thickness of LNAPL in soil (feet)

H_o = LNAPL thickness in well (feet)

P_w = Density of water (g/ml)

P_o = Density of hydrocarbon (g/ml)

Figure 3.10

Area Requiring Corrective Action

Legend

○	Geoprobe without Sample
◉	Geoprobe with TPH-DRO < TIER I
◉	Geoprobe with TPH-DRO > TIER 1
⊗	Former AST Location
⊕	Monitoring Well
➡	General Direction of Groundwater Movement (based on freshwater equivalent head)
▭	Stained Soil - Approximate
⬚	Extent of Free Product-Feb. 2014
🟥	SWMU Boundary

Imagery: ESRI (c) 2013 TPHC: Dames & Moore, 2002
Boundary, SWMUs, Wells: Deseret Chemical Depot

Feet
0 40 80

Projection & Grid Coorindates:
NAD83 StatePlane Utah Central

PARSONS

Date:	5/14/2015
Prepared:	RGS
Checked:	DS
Revision:	1

X:\GISCADD\projects\TEAD_S_13_30\Mapfiles\CMS_Workplan\13_correction_action_11_17.mxd 5/14/2015

Given a density of 1.0 g/ml for water, and a density of 0.866 g/ml for #2 heating oil, the estimated thickness of LNAPL in the soil surrounding monitoring wells S-CAM-1, S-CAM-2, and S-28-88 are approximately 0.235 ft, 0.144 ft, and 0.094 ft, respectively (Appendix J).

The estimated LNAPL thickness in soil can be combined with the other observations from the site to provide the following depth distribution of petroleum impacted soils within the area where LNAPL is present in groundwater:

Depth of petroleum stained soils: 8-15 ft bgs

Depth of LNAPL in soil: 11.5-12.5 ft bgs

Depth of water bearing zone: 12-20 ft bgs

Based on the LNAPL thickness estimated above, the volume of free phase LNAPL remaining at SWMU 13 within the 60,000 square foot area was derived as follows:

$$V = P_e\ (A\ \times\ Avg\ H_f)$$

V = Volume (cubic feet)

P_e = Effective porosity (%)

A = Area of affected media (square feet)

$Avg\ H_f$ = Thickness of hydrocarbon in soil (feet)

Assuming an effective porosity of 0.20 for silt (USEPA 1996), and an average thickness of free product of 0.158 ft surrounding monitoring wells S-CAM-1, S-CAM-2, and S-28-88, the volume of potentially recoverable free phase LNAPL remaining at SWMU 13 is estimated to be 1,900 cubic feet or 14,000 gallons (Appendix J). This portion will require corrective action due to the presence of free phase LNAPL. Additionally, a TPH-DRO concentration in soil of 8,400 mg/kg at 12 to 14 feet bgs (13-SS-02) exceeds the PAL of 5,000 mg/kg for petroleum contaminated sites.

3.6 PLANT UPTAKE EVALUATION

Groundwater at SWMU 13 is both shallow (approximately 10 ft bgs) and contaminated with petroleum hydrocarbons. Although parts of SWMU 13 are currently covered by buildings, building foundations, gravel roads, and asphalt, groundwater contamination extends outside of these areas to undeveloped and vegetated areas. Where there is vegetation overlying the shallow groundwater plume, it is possible that plants could take up the contaminants in groundwater resulting in ecological exposures to a) the herbivores that eat the plants and b) the carnivores that eat those herbivores.

The first step in determining whether plant uptake of contaminants in groundwater is possible is to determine whether the plants present in the area over the plume have roots that can reach groundwater. Rust (1997) described the vegetation from the westerns CAMDS fenceline to at least 1,100 feet to the west as follows: “important plant species include black greasewood (50 percent; Sarcobatus vermiculatus), bottlebrush squirreltail (15 percent; *Sitanion hystrix*); alkali sacaton (*Sporabolus airoides*), seepweed (*Suaeda occidentalis*), shadscale (*Atriplex confertifolia*), and trident saltbush (*Atriplex tridentate*) each comprise about 5 percent of the vegetation cover.”

According to Anderson (2004), the “maximum rooting depth of black greasewood is governed by the depth to a saturated zone,” with maximum rooting depths reported as deep as 20 ft bgs across the plant’s range. In Utah, the maximum reported rooting depth for black greasewood is 18 ft bgs (Anderson 2004). Thus, the roots of the predominant plant to the west of CAMDS over the groundwater plume may reach groundwater.

To determine whether bioaccumulative organics were present in groundwater due to past petroleum releases, select groundwater samples were analyzed for PAHs. The PAHs detected in groundwater include acenaphthene, anthracene, fluorene, 2-methylnaphthalene, naphthalene, phenanthrene, and pyrene (Table A.3). Although none of these are specifically listed as “persistent, bioaccumulative, and toxic pollutants” in the Risk Assumptions Document (AQS 2015), USEPA (2007a) indicates that they may bioaccumulate in plants and terrestrial invertebrates, but not small mammals. Therefore, potentially bioaccumulative organics are present in groundwater.

USEPA (2007a) provides bioaccumulation equations for soils to plants, but not for groundwater to plants. Therefore, to evaluate plant uptake from groundwater, measured concentrations in groundwater were converted to concentrations in soil using equilibrium partitioning. Soil concentrations were calculated assuming the soils immediately above the water table are silt and using the highest fraction of organic carbon specified in the Risk Assumptions Document (AQS 2015) for soils at TEAD-S (i.e., 0.57%). The equations used, parameter values, and estimated PAH concentrations in soils are shown in Table 3.12. Concentrations of PAHs in plants were then predicted using the chemical specific soil to plant uptake equations from USEPA (2007a). For 2-methylnapthalene, no chemical-specific equation was available; therefore, the generic low molecular weight PAH equation was used. Predicted concentrations of PAHs ranged from 0.0014 to 80 mg/kg in plant tissues, with a total low molecular weight PAH concentration of 98 mg/kg and a total high molecular weight PAH concentration of 5.6 mg/kg (Table 3.13).

To evaluate whether the predicted concentrations of PAHs in plants at SWMU 13 represent a potential hazard to ecological receptors, the USEPA Ecological Soil Screening Levels (EcoSSLs) were used.

Although USEPA (2007b) only provides screening levels for soils, the equation provided by USEPA (2003) to calculate hazard quotients in the EcoSSLs can be used to calculate a screening level for PAHs in plants protective of herbivores (i.e., the vole, with a diet of 100% flora).

TABLE 3.12
PREDICTED CONCENTRATIONS OF PAHs IN SOILS
TOOELE ARMY DEPOT - SOUTH

Equilibrium Partitioning Equation (USEPA 2002):

$$C_s = C_{gw} \times \left(K_{oc} \times f_{oc}\right) + \frac{\theta_w + \left(\theta_a \times H'\right)}{\rho_d}$$

Parameter	Units	Value	Source	Notes:
f_{oc}	unitless	0.0057	AQS (2014)	1
Θ_a	(L/L, or unitless)	0.322	USEPA (2004)	Using properties for silt
Θ_w	(L/L, or unitless)	0.167	USEPA (2004)	Using properties for silt
ρ_d	(kg/L)	1.35	USEPA (2004)	Using properties for silt
PAH	**C_{gw} (mg/L)**	**K_{oc} (L/kg)^2**	**H' (unitless)^2**	**C_{soil} (mg/kg)**
Acenaphthene	0.057	5.03E+03	7.52E-03	1.64
Anthracene	0.068	1.64E+04	2.27E-03	6.35
Fluorene	0.064	9.16E+03	3.93E-03	3.35
2-Methylnaphthalene	2.90	2.48E+03	2.12E-02	41.33
Naphthalene	0.73	1.54E+03	1.80E-02	6.52
Phenanthrene	0.83	2.24E+04	1.74E-03	106.02
Pyrene	0.025	5.43E+04	4.87E-04	7.75

Definitions:

C_{gw} = concentration in groundwater

C_s = concentration in soil or soil EPC

PAH = polycyclic aromatic hydrocarbon

Notes:

1 - Value for Hiko Peak Complex, Taylors Flat loam, and Bramwell silty loam

2 - From USEPA (2015), except for phenanthrene, which is from USEPA (2012)

TABLE 3.13
PREDICTED CONCENTRATIONS OF PAHs IN PLANTS
TOOELE ARMY DEPOT - SOUTH

PAH	C_{soil} (mg/kg)	Plant Uptake Factor (kg soil dw / kg plant dw)	Source	C_p (mg/kg)	Molecular Weight Category
Acenaphthene	1.64	$\ln(C_p) = -0.8556 * \ln(C_s) - 5.562$	USEPA (2007), Table 4b	2.51E-03	Low
Anthracene	6.35	$\ln(C_p) = 0.7784 * \ln(C_s) - 0.9887$	USEPA (2007), Table 4b	1.57E+00	Low
Fluorene	3.35	$\ln(C_p) = -0.8556 * \ln(C_s) - 5.562$	USEPA (2007), Table 4b	1.37E-03	Low
2-Methylnaphthalene	41.33	$\ln(C_p) = 0.4544 * \ln(C_s) - 1.3205$	USEPA (2007), Table 4b[1]	1.45E+00	Low
Naphthalene	6.52	$C_p = 12.2 * C_s$	USEPA (2007), Table 4b	7.95E+01	Low
Phenanthrene	106.02	$\ln(C_p) = 0.6203 * \ln(C_s) - 0.1665$	USEPA (2007), Table 4b	1.53E+01	Low
Pyrene	7.75	$C_p = 0.72 * C_s$	USEPA (2007), Table 4b	5.58E+00	High

Definitions:

C_p = concentration in terrestrial plants or plant EPC

C_s = concentration in soil or soil EPC

PAH = polycyclic aromatic hydrocarbon

Notes:

1 - No uptake equation for 2-methylnaphthalene.

Using general low molecular weight PAH uptake equation.

Although USEPA (2007b) EcoSSL could also be used to calculate a screening level for PAHs in invertebrates protective of insectivores (i.e., the shrew, with a diet of 100% invertebrates), invertebrates at SWMU 13 are not assumed to be exposed to PAHs. This is because PAH contamination at SMWU 13 is assumed to be in groundwater, which is at about 10 ft bgs, and soil invertebrates are not assumed to be exposed to soils that deep.

The original equation used to calculate EcoSSLs for herbivores (USEPA 2003) is as follows:

$$Hazard\ quotient = \frac{FIR \times \left[(C_s \times P_s) + C_p\right]}{TRV}$$

FIR = Food ingestion rate (kg/kg-d)

C_p = Concentration in plants (mg/kg)

C_s = Concentration in soil (mg/kg)

P_s = Proportion of soil in diet

TRV = Toxicity reference value (mg/kg-d)

Removing the terms for soils and re-arranging to solve for C_p results in the following equation:

$$C_p = \frac{TRV \times Hazard\ quotient}{FIR}$$

Using the values from USEPA (2007b) for FIR and the TRVs for high and low molecular weight PAHs with a target hazard quotient of one yields screening levels of 7 and 750 mg/kg for high and low molecular weight PAHs, respectively. Given that 1) total predicted low molecular weight PAH concentration is plants of 98 mg/kg is less than the EcoSSL for plants of 750 mg/kg and 2) the total predicted high molecular weight PAH concentration is plants of 5.6 mg/kg is less than the EcoSSL for plants of 7 mg/kg, it is assumed that PAH uptake by plants does not represent a potential ecological hazard.

3.7 EVALUATION OF GROUNDWATER DISCHARGE TO SURFACE WATER

To evaluate the potential for petroleum hydrocarbon constituents in groundwater at SWMU 13 to discharge to the unnamed wetland located along TEAD-S’ western boundary, the groundwater data from 2014 was compared the results from the last complete round of groundwater sampling at SWMU 13; i.e., Rust’s (1997) sampling in 1993. The two most downgradient wells from the ASTs that sampled in 2014 are S-30-88 and S-91-91. TPH-DRO and naphthalene were detected in both wells (S-30-88: 1,500 and 9.2 µg/L respectively; S-91-91:

130 and 0.57 µg/L, respectively) and several other petroleum hydrocarbon constituents were detected in S-30-88 at concentrations less than naphthalene (Figure 3.9). In 1993, TRPH and naphthalene were not detected in S-30-88 (detection limits of 1,150 and 0.5 µg/L, respectively) or S-91-91 (detection limits of 1,140 and 0.5 µg/L, respectively). Thus, the groundwater plume appears to have migrated since 1993.

To determine how far the groundwater plume may migrate in the future, BIOSCREEN-AT v1.45, a screening-level model developed by the Air Force Center for Environmental Excellence was used. BIOSCREEN simulates the migration and natural attenuation of dissolved hydrocarbons in groundwater at petroleum fuel release sites. The model is based on the Domenico analytical solute transport model, has the ability to simulate advection, dispersion, adsorption, and aerobic decay, as well as anaerobic reactions, which have been shown to be the dominant biodegradation processes at many petroleum release sites.

BIOSCREEN-AT v1.45 is an update to BIOSCREEN v1.4, which is still distributed by USEPA. BIOSCREEN-AT v1.45 is compatible with current versions of Excel and has also added an exact analytical solution for solute transport from a patch boundary condition within a semi-infinite aquifer.

