DEPARTMENT OF THE AIR FORCE
377TH AIR BASE WING (AFGSC)

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NMED
Hazardous Waste
Bureau

Colonel Richard W. Gibbs
377th Air Base Wing
2000 Wyoming Blvd SE
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Mr. John Kieling, Bureau Chief
Hazardous Waste Bureau (HWB)
New Mexico Environment Department (NMED)
2905 Rodeo Park Drive East, Building 1
Santa Fe NM 87505-6303

DEC 15 2017

Dear Mr. Kieling

Attached please find the *Work Plan for Vadose Zone Coring, Vapor Monitoring, and Water Supply Sampling Bulk Fuels Facility, Solid Waste Management Unit (SWMU) ST-106/SS-111, Kirtland Air Force Base, New Mexico, Revision R1 dated December 2017.* The enclosed work plan is submitted in accordance with the Notice of Deficiency letter dated 16 November 2017. The Air Force and the New Mexico Environment Department (NMED) acknowledge that the enclosed work plan doesn't completely reflect the changes that were agreed to in the 30 November 2017 conference call with NMED. For convenience and in response to NMED's request to expedite the review process, the enclosed work plan is submitted in both redline strike out and changes-accepted versions.

The following changes were agreed to by the Air Force and NMED during the 30 November 2017 conference call:

- Tables 3-2 and 3-3 and Figure 3-3 will be revised to clarify that coring will start ten feet above the 1970 high water mark, which is equivalent to the 1960 high water mark. These data will facilitate identifying when the LNAPL first encountered the water table. This approach is within the current contract scope and could be accomplished without contracting delays. Coring ten feet above the 1960 high water mark was also discussed during the call, however that work would require a contract modification and additional funding;
- Coring S-7, which is identified as optional in the work plan, will be drilled in the identified location and completed as a well;
- All new wells be sampled on a quarterly basis if and until a sampling optimization plan is approved by NMED. The current contract is limited to quarterly funding for one year but a contract modification and the additional funding will be obtained before the year is completed; and
- Well construction designs will be updated to address continued well viability with the rising water table.

During the 30 November 2017 conference call NMED requested that S-3 be moved closer to Well KAFB-106064 to obtain data on the extent of light non-aqueous phase liquids (LNAPL). During the call EA Engineering, Science, and Technology, Inc. (EA) expressed concerns that drilling in this area may adversely impact the bio-degradation pilot test. One option discussed was drilling the continuous core but not completing the core as a monitoring well. After discussions with APTIM, the contractor for the bio-degradation pilot test, several concerns arose, mostly related to the use of sonic drilling used to collect continuous core. Because of the vibration cause by sonic drilling, there is a concern that it could cause issues with the in-ground piping and the injection equipment housed within the Conex. Likewise, vibrations could also break up grout and disrupt the flow through preferred pathways in the formation. As this is a pilot study, introducing unknowns could cause unintended consequences that negatively affect the test, which will be ongoing through mid-2020. While moving this boring location is in scope we would like to meet with NMED to discuss possible options.

KAFB4634

During the 30 November 2017 conference call NMED also requested that the background borehole (ST106-SBBG) be sampled in intervals that match the investigatory boreholes. The contract currently requires coring from 460-520 feet below ground surface, or 60 total feet of core. These data could be obtained without any delays in the field schedule. Changing the coring interval to 0-520 feet below ground surface and adding the additional sampling would require a contract modification, additional funding and would delay the collection of data from the background coring location. The scope for this additional work would be included in the new contract discussed below.

Based upon our 4 December 2017 conference call with NMED, it is the Air Force's understanding that NMED will require the submittal of a revised work plan to incorporate these required changes. As was discussed, the work plan revision will require a contract modification.

Future work outside the currently contracted scope of work was also discussed in the 30 November 2017 conference call. This additional scope included the following:

- A coring, which will be completed as a monitoring well near Well KAFB 106-18;
- A coring, which will be completed as a monitoring well at the current S-3 location in the attached work plan and
- A monitoring well near S-14.

At this time the AF is unable to provide firm schedules for contract modifications or new contract awards; however, the standard turnaround time for execution of a contract modification is 90 days and for a new contract award is 120 days. It will take approximately 60-90 days to complete the work plan after contract award. The Air Force is continuing to work to get this additional scope under contract, and will keep NMED apprised of our progress during this process. If the content of this submittal does not fully address NMEDs requirements, please notify the individuals listed below at your convenience.

If you have any questions or concerns, please contact Mr. Christopher Segura at (505) 853-5443 or at christopher.segura.2@us.af.mil or Mr. Scott Clark at (505) 846-9017 or at scott.clark@us.af.mil.

Sincerely

RICHARD W. GIBBS, Colonel, USAF
Commander

Attachment:
Work Plan for Vadose Zone Coring, Vapor Monitoring, and Water Supply Sampling Bulk Fuels Facility, Solid Waste Management Unit (SWMU) ST-106/SS-111, Kirtland Air Force Base, New Mexico, Revision R1 dated December 2017

cc:
NMED (Borrego) letter
NMED GWQB (Agnew, Hunter), letter and CD
EPA Region 6 (King, Ellinger), letter and CD
COA (Faris), letter and CD
ABCWUA (Shean), letter and CD
SAF-IEE (Lynnes), electronic only
AFCEC/CZ (Bilbrey, Segura, Renaghan, Clark, O'Grady), electronic only
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KIRTLAND AIR FORCE BASE
ALBUQUERQUE, NEW MEXICO

WORK PLAN FOR VADOSE ZONE CORING, VAPOR MONITORING, AND WATER SUPPLY SAMPLING
BULK FUELS FACILITY
SOLID WASTE MANAGEMENT UNIT ST-106/SS-111
Revision 1

December 2017

377 MSG/CEI
2050 Wyoming Boulevard Southeast
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KIRTLAND AIR FORCE BASE
ALBUQUERQUE, NEW MEXICO

WORK PLAN FOR VADOSE ZONE CORING, VAPOR MONITORING, AND WATER SUPPLY SAMPLING BULK FUELS FACILITY SOLID WASTE MANAGEMENT UNIT ST-106/SS-111 Revision 1

December 2017

Prepared for
U.S. Army Corps of Engineers
Albuquerque District
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Prepared by
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Contract No. W9128F-13-D-0006/Delivery Order DM02

NOTICE

This Work Plan was prepared for the U.S. Army Corps of Engineers by EA Engineering, Science, and Technology, Inc., PBC for the purpose of performing vadose zone characterization and monitoring activities in addition to water supply sampling associated with the Kirtland Air Force Base (AFB) Bulk Fuels Facility, Solid Waste Management Unit ST-106/SS-111. This work is performed under the U.S. Air Force Environmental Restoration Program, under requirements set forth in the Resource Conservation and Recovery Act permit issued to Kirtland AFB, with the New Mexico Environment Department serving as the lead regulatory agency. Addressed are the tasks related to the installation of soil vapor monitoring wells for future pilot testing; soil vapor monitoring, continuous coring, and sampling water supply wells.

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REPORT DOCUMENTATION PAGE

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14. ABSTRACT

This Work Plan describes specific vadose zone treatability studies to be conducted under the Resource Conservation and Recovery Act for the Bulk Fuels Facility leak at Solid Waste Management Unit ST-106/SS-111 at Kirtland Air Force Base, New Mexico. The Work Plan includes the technical approach for continuous coring of soil borings to investigate the distribution and characteristics of petroleum hydrocarbons submerged by increasing aquifer elevations. This Work Plan also includes the technical approach for installation of soil vapor monitoring wells for future pilot testing in three of the coring locations, dual-completion soil vapor/groundwater monitoring wells in eight coring locations, performance of vadose zone network monitoring and maintenance, and sampling of water supply wells.

15. SUBJECT TERMS

Work Plan, Kirtland AFB, Bulk Fuels Facility; continuous coring; soil vapor monitoring wells installation; soil vapor monitoring, water supply well sampling, Solid Waste Management Unit ST-106/SS-111, Interim Measure; LNAPL

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I certify under penalty of law that this document and all attachments were prepared under my direction or supervision according to a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations.

DAWN A. NICKELL, Colonel, U.S. Air Force
Vice Commander, 377th Air Base Wing

14 Dec 17
Date

This document has been approved for public release.

KIRTLAND AIR FORCE BASE
377th Air Base Wing Public Affairs

14 Dec 17
Date

PREFACE

This Work Plan is prepared by EA Engineering, Science, and Technology, Inc., PBC for the U.S. Army Corps of Engineers (USACE), under Contract Number W9128F-13-D-0006, Delivery Order DM02. This Work Plan pertains to the conductance of vadose zone treatability studies to address a leak at the Kirtland Air Force (AFB) Base Bulk Fuels Facility (BFF) (site), Solid Waste Management Unit ST-106/SS-111. The site is located in Albuquerque, New Mexico. This Work Plan was prepared in accordance with the permit issued to Kirtland AFB under the Resource Conservation and Recovery Act (RCRA) and applicable federal, state, and local laws and regulations.

The objective of the Work Plan is to describe specific vadose zone field activities to be performed in the source area of the BFF as well as water supply sampling. The Work Plan provides the technical approach for the continuous coring for subsurface sample collection, installation of soil vapor monitoring wells for future pilot testing at three of the coring locations, dual-completion soil vapor/groundwater monitoring wells in eight of the coring locations, soil vapor network monitoring and maintenance, and sampling of water supply wells.

This Work Plan is prepared for work to be performed between December 1, 2017 and September 22, 2021. Mr. Trent Simpler, PE, is the USACE–Albuquerque District Project Manager. The Environmental Restoration Section Chief for this program is Mr. Scott Clark of Kirtland AFB. The Work Plan was prepared by Devon Jercinovic, PG, CPG, PMP; Theresa McMillan, PG; Dustin Graves, PG, CHMM; Pamela Moss; Joshua Messenger; and Denise Wilt of EA, as well as Rachel Hobbs and Ryan Wortman of Sundance Consulting, Inc. and Dr. Robert Hinchee of Integrated Science & Technology, Inc. Devon Jercinovic is the EA Project Manager.

Devon Jercinovic, PG, CPG, PMP
Project Manager
EA Engineering, Science, and Technology, Inc., PBC

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ACRONYMS AND ABBREVIATIONS

ºC	degrees Celsius
%	percent
AFB	Air Force Base
AFCEC	Air Force Civil Engineer Center
APP	Accident Prevention Plan
ARCH	air-rotary casing hammer
bgs	below ground surface
BFF	Bulk Fuels Facility
BTEX	benzene, toluene, ethylbenzene, and total xylenes
C&D	construction and demolition
CFR	Code of Federal Regulations
COA	City of Albuquerque
DO	dissolved oxygen
DoD	Department of Defense
EA	EA Engineering, Science, and Technology, Inc., PBC
EDB	ethylene dibromide (also known as 1,2-dibromoethane)
EDD	electronic data deliverable
ELAP	Environmental Laboratory Accreditation Program
ELLE	Eurofins Lancaster Laboratories Environmental, LLC
EPA	U.S. Environmental Protection Agency
ERPIMS	Environmental Resources Program Information Management System
GWM	groundwater monitoring
GWTS	groundwater treatment system
IDW	investigation-derived waste
LNAPL	light non-aqueous phase liquid
mg/kg	milligram(s) per kilogram
NMED	New Mexico Environment Department
No.	number
NTU	nephelometric turbidity unit
O&M	operation(s) and maintenance
ORP	oxidation reduction potential
PDF	portable document format
PID	photoionization detector
PLSOP	primary land survey objective point
QA	quality assurance

ACRONYMS AND ABBREVIATIONS (CONCLUDED)

QAPjP	Quality Assurance Project Plan
QC	quality control
RCRA	Resource Conservation and Recovery Act
Site	Bulk Fuels Facility site
SOP	Standard Operating Procedure
SSHP	Site Safety and Health Plan
SVE	soil vapor extraction
SVEW	soil vapor extraction well
SVM	soil vapor monitoring
SVMP	soil vapor monitoring point
SWMU	Solid Waste Management Unit
USACE	U.S. Army Corps of Engineers
USAF	U.S. Air Force
VA	Veterans Affairs
VOC	volatile organic compound

EXECUTIVE SUMMARY

This Work Plan has been prepared by EA Engineering, Science, and Technology, Inc., PBC (EA) with support from Sundance Consulting, Inc. and Integrated Science & Technology, Inc. to address activities to be performed at Solid Waste Management Unit (SWMU) ST-106/SS-111, the Bulk Fuels Facility (BFF) at Kirtland Air Force Base (AFB), New Mexico. The Work Plan demonstrates the U.S. Air Force's commitment to continue addressing fuel contamination resulting from the BFF fuel leaks. This Work Plan outlines activities to be performed in support of vadose studies that will advance the remediation in the BFF leak source area. In conjunction with the Quality Assurance Project Plan (QAPjP) provided in Appendix A, this Work Plan will become the procedural guidance document for conducting these activities. These documents meet the most recent requirements of the Department of Defense (DoD) regarding planning documents for DoD facilities. The Work Plan was written in accordance with Kirtland AFB's Resource Conservation and Recovery Act Permit Number NM9570024423.

The objective of the Work Plan is to detail the activities to be implemented performing vadose zone treatability studies to support a future corrective measures evaluation, and continued monitoring of water supply wells in proximity to the BFF plume. The work to be completed is presented under each of the tasks listed below:

- Perform continuous coring and sample collection from up to 12 borehole locations
- Install soil vapor monitoring (SVM) points for future pilot testing in two continuous coring locations, and an air-lift enhanced well in an additional coring location
- Install dual-completion soil vapor/groundwater monitoring wells for future pilot testing in up to eight of the continuous coring locations
- Perform vadose zone monitoring, maintenance, and reporting of the existing SVM network
- Perform sampling and reporting of water supply wells.

1. INTRODUCTION

Under Contract Number (No.) W9128F-13-D-0006, Delivery Order DM02, EA Engineering, Science, and Technology, Inc., PBC (EA) was contracted to perform tasks associated with vadose zone treatability studies at Solid Waste Management Unit (SWMU) ST-106/SS-111, at Kirtland Air Force Base (AFB), New Mexico. This SWMU is known as the Bulk Fuels Facility (BFF) site. Environmental restoration efforts at the BFF site are being conducted under requirements set forth in Resource Conservation and Recovery Act (RCRA) Permit No. NM9570024423 (RCRA Permit) with the New Mexico Environment Department (NMED) serving as the lead regulatory agency (NMED, 2010).

This Work Plan addresses tasks supporting vadose zone treatability studies and water supply sampling and is the procedural guidance document for activities to be executed as part of the RCRA Corrective Action Process. Additionally, the work to be performed in accordance to this plan will also address outstanding data gaps in the delineation of the nature and extent of residual light non-aqueous phase liquid (LNAPL) in the vadose zone and groundwater. This Work Plan meets the most recent requirements of the Department of Defense (DoD) regarding planning documents for DoD facilities.

The requirements for the protection of health and attaining safety on the job sites are addressed in the companion *Accident Prevention Plan (APP) for the Kirtland AFB BFF Expansion of the Groundwater Treatment System (GWTS) and Vadose Zone Treatability Studies (Revision 4)* (EA, 2017). The APP also incorporates the Site Safety and Health Plan (SSHP). The APP is a dynamic document that will be revised to cover all activity-specific concerns and will be updated as necessary.

1.1 Scope of Activities

The BFF site is located in Albuquerque, New Mexico (Figure 1-1). This Work Plan covers activities required to meet the performance objectives associated with supporting vadose zone treatability studies as well as sampling water supply wells. The work associated with the vadose zone treatability studies includes continuous coring at up to 12 locations in the vadose zone to characterize contaminant zones; installation of soil vapor monitoring (SVM) wells for future pilot tests at three of the coring locations; installation of dual-completion soil vapor/groundwater monitoring wells in up to eight of the coring locations; SVM network sampling, maintenance, and reporting; and water supply sampling. This Work Plan was prepared in accordance with the RCRA Permit for Kirtland AFB (NMED, 2010) and applicable federal, state, and local laws and regulations. For completeness, this Work Plan includes the required elements of a Sampling and Analysis Plan/Field Sampling Plan including soil sampling associated with drilling activities, water supply well sampling, soil vapor sampling, data management, and waste management.

1.2 Work Plan Organization

The Work Plan is divided into the following sections:

- ***Section 1***—Presents an introduction to the plan and the scope of activities and organization of the Work Plan.
- ***Section 2***—Presents the site description and operational history.

- ***Section 3***—Summarizes the project tasks with sufficient detail on how the objectives will be accomplished. To avoid repetitiveness, activities that are common to more than one project task are presented only once, in Section 3.2.

- ***Section 4***—Presents the project schedule.

- ***Section 5***—Provides information on the organizational plan for the execution of work.

- ***Section 6***—Refers to the data management requirements.

- ***Section 7***—Refers to the quality assurance (QA) and quality control (QC) requirements that are further detailed in the QAPjP provided in Appendix A.

- ***Section 8***—Presents information on the management and disposal of the waste generated during this project.

- ***Section 9***—Refers to the safe work practices to be employed while executing this project, which are further detailed in the APP (EA, 2017).

- ***Section 10***—Provides references cited in the Work Plan.

Figures and tables follow the main body of the Work Plan. Appendices provided at the end of this Work Plan include:

- Appendix A—QAPjP

- Appendix B— Bioventing Well Design, Air-Lift Enhanced Bioremediation Well Design, and Dual-Completion Soil Vapor/Groundwater Wells

- Appendix C—Relevant Standard Operating Procedures from Kirtland AFB Basewide Plan (Appendix B; 2004)

- Appendix D—Soil Vapor Sampling Standard Operating Procedure (SOP)

- Appendix E—Water Supply Well Monitoring SOP

- Appendix F—Field Forms

- Appendix G—Definition of Land Survey Objective/Measuring Points and Land Survey Campaign among the Kirtland AFB Monitoring Well Network

- Appendix H—Project Schedule

2. BACKGROUND INFORMATION

2.1 Site Description

Kirtland AFB is located in Bernalillo County, in central New Mexico, southeast of and adjacent to the City of Albuquerque (COA) and the Albuquerque International Sunport (Figure 1-1). The approximate area of the base is 52,287 acres. The BFF site is located in the northwestern portion of Kirtland AFB.

2.2 Site History

The BFF and associated infrastructure operated from 1953 until 1999. During this time, the fueling area was separated into a tank holding area where bulk shipments of fuel were received and a fuel loading area where individual fuel trucks were filled. Kirtland AFB removed the underground piping at the facility from service in 1999 due to discovery of underground leakage. Even though the fuel leak was identified by Kirtland AFB, the exact history of the leaks or releases is unknown. Releases could have occurred when fuel was transferred from railcars to the pump house. Initially, it was thought that the leak only affected surface soil around the identified source area; however, Kirtland AFB learned through characterization activities that the leaked fuel had reached the groundwater and the dissolved-phase fuel contamination migrated northeast and north of Kirtland AFB.

To comply with NMED Hazardous Waste Bureau requirements, Interim Measures were implemented for both groundwater and soil. The goals of the groundwater Interim Measure are to protect drinking water supply wells and collapse the distal ethylene dibromide (EDB) plume. The soil vapor extraction (SVE) system addressing light non-aqueous phase liquid (LNAPL) in the source area was shut down in Quarter 2 of 2015 (U.S. Army Corps of Engineers [USACE], 2017a).

2.3 Ongoing Soil Vapor Monitoring

Semiannual SVM has been ongoing as part of the ST-106/SS-111 investigation to monitor the nature and extent of soil vapor contamination in the vadose zone. A total of 284 soil vapor monitoring points (SVMPs) at 56 SVM locations are sampled. Future sampling activities will be conducted under this work plan beginning in January 2018.

2.4 Ongoing Water Supply Monitoring

Three drinking water production wells have been sampled monthly as part of the ST-106/SS-111 investigation to confirm that they have not been impacted by groundwater contaminants. These wells include ST106-VA2 on Raymond G. Murphy Veterans Affairs (VA) Medical Center property, and KAFB-003, KAFB-015, and KAFB-016 on Kirtland AFB property. Monthly sampling of these wells under this work plan will be conducted beginning in 2018. In addition, at least one private water supply well will be sampled quarterly.