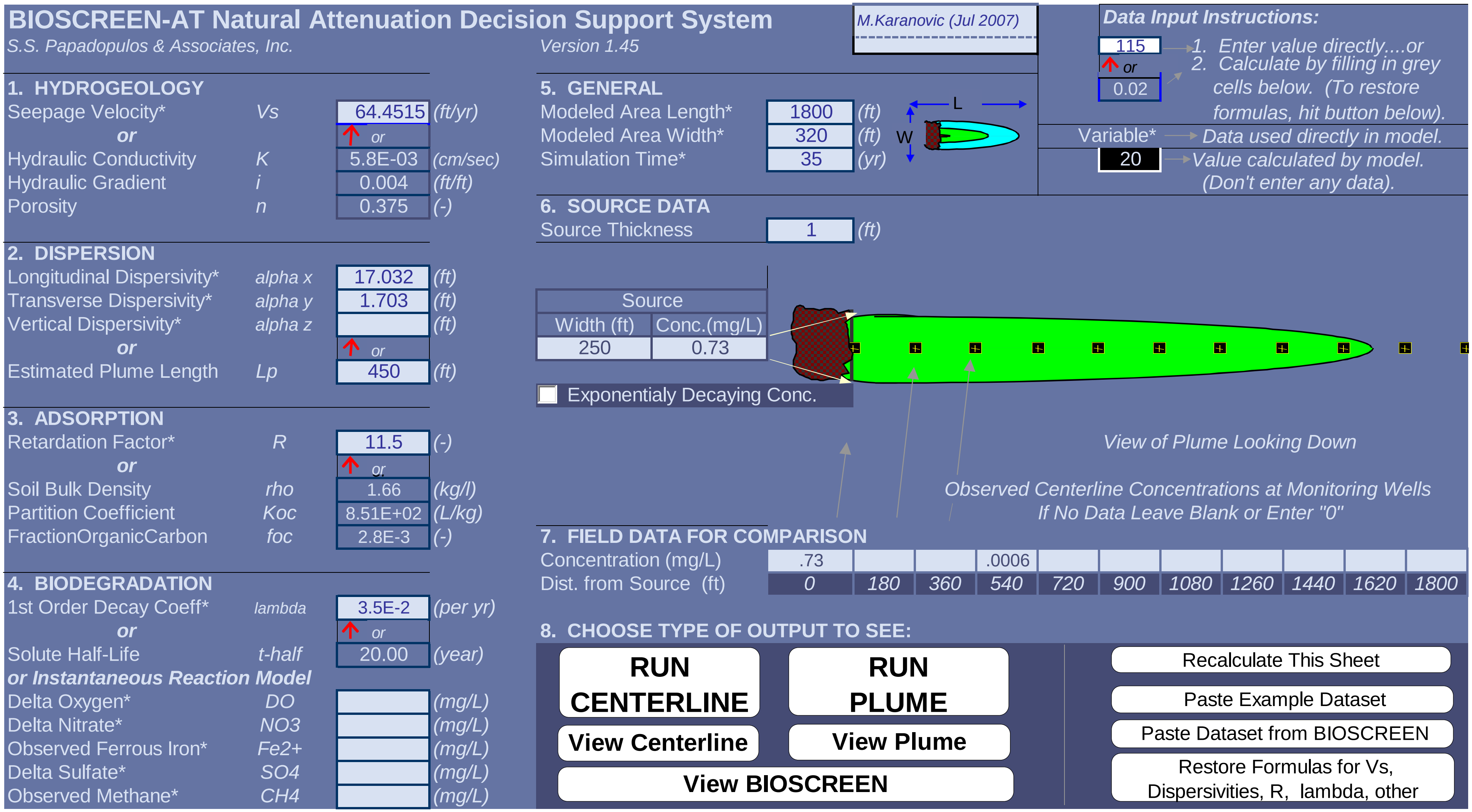
Since naphthalene was the petroleum hydrocarbon constituent detected at the highest concentration in the most downgradient well (i.e., S-91-91), BIOSCREEN-AT was used to model naphthalene. The extent of the naphthalene plume was estimated by assuming that S-91-91 represented the downgradient end of the plume and that the source was southernmost extent of LNAPL. Thus, the plume length was estimated at approximately 450 feet. The seepage velocity in the model was calculated using the upper hydraulic conductivity calculated by Rust (1997) for S-91-91 (0.00584 cm/sec) with the porosity (0.4) and hydraulic gradient (0.004 ft/ft) recommended in Parsons (2013a). To provide a more protective estimate of how far naphthalene can travel in an aquifer, the lower end f_{oc} (0.28%) provided in the Risk Assumptions Document (AQS 2015) and the K_{oc} for naphthalene in estuarine sand (851 L/kg) from Montgomery (2007) were used in the model. Default soil properties for sand from USEPA (2004) were used, in accordance with the description of the lithology in the screened interval for S-91-91 in Parsons (2013a). As the source of dissolved naphthalene in groundwater was assumed to be LNAPL, the source was assumed to be 1 ft thick and the source area was assumed to be 250 feet wide (i.e., the width of LNAPL in Figure 3.4) with a naphthalene concentration of 730 µg/L (i.e., the concentration at S-CAM-1). The input parameters are shown in Figure 3.11.

Since the release was assumed to have occurred sometime between 1980 and 1985, the model was initially run for 35 years. At 35 years, the model’s predictions for the no-degradation case approximately match observed concentrations, with 0.9 µg/L predicted at the approximate location of S-91-91, where naphthalene was measured at 0.57 µg/L (see Figure 3.12). However, if degradation is assumed (with a half-life of 6 months (Montgomery 2007)), the model estimates that the plume length should be considerably shorter (Figure 3.12). Thus, the half-life of naphthalene in groundwater at TEAD-S may be longer, potentially due to the higher salinities than are normally evaluated. Therefore, the model was calibrated to match observations and a half-life of 20 years was assumed (Figure 3.13).

Lastly, the model was run to predict the distribution of naphthalene at 200 years to evaluate whether naphthalene would eventually reach surface water. In 200 years, naphthalene could reach as far as approximately 1,600 feet downgradient in the absence of biodegradation. However, if naphthalene is assumed to degrade with a half-life of 20 years, naphthalene should migrate downgradient no further than approximately 1,000 feet (Figure 3.14). Note that naphthalene half-lives are generally much shorter than 20 years (e.g., Montgomery 2007). Therefore, the extent of the naphthalene plume developed for this evaluation is likely highly over-estimated. Given that the nearest surface water is approximately 3,000 feet to the west of SWMU 13, it is highly unlikely that the naphthalene in groundwater at SWMU 13 will reach surface water within the next 200 years.

FIGURE 3.11

BIOSCREEN-AT v1.45 Input Parameters



BIOSCREEN-AT Natural Attenuation Decision Support System

S.S. Papadopulos & Associates, Inc.

Version 1.45

M.Karanovic (Jul 2007)

Data Input Instructions:

115 → 1. Enter value directly....or
or
0.02 ← 2. Calculate by filling in grey cells below. (To restore formulas, hit button below).

Variable* → Data used directly in model.

20 → Value calculated by model. (Don't enter any data).

1. HYDROGEOLOGY

Seepage Velocity*	Vs	64.4515	(ft/yr)
or		or	
Hydraulic Conductivity	K	5.8E-03	(cm/sec)
Hydraulic Gradient	i	0.004	(ft/ft)
Porosity	n	0.375	(-)

2. DISPERSION

Longitudinal Dispersivity*	alpha x	17.032	(ft)
Transverse Dispersivity*	alpha y	1.703	(ft)
Vertical Dispersivity*	alpha z		(ft)
or		or	
Estimated Plume Length	Lp	450	(ft)

3. ADSORPTION

Retardation Factor*	R	11.5	(-)
or		or	
Soil Bulk Density	rho	1.66	(kg/l)
Partition Coefficient	Koc	8.51E+02	(L/kg)
FractionOrganicCarbon	foc	2.8E-3	(-)

4. BIODEGRADATION

1st Order Decay Coeff*	lambda	3.5E-2	(per yr)
or		or	
Solute Half-Life	t-half	20.00	(year)
or Instantaneous Reaction Model			
Delta Oxygen*	DO		(mg/L)
Delta Nitrate*	NO3		(mg/L)
Observed Ferrous Iron*	Fe2+		(mg/L)
Delta Sulfate*	SO4		(mg/L)
Observed Methane*	CH4		(mg/L)

5. GENERAL

Modeled Area Length*	1800	(ft)
Modeled Area Width*	320	(ft)
Simulation Time*	35	(yr)

6. SOURCE DATA

Source Thickness 1 (ft)

Source	
Width (ft)	Conc.(mg/L)
250	0.73

☐ Exponentialy Decaying Conc.

View of Plume Looking Down

Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

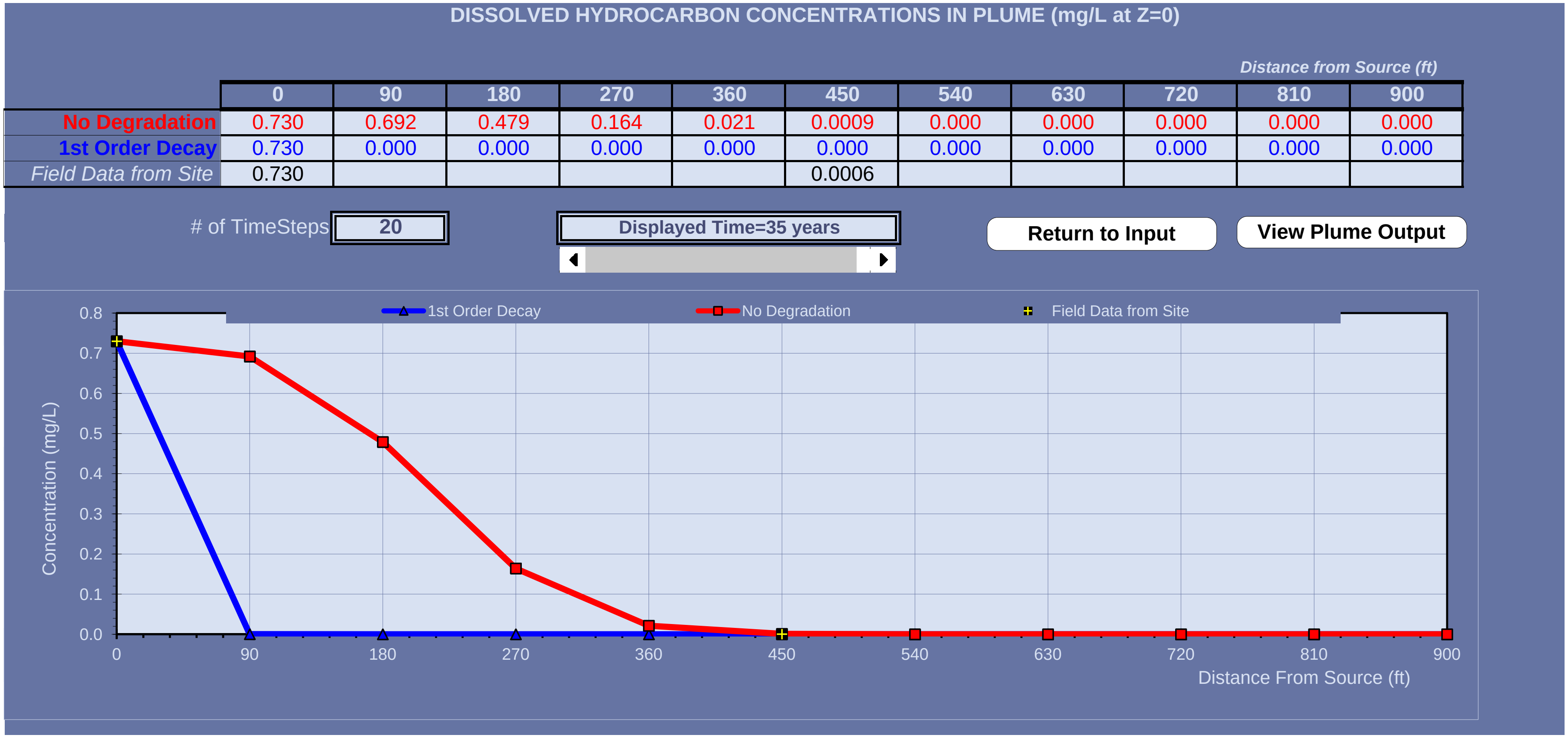
7. FIELD DATA FOR COMPARISON

Concentration (mg/L)	.73			.0006							
Dist. from Source (ft)	0	180	360	540	720	900	1080	1260	1440	1620	1800

8. CHOOSE TYPE OF OUTPUT TO SEE:

FIGURE 3.12

BIOSCREEN-AT Output at 35 Years with a Half-Life of 0.6 Years



DISSOLVED HYDROCARBON CONCENTRATIONS IN PLUME (mg/L at Z=0)

Distance from Source (ft)

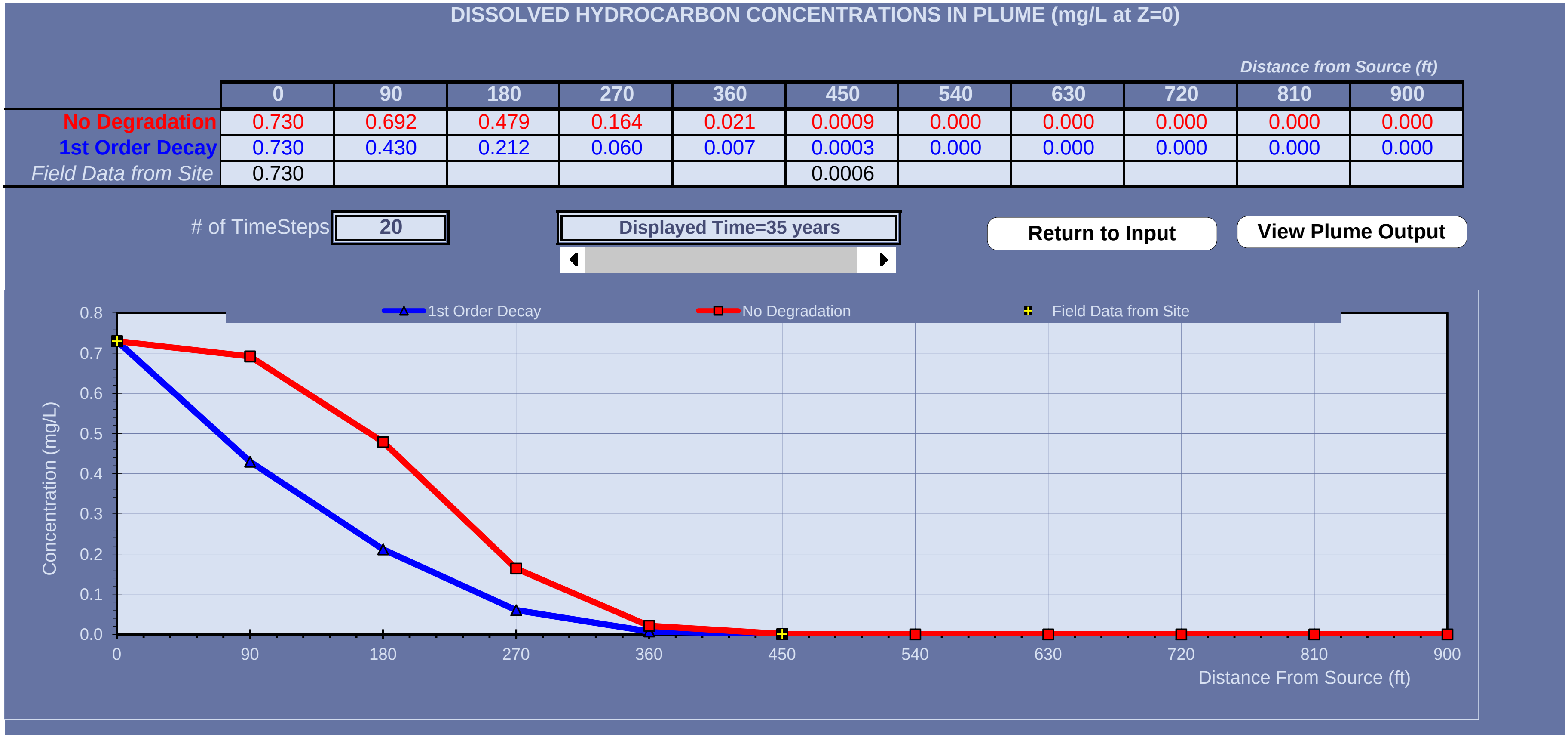
	0	90	180	270	360	450	540	630	720	810	900
No Degradation	0.730	0.692	0.479	0.164	0.021	0.0009	0.000	0.000	0.000	0.000	0.000
1st Order Decay	0.730	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Field Data from Site	0.730					0.0006					

# of TimeSteps: 20

Displayed Time=35 years

FIGURE 3.13

BIOSCREEN-AT Output at 35 Years with a Half-Life of 20 Years



DISSOLVED HYDROCARBON CONCENTRATIONS IN PLUME (mg/L at Z=0)

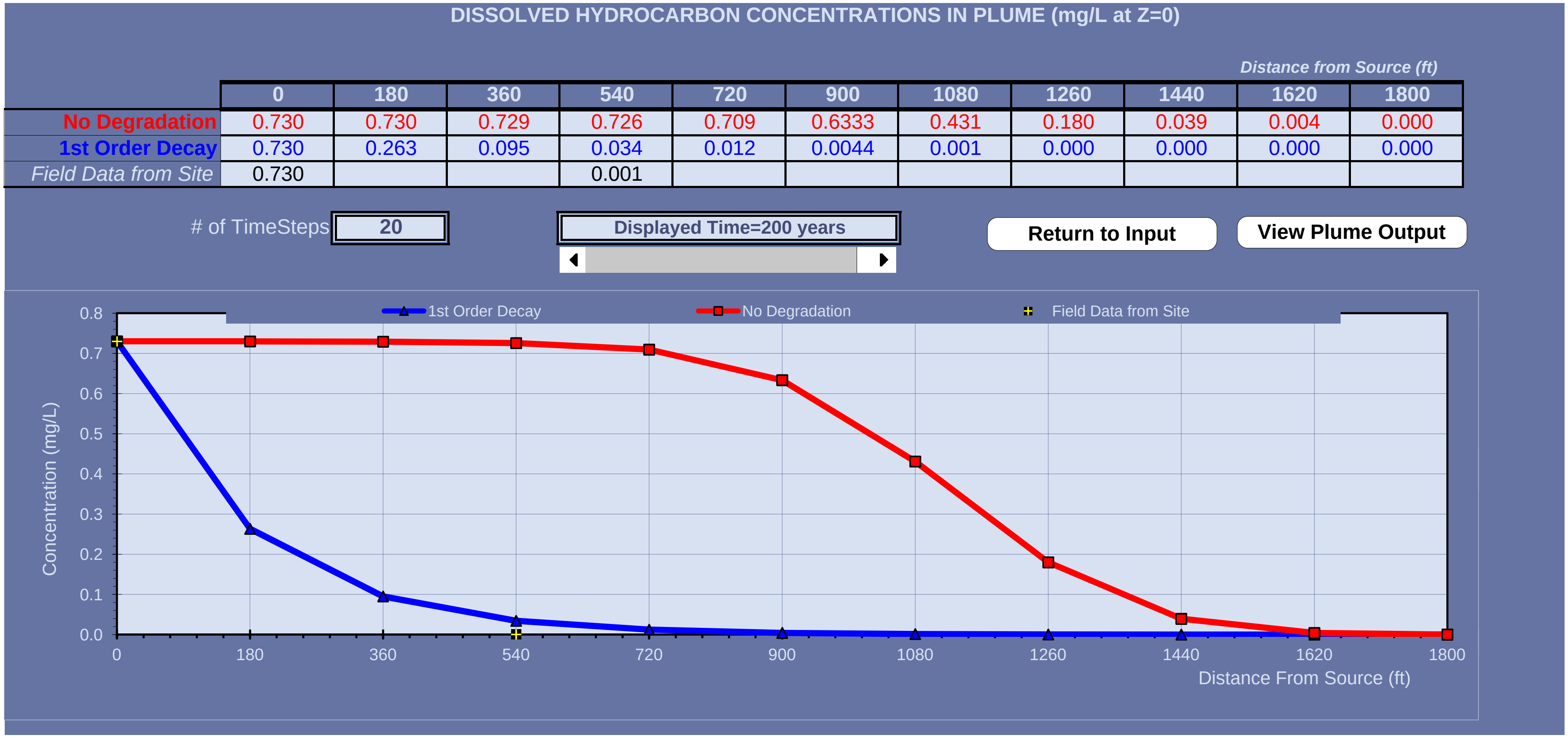
Distance from Source (ft)

	0	90	180	270	360	450	540	630	720	810	900
No Degradation	0.730	0.692	0.479	0.164	0.021	0.0009	0.000	0.000	0.000	0.000	0.000
1st Order Decay	0.730	0.430	0.212	0.060	0.007	0.0003	0.000	0.000	0.000	0.000	0.000
Field Data from Site	0.730					0.0006					

# of TimeSteps 20

Displayed Time=35 years

FIGURE 3.14
BIOSCREEN-AT Output at 200 Years with a Half-Life of 20 Years



DISSOLVED HYDROCARBON CONCENTRATIONS IN PLUME (mg/L at Z=0)

Distance from Source (ft)

	0	180	360	540	720	900	1080	1260	1440	1620	1800
No Degradation	0.730	0.730	0.729	0.726	0.709	0.6333	0.431	0.180	0.039	0.004	0.000
1st Order Decay	0.730	0.263	0.095	0.034	0.012	0.0044	0.001	0.000	0.000	0.000	0.000
Field Data from Site	0.730			0.001							

# of TimeSteps **20**

Displayed Time=200 years

SECTION 4.0
CORRECTIVE ACTION OBJECTIVES

The goal of the CMS is to identify corrective measures that will effectively mitigate impacts to soil and groundwater, in a manner that provides short-term and long-term protection of human health and the environment to the extent practicable. The CAOs are intended to be specific to the affected media, but sufficiently broad so as not to overly restrict the potential remedial technologies available. The CAOs for SWMU 13 were developed in accordance with the Module V, Appendix B of the TEAD-S RCRA Part B Permit.

Corrective Action Objectives can be specific and numerical (i.e., quantitative) or general and descriptive (i.e., qualitative). These objectives are achieved by reducing exposure and/or contaminant levels. Corrective Action Objectives are used to evaluate what areas within a site may require corrective measures, and which corrective measures alternative best achieves the goal of protecting human health and the environment.

The Rust (1997) human health risk assessment (HHRA) indicated that there were no unacceptable risks or hazards to onsite Depot workers under the current land use scenario. However, under the future land use scenarios, although the HHRA results indicated that SWMU 13 presents no unacceptable risks or hazards to construction workers, unacceptable risks and hazards are present under the hypothetical residential exposure scenario. Thus, UAC R315-101 requires that a CMS be performed (including management measures). Based on the results of the CMS work plan (Rust 1998), no COCs were identified at SWMU 13 and the ecological risk assessment (ERA) identified no adverse impacts to key receptor populations or habitat. However, TPH concentrations detected in soil at SWMU 13 exceeded the State of Utah Tier-1 screening level of 5,000 mg/kg for petroleum impacted soil, and free product was found in source monitoring wells. The risk assessment performed as part of the RFI (Rust 1997) was based on data collected prior to the closure of CAMDS (URS 2012) and the final nature and extent investigation, and that the risk assessment in the RFI (Rust 1997) did not follow the TEAD-S Risk Assumptions Document (RAD) (AQS 2015) or adequately address the requirements of R315-101 of the UAC. Additionally, the CMS Data Gap Investigation (see Section 3.0) identified unacceptable risks under residential and industrial worker exposure scenarios from vapor intrusion of chloroform in the vicinity of the former ETF, the potential for unacceptable residential risks from vapor intrusion of non-detected chemicals with elevated detection limits in soil gas in the vicinity of the former AST, and potentially explosive levels of methane in the vicinity of the former AST.

The results of the CMS Data Gap Investigation (see Section 3.0) indicate that the current soil and groundwater conditions remain relatively unchanged from the findings of the Rust (1997) Phase II RFI. However, additional information regarding current groundwater, soil gas, and soil contaminant concentrations were collected during the CMS Data Gap Investigation to complete an adequate risk assessment and CMS Report. TPH-DRO concentrations exceeding the Utah Tier-1 screening levels of 5,000 mg/kg and 10 mg/L for petroleum impacted soil and groundwater, respectively, remain on the site. Free product remains present in monitoring wells S-28-90, S-CAM-1 and S-CAM-2 at thicknesses ranging from 0.57 to 1.34 ft. Soil borings and groundwater samples indicate that the TPH-DRO in soil and groundwater has remained relatively immobile.

Based on the results of the Rust (1997) RFI and CMS Data Gap Investigation (Section 3.0), the following five CAOs have been developed for SWMU 13. CAOs may be updated as required based on the evaluations conducted under the CMS. The CAOs address further degradation of groundwater, human exposure under the current and hypothetical future land use, and media cleanup standards specified in the Utah guidelines for risk based corrective action of petroleum related sites.

1. *Prevent exposure to petroleum contaminated soil and groundwater:* Specific goals include preventing hypothetical intrusive site activities that would result in direct contact with contaminated soil and groundwater.

2. *Prevent further degradation of groundwater:* Specific goals include implementation of corrective measures to remove petroleum hydrocarbon free product and future groundwater monitoring to demonstrate non-degradation of groundwater in accordance with UAC R315-101-3.

3. *Comply with requirement of UAC R315-101, Corrective Action for Hazardous Waste Sites, to meet screening levels for petroleum constituents:* Specific goals include implementation of corrective measures that will meet the RSLs for petroleum constituents.

4. *Prevent groundwater use:* Specific goals include preventing the access to or use of groundwater at the site.

5. *Prevent exposure to elevated levels of volatiles in soil gas*: Specific goals include 1) implementation of appropriate mitigation measures to prevent on-site worker exposure to methane vapors during construction, operation, and maintenance of the corrective action alternative, 2) preventing hypothetical future residential and industrial worker exposures to elevated levels of chloroform in indoor air at the former ETF, 3) preventing hypothetical future residential exposures to non-detected chemicals with elevated detection limits in indoor air in the vicinity of the former AST, and 4) ensuring proper mitigation measures are used if new buildings are constructed over the area with potentially explosive levels of methane in soil gas.

SECTION 5.0
CMS APPROACH

5.1 GENERAL APPROACH

The purpose of a CMS is to identify and screen technologies, and to develop and evaluate potential viable corrective measure alternatives that will meet the CAOs identified in Section 4.0. As no unacceptable risks or hazards were identified for the current land use during the RFI (Rust 1997) and Data Gap Investigation (Section 3.0), the alternatives developed and evaluated in the CMS are limited to actions required to prevent future exposure to contaminated soil and soil gas, removal of free product, and prevent further degradation of groundwater.

5.2 CORRECTIVE MEASURES IDENTIFICATION AND SCREENING

Technologies that may be appropriate corrective measures for SWMU 13 are identified and screened in Section 6.0 of this document. Technologies retained through the screening process may be used in combination or as stand-alone alternatives to be evaluated in the CMS. Technologies were screened to identify those having severe limitations or safety hazards, or did not meet the requirements of Module V of the TEAD-S RCRA Part B Permit. Technologies may be eliminated based on these criteria. Site, waste, and technology characteristics were considered in screening each technology.

5.3 ALTERNATIVE EVALUATION

The detailed analysis of the corrective measures assembled in Section 7.0 of this document was conducted as part of the CMS. The CMS includes a cost estimate consisting of both capital and operation and maintenance (O&M) costs, and a detailed evaluation of each corrective measure alternative with respect to the following criteria as established in Module V, Appendix B of the TEAD-S RCRA Part B Permit, and fully described in Section 8.1:

- Technical
    - Performance,
    - Reliability,
    - Implementability, and
    - Safety
- Human Health
- Environmental
- Administrative Feasibility
- Cost

5.4 REMEDY SELECTION PROCESS

The selection of the final corrective measures will include stakeholder input, including input from the DWMRC and the public. The preferred corrective measures will be summarized in a Statement of Basis (SOB) which will be made available for public comment and review. Following the public comment period, a final decision and response to comments will be prepared to document the selected corrective measures, the justification for the selection, and responses to the public comments.

SECTION 6.0
SCREENING OF CORRECTIVE MEASURES TECHNOLOGIES

6.1 SCREENING PROCESS

Based on the available site information and the CAOs presented in Section 4.0, a range of response actions and associated technologies were identified to provide potential remedies, or components of corrective measures alternatives. Limitations, applicability, and cost data for the screening of technologies were collected from the ITRC (2009a) and USEPA (1996). Potential technologies that were identified for use at SWMU 13 and considered in the screening process include:

- Institutional controls
    - Groundwater restrictions
    - Excavation restrictions
    - Groundwater monitoring
    - Building restrictions
- Mass recovery
    - Excavation
    - LNAPL skimming
    - Dual pump liquid extraction
    - Multiphase extraction
    - Groundwater treatment
    - Water flooding
- Phase change
    - Natural attenuation
    - Air sparging/soil vapor extraction
    - Bio-slurping/enhanced fluid recovery
    - In-situ chemical oxidation
    - Advanced aerobic biodegradation
    - Bio-ponding
- Phase change and mass removal
    - Surfactant enhanced subsurface remediation
    - Steam/hot air injection
- Mass control
    - Extraction trench
    - In-situ soil mixing (stabilization)

Table 6.1 identifies the advantages and disadvantages of each technology, the effectiveness of each technology in meeting the CAOs, and a summary of the technology screening. Details regarding the screening of each technology are provided in Appendix H. Potential corrective measures technologies were evaluated and screened with respect to the factors listed below.

6.2 SITE CHARACTERISTICS

Site data was reviewed to identify conditions that may limit the use of certain technologies. Technologies that were clearly precluded by site characteristics or safety hazards were eliminated from further consideration.

6.3 WASTE CHARACTERISTICS

Waste characteristics that limit the effectiveness of potential technologies were considered as part of the screening process. Technologies clearly limited by the SWMU 13 waste characteristics were eliminated from consideration. Waste characteristics affect the feasibility of in-situ methods, direct treatment methods and land disposal.

6.4 TECHNOLOGY LIMITATIONS

During the screening of technologies, the level of technology development, performance record, and construction, operation and maintenance problems were considered. Technologies that are unreliable, perform poorly, or have not been fully demonstrated were not included in the screening process.

TABLE 6.1
SUMMARY OF THE TECHNOLOGY SCREENING
TOOELE ARMY DEPOT - SOUTH

Technology Type	Technology	Technology Description	Advantages	Disadvantages	Effectiveness (CAOs Satisfied)	Site Characteristics			Waste Characteristics	Technology Limitations				Retain/ Reject
						Applicable Geology (Fine/ Coarse)	Applicable to Unsaturated or Saturated Zone	Safety Hazard	Applicable Type of LNAPL[1]	Remedial Time Frame[2]	Waste Generation and Management[3]	Technical Implementability	Cost[4]	
Institutional Controls	Groundwater Restrictions	Limit or prohibit access to or use of groundwater.	Restricts or limits access	Provides no protection of the environment	1) Prevents exposure to contaminated groundwater 2) Prevents use of groundwater	Not applicable	Not applicable	None	Not applicable	Long	None	High	Low	**Retain**
	Excavation Restrictions	Restrictions prohibiting excavation without proper management of excavated soil.	Restricts or limits access	Provides no protection of the environment	1) Prevents exposure to contaminated soil	Not applicable	Not applicable	None	Not applicable	Long	None	High	Low	**Retain**
	Groundwater Monitoring	Used to determine if further degradation of groundwater is occurring and if LNAPL and contaminated groundwater are migrating.	Provides monitoring of groundwater degradation and contaminant migration	Provides no protection of the environment	1) Prevents future degradation of groundwater by detecting changes in contaminant concentrations	Not applicable	Not applicable	Low	Not applicable	Long	Low	High	Low	**Retain**
	Building Restrictions	Limit locations where buildings may be constructed or require new buildings to have a vapor barrier and/or sub-slab venting system.	Restricts or limits access; mitigates risks from methane and vapor intrusion	Provides no protection of the environment	1) Prevents exposure to elevated levels of volatiles in soil gas	Not applicable	Not applicable	None	Not applicable	Short	None	High	Low	**Retain**
Mass Recovery	Excavation	The LNAPL body is physically removed from the subsurface via excavation or large diameter borings. Excavated material is treated on-site of disposed of off-site.	1) Implementation time-frame 2) High percentage of LNAPL body removed	1) Depth limitations 2) Cost 3) Waste generation, management and disposal	1) Prevents human and ecological soil exposure 2) Complies with UAC R315-101 requirements 3) Prevents further degradation of groundwater	Fine/Coarse	Saturated/ Unsaturated	Moderate	LV, LS, HV, HS	Short	High	Moderate	High	**Retain**
	LNAPL Skimming	Uses a single pump or hydrophobic belt (e.g., bladder pump, pneumatic pump, or belt skimmer) to extract LNAPL from a well.	1) Proven implementable technology 2) Vapor control	1) Implementation time-frame 2) Limited to mobile LNAPL	1) Prevents further degradation of groundwater 2) Complies with UAC R315-101 requirements	Fine/Coarse	Saturated	Low	LV, LS, HV, HS	Long	Moderate	Moderate	Moderate	**Retain**
	Dual Pump Liquid Extraction	LNAPL is hydraulically recovered by using two pumps simultaneously to remove LNAPL and groundwater.	1) Proven implementable technology 2) Vapor control	1) Implementation time-frame 2) Limited to mobile LNAPL	1) Prevents further degradation of groundwater 2) Complies with UAC R315-101 requirements	Coarse	Saturated	Moderate	LV, LS, HV, HS	Long	High	Moderate	Moderate	*Reject*
	Multiphase Extraction	LNAPL and groundwater are removed through the use of dedicated pumps. Vacuum enhancement is typically added to increase LNAPL hydraulic recovery rates.	1) Proven implementable technology 2) Hydraulic control	Required treatment of extracted LNAPL and groundwater	1) Prevents further degradation of groundwater 2) Complies with UAC R315-101 requirements	Coarse	Saturated	Moderate	LV, LS, HV, HS	Medium	High	Moderate	Moderate	*Reject*