3. TASKS AND ACTIVITIES

Section 3.1 describes the tasks that will be performed under this project. Section 3.2 provides detail of activities that are common to more than one task.

3.1 Project Tasks

3.1.1 Continuous Coring

One of the principal drivers for the completion of continuous coring near the BFF source area is to address the data gaps of horizontal and vertical extent of LNAPL. Due to capillary forces and the physical properties of LNAPL, and after over 10 years of active SVE, residual fuel may remain in pore spaces and sorbed to soil particles in both the vadose zone and in the smear zone near the groundwater and vadose zone interface. Soil vapor hydrocarbon measurements as high as 30,000 parts per million by volume, suggest the hold up of free-phase fuel hydrocarbons in the vadose zone; however, the amount and chemical composition of the residual are not known. The objectives of the continuous coring are to provide supplemental data on the nature and extent of the residual fuels, and to characterize the subsurface biogeochemical conditions relative to residual hydrocarbon and EDB treatment potential.

When the fuel leak began, the water table was approximately 60 feet higher than current elevations (Rice et al., 2014). Water levels began dropping due to the development of the COA well fields, and reached their lowest level at the end of 2009. Groundwater fluctuations created a smear zone located from the maximum height of the LNAPL layer above the highest historical water table elevation to the minimum height of LNAPL-water interface at the lowest water table elevation (USACE, 2017a).

Nine continuous core locations (Figure 3-1) including one background location, were selected to characterize residual hydrocarbon within the vadose zone and saturated zone. Three additional locations are optional, and will be cored if field observations dictate a need for additional data in between the nine planned coring locations. Specific data objectives for the coring include:

- Provide supplemental information on the nature and thickness of the smeared LNAPL zone
- Collect data to support future intrinsic biodegradation pilot tests
- Accommodate well construction for future bioventing wells (KAFB-106V1 and KAFB-106V2)
- Accommodate well construction as air-lift enhanced well (KAFB-106S1) to support the future air-lift enhanced bioremediation pilot test
- Accommodate dual-completion of soil vapor/groundwater monitoring wells to support future vadose zone pilot tests and soil vapor and groundwater monitoring.

3.1.1.1 Drilling Approach and Methodology

Each proposed borehole location is referenced to an existing logged borehole; the closest existing borehole present that is believed to afford the best idea of the underlying geology at the location of the proposed coring locations. Table 3-1 provides a summary of the coring locations and rationale for each location.

Table 3-2 summarizes the drilling methodology and depths for each boring location. Figure 3-2 provides a decision logic and borehole sequence that is discussed in more detail below. The designated coring intervals (Table 3-3) at all borehole locations will be drilled using an 8-inch diameter sonic drilling rig with 4-inch diameter core barrel. Figures 3-3 and 3-4 show a cross sectional view of the lithology, historical data, and anticipated coring intervals for KAFB-106S1 through KAFB-106S9. Figures 3-5 and 3-6 show cross sectional transects, and cross sections, respectively, for the area near KAFB-106V1 and KAFB-106V2.

KAFB-106V1 and KAFB-106V2 will be cored continuously from ground surface to total depth. Due to the relatively shallow depths for KAFB-106V1 and KAFB-106V2, these borings will be completed entirely with sonic drilling to 10-inch nominal diameter. KAFB-106S1 and KAFB-106S9 will also be cored continuously from ground surface to total depth, and these borings will be over-reamed via air-rotary casing hammer (ARCH) technique to the nominal 10-inch diameter. All other borings will be accomplished using a combination of ARCH drilling to the designated coring depth, followed by sonic drilling to obtain undisturbed cores from the designated coring intervals. Upon achieving the top of the designated coring interval depth, the ARCH rig will be moved off each location while leaving the casing downhole, and the sonic rigs will be positioned at the cased holes to core the prescribed designated coring intervals and then subsequently reamed with a 9 ⅝-inch bit with the ARCH drilling rig to provide a large enough borehole for well construction. Figure 3-2 provides a decision logic and borehole sequence that will be followed to allow for modifications of the designated coring intervals, target depth intervals, and selection of optional borings to be completed.

Heating during continuous core collection can impact contaminant, geochemical and microbial properties and adversely affect sample representativeness. In addition to advancing the borehole to the designated coring depth with the ARCH rig, to minimize the heating potential, heating of the sonic drilling core barrels in the unsaturated zone can be controlled by any one or combination of the following:

- Advancing shorter sampling runs (5-10 feet versus 20 feet)
- Allowing the core barrel to cool (or pre-cooling the core barrel) before tripping back into the borehole
- Changing the vibration level and rotation speed
- Injecting small quantities of potable water between the override casing and the core barrel without compromising sample integrity as described in ASTM International D6914/D6914M-16.

Temperature inside the core will be monitored when returned to the surface to ensure that heating of the core barrel is not impacting sample selection or integrity. Background soil vapor temperatures in the vadose zone have historically averaged from 20 to 22 degrees Celsius (^{o}C). Average groundwater temperatures at the site are 19°C. Any core heating over 20°C will require mitigation steps as outlined above. If water is injected, the bottom few inches of the core intervals that are possibly in contact with water accumulating in the bottom of borehole will be discarded prior to collection of samples. Sonic core barrels in the saturated zone are naturally cooled by the presence of formation water; however, similar steps will be implemented as described above to ensure sample representativeness.

Table 3-3 summarizes the designated coring intervals and target sample depths for each borehole based on historical lithology, noted presence of hydrocarbons, and maximum and minimum depth to groundwater since the historical release. For borings that are not continuously cored from ground surface to total depth, the top of the designated coring intervals was selected based on historical data, anticipated

lithology (from nearby boreholes), or as 10-feet above the historical high water elevation (approximately 4930 feet amsl). The bottom of the designated coring intervals extends approximately 10 - 20 feet below the lowest historic recorded water level (2009) to ensure that the deepest vertical LNAPL migration elevation is evaluated. Target sample depths have been prescribed within each designed coring interval, as discussed in detail in Section 3.1.1.2. The designated coring intervals and target sample depths may be modified based on field observations and field screening measurements, and will be collaboratively coordinated with NMED and the project team. The target sample depths are intended as a baseline minimum (that maybe modified based on field conditions) that will not be eliminated or replaced, but may be supplemented with additional samples as outlined in the Decision Logic (Figure 3-7), and summarized on Table 3-3.

3.1.1.2 Rationale for Sampling Depth Intervals

KAFB-106S9 will be drilled first (Figure 3-2) and will be continuously cored to total depth. Designated coring intervals on subsequent borings may be adjusted based on field observations and data from KAFB-106S9 (with exception of KAFB-106S1 which will also be cored continuously to total depth), and other borings as the work progresses. Prescribed designated coring intervals were established from site data, as discussed below, and to serve as a baseline for planning purposes.

The probable underlying geology present at the location of the selected boreholes is inferred from borehole logs created during the construction of nearby monitoring wells. Photoionization detector (PID) measurements and qualitative data (e.g., presence of petroleum odor) recorded during the construction of these wells, and historic water level measurements were considered. The compilation of information was used to construct a cross-section of each proposed coring, and assisted in the determination of the number and location of target samples (Figures 3-3 and 3-4). Ultimately, the selected target sampling depths are located where changes in lithology were noted (e.g., lean clay to poorly graded sand) that could have influenced vertical hydrocarbon migration, where historical high PID readings or notable odor were recorded (from drilling or soil vapor monitoring in Quarter 4 2016 (USACE, 2017b)), or at historical or current water elevations. Target sample depths are generally prescribed in fine-grained lithologic units that might retain organics (i.e., silt and clay), or locations where the contaminants might have become perched or smeared. As discussed in Section 3.1.1.3, additional sample locations may be selected within each boring based on field screening (i.e. PID measurements).

3.1.1.3 Field Screening for Hydrocarbons

When advancing the borehole to the designated coring interval with ARCH, all cuttings will be logged and PID measurements will be taken at a minimum of every 20 feet as described in Section 3.2.10. If any PID measurements exceed 500 ppm, the material with the highest PID reading within the prescribed 100-foot depth interval(s) will be sampled for total petroleum hydrocarbons (TPH) (Table 3-3 and Figure 3-7), and PID measurements will subsequently be recorded for every 10 feet to the top of the designated coring interval depth.

Within the designated coring interval, PID readings will be collected every 10 ft. Additional measurements will be collected if qualitative data (e.g., staining, odor, etc.) indicate possible LNAPL (Figure 3-7). If any PID measurements exceed 1,000 ppm, the material with the highest PID reading within the prescribed 100-foot depth interval(s) will be sampled for multiple analytes, as discussed in Section 3.1.1.4 and shown on Table 3-3 and Figure 3-7. Historical PID measurements in the source area on split-spoon samples collected in advance of ARCH were on the magnitude of 4,000-6,000 ppm in fine grained units and directly above fine-grained units where LNAPL is indicated (Figure 3-6). PID measurements were not recorded on boring logs for wells that had historical LNAPL present, or had core

samples/LNAPL fluorescence collected (2011). Although references that correlate PID readings to the presence of LNAPL were not readily found, at least one reference provided an approximation that 1,000 ppm could potentially indicate NAPL presence (Golder Associates, 2011).

3.1.1.4 Laboratory Analyses for Selected Core Samples

Samples for laboratory analyses will be selected based on PID measurements (augmented by lithologic and qualitative data) and the prescribed sampling and analytical methodology outlined in Table 3-3. Selection of target sample depths will follow the decision logic presented in Figure 3-7, or may be modified based on field observations and data. Table 3-3 summarizes the laboratory analyses for selected samples, and provides information for each of the analyses regarding sample containers, required sample volumes, and sample preservation methods, and includes the laboratories to which specific samples should be shipped. Analyses are detailed in the QAPjP and include:

- Volatile organic compounds (VOCs) (EPA Method 8260C); EDB (EPA Method 8011), total petroleum hydrocarbons-gasoline range organics/diesel range organics/oil range organics (EPA Method 8015D); TestAmerica, Inc., Arvada, Colorado.