TABLE 6.1 (Continued)
SUMMARY OF THE TECHNOLOGY SCREENING
TOOELE ARMY DEPOT - SOUTH

Technology Type	Technology	Technology Description	Advantages	Disadvantages	Effectiveness (CAOs Satisfied)	Site Characteristics			Waste Characteristics	Technology Limitations				Retain/ Reject
						Applicable Geology (Fine/ Coarse)	Applicable to Unsaturated or Saturated Zone	Safety Hazard	Applicable Type of LNAPL[1]	Remedial Time Frame[2]	Waste Generation and Management[3]	Technical Implementability	Cost[4]	
Mass Recovery (Cont'd)	Groundwater Treatment	Groundwater is extracted and treated through carbon absorption and/or air stripping and re-injected.	1) Proven implementable technology 2) Removal of dissolve phase LNAPL from groundwater	Requires removal of LNAPL prior to implementation	1) Prevents further degradation of groundwater 2) Complies with UAC R315-101 requirements	Fine/Coarse	Saturated	Moderate	LV, LS, HV, HS (dissolved phase)	Medium	High	Moderate	High	*Reject*
	Water Flooding	Water is injected to enhance the hydraulic LNAPL gradient toward recovery wells or trenches. Hot water may be injected to reduce interfacial tension and viscosity of the LNAPL and further enhance LNAPL removal by hydraulic recovery.	Proven implementable technology	1) Capital equipment 2) Hydraulic control required 3) Homogeneity 4) Dispersion efficiency	1) Prevents further degradation of groundwater 2) Complies with UAC R315-101 requirements	Coarse	Saturated	Moderate	LV, LS, HV, HS	Medium	High	Low	High	*Reject*
Phase Change	Natural Attenuation	LNAPL constituents are naturally depleted from the LNAPL body over time by volatilization, dissolution, dispersion, absorption and, degradation.	1) Highly implementable 2) No site disturbance 3) Cost	1) Remedial time-frame 2) Containment	1) Complies with UAC R315-101 requirements	Fine/Coarse	Saturated/ Unsaturated	Low	HV, HS LV, LS (volatile fractions)	Long	Low	High	Low	**Retain**
	Air Sparging/Soil Vapor Extraction	AS injects air into LNAPL body to volatilize LNAPL constituents, and vapors are vacuum extracted. AS or SVE can also be used individually if conditions are appropriate.	1) Proven implementable technology 2) Vapor control	1) Does not treat heavy end LNAPLs/low permeability soils 2) Treatment or management of off-gas vapor	1) Prevent further degradation of groundwater 2) Complies with UAC R315-101 requirements	Coarse	Saturated/ Unsaturated	Moderate	HV, HS	Short	Moderate	Moderate	Moderate	*Reject*
	Bioslurping/ Enhanced Fluid Recovery	LNAPL is remediated via a combination of vacuum-enhanced recovery and bioventing processes.	1) Proven implementable technology 2) Vapor control	1) Remedial time-frame 2) Limited to mobile LNAPL	1) Prevent further degradation of groundwater 2) Complies with UAC R315-101 requirements.	Fine/Coarse	Saturated/ Unsaturated	Low	LV, LS, HV, HS	Long	Moderate	Moderate	Moderate	*Reject*
	In Situ Chemical Oxidation	LNAPL is depleted by accelerating LNAPL solubilization by the addition of a chemical oxidant into the LNAPL zone.	1) Remedial time-frame 2) High percentage of LNAPL body removed	1) Number of injection points 2) Rate limited hydraulic control required 2) By-products 3) Cost 4) Vapor generation	1) Prevent further degradation of groundwater 2) Complies with UAC R315-101 requirements.	Coarse	Saturated/ Unsaturated	High	HV, HS	Short	Low	Low	High	*Reject*
	Enhanced Aerobic Biodegradation	Oxygen releasing compounds (ORC) are introduced into the saturated zone and groundwater to increase the number of indigenous micro organisms capable of degrading petroleum hydrocarbons	1) Ability to treat residual concentrations 2) Proven implementable technology	1) Remedial time-frame 2) Effectiveness dependent on volume of LNAPL remaining	1) Prevent further degradation of groundwater 2) Complies with UAC R315-101 requirements.	Fine/Coarse	Saturated/ Unsaturated	Low	LV, LS, HV, HS	Long	Low	High	High	**Retain**

TABLE 6.1 (Continued)
SUMMARY OF THE TECHNOLOGY SCREENING
TOOELE ARMY DEPOT - SOUTH

Technology Type	**Technology**	**Technology Description**	**Advantages**	**Disadvantages**	**Effectiveness (CAOs Satisfied)**	**Site Characteristics**			**Waste Characteristics**	**Technology Limitations**				**Retain/ Reject**
						Applicable Geology (Fine/ Coarse)	**Applicable to Unsaturated or Saturated Zone**	**Safety Hazard**	**Applicable Type of LNAPL[1]**	**Remedial Time Frame[2]**	**Waste Generation and Management[3]**	**Technical Implementability**	**Cost[4]**	
Phase Change (Cont'd)	Bio-Ponding	Aeration of groundwater and soil promotes enhanced biodegradion by increasing the number of indigenous micro organisms capable of degrading petoleum hydrocarbons.	1) Enhances biodegradation 2) Allow for re-use of treated soil as backfill	1) Potential safety issues related to open hole. 2) Aeration effectiveness limited by size of excavation	1) Prevent further degradation of groundwater 2) Complies with UAC R315-101 requirements.	Coarse	Saturated/ Unsaturated	Moderate	LV, LS, HV, HS	Long	High	Moderate	High	**Retain**
Phase Change and Mass Removal	Surfactant Enhanced Subsurface Remediation	A surfactant is injected that increases LNAPL solubilization and LNAPL mobility. The dissolved phase and LNAPL are then recovered via hydraulic recovery.	1) Remedial time-frame 2) Source removal	1) Hydraulic control required 2) By-products 3) Required homogeneity 4) Groundwater treatment required	1) Prevent further degradation of groundwater 2) Complies with UAC R315-101 requirements.	Coarse	Saturated	Moderate	LV, LS, HV, HS	Medium	Moderate	Low	High	*Reject*
	Steam/Hot Air Injection	LNAPL is removed by forcing steam into the aquifer to vaporize, solubilize, and induce LNAPL flow. Vapors, dissolved phase, and LNAPL are recovered via vapor extraction and hydraulic recovery.	1) Remedial time-frame 2) Source removal	1) Hydraulic control required 2) By-products generated 3) Vapor generated 4) Dispersion efficiency	1) Prevent further degradation of groundwater 2) Complies with UAC R315-101 requirements.	Coarse	Saturated/ Unsaturated	High	LV, LS, HV, HS	Short	Moderate	Low	High	*Reject*
Mass Control	Extraction Trench	An intercept trench is installed. Physical containment uses engineered barriers to control horizontal migration of LNAPL, isolate LNAPL, and allow for removal of LNAPL by hydraulic recovery.	1) Source control 2) Limits down-gradient migration	1) Hydraulic control required 2) Depth and geologic limitations 3) limited to mobile LNAPL	1) Prevent further degradation of groundwater 2) Complies with UAC R315-101 requirements.	Fine/Coarse	Saturated	Moderate	LV, LS, HV, HS	Long	Moderate	Moderate	Moderate	**Retain**
	In Situ Soil Mixing (Stabilization)	Uses mechanical mixing of soil or aquifer materials with low-permeability materials such as clay and/or reactive media such as chemical oxidants or electron acceptors and/or stabilizing media such as Portland cement.	1) Source control 2) Time frame	1) Depth limitations 2) Homogeneity required 3) Long-term residual management	1) Prevent further degradation of groundwater 2) Complies with UAC R315-101 requirements.	Fine/Coarse	Saturated/ Unsaturated	High	LV, LS, HV, HS	Short	Low	Moderate	High	**Retain**

Notes:

[1] LNAPL type: LV, LS = low volatility, low solubility, medium or heavy LNAPL (e.g., weathered gasoline, diesel, jet fuel, fuel oil, crude oil); HV, HS = high volatility, high solubility, light LNAPL (e.g., gasoline, benzene)

[2] Very short = <1 year, Short = 1–3 years, Medium = 2–5 years, Long = 5–10 years, Very long = >10 years

[3] Waste Generation and Management - Level of effort required to manage waste streams generated by the technology

[4] Cost relative to other considered corrective action technologies

SECTION 7.0
ASSEMBLY OF CORRECTIVE MEASURES ALTERNATIVES

7.1 INTRODUCTION

This section assembles those corrective measures technologies that passed the technology screening process in Section 6.0 into corrective measures alternatives capable of meeting the CAOs for SWMU 13. Although a number of potential technologies were identified and screened in Section 6.0, site conditions at SWMU 13 limit the effectiveness of many of those technologies. Site conditions that limit the effectiveness these technologies include site geology and groundwater gradient. Shallow soils at SWMU 13 are fine grained sands and gravels interbedded with silts and clays, with poor transmissivity. Thus, technologies that require coarse grained soils and/or high transmissivites will perform poorly at SWMU 13. Additional details regarding site geology and hydrogeology can be found in Section 2.3. The alternatives assembled in this section are evaluated further in Section 8.0.

7.2 DEVELOPMENT OF CORRECTIVE MEASURES ALTERNATIVES

Corrective measures alternatives are developed by combining technologies retained from the technology screening process. The most important objective in developing remedial alternatives is to adequately represent the range of technologies that could be practically applied to SWMU 13. Not all technology options or combinations are included; rather, engineering judgment is used to formulate a manageable range of alternatives that are developed and carried forward for evaluation in the CMS.

7.3 ASSEMBLED ALTERNATIVES

Based on CAOs for SWMU 13 (Section 4.0), site conditions, and available technologies, the following corrective action alternatives were developed for further evaluation in Section 8.0:

- Alternative 1 – Excavation and enhanced biodegradation with institutional controls
- Alternative 2 - LNAPL skimming/natural attenuation with institutional controls
- Alternative 3 - In-situ soil mixing (stabilization) with institutional controls
- Alternative 4 – Extraction trench/natural attenuation with institutional controls
- Alternative 5 – Bio-ponding and institutional controls

The components/technologies that comprise each of the above alternatives are fully described in Sections 7.3.1 through 7.3.5. Estimated time frames for monitoring included in Alternatives 1 through 5 were assumed for cost estimating purposes.

7.3.1 Alternative 1 – Excavation and Enhanced Biodegradation with Institutional Controls

- Within the footprint of free product in groundwater (Figure 3.4), excavate and stock-pile clean soil to the depth of petroleum impacted (i.e., visibly stained) soils,
- Excavate petroleum impacted soils,
- Add oxygen releasing compound (ORC) in the excavation to enhance the biodegradation of any free product that was not removed,
- Back-fill and compact with stock-piled and clean soil,
- Characterize, transport, and treat/dispose of contaminated soil in accordance with State and Federal regulations,
- Impose use restrictions (i.e., prevent residential land use and require engineering controls protective of indoor air),
- Impose groundwater use and excavation restrictions, and
- Implement a monitored natural attenuation (MNA)/groundwater monitoring program to include the presence/thickness of LNAPL, TPH-DRO, petroleum constituents and other non-fuel related VOCs using EPA Method 8260 (full scan), and natural attenuation indicators. Groundwater monitoring is assumed to be for 30 years.

7.3.2 Alternative 2 – LNAPL Skimming/Natural Attenuation with Institutional Controls

- Skim measureable free product from existing monitoring wells and/or new free product extraction wells,
- Collect, characterize, transport, and dispose/treat recovered product in accordance with State and Federal regulations,
- Impose use restrictions (i.e., prevent residential land use and require engineering controls protective of indoor air),
- Impose groundwater use and excavation restrictions, and
- Implement a MNA/groundwater monitoring program to include the presence/thickness of LNAPL, TPH-DRO, petroleum constituents and other non-fuel related VOCs using EPA Method 8260 (full scan), and natural attenuation indicators. Groundwater monitoring is assumed to be for 30.

7.3.3 Alternative 3 – In-Situ Soil Mixing (Stabilization) with Institutional Controls

- Within the footprint of visible free product in groundwater (Figure 3.4), excavate and stock-pile clean soil to the depth of petroleum impacted (i.e., visibly stained) soils,
- Solidify/stabilize contaminated soil by mixing and injecting chemical reagents,
- Back-fill and compact with stockpiled and clean soil,

- Impose use restrictions (i.e., prevent residential land use and require engineering controls protective of indoor air),
- Impose groundwater use and excavation restrictions, and
- Implement a MNA/groundwater monitoring program to include the presence/thickness of LNAPL, TPH-DRO, petroleum constituents and other non-fuel related VOCs using EPA Method 8260 (full scan), and natural attenuation indicators. Groundwater monitoring is assumed to be for 30 years.

7.3.4 Alternative 4 – Extraction Trench/Natural Attenuation with Institutional Controls

- Construct extraction trenches with collection sumps,
- Skim measureable free product from collection sumps using solar powered skimming pumps,
- Collect, characterize, transport, and dispose/treat recovered product in accordance with State and Federal regulations,
- Impose use restrictions (i.e., prevent residential land use and require engineering controls protective of indoor air),
- Impose groundwater use and excavation restrictions, and
- Implement a MNA/groundwater monitoring program to include the presence/thickness of LNAPL, TPH-DRO, petroleum constituents and other non-fuel related VOCs using EPA Method 8260 (full scan), and natural attenuation indicators. Groundwater monitoring is assumed to be for 30 years.

7.3.5 Alternative 5 – Bio-Ponding and Institutional Controls

- Excavation of a open pit within the footprint of visible free product in groundwater (Figure 3.4),
- Installation of an aeration system to provide oxygenation,
- Land-farming petroleum contaminated soil on site,
- Impose use restrictions (i.e., prevent residential land use and require engineering controls protective of indoor air), and
- Implement a MNA/groundwater monitoring program to include the presence/thickness of LNAPL, TPH-DRO, petroleum constituents and other non-fuel related VOCs using EPA Method 8260 (full scan) and natural attenuation indicators. Groundwater monitoring is assumed to be for 30 years.

SECTION 8.0
EVALUATION OF RETAINED CORRECTIVE MEASURES ALTERNATIVES

8.1 DESCRIPTION OF EVALUATION CRITERIA

A detailed analysis of each corrective measures alternative assembled in Section 7.0 was completed with respect to the following criteria as established in Module V, Appendix B of the TEAD-S RCRA Part B Permit.

8.1.1 Technical

Corrective measures alternatives were evaluated based on performance, reliability, implementability, and safety.

A. Performance includes the effectiveness and useful life of the remedy. Effectiveness was evaluated in terms of the ability to perform intended functions. The evaluation also considered the effectiveness of combinations of technologies. Each corrective measures alternative was also evaluated in terms of the projected service life of its component technologies.

B. Reliability measures the risk and effect of failure, and includes O&M requirements and their demonstrated effectiveness under similar conditions. Technologies requiring complex and frequent O&M are regarded as less reliable than technologies requiring occasional or basic O&M. Demonstrated technologies are also considered more reliable.

C. Implementability includes relative ease of installation (constructability) and the time required to achieve a given level of response. Constructability may include factors such as equipment availability, special permit requirements, location of existing facilities, and costs.

D. Safety considerations include threats to safety of nearby communities and environment, as well as workers during implementation.

8.1.2 Environmental

The environmental assessment focused on facility conditions and the exposure pathways addressed by each alternative. The assessment includes the short and long-term effects of corrective measures, effects on environmentally sensitive areas, and an analysis of measure to mitigate any adverse effects.

8.1.3 Human Health

Each alternative was evaluated to determine the extent to which it mitigates potential short and long-term exposures to any residual contamination and protects human health, both during and after implementation of the corrective measure.

8.1.4 Institutional

Each alternative was evaluated to assess its compliance with federal and state regulations and standards.

8.1.5 Cost

A cost estimate was developed for each corrective measures alternative. The cost estimate includes both capital and O&M costs.

8.2 DETAILED ANALYSIS OF ALTERNATIVES

This section evaluates the five corrective measures alternatives assembled in Section 7.0 in relation to the RCRA evaluation criteria described in Section 8.1, and considered technical criteria, protection of human health and the environment, administrative feasibility, and cost.

These alternatives are designed to address petroleum impacts within the footprint of observable free product in groundwater (Figure 3.4). Further, these alternatives are based on the following depth profile within that area:

Depth of petroleum stained soils: 8-15 ft bgs

Depth of LNAPL in soil: 11.5-12.5 ft bgs

Depth of water bearing zone: 12-20 ft bgs

Conceptual designs for each of the alternatives evaluated in this Section are provided as Figures 8.1 through 8.5. These conceptual designs were developed to assist in developing cost estimates for each alternative. The actual design of the corrective measures alternative selected will be developed as part of the corrective measures implementation/engineering design.

8.2.1 Alternative 1 – Excavation and Enhanced Biodegradation with Institutional Controls

Alternative 1 consists of removing the visibly stained soil (i.e., containing both free product and residual LNAPL) within the footprint of free product in groundwater (Figure 3.4) to the extent practicable, off-site treatment/disposal of the excavated soil, imposing groundwater use and excavation restrictions, residential use restrictions, vapor intrusion restrictions, and implementing a MNA/groundwater monitoring program.

To implement this alternative, unstained soil would be excavated and stock-piled on site to be used as backfill material. Based on the CMS data gap investigation observations, it is assumed that stained soil could be excavated at 8 – 15+ ft bgs within the impacted area (60,000 square feet) (see Figures 3.6, 8.1) with an estimated volume of approximately 18,000 cubic yards to be used as backfill. Confirmation samples will be collected from the stock-piled soil to ensure that it is suitable for use as backfill.

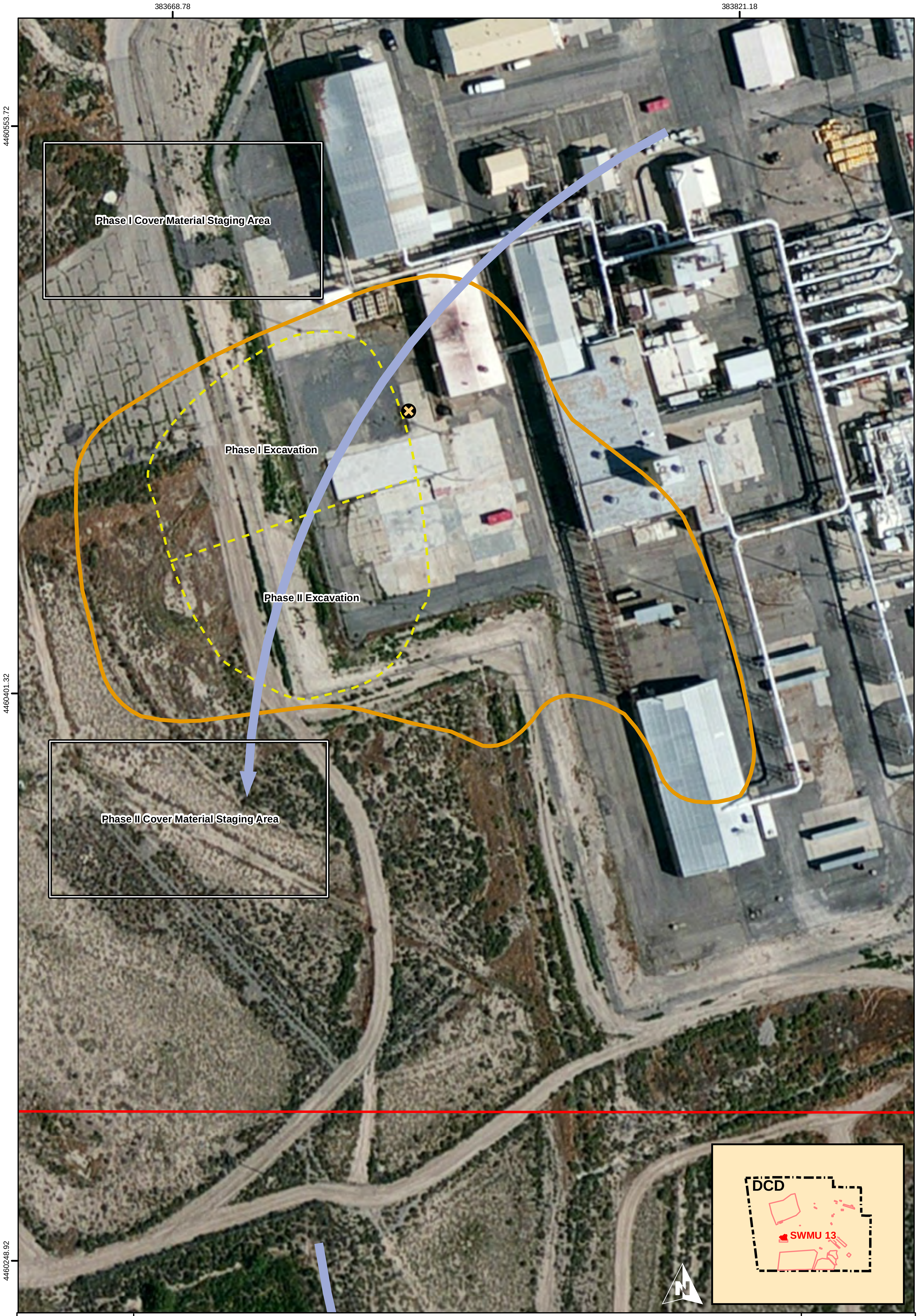


Figure 8.1

Alternative 1 Conceptual Design

Legend

⊗	Former AST Location
➡	General Direction of Groundwater Movement (based on freshwater equivalent head)
▭	Stained Soil - Approximate
⬚	Area to be Excavated and Backfilled
▭	SWMU Boundary

Imagery: ESRI (c) 2015
Boundary, SWMUs, Wells: Deseret Chemical Depot

Feet
0 40 80

Projection & Grid Cooridnates:
NAD83 StatePlane Utah Central

PARSONS

Date:	12/3/2015
Prepared:	RGS
Checked:	DS
Revision:	1

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Visibly stained soil, at an interval of 8-15+ ft bgs within the impacted area (60,000 square feet), will be excavated, transported off-site, and treated/disposed of at a soil regeneration facility. Based on the CMS data gap observations, it is assumed that approximately 13,000 cubic yards of soil will require treatment/disposal (see Figure 8.1).

As it is unlikely that all free product will be removed from below the water table, ORC will be mixed with the backfill material prior to placement in the excavation. This will enhance the aerobic biodegradation of the remaining petroleum constituents in soil and groundwater. In addition to the fill material stock-piled on site, approximately 13,000 cubic yards of fill will be imported from an on-post borrow pit.

Groundwater monitoring will be conducted on an annual basis for 30 years to monitor LNAPL levels, TPH-DRO, petroleum constituents, and other non-fuel related VOC concentrations to ensure no further degradation of groundwater. Groundwater monitoring will also include the analysis of natural attenuation parameters such as dissolved oxygen, nitrate, sulfate, and methane from up-gradient and down-gradient monitoring wells to monitor ongoing biodegradation. Detailed monitoring and data tracking and analysis requirements will be included in a natural attenuation and long-term monitoring (LTM) work plan following implementation of the corrective measures.

In addition, this alternative includes land use restrictions preventing a) the potable use of groundwater, b) excavation, and c) residential use. Additionally, land use restrictions requiring either a) the use of engineering controls at any potential future buildings at the site to limit vapor intrusion or b) an investigation to determine whether soil gas concerns remain on the site. Engineering controls that may be implemented include, but are not limited to: a vapor barrier, which may be either impervious or vented in such a way as to prevent vapor intrusion; or the use of other appropriate measures such as negative/positive exchange/ventilation systems. The groundwater, excavation and land use restrictions will be incorporated into TEAD's master land use plan and/or the TEAD-S RCRA Part B hazardous waste permit.

Corrective action and monitoring time frames associated with this alternative were assumed for cost estimating purposes.

8.2.1.1 Technical Evaluation

Performance

Excavation of visibly stained soil (i.e., containing both free product and residual LNAPL), along with enhancement of the natural biodegradation process, meets the CAOs developed in Section 4.0. This alternative also complies with UAC R315-101-3, the "Principle of Non-Degradation," by minimizing the LNAPL source that may migrate from soil to groundwater. Alternative 1 will meet the identified CAOs with no decrease in effectiveness over time. Although a significant volume of the source material would be removed, some residual free product will remain in the subsurface for an undetermined period of time. Groundwater, excavation, and land use restrictions will prevent future residential use and potential exposure to residual contaminants in soil and groundwater.

As stated in Section 3.4.6, although there is a slight downward vertical gradient, the downward migration of TPH-DRO and petroleum constituents is believed to be primarily due to diffusion. Alternative 1 would reduce further downward diffusion by removing the free product and residual LNAPL (i.e., visibly stained soil). Additionally, adding ORC to the backfill material will enhance the aerobic biodegradation of the remaining petroleum constituents in soil and groundwater. As the zone of influence of the ORC is likely to be only a few feet, it is assumed that the petroleum constituents already in groundwater below the bottom of the excavation in Alternative 1 would be addressed by natural attenuation. As indicated in Section 3.3.6.1, none of the petroleum constituents that were detected in the deep monitoring well (S13-CAM-DW1) were detected at concentrations above the tapwater RSLs and multiple degradation products of petroleum were detected (including methane), indicating that natural attenuation has mitigated downward diffusion of petroleum constituents.

Reliability

The excavation and off-site treatment/disposal of free product and residual LNAPL contaminated soil, enhancement of the natural degradation process, and land use restrictions will be effective over the long-term, having been implemented effectively at many sites. Alternative 1 minimizes potential installation worker exposure to contaminated soil and groundwater at SWMU 13 and prevents potential future residential exposure to residual contaminants. No long-term management of waste materials is required. Long-term groundwater monitoring and monitoring/enforcement of restrictions will be required in order to maintain the alternatives' reliability.

Implementability

Excavation equipment required to implement Alternative 1 is readily available, and a permitted soil regeneration facility is located within 50 miles of TEAD-S. As this alternative requires excavation, the possible presence of subsurface utilities may affect its implementation. Implementing and maintaining groundwater and land use restrictions at SWMU 13 should not be an issue as the anticipated future land use of the site is continued military use. It is expected that the excavation, transportation and disposal, and backfilling could be accomplished in eight months or less, with groundwater monitoring to continue for up to 30 years.

Safety

Alternative 1 poses a low short-term risk to the surrounding communities and on-site workers. The surrounding communities could be exposed to contaminated soil during transportation through vehicular accidents or improper containment in transport vehicles. Onsite workers may be exposed to contaminated soil during excavation and other soil-handling activities if appropriate precautionary measures are not implemented and maintained.

8.2.1.2 Human Health Assessment

Excavation and off-post treatment/disposal of contaminated soil, advanced aerobic biodegradation, and institutional controls protect human health by preventing both short and long-term exposure to contaminated soil and groundwater. The residual risk remaining on the site for soil and groundwater results from residual concentrations of TPH-DRO constituents above acceptable residential levels.

8.2.1.3 Environmental Assessment

No adverse impacts to ecological receptors were identified in the Rust (1997) Phase II RFI, or Parsons CMS data gap investigation (see Section 3). The removal of free product and residual LNAPL and enhanced biodegradation will mitigate any potential risk to ecological receptors by removing contaminants from the site.

8.2.1.4 Administrative Feasibility

This alternative complies with applicable Federal and State laws and regulations, including the requirements of UAC R315-101, by removing free product and residual LNAPL in soil and groundwater. The excavated soil to be treated and disposed of off-site will be transported in accordance with applicable DOT regulations. A modification of the RCRA Part B permit will be required to incorporate the institutional controls to be implemented and administered by TEAD-S.

8.2.1.5 Cost

Capital costs for implementing Alternative 1 are $1,730,916 with groundwater monitoring for 30 years at $71,916 per year. The total present worth cost for Alternative 1 is $3,888,396. Table K-1 of Appendix K provides a detailed cost estimate.

8.2.2 Alternative 2 – LNAPL Skimming/Natural Attenuation with Institutional Controls

Alternative 2 consists of skimming free product from monitoring wells, natural attenuation of residual petroleum constituents in soil and groundwater, imposing groundwater use and excavation restrictions, land use restrictions, and implementing a MNA/groundwater monitoring program.

To implement this alternative, skimming pumps will be placed and operated in monitoring wells S-CAM-1, S-CAM-2, S-28-88, and two new wells with one near the CAMDS boundary midway between S-28-88 and S-CAM-1, and one slightly downgradient of the former AST location (see Figure 8.2). The skimming pumps will remove the free product from groundwater, which will be replaced by free product from the surrounding soils via diffusion and capillary action, until no free product is left in the surrounding soils. Skimming pumps will be pneumatic solar powered units with controllers capable of cycling on and off as free product recovery occurs within the wells. Recovered free product will be accumulated on site in 55-gallons drums to be disposed of off-site as required.

In addition, this alternative includes land use restrictions preventing a) the potable use of groundwater, b) excavation, and c) residential use. Additionally, land use restrictions requiring either a) the use of engineering controls at any potential future buildings at the site to limit vapor intrusion or b) an investigation to determine whether soil gas concerns remain on the site. Engineering controls that may be implemented include, but are not limited to: a vapor barrier, which may be either impervious or vented in such a way as to prevent vapor intrusion; or the use of other appropriate measures such as negative/positive exchange/ventilation systems. The groundwater, excavation and land use restrictions will be incorporated into TEAD's master land use plan and/or the TEAD-S RCRA Part B hazardous waste permit.