- LNAPL transmissivity and mobility, grain size, fluid properties, capillary pressure air/water drainage, free product mobility, relative permeability, and hydraulic conductivity; PTS Laboratories, Santa Fe Springs, California.

- LNAPL physical properties including gravity, hydrocarbon component analysis, flash point, and viscosity; Saybolt LP, Core Companies, Deer Park, Texas.

- Mineralogy using x-ray diffraction and energy dispersive x-ray spectrometry; IMR Metallurgical Services, Louisville, Kentucky.

- Microbial analysis using QuantArray-Chlor to identify and quantify halorespiring bacteria; Microbial Insights, Inc., Knoxville, Tennessee.

- Moisture analyses (ASTM D2216); Daniel B. Stephens & Associates Soil Testing Laboratory, Albuquerque, New Mexico.

3.1.2 Soil Vapor Monitoring Point Installation in Boreholes KAFB-106V1 and KAFB-106V2

KAFB-106V1 and KAFB-106V2 SVMPs will be completed in 10-inch diameter boreholes for use as observation SVMPs in the Bioventing Pilot Test, and will be a nested construction using Schedule 80 ¾-inch polyvinyl chloride from ground surface to deepest well depth of approximately 275 feet below ground surface (bgs). Screened intervals for both nested SVMP locations, and the rationale for the depth selections, are summarized on Table 3-4 and are shown on diagrams B-1 through B-6 (Appendix B).

The screened intervals for each SVMP are 2.5 feet in length with 20-slot screen and 10-20 filter pack. A schematic of the KAFB-106V1 and KAFB-106V2 completions are provided in Appendix B. The final construction diagrams will be submitted to NMED following installation, in the first post-construction report, to accurately document as-built conditions.

Table 3-4 also identifies possible future injection SVMPs and their paired screened intervals with these observation SVMP screened intervals. Table 3-5 summarizes possible injection SVMPs and the available observation SVMPs (including the new KAFB-106V1 and KAFB-106V2) that could be utilized in a future test and includes the lateral distances between the injection SVMPs and the available observation SVMPs.

3.1.3 Air-Lift Well Completion KAFB-106S1

KAFB-106S1 will be completed in a 10-inch diameter borehole for use in the Air-Lift Enhanced Bioremediation Pilot Test, and will be constructed using Schedule 80, 4-inch polyvinyl chloride. The air-lift enhanced bioremediation well will include a 4-inch diameter, continuous 60-foot screen (30-slot), with approximately 20 feet of screen below the water table, and approximately 40 feet of screen above the water table. A general schematic of the KAFB-106S1 completion is provided as diagram B-7 (Appendix B).

The pilot test Work Plan for bioventing has been submitted to NMED under separate cover. The Air-Lift Enhanced Bioremediation Pilot Test will be conducted using the 4-inch well installed in soil coring KAFB-106S1. The proposed air lift mechanism will consist of an air diffuser installed in a 2-inch diameter conductor pipe. The conductor pipe will be open near the base of the well and the air-lift diffuser installed inside the conductor pipe on a ¾-inch diameter airline pipe. The conductor pipe will serve as the “stripping reactor” in the air-lift process and will be open above the anticipated high water level to facilitate outflow of air-lifted oxygenated groundwater to the impacted aquifer at the water table. This oxygenated groundwater will then flow outward through the well screen setting up a vertical “recirculation” cell.

Two piezometers will be installed in the annulus of the air-lift pilot test well to allow placement of downhole multi-parameter probe to record water levels and geochemical parameters (e.g., dissolved oxygen [DO], oxidation reduction potential [ORP], pH, temperature, and specific conductance). Air supply to the system will be via air compressor and pressure regulator to ensure adjustable, constant air flow rates during the test.

Further details of the well and apparatus completion are documented in the Work Plan for Bioventing and Air-lift Enhanced Bioremediation Pilot Tests, to be submitted to NMED under separate cover.

3.1.4 Dual-Completion Vadose Zone/Groundwater Monitoring Wells

KAFB-106S2 through KAFB-106S9 will be completed in 10-inch diameter boreholes for use in future vadose zone pilot tests and monitoring, and will be constructed using Schedule 80, 4-inch polyvinyl chloride from ground surface to a depth approximately six feet below the current water table. Multiple 30-slot screened intervals will be installed with five feet of blank casing between each screened interval. The deepest screen will be 20 feet in length and the two screened intervals above will be 10 feet in length. The annulus will be completed with a 10/20 Colorado sand silica filter pack with bentonite seals placed across each interval of blank casing. A general schematic of the KAFB-106S2-KAFB-106S9 completion is provided as diagram B-8 (Appendix B). The design of the wells is intended to allow for options of future monitoring, for both soil vapor and/or groundwater, including possible retrofitting in the future with the anticipation of continued water level rise. The final construction diagrams will be submitted to NMED following construction.

3.1.5 Vadose Zone Monitoring and Reporting

The current SVM network consists of a total of 284 SVMPs installed at 56 SVM locations (Figure 3-8). Table 3-6 describes the SVM network including each SVM location, its associated SVMPs, and their associated easting and northing coordinates. In Summary, the SVM network includes:

- One SVM location contains four SVMPs co-located in the same vault as a GWM well in Bullhead Park (KAFB-106028; see location number one in Table 3-6).

- Thirty-five locations installed in 2010 and 2011, each with six SVMPs, are located throughout the BFF, on base property north of the BFF, on COA property in Bullhead Park and its open space area, and on VA property. These locations are named using the convention KAFB-106XXX to signify that they were installed as part of the investigation at SWMU ST-106/SS-111. Numbering at these 35 SVM locations ranges from KAFB-106108 through KAFB-106142 (see locations 2 through 36 in Table 3-6). Individual SVMPs at each location are further identified using the bottom of the screen depth of each point (e.g., KAFB-106108-050).

- Twenty locations installed inside the BFF named using the convention "soil vapor extraction well (SVEW)-XX" or "soil vapor monitoring well (SVMW)-XX" (see locations 37 through 56 in Table 3-6).

  — Four of these 20 locations have both SVMW and SVEW type SVMPs at a single location. For example, SVM Location Number 54 includes SVMW-13 (comprised of four SVMPs screened between 150 and 450 feet deep) and SVEW-11 (with one SVMP) all located together in a single well vault.

Semiannual monitoring of the SVM network was approved for ST-106/SS-111 on January 4, 2017 (NMED, 2017a), and will include sampling of the entire 284 SVMP network beginning in Quarter 2 2018. All field personnel collecting soil vapor samples are required to be trained and fully understand the sampling SOP provided in Appendix D. The Horiba Model MEXA 584L (or equivalent) will be used to measure total hydrocarbons, oxygen, and carbon dioxide.

Samples will be shipped to TestAmerica, Inc. in West Sacramento, California, where they will be analyzed for an optimized list of VOCs in air by modified Method TO-15 (NMED, 2017a, 2017b).

Data validation will be performed at the SVM locations listed in Table 3-7 and shown on Figure 3-9. A total of 21 locations (68 SVMPs) were chosen for data validation based on their location in relation to residential neighborhoods, or planned interim measures. The rationale for each location chosen is listed in Table 3-7. The SVM locations listed in Table 3-7 represent 23 percent (%) data validation, which exceeds the industry standard of 10%, and meets EPA guidance and the requirements of Section 6.5.1.8.3 of the RCRA permit. A 100% data validation will be performed at any new SVM locations until four events of baseline sampling have been established.

3.1.6 Maintenance of the Soil Vapor Monitoring Well Network

Maintenance for the SVM network will be performed during the sampling events. Prior to the first sampling event in 2018, the SVM network will be retrofitted to accommodate a transition to SUMMA® canister sampling (versus the previously utilized Bottle Vac™ samplers). During each sampling event, the condition of each well port will be examined by the field personnel to confirm the integrity of each

fitting and to immediately address and mitigate any problems or replace any defective parts. Wellheads will be inspected for integrity and necessary repairs will be performed as soon as possible. The findings of the inspections and any repairs made will be documented by photographs and on the appropriate field forms (Appendix F), which will be included in the corresponding Quarterly Monitoring Reports.

3.1.7 Water Supply Sampling and Reporting

Four drinking water supply wells (ST-106-VA-2 on the VA Medical Center property and KAFB-003, KAFB-015, and KAFB-016 at Kirtland AFB) will be sampled monthly beginning in January 2018 to confirm that they have not been impacted by groundwater contaminants (Figure 3-10). Table 3-8 lists the coordinates of each of these four wells. Samples will be analyzed for volatile organic compounds including EDB and benzene, toluene, ethylbenzene, and xylene (BTEX). Under another contract, additional analyses are performed semiannually for select total metals (total arsenic, calcium, lead, magnesium, potassium, and sodium), and select dissolved metals (iron and manganese), anions (ammonia nitrogen, bromide, chloride, nitrite/nitrate nitrogen, sulfate, and sulfide), and alkalinity. Field parameters will be recorded during sampling. These analytical requirements may also be revised in the future based on Technical Working Group recommendations and NMED agreement.

These existing drinking water supply wells at Kirtland AFB and the VA Hospital actively provide drinking water to the facilities' employees and inhabitants. Because the wells will be actively producing water during sampling, water levels at these wells will not be measured prior to sampling. In addition, one well volume will not be purged prior to sampling.

The drinking water supply well analytical data will be provided monthly in a technical memorandum. Analytical results will also be reported in the Quarterly Monitoring reports for Solid Waste Management Unit (SWMU) ST-106/SS-111.

In addition to the drinking water supply well sampling, private water supply wells within the vicinity of the EDB plume will be sampled on a quarterly basis with the consent of the well owner. Samples will be analyzed for volatile organic compounds including EDB and BTEX. Field parameters will be recorded during sampling. Production of a one-page technical memorandum with a summary of the quarterly analytical results will also be prepared and provided to USACE and Air Force Civil Engineer Center (AFCEC) for approval prior to sending to the homeowner(s) and NMED. Sampling and reporting will be performed in accordance with the Water Supply Well SOP (Appendix E). The private water supply wells are used for irrigation purposes, not for drinking water.