Groundwater monitoring will be conducted on an annual basis for 30 years to monitor LNAPL levels, TPH-DRO, petroleum constituents, and other non-fuel related VOC concentrations to ensure no further degradation of groundwater. Groundwater monitoring will also include the analysis of natural attenuation parameters such as dissolved oxygen, nitrate, sulfate, and methane from up-gradient and down-gradient monitoring wells to monitor ongoing biodegradation. Detailed monitoring and data tracking and analysis requirements will be included in a natural attenuation and LTM work plan following implementation of the corrective measures.

Corrective action and monitoring time frames associated with this alternative were assumed for cost estimating purposes.

8.2.2.1 Technical Evaluation

Performance

The skimming of free product from existing and newly installed monitoring wells, natural attenuation, and institutional controls complies with the requirements of UAC-R315-101-3, the "Principle of Non-Degradation," by limiting continued impacts to groundwater and preventing exposure to current and anticipated future receptors. Alternative 2 relies on a) the migration of free product from the surrounding soils into the monitoring wells via diffusion and capillary action to remove free product from soils and b) natural attenuation to remove residual LNAPL in soil and petroleum constituents in groundwater. Based on available vendor information, skimming pumps are an effective recovery method, but due to the fine grained soil present at SWMU 13 and the volume within the monitoring wells available for recovery, the performance of Alternative 2 is expected to be limited. Groundwater, excavation, and land use restrictions will prevent future residential use and potential exposure to contaminants in soil and groundwater.

Figure 8.2 Alternative 2 Conceptual Design

Legend

⊗	Former AST Location
●	Monitoring Well with Free Phase LNAPL, Skimmer Pump Installed
○	New Monitoring Well with Skimmer Pump Installed
➡	General Direction of Groundwater Movement (based on freshwater equivalent head)
▭	Stained Soil - Approximate
⬚	Extent of Free Product-Feb. 2014
🟥	SWMU Boundary

Imagery: ESRI (c) 2015
Boundary, SWMUs, Wells: Deseret Chemical Depot

Feet
0 40 80

Projection & Grid Coorindates:
NAD83 StatePlane Utah Central

PARSONS

Date:	12/3/2015
Prepared:	RGS
Checked:	DS
Revision:	1

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As stated in Section 3.4.6, although there is a slight downward vertical gradient, the downward migration of TPH-DRO and petroleum constituents is believed to be primarily due to diffusion. Alternative 2 would reduce further downward diffusion by removing the free product and residual LNAPL (i.e., visibly stained soil). It is assumed that the petroleum constituents already in groundwater below the zone of influence of Alternative 2 would be addressed by natural attenuation. As indicated in Section 3.3.6.1, none of the petroleum constituents that were detected in the deep monitoring well (S13-CAM-DW1) were detected at concentrations above the tapwater RSLs and multiple degradation products of petroleum were detected (including methane), indicating that natural attenuation has mitigated downward diffusion of petroleum constituents.

Reliability

The removal of free product from existing and newly installed monitoring wells will reduce impacts to groundwater over the long-term. Monitoring of the site will measure the effectiveness of the anticipated natural attenuation of petroleum constituents in soil and groundwater. Institutional controls if implemented, monitored, and enforced are effective over the long-term, and have been implemented with positive results at many sites. Alternative 2 will require operation and maintenance of the skimming pumps, management and disposal of recovered free product, and monitoring of the natural attenuation of petroleum constituents over the long-term.

Implementability

Pneumatic solar powered skimming pumps are readily available that can be installed in monitoring wells over two inches in diameter. Implementing groundwater use, excavation and land use restrictions are readily implementable. Management of waste (recovered free product) poses no significant issues and can be easily implemented. It is expected that implementation of Alternative 2 (installation of skimming pumps and new wells) could easily be implemented in less than 6 months. Based on the results of the free product recovery test conducted during the SWMU 13 CMS data gap investigation (see Section 3.4.2) it was determined that the average initial recovery rate of the three wells tested was 3.6 gallons per day. As recovery rates are expected to decline significantly after startup, as the extractable free product in the adjacent soils is depleted, it was assumed that 25% of the initial recovery rate (.92 gallons per day) could be removed from each of the five monitoring wells over the long-term. Based on this assumption, it expected that operation and maintenance of the skimming pumps will be required for approximately 8.5 years to remove the estimated 14,000 gallons (see Section 3.5) of free phase LNAPL remaining in the subsurface. In addition to the operations and maintenance of the skimming pumps, groundwater monitoring is expected to be required for up to 30 years.

Safety

Alternative 2 poses a low short-term risk to the surrounding communities and on-site workers. The installation, operation, and maintenance of the skimming system could result in the exposure of onsite workers to recovered free product if appropriate precautionary measures are not implemented and maintained. The surrounding communities could be exposed to recovered free product during vehicular accidents or improper containment in transport vehicles.

8.2.2.2 Human Health Assessment

Under the anticipated continued military use of the site, Alternative 2 presents no unacceptable risk to human health by preventing both short-term and long-term exposure to contaminated soil and groundwater. The residual risk remaining on the site for soil and groundwater results from residual concentrations of TPH-DRO constituents above acceptable residential levels.

8.2.2.3 Environmental Assessment

No adverse impacts to ecological receptors were identified in the Rust (1997) Phase II RFI, or Parsons CMS data gap investigation (see Section 3). The removal of free product and continued biodegradation of residual LNAPL will mitigate any potential risk to ecological receptors by removing contaminants from the site.

8.2.2.4 Administrative Feasibility

Alternative 2 complies with applicable Federal and State laws and regulations, including the requirements of UAC R315-101, by removing free product and residual LNAPL in soil and groundwater. The recovered free product will be treated and disposed of off-site, and will be transported in accordance with applicable Department of Transportation (DOT) regulations. A modification of the RCRA Part B permit will be required to incorporate the institutional controls to be implemented and administered by TEAD-S.

8.2.2.5 Cost

Capital costs for implementing Alternative 2 are $135,700 with 8.5 years of operations and maintenance at $64,403 per year, and 30 years of groundwater monitoring at $71,916 per year. The total present worth cost for implementation of Alternative 2 is $2,840,606. Table K-2 of Appendix K provides a detailed cost estimate.

8.2.3 Alternative 3 – In-Situ Soil Mixing (Stabilization) with Institutional Controls

Alternative 3 consists of in-situ stabilization of visibly stained soil (i.e., containing both free product and residual LNAPL) within the footprint of free product in groundwater (Figure

3.4) to the extent practicable, imposing groundwater use and excavation restrictions, land use restrictions, and implementing a MNA/groundwater monitoring program.

To implement this alternative, unstained soil would be excavated and stock-piled on site to be used as backfill material. Based on the CMS data gap investigation observations, it is assumed that stained soil could be excavated at 8-15+ ft bgs within the impacted area (60,000 square feet) (see Figures 3.6, 8.3) with an estimated volume of approximately 18,000 cubic yards to be used as backfill. Confirmation samples will be collected from the stock-piled soil to ensure that it is suitable for use as backfill.

A cement based slurry reagent will be mixed with the visibly stained soil at a depth of 8-15+ ft bgs throughout the 60,000 square foot area using a large diameter hollow stem auger approximately 10 feet in diameter (see Figures 3.6, 8.3). As the auger penetrates the soil, the slurried reagent will be pumped through the auger stem and injected into the subsurface through jets located on the auger flights. Approximately 13,000 cubic yards of impacted soil will be stabilized. Due to the large area requiring corrective action, stabilization will be conducted in two phases (see Figure 8.3).

In addition, this alternative includes land use restrictions preventing a) the potable use of groundwater, b) excavation, and c) residential use. Additionally, land use restrictions requiring either a) the use of engineering controls at any potential future buildings at the site to limit vapor intrusion or b) an investigation to determine whether soil gas concerns remain on the site. Engineering controls that may be implemented include, but are not limited to: a vapor barrier, which may be either impervious or vented in such a way as to prevent vapor intrusion; or the use of other appropriate measures such as negative/positive exchange/ventilation systems. The groundwater, excavation and land use restrictions will be incorporated into TEAD’s master land use plan and/or the TEAD-S RCRA Part B hazardous waste permit.

Groundwater monitoring will be conducted on an annual basis for 30 years to monitor LNAPL levels, TPH-DRO, petroleum constituents, and other non-fuel related VOC concentrations to ensure no further degradation of groundwater. Groundwater monitoring will also include the analysis of natural attenuation parameters such as dissolved oxygen, nitrate, sulfate, and methane from up-gradient and down-gradient monitoring wells to monitor ongoing biodegradation. Detailed monitoring and data tracking and analysis requirements will be included in a natural attenuation and LTM work plan following implementation of the corrective measures.

Corrective action and monitoring time frames associated with this alternative were assumed for cost estimating purposes.

8.2.3.1 Technical Evaluation

Performance

In-situ stabilization complies with UAC-R315-101-3, the "Principle of Non-Degradation," by immobilizing the free product source, thus eliminating future contaminant migration to groundwater. Although a significant volume of the source material would be immobilized, some residual LNAPL may remain in the subsurface for an undetermined period of time. Alternative 3 achieves the remaining qualitative CAOs developed in the Section 4.0 by preventing human exposure to residual contaminants, with no decrease in effectiveness over time. Groundwater, excavation, and land use restrictions will prevent future residential use and potential exposure to contaminants in soil and groundwater.

As stated in Section 3.4.6, although there is a slight downward vertical gradient, the downward migration of TPH-DRO and petroleum constituents is believed to be primarily due to diffusion. Alternative 3 would reduce further downward diffusion by immobilizing the free product and residual LNAPL (i.e., visibly stained soil). It is assumed that the petroleum constituents already in groundwater below the zone of influence of Alternative 3 would be addressed by natural attenuation. As indicated in Section 3.3.6.1, none of the petroleum constituents that were detected in the deep monitoring well (S13-CAM-DW1) were detected at concentrations above the tapwater RSLs and multiple degradation products of petroleum were detected (including methane), indicating that natural attenuation has mitigated downward diffusion of petroleum constituents.

Reliability

Stabilization of impacted soil along with institutional controls will be effective over the long-term. Soil mixing and institutional controls are proven technologies implemented at similar sites. Alternative 3 minimizes potential installation worker exposure to contaminated soil and groundwater at SWMU 13 and prevents potential future residential exposure to site contamination. No long-term management of waste materials is required. Long-term groundwater monitoring and monitoring/enforcement of restrictions will be required in order to maintain the alternative's reliability.

Implementability

Large diameter hollow stem augers equipped to inject slurried reagents are available that are capable of injecting to the required depths at SWMU 13. As Alternative 3 requires a significant subsurface disturbance of the entire site, abandoned or active subsurface utilities may affect its implementation. Implementing and maintaining groundwater, excavation and land use restrictions at SWMU 13 should not be an issue as the anticipated future land use of the site is continued military use. Soil mixing could be accomplished in 6 months or less, with groundwater monitoring to be required for up to 30 years.

Figure 8.3

Alternative 3 Conceptual Design

Legend

- ○ 10 ft Diameter Boring/Slurry Injection Point
- ⊗ Former AST Location
- ➡ General Direction of Groundwater Movement (based on freshwater equivalent head)
- ▭ Stained Soil - Approximate
- ⬚ Area to be Stabilized
- ▭ SWMU Boundary

Imagery: ESRI (c) 2015
Boundary, SWMUs, Wells: Deseret Chemical Depot

Feet
0 40 80

Projection & Grid Coorindates:
NAD83 StatePlane Utah Central

PARSONS

Date:	12/3/2015
Prepared:	RGS
Checked:	DS
Revision:	1

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Safety

Alternative 3 poses no short-term risk to the surrounding communities, as all corrective action activities will be conducted on site. Onsite workers may be exposed to contaminated soil and reagents during soil mixing operations if appropriate precautionary measures are not implemented and maintained. Other onsite worker safety concerns are associated with the use on drilling equipment, reagent mixing equipment, and injection systems, but can adequately be managed through an appropriate health and safety program.

8.2.3.2 Human Health Assessment

In-situ soil mixing (stabilization) and institutional controls protect human health by preventing both short and long-term exposure to contaminated soil and groundwater. The residual risk remaining on the site for soil and groundwater results from residual concentrations of TPH-DRO constituents above acceptable residential levels.

8.2.3.3 Environmental Assessment

No adverse impacts to ecological receptors were identified in the Rust (1997) Phase II RFI, or Parsons CMS data gap investigation (see Section 3). The stabilization of free product and residual LNAPL will mitigate potential risk to ecological receptors by immobilizing contaminants on the site.

8.2.3.4 Administrative Feasibility

Alternative 3 complies with applicable Federal and State laws and regulations, including the requirements of UAC R315-101, by immobilizing free product and residual LNAPL, thus preventing future degradation of groundwater. A modification of the RCRA Part B permit will be required to incorporate the institutional controls to be implemented and administered by TEAD-S.

8.2.3.5 Cost

Capital costs for implementing Alternative 3 are $2,134,162 with 30 years of groundwater monitoring at $71,916 per year. The total present worth cost for implanting Alternative 3 is $4,291,642. Table K-3 of Appendix K provides a detailed cost estimate.

8.2.4 Alternative 4 – Extraction Trench, Natural Attenuation, and Institutional Controls

Alternative 4 consists of the construction of extraction trenches to enable recovery of free product, natural attenuation, imposing groundwater use and excavation restrictions, land use restrictions, and implementing a MNA/groundwater monitoring program. The intercept trenches will remove the free product from groundwater, which will be replaced by free product from the surrounding soils via diffusion and capillary action, until no free product is left in the surrounding soils.

To implement Alternative 4, three trenches will be located across the 60,000 square foot footprint of free product in groundwater (Figure 3.4), with two legs in a broad chevron (“V”) configuration with the apex of each chevron in the down gradient direction of groundwater flow (see Figure 8.4). Unstained soil will be excavated from each trench and stockpiled on site for reuse as backfill material. Stained and saturated soil will be excavated from each trench and transported off-site for treatment/disposal. Granular backfill will be placed within the saturated zone at the bottom of the trench to allow collection of the free product and direct it to vertical perforated collection sumps. Stockpiled/unstained soil will be used as backfill on top of the granular material, with additional backfill to be imported as needed from a TEAD-S borrow area. As free product accumulates in each of the collection sumps, it will be removed using pneumatic solar powered skimming pumps with controllers capable of cycling on and off as free product recovery occurs within each sump. Recovered free product will be accumulated on site in 55-gallons drums to be disposed of off-site as required. It is anticipated that the three intercept trenches will total approximately 500 ft in length and will be approximately 15 ft deep x 2.5 ft wide. Collection sumps, consisting of perforated drain pipe, will be placed vertically every 50 ft along the length of the trenches.

In addition, this alternative includes land use restrictions preventing a) the potable use of groundwater, b) excavation, and c) residential use. Additionally, land use restrictions requiring either a) the use of engineering controls at any potential future buildings at the site to limit vapor intrusion or b) an investigation to determine whether soil gas concerns remain on the site. Engineering controls that may be implemented include, but are not limited to: a vapor barrier, which may be either impervious or vented in such a way as to prevent vapor intrusion; or the use of other appropriate measures such as negative/positive exchange/ventilation systems. The groundwater, excavation and land use restrictions will be incorporated into TEAD’s master land use plan and/or the TEAD-S RCRA Part B hazardous waste permit.