TestAmerica, Inc., Savannah, Georgia, will provide analytical testing services in support of this task for the EDB and BTEX analyses using EPA drinking water methods EPA 504.1 and 524.2, respectively. TestAmerica, Inc. maintains State of New Mexico drinking water certification for these methods. The metals and anions will be analyzed at Eurofins Lancaster Laboratories Environmental (ELLE), Lancaster, Pennsylvania. ELLE maintains current DoD Environmental Laboratory Accreditation Program (ELAP) certification and has the analytical expertise to perform the analyses required for this task in accordance with DoD Quality Systems Manual Version 5.0 (DoD, 2013) and EPA or other industry standard analytical methodologies. ELLE is also analyzing the quarterly groundwater samples associated with the BFF monitoring wells. TestAmerica, Inc. and ELLE reporting limits will achieve the EPA maximum contaminant levels and the New Mexico Water Quality Control Commission standards.

3.2 Activities Common to More than One Task

This section details the activities that are pertinent to more than one project task outlined in Section 3.1. The activities involve field implementation, and are described herein to avoid repetitiveness. Overall, the activities presented herein conform to the requirements of the Base-Wide Plans for the Environmental Restoration Program at Kirtland AFB (U.S. Air Force [USAF], 2004) ensuring that the data will be appropriate for the decision-making process. The following Kirtland AFB SOPs (USAF, 2004) are applicable to the work performed under this project, unless otherwise indicated in this Work Plan:

- B1.1, Borehole and Sample Logging
- B1.4, Monitoring Well Development
- B1.11, Equipment Decontamination
- B2.3, Subsurface Soil Sampling
- B3.1, PIDs and Organic Vapor Analyzers
- B5.1, pH
- B5.2, Specific Conductance
- B5.3, Water Temperature
- B5.4, DO
- B5.5, ORP.

The SOPs listed above are included in Appendix C.

3.2.1 Site Clearance and Utilities Location/Relocation

A utilities clearance will be conducted to locate all underground and suspended utilities both on Kirtland AFB property and off-base. On-base, utilities clearance activities will be conducted as prescribed by and in accordance with the Kirtland AFB site representative policies and procedures. Clearances will be renewed if they expire. No intrusive work will be initiated unless all locations are staked, the clearances from all on-base and off-base utilities have been obtained, and digging permits have been obtained. Utilities clearance activities at adjacent off-Base locations and COA right-of-ways will be prescribed by and in accordance with state of New Mexico utilities regulations. All underground utilities will be clearly marked before the start of any intrusive activities. All intrusive activities will take into account any existing utilities. The state of New Mexico's "New Mexico One Call" utility excavation clearance system will be used for all off-base drilling and excavation locations. Pot-holing will be performed to physically observe all utilities (using an approach adequately protective of the utility [e.g., hydro-vacuuming, air knife, hand digging, etc.]).

3.2.2 Permitting, Right-of-Way Agreements, and Right-of-Entry Agreements

Prior to any mobilization, copies of the right-of-way and right-of-entry agreements will be obtained for the location where work will be performed and documentation will be onsite with the field crew so that it is available in case inspections are being performed. In addition to access and site clearance, the appropriate permits will be obtained for the various field activities. The representative list of permits is presented below. Special attention will be taken for those permits that have an expiration date. The permitting process will be timed such that permit approvals will be received in time to maintain the schedule, but not too early in the process so that they expire before work is initiated. Permit renewals will be initiated such that the work will proceed with no interruption. Depending on the timing, permits may be combined. The list of permits/plans applicable to this project include:

- USACE Work Plan Vadose Zone Coring, Soil Vapor Monitoring, and Water Supply Sampling (when approved by NMED Hazardous Waste Bureau).
- USACE Work Plan for Bioventing and Air-Lift Enhanced Bioremediation Pilot Tests (in progress)
- New Mexico Office of the State Engineer Well Drilling Permits for each of the coring locations, SVM well locations, and GWM well locations with no consumptive use of water.
- COA Right-of-Way Licenses for SVM and GWM wells: these are already in place and will be kept on file to be available in case of inspections.
- COA specific plans:
  - Noise Control Plan/Permit for drilling.
  - Excavation/Barricade Permits for each drilling location off-Base.
- Kirtland AFB specific permits:
  - Erosion and Sediment Control Plan
  - 813 Request for Environmental Impact Analysis
  - Civil Engineer Digging Permit Request.
- Right-of-Entry Agreements and Licenses for accessing off-base locations for coring and SVM monitoring:
  - COA
  - Department of VA Health Care System
  - Private property owners of private irrigation wells.

3.2.3 Readiness Review Meetings

Readiness review meetings will be conducted with USACE and USAF a minimum of one week in advance of any new field activities. The meeting will be conducted to ensure that all pre-mobilization elements (e.g., approved plans, permits, right-of-way agreements, Kirtland AFB badging, and community notification) and mobilization elements (e.g., required staffing, equipment, and materials) have been completed.

3.2.4 Mobilization/Demobilization

Subject to USACE and USAF approval, EA (and our subcontractors) will maintain four laydown areas to support field activities. A BFF field office location has been located at Kirtland AFB, proximal to the BFF and a second field office near the GWTS and existing investigation-derived waste (IDW) storage yard. A secure fenced equipment yard has been established near the Truman gate for both heavy

machinery and materials; this yard will also hold materials and supplies meant for use on the project at locations outside of Kirtland AFB, as required. Roll-off containers filled with solid waste (soil cuttings and mud) may be stored at the IDW storage area near the GWTS. Due to the large number of roll-off containers required for delivery and transfer during daily drilling activities, waste management support is a key element of mobilization. Laydown site locations are presented on Figure 3-11.

3.2.5 Site Security

A safe and secure construction site will be maintained during the execution of all activities taking place inside or outside of Kirtland AFB. EA site and safety personnel will coordinate with USACE, USAF point of contact, and the current contractor to gain insight into site security precautions (i.e., after hours security guards) that are currently in progress. Based on lessons learned, a plan to control public access and reduce interference with the surrounding area (traffic control, noise control, and site security) will be implemented and a safe work environment for the field teams and the surrounding community will be established. On-Base, all critical laydown yards will be secured by fencing and locked gates and the office trailer will be locked.

3.2.6 Barricading/Traffic Control

Work areas for coring, SVM, or GWM well drilling, installation, or abandonment will be protected from pedestrian and vehicular access. Barricades, temporary traffic control measures, and detour routes will be established where necessary in accordance with COA Construction Services Division requirements. EA will comply with the COA's Construction Coordination Section for work within the public right-of-way, including barricade and excavation permits and fees, and providing data for traffic reports.

3.2.7 Erosion and Sediment Control

All construction subcontractor(s) will obtain the necessary National Pollutant Discharge Elimination System Construction General Permit and submit any required Notice of Intent to the local agencies if required to support tasks on this project. A Stormwater Pollution Prevention Plan will be developed and posted at the work site. Stormwater Pollution Prevention Plan inspections will be completed in compliance with the permit and after rain events. Best management practices for sediment control (i.e., silt fences) will be implemented and maintained to manage stormwater and sediment discharge from work areas.

3.2.8 Decontamination

Final decontamination of all equipment will take place in designated decontamination areas specific to the work activity and approved by Kirtland AFB. Water from decontamination will be managed as per Section 8.

The objective of field decontamination is to remove contaminants of concern from sampling, drilling, and other field equipment to concentrations that will not impact study objectives. Specifications for decontamination materials are as follows:

- Use a standard brand of phosphate-free laboratory detergent, preferably either liquid Liquinox® or powder Alconox®.

- Use tap water from a municipal water treatment system or use bottled drinking water for the wash. Soap and tap water will remove the gross contamination from the sampling equipment.

- Use deionized water for the final rinse of sampling equipment that has direct contact to the sampling medium (e.g., the non-dedicated pumps used to sample monitoring wells).

3.2.9 Borehole Logging

During drilling, each boring will be fully described on the boring log form (Appendix F) in accordance with ASTM International D5434 and will include the following, when applicable:

- Identification number and location of each boring

- A general description of the drilling equipment used that includes such information as rod size, bit type, pump type, rig manufacturer, and model

- Date and time of start and completion of boring

- Name of contractor, driller, and drill site geologist

- Size and length of casing used in each borehole

- Soil classification in accordance with the United Soil Classification System, color, relative density and consistency, soil components, soil moisture, stratification, hardness, grain size and size distribution, and odor

- Mineralogical content of the core (for correlation)

- Depth to water as first encountered during drilling, along with method of determination

- Observations during drilling will be noted, such as bit chatter, rod binding, rod drops, and flowing or heaving sands (if drilling fluid is used, the fluid losses, interval over which they occur, and the quantity lost will be recorded)

- Depth limits, type, and number of each sample taken

- Observations of visible contamination for each sample or from cuttings that appear to be contaminated.

3.2.10 Photoionization Detector

PIDs will be used to determine the location of soil samples, if any soil samples will be collected for chemical analysis. The need for a PID for soil sampling will be determined once the drilling techniques are selected. The PID will be calibrated and tested as required in the QAPjP.

3.2.11 Headspace Screening

Headspace field screening will be performed in accordance with the following procedures.

1. Take PID measurements from cuttings/core with the frequency described in future revisions of this Work Plan.

2. Immediately upon the retrieval, collect a representative portion of the sample and place in a clean, dedicated (e.g., single sample) 1-gallon press-and-seal plastic food storage bag.

3. Vigorously agitate the bag for at least 15 seconds then allow a minimum of 10 minutes for the sample to adequately volatilize.

4. During cold weather, warm the samples to room temperature prior to taking the headspace measurement.

5. Re-shake the bag and quickly insert the vapor sampling probe and record the maximum meter response (this should be within the first 2-5 seconds).

6. Record headspace screening data on the boring log.

PID measurements will be recorded at a minimum of every 20 feet of core following the process below. Note that specific drilling tasks may have additional monitoring requirements.

1. Immediately upon the retrieval of the 2-4 feet of core, cut a small hole in the plastic core sleeve and insert the PID and record the highest reading.

2. Seal hole in a plastic core sleeve with tape.

3. Record headspace screening data on the boring log and core sleeve.

3.2.12 Sonic Core Handling and Photography

Core from sonic drilling will be extruded into plastic core sleeves at 2- to 4-foot increments over a 10-foot interval. Core sleeves will be labeled with the depth interval and the top of the core will be indicated. Once PID measurements and soil samples have been collected and the core has been logged by the geologist, the core will be placed in core boxes and photographed using a high resolution digital camera. The core boxes will be secured at the end of the project to the designated Kirtland AFB facility currently used to store project cores.

3.2.13 Well Construction Diagrams

Construction diagrams will be completed for the SVMP's KAFB-106V1, KAFB-106V2, and the air-lift well KAFB-106S1, as well as the dual completion vadose zone/groundwater monitoring wells. Well design will be approved in advance by NMED, and well construction will be documented on forms such as the one provided in Appendix B. Each form will include:

- Project and site names, well number, and total depth of the well

- Depth of any grouting or sealing, the amount of cement and/or bentonite used, and the total depth of the boring

- Depth and type of well casing

- Static water level upon completion of the well and after well development (except for SVMP's KAFB-106V1 and KAFB-106V2)
- Installation date or dates, and name of the driller and the geologist installing the well; each installation diagram will be signed by the preparer
- All pertinent construction details of the wells, such as depth to and description of backfill materials installed (i.e., gravel pack, bentonite, and grout); gradation of gravel pack, length, location, diameter, slot size, material and manufacturer of well screen(s); position of centralizers; and location of any blank pipe installed in the well
- Description of surface completion, including protective steel casing, protective pipes, and concrete surface seal
- A description of any difficulties encountered during well installation
- Survey coordinates and the elevation of the top of ground and top of well riser.

3.2.14 Soil Sampling

Soil samples will be collected to characterize the distribution of LNAPL in the identified subsurface target zones as related to the objectives of the borehole drilling. Soil samples will be collected as described below.

3.2.14.1 Soil Sampling for Chemical Analysis

Soil samples may be collected for chemical analysis during drilling of the continuous coring locations (Table 3-3). Once the sample depths have been determined, soil samples will be collected using EnCore® samplers for analysis of volatile-type compounds. Analyses performed for physical testing and/or biological testing have sampling specific container and handling requirements as outlined in Table 3-4 of the QAPjP.

3.2.14.2 Investigation-Derived Waste Sampling for Chemical Analysis

Samples submitted for solid IDW profiling will be collected as a five-point composite from each roll-off bin. A sampling scoop with a long handle will be used to collect each aliquot for homogenization from below the waste surface. The soil will be homogenized with a stainless steel sampling tool in a disposable container and aliquots will be collected to fill containers as per the QAPjP. Section 8 provides additional information for the chemical analyses to be performed on IDW samples.

3.2.14.3 Soil Sampling for Geotechnical Testing

Moisture content will be performed on selected core samples, when retrieved core represents different lithologic intervals. The samples will be sent to Daniel B. Stephens & Associates soil testing laboratory in Albuquerque, New Mexico for analysis by ASTM D2216. The soil will be collected by field staff donning nitrile gloves and using a stainless steel trowel and placed in 1-gallon plastic baggies. Samples will be collected, labeled, and handled as outlined in the QAPjP.

3.2.15 Well Development

KAFB-106S1 will be installed as a groundwater monitoring well, and KAFB-106S2 through KAFB-106S9 will be completed as dual-completion vadose zone/groundwater monitoring wells. KAFB-106S1 will be developed within 1 week after installation but no sooner than 48 hours after grout installation by bailing and surging. Wells KAFB-106S2 through KAFB-106S9 will be developed when there is sufficient water column available in the wells. Well development details are as follows:

- Initial development will consist of swabbing and bailing until little or no sediment enters the well (approximately 2-4 hours). Development and purge water will be contained in a temporary tank. If the addition of water is necessary to facilitate surging and bailing, only clean potable water will be used.

- A bailer fitted with a toggle valve will be lowered into the well and used to gently surge the screen interval to remove any accumulated sand, silt, and debris accumulated in the well bore. When the bailer is brought to the surface, an Imhoff cone will be used to collect water from the first bailer run to evaluate the amount of silt and sediment in the water. This process will be repeated after each cycle of surging development.

- A minimum of five casing volumes of water will be developed from the well.

- At the completion of well development, a sample will be collected and immediately photographed to document the results of the procedure.

The main goal of well development is to reduce the turbidity to less than 10 Nephelometric Turbidity Units (NTUs) (under 100 NTUs is acceptable). The site geologist will monitor field parameters including pH, temperature, and specific conductance, and record the results and other pertinent information on the well development record form (Appendix F).

3.2.16 Groundwater Gauging and Sampling

Following well development, groundwater and LNAPL (top and bottom) will be measured in KAFB-106S1, and all boreholes completed as dual completion vadose zone/groundwater monitoring wells. The wells will be allowed to recover a minimum of 24-hours following development prior to gauging, or water sampling. A baseline groundwater sample will be collected from the well utilizing a portable pump and dedicated tubing. Groundwater sampling will be performed in accordance with the procedures outlined in the Work Plan for Bulk Fuels Facility Expansion of the Dissolved-Phase Plume Groundwater Treatment System Design (USACE, 2017c). The new wells installed in this work plan will be incorporated into the groundwater monitoring program as soon as available (i.e. following proper development), and sampled as “newly-installed” wells quarterly during the one year baseline period. Following the baseline sampling, the wells will be proposed for a sampling frequency consistent with plume monitoring in each well location. If additional data are required, nearby wells may be sampled more frequently than the monitoring program in frequency provided in the Work Plan for Bulk Fuels Facility Expansion of the Dissolved-Phase Plume Groundwater Treatment System Design (USACE, 2017c). Future sampling and sample frequency of the air lift well, and any wells used in the pilot tests, will be described in the air-lift test plan. KAFB-106S1 will not be incorporated into the GWM network until completion of the air-lift pilot test and removal of downhole equipment.

3.2.17 Sample Packaging and Shipping

Sample packaging and shipping requirements are designed to maintain sample integrity from the time a sample is collected until it is received at the analytical laboratory. All chain-of-custody forms, sample labels, custody seals, and other sample documents will be completed as specified in the QAPjP. Specific procedures for packaging and shipping of environmental samples are presented below:

1. Complete sample label with indelible ink and attach to the sample bottle. Place sample bottles in a cooler for shipping.

2. In preparation for shipping samples, tape the drain plug shut so that no fluids, such as melted ice, will drain out of the cooler during shipment. A large plastic bag may be used as a liner for the cooler. Place packing material, such as bubble wrap, in the bottom of the liner. Place ice at the bottom of the cooler.

3. Place the containers in the lined cooler. Place cardboard separators or bubble wrap between the containers at the discretion of the shipper.

4. All samples for chemical analysis must be shipped cooled to ≤6 degrees Celsius with ice. Include a temperature blank in each sample container prior to shipment.

5. Tape the liner closed, if used, and use sufficient packing material to prevent sample containers from making contact or rolling around during shipment.

6. Place a copy of the chain-of-custody form inside the cooler.

7. Close and tape the cooler shut with strapping tape (filament-type).

8. Place custody seals on the cooler. Place clear tape over the custody seals to help prevent them from being accidentally torn or ripped off.

Ship the cooler of samples via an overnight carrier. A copy of the shipping bill will be retained with the field records and sent electronically to the Project Chemist.

3.2.18 Site Restoration

Site restoration will consist of backfilling and compaction, surface restoration/resurfacing, and landscaping restoration. Work areas will be restored to original conditions; and, in the residential areas, pavement of the type and thickness meeting COA Department of Municipal Development requirements will be replaced.

3.2.19 Survey

Land surveying activities will occur before, during, and after well installation activities. The surveys will be conducted at locations on Kirtland AFB, adjacent residential neighborhoods, and COA right-of-ways, as required. The surveys will establish northings, eastings, and elevations at all locations. All survey points will be verified, determined, marked, and documented per the provisions specified in the Definition of Land Survey Objective/Measuring Points and Land Survey Campaign among the Kirtland AFB Monitoring Well Network, which is included in draft form as Appendix G. This draft documentation includes an SOP and preliminary work plan for completing a survey of 400 existing monitoring wells

within and nearby the Kirtland AFB in southeastern Albuquerque. For the purpose of the resurvey, wells have been divided into two categories, as follows: Category I wells include groups or clusters of wells within close proximity and which, therefore, represent minimal groundwater potentiometric surface gradients; and Category II wells include wells that are more distal to one another with larger groundwater potentiometric surface gradients. Datum specifications (refer to Appendix G for additional detail) are as follows for the two categories:

- New Mexico State Plane Coordinate System, Central Zone, North American Datum of 1983
- Category I and II horizontal uncertainty at the primary land survey objective point (PLSOP) = <0.03 feet
- North American Vertical Datum 1988
- Category I altitude uncertainty at the PLSOP = < 0.01 feet
- Category II altitude uncertainty at the PLSOP = < 0.15 feet.

A survey of horizontal positions (x-y coordinates) for existing wells will be completed in future years under a separate contract. For the survey of new wells to be installed under this Work Plan, the same procedures will be followed by a state of New Mexico-registered professional land surveyor or licensed Professional Engineer. Applicable requirements for uncertainty will also be used for excavation extents, temporary benchmarks as required for site controls, and as-built determination surveys.

Daily reports will consist of the following: a tabulation of the location, identification, coordinates, and elevations of each point surveyed that day. The elevations at junctions for all conveyance lines will be inverted.

As the documentation provided in Appendix G is still in draft form and further revisions are anticipated, survey work will be conducted throughout the duration of the project according to the version of these specifications current at the time work is being performed.