Groundwater sampling will be conducted on an annual basis for 30 years to monitor LNAPL levels, TPH-DRO, petroleum constituents, and other non-fuel related VOC concentrations to ensure no further degradation of groundwater. Groundwater monitoring will also include the analysis of natural attenuation parameters such as dissolved oxygen, nitrate, sulfate, and methane from up-gradient and down-gradient monitoring wells to monitor ongoing biodegradation. Detailed monitoring and data tracking and analysis requirements will be included in a natural attenuation and LTM work plan following implementation of the corrective measures.

Corrective action and monitoring time frames associated with this alternative were assumed for cost estimating purposes.

Figure 8.4 Alternative 4 Conceptual Design

Legend

- ✖ Former AST Location
- ● Monitoring Well with Free Phase LNAPL
- ○ Collection Sump and Skimmer Pump
- ▬ LNAPL Collection Trench
- ➡ General Direction of Groundwater Movement (based on freshwater equivalent head)
- ▭ Stained Soil - Approximate
- ┅ Extent of Free Product-Feb. 2014
- 🟥 SWMU Boundary

Feet
0 40 80

Projection & Grid Coorindates:
NAD83 StatePlane Utah Central

PARSONS

Date:	12/3/2015
Prepared:	RGS
Checked:	DS
Revision:	1

Imagery: ESRI (c) 2015
Boundary, SWMUs, Wells: Deseret Chemical Depot

8.2.4.1 Technical Evaluation

Performance

The skimming of free product from an extraction trench and natural attenuation meets UAC-R315-101-3, the “Principle of Non-Degradation,” by removing free product and limiting continued impacts to groundwater. Alternative 4 relies on a) the migration of free product from the surrounding soils into the extraction trench via diffusion and capillary action to remove free product from soils and b) natural attenuation to reduce concentrations of residual TPH-DRO constituents in soil and those dissolved in groundwater. Based on available vendor information, skimming pumps are an effective recovery method, but due to the fine grained soil present at SWMU 13 and the volume requiring recovery, Alternative 4 will require long-term operation and maintenance. Alternative 4 achieves the remaining qualitative CAOs developed in the Section 4.0 by preventing human exposure to residual contaminants, with no decrease in effectiveness over time. Groundwater, excavation, and land use restrictions will prevent future residential use and potential exposure to contaminants in soil and groundwater.

As stated in Section 3.4.6, although there is a slight downward vertical gradient, the downward migration of TPH-DRO and petroleum constituents is believed to be primarily due to diffusion. Alternative 4 would reduce further downward diffusion by removing the free product and residual LNAPL (i.e., visibly stained soil). It is assumed that the petroleum constituents already in groundwater below the zone of influence of Alternative 4 would be addressed by natural attenuation. As indicated in Section 3.3.6.1, none of the petroleum constituents that were detected in the deep monitoring well (S13-CAM-DW1) were detected at concentrations above the tapwater RSLs and multiple degradation products of petroleum were detected (including methane), indicating that natural attenuation has mitigated downward diffusion of petroleum constituents.

Reliability

The removal of free product from an extraction trench will reduce impacts to groundwater over the long-term. Monitoring of the site will measure the effectiveness of the anticipated natural attenuation of petroleum constituents in soil and groundwater. Institutional controls if implemented, monitored, and enforced are effective over the long-term, and have been implemented with positive results at many sites. Alternative 4 will require operation and maintenance of the skimming pumps, management and disposal of recovered free product, and monitoring of the natural attenuation of petroleum constituents over the long-term.

Implementability

Implementation of Alternative 4 will require only standard excavation equipment for the construction of the extraction trench. Solar powered skimming pumps are readily available and have been used in similar applications for the recovery of free product. As Alternative 4 will require trenching across the former CAMDS site, abandoned or active subsurface utilities may affect its implementation. Implementation and maintenance of institutional controls at SWMU 13 should not be an issue as the anticipated future land use of the site is continued military use. Construction of the extraction trench could be accomplished in less than six months. Based on the results of the free product recovery test conducted during the SWMU 13 CMS data gap investigation (see Section 3.4.2) it was determined that the average initial recovery rate of the three wells tested was 3.6 gallons per day. As recovery rates are expected to decline significantly after startup, as the extractable free product in the adjacent soils is depleted, it was assumed that 25% of the initial recovery rate (.92 gallons per day) could be removed from each of the 13 collection sumps over the long-term. Based on this assumption, it expected that operation and maintenance of the extraction trench will be required for approximately 3.5 years to remove the estimated 14,000 gallons (see Section 3.5) of free product remaining in the subsurface. In addition to the operations and maintenance of the skimming pumps, groundwater monitoring is expected to be required for up to 30 years.

Safety

Alternative 4 poses no short-term risk to the surrounding communities, as all corrective action activities will be conducted on site. Onsite workers may be exposed to diesel fuel, fuel constituents, and methane vapors during construction, operation, and maintenance activities if appropriate precautionary measures are not implemented and maintained. Other onsite worker safety concerns are typical to environmental remediation activities, but can adequately be managed through an appropriate health and safety program.

8.2.4.2 Human Health Assessment

Removal of free product, institutional controls, and natural attenuation of fuel constituents will protect human health by preventing both short and long-term exposure to contaminated soil and groundwater. The residual risk remaining on the site for soil and groundwater results from residual concentrations of TPH-DRO constituents above acceptable residential levels.

8.2.4.3 Environmental Assessment

No adverse impacts to ecological receptors were identified in the Rust (1997) Phase II RFI, or Parsons CMS data gap investigation (see Section 3). The removal of free product and continued biodegradation of residual LNAPL will mitigate any potential risk to ecological receptors by removing contaminants from the site.

8.2.4.4 Administrative Feasibility

Alternative 4 complies with applicable Federal and State laws and regulations, including the requirements of UAC R315-101, by removing free product and residual LNAPL, thus preventing future degradation of groundwater. A modification of the RCRA Part B permit will be required to incorporate the institutional controls to be implemented and administered by TEAD-S.

8.2.4.5 Cost

Capital costs for implementing Alternative 4 are $207,543 with 3.5 years of operation and maintenance at $67,294 per year, and 30 years of groundwater monitoring at $71,916 per year. The total present worth cost for implementing Alternative 4 is $2,600,552. Table K-4 of Appendix K provides a detailed cost estimate.

8.2.5 Alternative 5 – Bio-Ponding and Institutional Controls

Alternative 5 consists of removing the visibly stained soil (i.e., containing both free product and residual LNAPL) within the footprint of free product in groundwater (Figure 3.4) to the extent practicable, land-farming of contaminated soil on site, aeration of contaminated groundwater, imposing groundwater use, excavation, and land use restrictions, and implementing a MNA/groundwater monitoring program.

To implement Alternative 5, unstained soil would be excavated and stock-piled on site to be used as backfill material. Based on the CMS data gap investigation observations, it is assumed that stained soil could be excavated at 8 – 15+ ft bgs within the impacted area (60,000 square feet) (see Figures 3.6, 8.5) with an estimated volume of approximately 18,000 cubic yards to be used as backfill. Confirmation samples will be collected from the stock-piled material to ensure that it is suitable for use as backfill.

Soil impacted by free product and residual LNAPL at an interval of 8-15+ ft bgs within the impacted area (60,000 square feet) will be excavated and treated on site by means of land farming. Due to the shallow depth to groundwater at SWMU 13, treatment will occur within a lined treatment cell to prevent further degradation of site soil and groundwater. Based on the CMS data gap observations, it is assumed that approximately 13,000 cubic yards of soil will require treatment/disposal (see Figure 8.5).

Visibly stained soil will be treated on-site in batches within a treatment cell measuring 200 feet by 200 feet. Visibly stained soil will be placed in the treatment cell in lifts of approximately two feet thick allowing for the treatment of approximately 2,950 cubic yards in each batch. To treat all impacted soil, at least five treatment batches will be required. It may be desirable to remove only the top of the remediated lift, and placing a new lift my adding contaminated soil and mixing. This may inoculate the added material with an active degrading microbial culture.

After each batch of visibly stained soil is excavated, the resulting excavation would be left open for the purpose of aerating contaminated groundwater. A temporary system consisting of a pump and aeration nozzles would be installed to circulate and provide oxygenation of groundwater within the excavation, thus enhancing natural degradation of groundwater constituents.

In addition, this alternative includes land use restrictions preventing a) the potable use of groundwater, b) excavation, and c) residential use. Additionally, land use restrictions requiring either a) the use of engineering controls at any potential future buildings at the site to limit vapor intrusion or b) an investigation to determine whether soil gas concerns remain on the site. Engineering controls that may be implemented include, but are not limited to: a vapor barrier, which may be either impervious or vented in such a way as to prevent vapor intrusion; or the use of other appropriate measures such as negative/positive exchange/ventilation systems. The groundwater, excavation and land use restrictions will be incorporated into TEAD's master land use plan and/or the TEAD-S RCRA Part B hazardous waste permit.

Groundwater monitoring will be conducted on an annual basis for 30 years to monitor LNAPL levels, TPH-DRO, petroleum constituents, and other non-fuel related VOC concentrations to ensure no further degradation of groundwater. Groundwater monitoring will also include the analysis of natural attenuation parameters such as dissolved oxygen, nitrate, sulfate, and methane from up-gradient and down-gradient monitoring wells to monitor ongoing biodegradation. Detailed monitoring and data tracking and analysis requirements will be included in a natural attenuation and LTM work plan following implementation of the corrective measures.

Corrective action and monitoring time frames associated with this alternative were assumed for cost estimating purposes.

8.2.5.1 Technical Evaluation

Performance

Alternative 5 meets the CAOs developed in Section 4.0. This alternative also complies with UAC R315-101-3, the "Principle of Non-Degradation" by minimizing the free product source that may migrate from soil to groundwater and the removal of dissolved contaminants from groundwater through aeration. Alternative 5 will meet the identified CAOs with no decrease in effectiveness over time. Although a significant volume of the source material would be removed and treated, some residual LNAPL will remain in the subsurface for an undetermined period of time. Groundwater, excavation, and land use restrictions will prevent future residential use and potential exposure to contaminants in soil and groundwater.

As stated in Section 3.4.6, although there is a slight downward vertical gradient, the downward migration of TPH-DRO and petroleum constituents is believed to be primarily due to diffusion. Alternative 5 would reduce further downward diffusion by removing the free product and residual LNAPL (i.e., visibly stained soil).

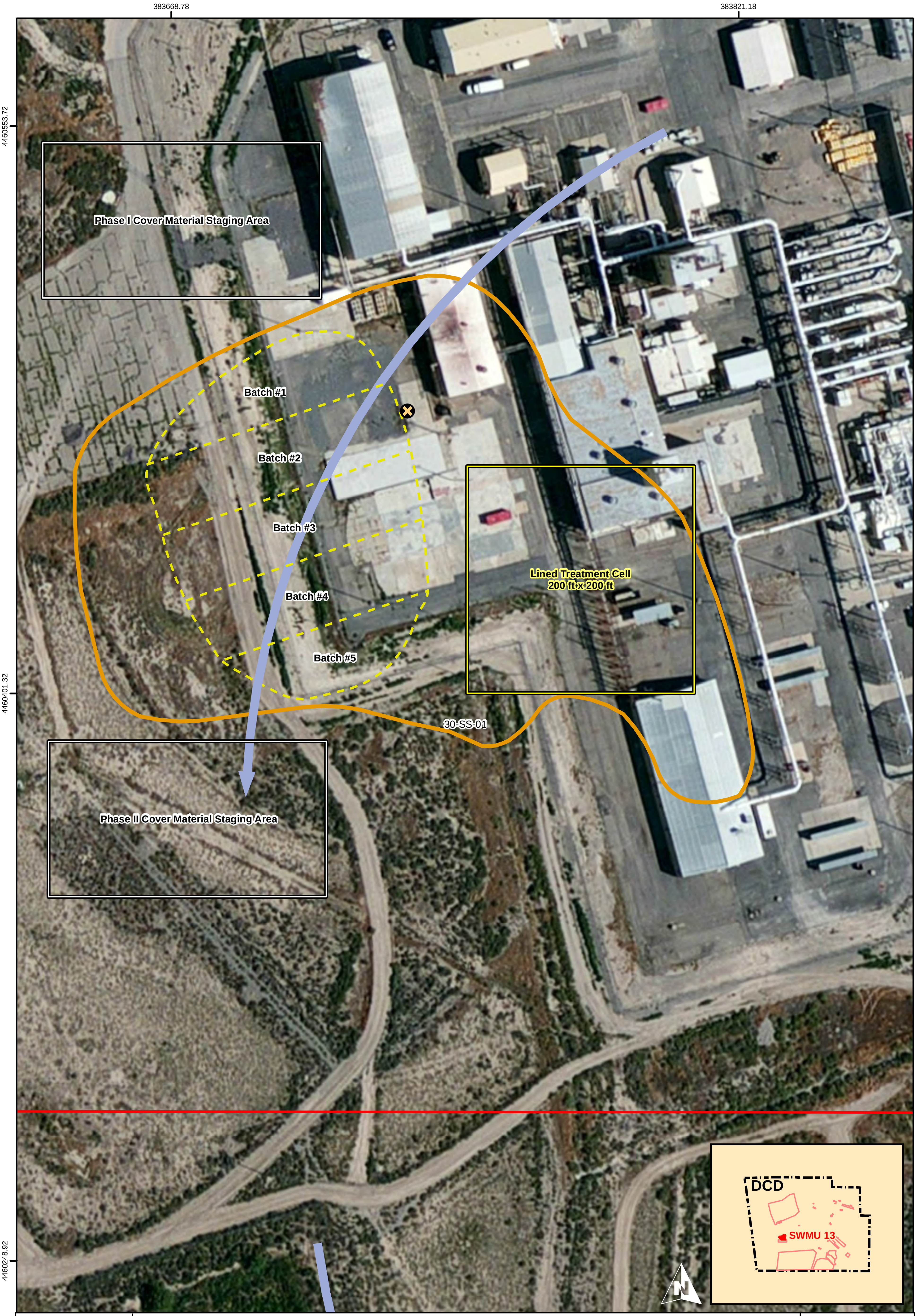

Figure 8.5

Alternative 5 Conceptual Design

Legend

- ⊗ Former AST Location
- ➔ General Direction of Groundwater Movement (based on freshwater equivalent head)
- ▭ Stained Soil - Approximate
- ⬚ Area to be Excavated and Backfilled
- ▭ SWMU Boundary

Imagery: ESRI (c) 2015
Boundary, SWMUs, Wells: Deseret Chemical Depot

Feet
0 40 80

Projection & Grid Coorindates:
NAD83 StatePlane Utah Central

PARSONS

Date:	12/3/2015
Prepared:	RGS
Checked:	DS
Revision:	1

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It is assumed that the petroleum constituents already in groundwater below the zone of influence of Alternative 5 would be addressed by natural attenuation. As indicated in Section 3.3.6.1, none of the petroleum constituents that were detected in the deep monitoring well (S13-CAM-DW1) were detected at concentrations above the tapwater RSLs and multiple degradation products of petroleum were detected (including methane), indicating that natural attenuation has mitigated downward diffusion of petroleum constituents.