3.2.20 Analytical Services

Groundwater, drinking water, soil vapor, soil, and LNAPL samples will be collected, labeled, packaged, and shipped to the subcontractor laboratory as indicated below:

- ***Eurofins Lancaster Laboratories Environmental, LLC (ELLE), Lancaster, Pennsylvania***—Groundwater monitoring samples and well installation soil samples. ELLE maintains a current DoD ELAP certification for the analyses required under this contract (Appendix A, Attachment 1).
- ***TestAmerica, Inc., Arvada, Colorado***—Soil samples associated with the coring activities. Test America, Inc. maintains current DoD ELAP certification (Appendix A, Attachment 2).
- ***TestAmerica, Inc., Savannah, Georgia***—Drinking water samples from supply wells and domestic irrigation wells. TestAmerica, Inc., Savannah maintains current State of New Mexico drinking water analysis certification (Appendix A, Attachment 2).

- ***TestAmerica, Inc., West Sacramento, California***–Soil vapor samples associated with semiannual SVE monitoring. TestAmerica, Inc. maintains current DoD ELAP certification (Appendix A, Attachment 3).

- ***PTS Laboratories, Inc., Santa Fe Springs, California***–Soil coring samples for LNAPL transmissivity and mobility (Appendix A, Attachment 4).

- ***Saybolt LP, Core Companies, Deer Park, Texas***–LNAPL component testing associated with continuous coring activities (Appendix A, Attachment 5).

- ***IMR Metallurgical Services, Louisville, Kentucky***–Soil sample testing for x-ray diffraction and energy dispersive x-ray spectrometry associated with continuous coring activities (Appendix A, Attachment 6).

- ***Microbial Insights, Inc., Knoxville, Tennessee***–Soil samples for halorespiring bacteria to support vadose zone treatability studies (Appendix A, Attachment 7).

- ***Daniel B. Stephens & Associates***–Soil samples collected for geotechnical analyses to determine soil properties associated with well installations (Appendix A, Attachment 8).

3.2.21 Data Validation

Analytical data generated in support of this contract will undergo data validation by the Project Chemist and an independent third party validation subcontractor to ensure compliance with data quality and project objectives per the QAPjP (Appendix A). All project data will undergo data verification by the Project Chemist or designee. For new data collection activities, 100% of the coring data and new well groundwater data will undergo EPA Stage 3 (formerly EPA Level 3) data validation for the criteria specified in the QAPjP. Due to the robust data set associated with SVM, 23 percent of analytical data for soil vapor is proposed for EPA Stage 3 data validation. Data qualifiers will be uploaded to the project database prior to finalizing data for use in project reports. Results of the data verification and validation efforts will be documented in the data validation report to be included with the Periodic Monitoring Reports. Data validation will be conducted in accordance with the requirements presented in the QAPjP.

3.2.22 Environmental Resources Program Information Management System Data Upload

Analytical and field data associated with the coring, drilling, and sampling activities will be managed and stored using EQuIS® Environmental Data Management System (Version 6.0). In addition to the EQuIS electronic deliverable, EA will receive Environmental Resources Program Information Management System 6.0 (ERPIMS) formatted deliverables from the laboratory for processing and submittal to the USAF Data Management ERPIMS support contractor on a semiannual basis for upload to the USAF Data Repository. ERPIMS submittals will include all soil vapor and groundwater data in addition to the chemical analysis of soil samples. IDW data will not be submitted to ERPIMS.

3.2.23 Public Notification

The public will be informed through door-to-door notifications at least seven days prior to mobilizing off-Base for intrusive activities, such as drilling.

4. PROJECT SCHEDULE

The project schedule is provided in Appendix H.

5. ORGANIZATIONAL PLAN

5.1 Organizational Structure

The organizational structure for this project is shown in Figure 5-1.

5.2 Responsibilities, Qualifications, and Authority of Key Personnel

Table 5-1 summarizes roles and responsibilities, qualifications, and authorities of project team members for the vadose zone treatability studies.

6. DATA MANAGEMENT

This section provides the data management process and procedures to be implemented for the field data and analytical laboratory data generated from work activities in support of the BFF pilot tests. The data management will satisfy the requirements of the QAPjP (Appendix A).

6.1 Personnel Roles and Responsibilities Specific to Data Management

Specific data management roles and responsibilities for the Data Management Lead and Field Team Lead are discussed below:

- ***Data Management Lead***—Responsible for oversight of transfer of field data to electronic data deliverable (EDD) format for loading to the project database, loading of laboratory EDDs, updating the database as required with current data pulls from the Environmental Resources Program Information Management System (ERPIMS) data repository, and running reports to provide current and historical data from the database. Also responsible for uploading the database with data validation qualifiers following validation, edits resulting from data validation, and delivering the ERPIMS data deliverable to the USAF data management contractor.

- ***Field Team Lead (responsibility will be assigned for each task to qualified staff)***—Responsible for the accuracy of all field activity-related documentation and records collected in support of project plan implementation including all information related to field sample collection; field instrumentation and measurements; equipment decontamination; and sample management and shipping documentation, field variance, and corrective action.

6.2 Project Data Types and Records

Field and analytical data will be collected as appropriate in support of activities associated with the BFF vadose zone treatability studies including coring, long-term SVM, well drilling and installation, drinking water supply well sampling, and irrigation well sampling. The following section describes the types of records and documentation that will be included for current and historical datasets, databases that will be used, database input requirements, and how data will be maintained and archived.

6.2.1 Project Data and Records

Project data will be documented and recorded using various methods as applicable. The following is a list of the various field and laboratory documentation and records that may be generated during project data gathering activities as applicable.

- Air bills and sample shipping documentation
- Analytical laboratory reports
- Chain-of-custody records
- Communication logs/e-mails
- Corrective action reports

- Documentation of corrective action results
- Documentation of deviations from methods (variances)
- Documentation of internal QA reviews
- Laboratory EDDs
- Field data collection forms, including boring logs, well construction logs, and field parameter logs
- Sampling notes in bound, waterproof field logbooks or on designated field forms
- Field instrumentation calibration logs
- Survey files for well location
- Identification of QC samples
- Photographs
- Sampling equipment decontamination records
- Sampling location figures (based on targeted and actual coordinates)
- Field variance request forms.

These records will be created in either written (e.g., sampling notes) or electronic formats (e.g., Global Positioning System files, measurement instrument/data-logger files, field databases, etc.). All records will undergo an independent review either at the laboratory or in the field by the technical leads, QA Officer, or the Project Manager. Additional information is provided in the QAPjP (Appendix A).

6.2.2 Laboratory Analytical Testing

Laboratory samples to be collected in support of the project include soil, soil vapor, and water for chemical analysis data and geotechnical soil testing data. Data deliverables to be provided by laboratories will be project- and data-type specific. Laboratory data will include:

- ***Chemical Analytical Data***—EPA Level IV-type data report (in portable document format [PDF]) and electronic data files in EQuIS® format and ERPIMS Version 6.0.
- ***Geotechnical Soil Data***—Electronic data file in Microsoft® Excel and summary report PDF.

6.2.3 Chemical Analytical Data

Chemical analytical data will include sample results from soil, soil vapor, and groundwater samples generated by the laboratory subcontractors. These data may include both routine and non-routine analytical testing. For all chemical analytical data, the laboratory will provide level 4 type data reports as defined in the QAPjP, EQuIS® 6 EDD for validation and loading into the project database and ERIPMS

version 6.0 EDDs for processing and submittal of validated analytical data to the AFCEC data management contractor. The PDF data deliverable will be consistent with the requirements specified in the project-specific subcontractor statement of work.

The laboratories are responsible for ensuring that all analytical data reported in the electronic copy and level 4 type data report are consistent, accurate and complete in accordance with their scope. Verification of EDD formatting and completeness will be performed by the EA data management personnel during data review and upload of electronic data files. EDDs and data reports received from the laboratory that contain errors will be returned to the laboratory for correction and resubmittal. All chemical analytical data will be uploaded to the USAF data repository.

6.2.4 Geotechnical Data

Moisture content data will be generated by the subcontractor geotechnical testing laboratory. Testing results will be provided in Microsoft® Excel format and in a PDF data report. Geotechnical data results are not required to be submitted in ERPIMS format and will not be uploaded to the USAF data repository. This type of data will be reviewed by the Field Team Lead and the geotechnical data will be maintained in the electronic project files and provided in project reports.

6.3 Handling and Management of Project Generated Data

Data handling and management procedures are established to effectively process analytical and measurement data generated during field activities such that the relevant data are readily accessible and accurately maintained. There are multiple activities involved in the recording, storage, processing, and maintenance of project datasets and systems to manage these. In order to ensure that data are accurately recorded and stored, data tracking systems will be implemented. Automated and manual QC checks will be conducted to verify that data have been accurately recorded and appropriately stored. Corrective actions will be taken and documented in the event data have not been properly handled. General data handling and management as well as information on naming conventions, loading, and reporting of laboratory analytical data are discussed in this section.

The following subsections describe the data handling and management of data collected during field activities at Kirtland AFB, including onsite field and measurement data and offsite laboratory data. Field measurement and analytical data will be loaded into an EQuIS® database using Microsoft® Excel files and laboratory EDDs provided in the appropriate format per the templates provided by the data management team. These files will be saved and stored in Kirtland AFB project-specific folders located on the EA secure server.

6.3.1 Data Management Processes for Field-Related Data

Three general types of data will be collected and recorded in the field:

- Data to support sample collection and analysis
- Field measurements
- Field observations.

Project data collected during monitoring, investigation, and remediation sampling activities will be managed and stored using the EQuIS® Environmental Data Management System (Version 6.4). The types of field data to be managed in EQuIS® include field sampling parameters collected during well sampling and vapor monitoring, water level measurements, sampling observations, and sample location information

such as coordinates, etc. Field data will be recorded on the appropriate forms or electronically, and reviewed and transferred to the field data electronic format as appropriate. The EDDs will be reviewed for accuracy and completeness against field records prior to being loaded into the EQuIS® database. The Data Management Lead will be responsible for ensuring that all field data files uploaded into EQuIS and ERPIMS are maintained on the corporate project server along with the ERPIMS submittal files and the project-specific database.

Field data that cannot be integrated into the database (i.e., site photographs, field logbooks, or field forms) will be stored electronically in the project-specific network folders and/or in the project files, along with supporting metadata such as author/creator of data, date, location, and a brief description. The Field Team Leads will be responsible for ensuring that all field data files are stored electronically in the project-specific network folders and all paper copies scanned and stored electronically in the project folders.