Reliability

The on-site land farming of visibly stained soil, aeration of contaminated groundwater, and institutional controls will be effective over the long-term. Alternative 5 minimizes potential installation worker exposure to contaminated soil and groundwater at SWMU 13 and prevents potential future residential exposure to residual contaminants. No long-term management of waste materials is required. Long-term groundwater monitoring and monitoring/enforcement of institutional controls will be required in order to maintain the alternatives reliability.

Implementability

Implementation of Alternative 5 will present challenges due to the large volume of soil requiring treatment. Soil will require treatment in multiple batches, as the treatment of all visibly stained soil would require a treatment cell approximately 1,000,000 square feet. Alternative 5 will require the removal of subsurface soils over a significant portion of the former CAMDS site therefore abandoned or active subsurface utilities may affect its implementation. Pilot testing will be required to determine if amendments or additional nutrients would be required to grow an effective microbial population, and to determine the remediation timeframe for completion of the corrective measures. Air permitting may be required during the treatment process. As additional pilot testing will be required to determine the effectiveness and remedial time-frame required for implementation, estimating a remedial time frame at this time is difficult. For the purpose of comparison of this alternative against others, it is assumed that 18 months will be required to treated each batch of soil. As five batches are expected to be treated, land farming of the impacted soil is expected to take approximately 7.5 years with groundwater monitoring to be required for up to 30 years.

Safety

Due to the presence of free product, Alternative 5 poses a short-term risk from the volatization of petroleum constituents into the atmosphere. Onsite workers may be exposed to diesel fuel and fuel constituents during operation and maintenance activities if appropriate precautionary measures are not implemented and maintained. Other onsite worker safety concerns are typical to environmental remediation activities, but can adequately be managed through an appropriate health and safety program.

8.2.5.2 Human Health Assessment

Removal of free product and residual LNAPL, institutional controls, and natural attenuation of fuel constituents will protect human health by preventing both short and long-term exposure to contaminated soil and groundwater. The residual risk remaining on the site for soil and groundwater results from residual concentrations of TPH-DRO constituents above acceptable residential levels.

8.2.5.3 Environmental Assessment

No adverse impacts to ecological receptors were identified in the Rust (1997) Phase II RFI, or Parsons CMS data gap investigation (see Section 3). The removal of free product and continued biodegradation of residual LNAPL will mitigate any potential risk to ecological receptors by removing contaminants from the site.

8.2.5.4 Administrative Feasibility

Alternative 5 complies with applicable Federal and State laws and regulations, including the requirements of UAC R315-101, by removing free product and preventing the future degradation of groundwater. A modification of the RCRA Part B permit will be required to incorporate the institutional controls to be implemented and administered by TEAD-S.

8.2.5.5 Cost

Capital costs for implementing Alternative 5 are $1,623,189 with 30 years of groundwater monitoring at $71,916 per year for a total present worth implementation cost of $3,780,669. Table K-5 of Appendix K provides a detailed cost estimate.

8.3 COMPARATIVE ANALYSIS OF ALTERNATIVES

Table 8.1 and the following discussion summarize the comparative analysis of the five corrective measures alternatives developed for the CAMDS Diesel Fuel Release (SWMU 13).

8.3.1 Technical Evaluation

8.3.1.1 Performance

Alternative 3 meets the CAOs identified in Section 4.0 by immobilizing free product and residual LNAPL, preventing future degradation of groundwater. Alternatives 1, 2, 4, and 5 meet the CAOs by removing free product with natural degradation of residual LNAPL over the long-term. Alternatives 1 and 3 are rated high with respect to performance, as free product and residual LNAPL are removed over the short-term. Alternatives 2 and 4 are rated moderate, as free product is removed over the long-term and residual LNAPL concentrations are reduced through natural attenuation. Alternative 5 is rated low, as free product and residual LNAPL are only removed through natural attenuation processes.

TABLE 8.1
COMPARATIVE ANALYSIS OF CORRECTIVE MEASURES ALTERNATIVES FUEL SPILL SITE (SWMU 13)
TOOELE ARMY DEPOT - SOUTH

Corrective Measures Alternative		Technical Evaluation				Human Health Assessment	Environmental Assessment	Administrative Feasibility	Corrective Measures Implementation	Operations and Maintenance	Groundwater[b] Monitoring (30 yrs)	Total Cost (Present Worth)
		Performance	**Reliability**	**Implementability**	**Safety**							
1	Excavation, Advanced Aerobic Biodegradation with Institutional Controls	High	High	Moderate	Moderate	High	High	High	$1,730,916	$0	$2,157,480	**$3,888,396**
2	LNAPL Skimming/Natural Attenuation with Institutional Controls	Moderate	Low	High	High	High	Low	High	$135,700	$547,426[c]	$2,157,480	**$2,840,606**
3	In-situ Soil Mixing (Stabilization) with Institutional Controls	High	Moderate	Moderate	High	High	High	High	$2,134,162	$0	$2,157,480	**$4,291,642**
4	Extraction Trench/Natural Attenuation with Institutional Controls	Moderate	Moderate	High	High	High	Moderate	High	$207,543	$235,529[d]	$2,157,480	**$2,600,552**
5	Bio-ponding and Institutional Controls	Low	Low	Low	Moderate	High	Moderate	High	$1,623,189	$0	$2,157,480	**$3,780,669**

Note: a - Rankings indicate how well each alternative meets the evaluation criteria, relative to other alternatives
b - 30 years of groundwater monitoring at $71,916 per year
c - Annual O/M cost of $64,403 for 8.5 years (pump maintenenance, waste management, etc.)
d - Annual O/M cost of $67,294 for 3.5 years (pump maintenenance, waste management, etc.)

8.3.1.2 Reliability

Alternative 1 has been rated high for reliability as it is a technology that has been proven to be effective at other sites and requires no long-term operations and maintenance requirements. Alternative 2 requires long-term operations and maintenance, and is rated low as even though skimming from wells is commonly done, the fine grained soils at SWMU 13 will minimize the volume of recoverable free product in monitoring wells.

Additionally, even though degradation of petroleum constituents appears to be occurring on the site, it is unknown how long it will take to degrade petroleum constituents in soil to acceptable levels under Alternative 2. Alternative 3 has been rated moderate, as even though it has been shown to be effective at other sites, the volume requiring treatment at SWMU 13 is significantly more than is typically treated using this in-situ stabilization. Alternative 4 has been rated moderate for reliability as this alternative relies on natural attenuation of petroleum constituents in soil. Even though degradation of petroleum constituents appears to be occurring on the site, it is unknown how long it will take to degrade petroleum constituents in soil to acceptable levels under Alternative 4. Additionally, Alternative 4 has been shown to be effective at other sites, and requires minimal operation and maintenance over the long-term. Alternative 5 is rated low as it is unknown if the concentrations of free product and residual TPH-DRO constituents in soil and groundwater can be effectively treated by land farming.

8.3.1.3 Implementability

Alternatives 2 and 4 are rated high as they are easy to implement. Equipment, materials, and contractors required to implement these alternatives are readily available. Alternatives 1 is rated moderate, as even though equipment, contractors, and materials are readily available, the large volume requiring removal will present logistical challenges.

As it is unlikely that all free product will be removed through excavation in Alternative 1, concentrations of the remaining free product and residual LNAPL will be reduced over time through the placement or ORC in the excavation. Alternative 3 is rated moderate due to the area and volume requiring treatment. Surface features such as concrete pads and foundations, along with potential underground utilities may require removal or relocation prior to treatment. Alternative 5 is rated low due to the volume requiring removal and treatment, requiring a large area for land farming. Surface features such as concrete pads and foundations, along with potential underground utilities may require removal or relocation prior to excavation and land farming of impacted soil.

8.3.1.4 Safety

Alternatives 2, 3, and 4 are rated high as all remedial activities will conducted on site and pose no short-term risk to surrounding communities. Alternative 1 is rated moderate as surrounding communities could be exposed to contaminated media through vehicular accidents or improper containment of contaminated media. Due to the volume of material requiring treatment and concentrations of TPH-DRO constituents, volatization of contaminants to the atmosphere, Alternative 5 may pose a short-term risk to site and installation workers.

8.3.2 Human Health Assessment

Under the anticipated continued military use of the site, Alternatives 1 through 5 are rated high as they prevent both short-term and long-term exposure to contaminated soil and groundwater.

8.3.3 Environmental Assessment

Even though no adverse impact to ecological receptors were identified in the Rust (1997) Phase II RFI, or Parsons CMS data gap investigation (see Section 3), Alternatives 1 and 3 are rated high as contaminants would be removed or stabilized in the short-term, thus mitigating any potential risks to ecological receptors. Alternatives 4 and 5 are rated moderate as they cannot be implemented in the short-term, and may take several years to remove or treat significant quantities of contaminants. Even though Alternative 2 utilizes the same recovery technology as Alternative 4, Alternative 2 is expected to require a significantly longer period of time to remove significant quantities of LNAPL, as the volume to recover in monitoring wells will be significantly less that the extraction trench.

8.3.4 Administrative Feasibility

Alternatives 1 through 5 are rated high as they all comply with the “Principle of Non-Degradation” in UAC R315-101-3. Institutional controls are the same for all five alternatives, and are appropriate means of preventing human exposure to soil and groundwater contaminants at SWMU 13.

8.3.5 Cost

Costs for implementation, operations and maintenance, and monitoring of the alternatives considered for SWMU 13 range from $2,840,606 (LNAPL Skimming/Natural Attenuation with Institutional Controls) to $4,291,642 (In-situ Soil Mixing/Stabilization with Institutional Controls). Although Alternative 2 may meet the CAOs at the lowest cost, it has been rated the lowest overall due to the fine grained soils at SWMU 13 which will minimize the volume of recoverable free product. Alternative 4 (i.e., Extraction Trench/Natural Attenuation with Institutional Controls, $2,600,552) will meet the CAOs at a cost significantly less than Alternatives 1, 3 and 5.

SECTION 9.0
STATEMENT OF BASIS

9.1 INTRODUCTION

This Section presents the proposed corrective measures for the SWMU 13 fuel spill at TEAD-S. The fuel spill was the result of a leak in an underground diesel fuel line that occurred between 1980 and 1985. The leak went undetected for an unknown period of time and up to 38,000 gallons of fuel may have been released. This Section summarizes information that can be found in greater detail in previous Sections of this report.

9.2 SUMMARY OF ALTERNATIVES

The corrective measures alternatives evaluated in the CMS for the SWMU 13 fuel spill were the following:

- Alternative 1 – Excavation and enhanced biodegradation with institutional controls
- Alternative 2 – LNAPL skimming and natural attenuation with institutional controls
- Alternative 3 – In-situ soil mixing (stabilization) with institutional controls
- Alternative 4 – Extraction trench/natural attenuation with institutional controls
- Alternative 5 – Bio-ponding and institutional controls.

Details regarding the components of each alternative are presented in Section 7.0. Calculated costs associated for the implementation of each of the evaluated alternatives are as follows:

Alternative	Implementation	Operations and Maintenance	Long-Term Monitoring (30 yrs)	Total (Present Worth)
1	$1,730,916	$0	$2,157,480	**$3,888,396**
2	$135,700	$547,426	$2,157,480	**$2,840,606**
3	$2,134,162	$0	$2,157,480	**$4,291,642**
4	$207,543	$235,529	$2,157,480	**$2,600,552**
5	$1,623,189	$0	$2,157,480	**$3,780,669**

9.3 PROPOSED CORRECTIVE MEASURES ALTERNATIVE

Based on the comparative analysis presented in Section 8.0, Alternative 4 (i.e., Extraction Trench/Natural Attenuation with Institutional Controls) is recommended as the proposed corrective measures alternative for SWMU 13 as:

- It meets the quantitative and qualitative CAOs, including protection of human health and the environment and compliance with the "Principle of Non-Degradation," as required by UAC R315-101-3;
- Skimming of free product has been demonstrated to be effective at other sites;
- It is reliable and easy to implement; and
- It requires minimal long-term operations and maintenance.

9.4 SCOPE OF CORRECTIVE ACTION

Corrective action will consist of extraction trenches to recover free product, natural attenuation of petroleum constituents in soil and groundwater, groundwater use restrictions, excavation restrictions, land use restrictions, and long-term groundwater monitoring.

Three trenches will be located across the footprint of free product in groundwater (Figure 3.4), with two legs in a chevron ("V") configuration, with the apex of each chevron in the down gradient direction of groundwater flow (see Figure 8.4 for conceptual design). Granular backfill in the bottom of the trench will allow the free product to flow to collection sumps located throughout the trenches. As free product accumulates in each of the collection sumps, it will be removed using pneumatic solar powered skimming pumps within each sump. The free product that is removed will be replaced by free product from the surrounding soils via diffusion and capillary action, until no free product is left in the surrounding soils. Recovered free product will be accumulated on site in containers (e.g., 55-gallons drums) that will be disposed of off-site, as required.

Land use restrictions will be placed on the site to prevent the potable use of groundwater, excavation, and residential use of the site. Additionally, land use restrictions will be implemented that require either a) the use of engineering controls at any potential future buildings at the site to limit vapor intrusion or b) an investigation to determine whether soil gas concerns remain on the site. Engineering controls that may be implemented include, but are not limited to: a vapor barrier, which may be either impervious or vented in such a way as to prevent vapor intrusion; or the use of other appropriate measures such as negative/positive exchange/ventilation systems. Land use restrictions placed on the site will be incorporated into TEAD's master land used plan and/or the TEAD-S RCRA Part B hazardous waste permit.

Groundwater monitoring will be conducted on an annual basis to monitor LNAPL levels, TPH-DRO, petroleum constituents, and other VOCs known to be present in groundwater. Groundwater monitoring will also include the analysis of natural attenuation parameters such as dissolved oxygen, nitrate, sulfate, and methane from up-gradient and down-gradient monitoring wells to monitor ongoing natural attenuation/biodegradation. Groundwater data will be collected and maintained in such a manner to allow for trend analyses to ensure that no further degradation of groundwater occurs, as required by UAC R315-101-3.

9.5 PUBLIC PARTICIPATION

Public participation and input will be solicited on the proposed corrective measures and other alternatives evaluated in the CMS. The public will be invited to provide comments or input on other corrective measures alternatives not addressed in the CMS. A public comment period will be set to encourage the public to review the proposed corrective action and submit any comments or concerns.

SECTION 10.0
DATA AND INFORMATION SOURCES

This section presents a list of existing data acquired during the Phase II RFI (Rust 1997), CMS Data Gap Investigation (see Section 3), and a list of additional literature that was used during the CMS.

10.1 EXISTING INVESTIGATION DATA

The Phase II RFI (Rust 1997) and CMS Data Gap Investigation (see Section 3) included the collection of a variety of environmental media data as well as geologic and hydrogeologic data. Data that was used during the corrective measures alternatives evaluation included:

- Field logs,
- Soil boring logs,
- Soil gas sampling analytical results,
- Soil sampling analytical results,
- Groundwater sampling analytical results
- Water level measures measurements
- Free product thickness measurements
- Free product recovery data, and
- Current and future land use at TEAD-S.

10.2 LITERATURE DATA

In addition to data collected during the RFI and CMS Data Gap Investigation, the CMS evaluation utilized literature data from other sources that represent similar current and/or future conditions anticipated at SWMU 13. These literature sources included:

- Regional geologic or hydrogeologic studies,
- TEAD-S specific hydrogeologic studies,
- Data associated with the successful implementation of treatment technologies at similar sites (Appendix N), and
- Technical guidance documents prepared by other organizations, such as the Interstate Technology and Regulatory Council.

SECTION 11.0
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