6.3.2 Analytical Data Management and Data Validation

Procedures for collecting field samples for laboratory analysis and the types of analyses to be conducted during the field activities are provided in Table 3-1 of the QAPjP (Appendix A). This section provides an overview of the EDD to be used for analytical data, the EDD loading process, field data verification, and analytical data validation. Record-by-record review of hard copy to electronic data transmittals from laboratories will be verified including validation qualifiers provided by the validation subcontractor.

Data management staff will review data and records received from the field team, subcontractor laboratories, and other subcontractors using the following process to ensure accuracy:

- Review field notes, logbooks, and field forms
- Verify field coordinates with the Geographic Information System group
- Record-by-record review of hard copy or electronic data transmittals from laboratories to data validators against the records loaded in the database for all validated results
- For data transmitted through subcontractors (not including the laboratories), 5-10 percent of loaded data records will be checked against data transmittals to verify import procedures
- For calculated or reported total analyte results, calculations will be performed on 100 percent of data to verify concentrations.

Laboratories will be required to submit their results in ERPIMS and EQuIS® EDD formats to be obtained from the laboratory secure website. Designated data management personnel will check and load the EDDs into the EQuIS® and ERPIMS database systems. Any errors in the EDD for a given sample delivery group will prevent loading of data from that sample delivery group and the issue will be communicated to the Laboratory Project Manager for correction and resubmission. Analytical data will be managed in EQuIS® for validation and reporting purposes. The ERPIMS data deliverables will be submitted to the USAF data management subcontractor and processed for upload to the USAF data repository.

One hundred percent of the analytical data generated by the subcontractor laboratories in support of the coring project and drinking water supply sampling will undergo EPA Stage 3 validation in accordance with the requirements in the project QAPJP. Soil vapor validation requirements for specific SVMPs are specified in Section 3.1.5. Validation qualifiers will be applied to the data results in the EQuIS® EDD

and uploaded to the project database. Validation qualifiers will be included in the upload to the USAF data repository.

6.4 Data Security

The information systems that will house the BFF data, including field and analytical data as well as other electronic information, include systems maintained and managed within contractor offices. Servers located in contractor facilities are physically secured in locked buildings and rooms with access limited to authorized personnel.

Corporate servers are electronically secured behind firewalls with multiple layers of anti-malware software that protect the firewall, the local area network, and e-mail networks. The servers are backed up nightly. Corporate servers and networking equipment are connected to battery-based uninterruptable power supplies with automated shutdown procedures in the event of a power outage.

7. QUALITY ASSURANCE/QUALITY CONTROL

QA/QC activities for the soil and water sampling will be conducted in accordance with the processes and procedures documented in the QAPjP (Appendix A).

8. WASTE MANAGEMENT

IDW generated during the implementation of this project will be managed as specified in this Work Plan. Prior to initiation of field activities, EA will ensure that all waste management procedures have been refined and approved by NMED and that all waste streams and volumes have been properly planned for. This is especially important when large volumes of liquids from well drilling and development are produced at an off-Base drilling location. Waste volumes will be minimized to the extent practical and eliminate the potential for the local population's exposure to IDW during and after work hours. IDW will be stored for no longer than 90 days prior to disposal; refer to Figure 3-11 for the location of the IDW storage area.

8.1 Water Investigation-Derived Waste

All excess water generated during well development, sampling, or during drinking water supply sampling events will be 100% captured and contained during generation. The following categories of water are discussed in the paragraphs below:

- **Non-hazardous water** generated from:
  - Purging or development of wells prior to sampling for which the sampling data for two consecutive preceding sampling events document no contaminants are present at concentrations that met the definition of characteristic hazardous waste (40 Code of Federal Regulations [CFR] Part 261 [2015]).
  - Decontamination water from equipment cleaning across all site activities.
- **Hazardous/potentially hazardous water** generated from:
  - Purging or development of wells during sampling events for which any data from two consecutive preceding sampling events have documented that contamination is present at concentrations that exceed the characteristic hazardous waste toxicity criteria (40 CFR Part 261.24).
  - Purge water from wells for which historical data show water quality fluctuating between non-hazardous and hazardous classification.
  - Purge water that had concentrations relatively close to the regulatory standard in 40 CFR Part 261.24 (e.g., water that exhibited benzene above 0.4 milligrams per liter in at least one of the previous two events).
- **Water of unknown quality** generated from development and sampling of new wells (i.e. KAFB-106S1) will rely on actual sample results from the IDW for waste profiling.

The QAPjP in Appendix A presents additional information regarding analytical requirements.

8.1.1 Non-Hazardous Water

Non-hazardous water generated from groundwater sampling activities may contain concentrations of dissolved iron and manganese that exceed the influent acceptance limits specified in the GWTS O&M

Plan (USACE, 2017d). Non-hazardous water will be managed as described below depending on dissolved metals concentrations.

8.1.1.1 Non-Hazardous Water with Dissolved Metals Exceeding Groundwater Treatment System Influent Acceptance Limits

IDW water that contains dissolved iron and manganese exceeding the GWTS influent acceptance limits will be kept segregated by point of origin both during transport and in storage and will not be discharged directly to the GWTS. Upon generation, the water will be placed in dedicated drums and transported to "pending analysis" storage facility where the drums will be labeled and stored pending laboratory analytical results. The storage containers will not be left unattended at off-Base locations during work hours. This water will be profiled for offsite disposal based on the analytical data from the sample collected from the well purged.

8.1.1.2 Non-Hazardous Water with Dissolved Metals Less than the Groundwater Treatment System Influent Acceptance Limits

For IDW waste meeting the dissolved iron and manganese GWTS influent acceptance limits, the water will be segregated while in storage until waste profile analytical data are available. Fluids purged or generated at the wellheads will be placed, to the acceptable filling capacity, in 55-gallon drums or larger containers (totes) that are secured to a truck bed and, upon conclusion of the work day, transferred to the IDW storage area. The storage containers will not be left unattended at off-Base locations during work hours. The quantity of IDW water from each well and the total quantity of water transferred to the GWTS will be recorded. A minimal amount of fines is anticipated to be present in this water and pre-filtering before batching into the GWTS is not anticipated.

If, for any reason, the GWTS cannot accept the purge water as it is generated (e.g., shut down for maintenance), the water will be temporarily stored in the IDW storage area on pallets and properly labeled until it can be discharged to the GWTS.

8.1.2 Hazardous/Potentially Hazardous Water

Characteristically hazardous water generated from any well development or sampling activities will be kept segregated by point of origin both during transport and in storage. Upon generation, the water will be placed in dedicated drums and transported to the less than 90-day accumulation area where the drums will be labeled and stored pending laboratory analytical results. The storage containers will not be left unattended at the residential sites during work hours. This water will be profiled for disposal based on the analytical data from the sample collected from the well purged. A minimal amount of fines is anticipated to be present in this water. Water generated from purging of new wells due to undocumented water quality will be treated the same way as the hazardous water until proven non-hazardous. The quantity of water purged from each well will be recorded.

8.1.3 Water of Unknown Quality

Water of unknown quality associated with drilling activities will initially be placed in portable tanks located at the wellhead where it is produced. The fines will be allowed to settle before the water will be transported, on a daily basis, using vacuum trucks from the wellhead to a centralized storage area where it will be pumped in storage tanks. The quantity of water extracted during development of each well and the total quantity of water transferred into the storage tank will be recorded. Upon conclusion of the development or when the storage tank capacity is reached, one water sample will be collected from a

spigot situated at the bottom of the tank; proper disposal will take place upon receipt of analytical results. The sample will be analyzed for the analytical suites presented in Table 8-1. Upon receipt of the analytical results confirming that the water is non-hazardous and that the dissolved iron and manganese meet the GWTS influent acceptance limits, the water will be batched through the GWTS. A pre-filter to capture fines is anticipated for well development water. If the water is hazardous based on toxicity characteristics, it will be disposed of offsite in accordance with NMED regulations. If the water does not meet the GWTS influent acceptance limits, the IDW water will be profiled for offsite disposal.

8.2 Soil Investigation-Derived Waste

Soil will be 100% captured and contained at the drill site during coring and/or well drilling. All necessary equipment will be provided to contain and transport soil IDW back to the IDW storage area for further handling (i.e., characterization, temporary storage, and disposal). IDW soil from drilling sites will be collected, secured, and transported in 20-cubic yard lined roll-off bins to the IDW storage area pending receipt of waste characterization profiling results.

For profiling of solid waste, each roll-off containing soil will be characterized for disposal at the Kirtland AFB Construction and Demolition (C&D) Landfill with a 5-point composite IDW sample. Depending on the type and provenance of the waste, the samples will be analyzed for the suites outlined in Table 8-1. Soil will have to meet the waste acceptance criteria for the Kirtland C&D Landfill (USAF, 2009). The suite for profiling soil originating at locations where extraction and observation wells are installed is reduced, as it is historically known that the waste from that general location is petroleum-based.

Once the analytical results for soil IDW are received and reviewed, a Request for Disposal letter will be provided to Kirtland AFB for approval to dispose of the contents of each container. All documentation regarding waste characterization and disposal will be provided in the appendices of the document describing the activities during which waste was generated.

Should the petroleum levels exceed what the Kirtland C&D Landfill is allowed to accept (benzene, toluene, ethylbenzene, and toluene >50 milligrams per kilogram [mg/kg], benzene >10 mg/kg, or total petroleum hydrocarbons >100 mg/kg), it will require characterization as “special waste” and disposed at an offsite permitted landfill. Samples will be handled per Section 3.2.17 of this Work Plan. The QAPjP (Appendix A) presents additional information regarding analytical requirements.

9. ACCIDENT PREVENTION PLAN/SITE SAFETY AND HEALTH PLAN

The safety requirements for the field implementation of this project are addressed in the companion document, *APP for the Kirtland AFB BFF Expansion of the GWTS and Vadose Zone Treatability Studies (Revision 5)* that also contains the SSHPs (EA, 2017). All field personnel associated with the project will be required to read and understand the elements of the APP, and the document will be available at the project location at all times.

10. REFERENCES

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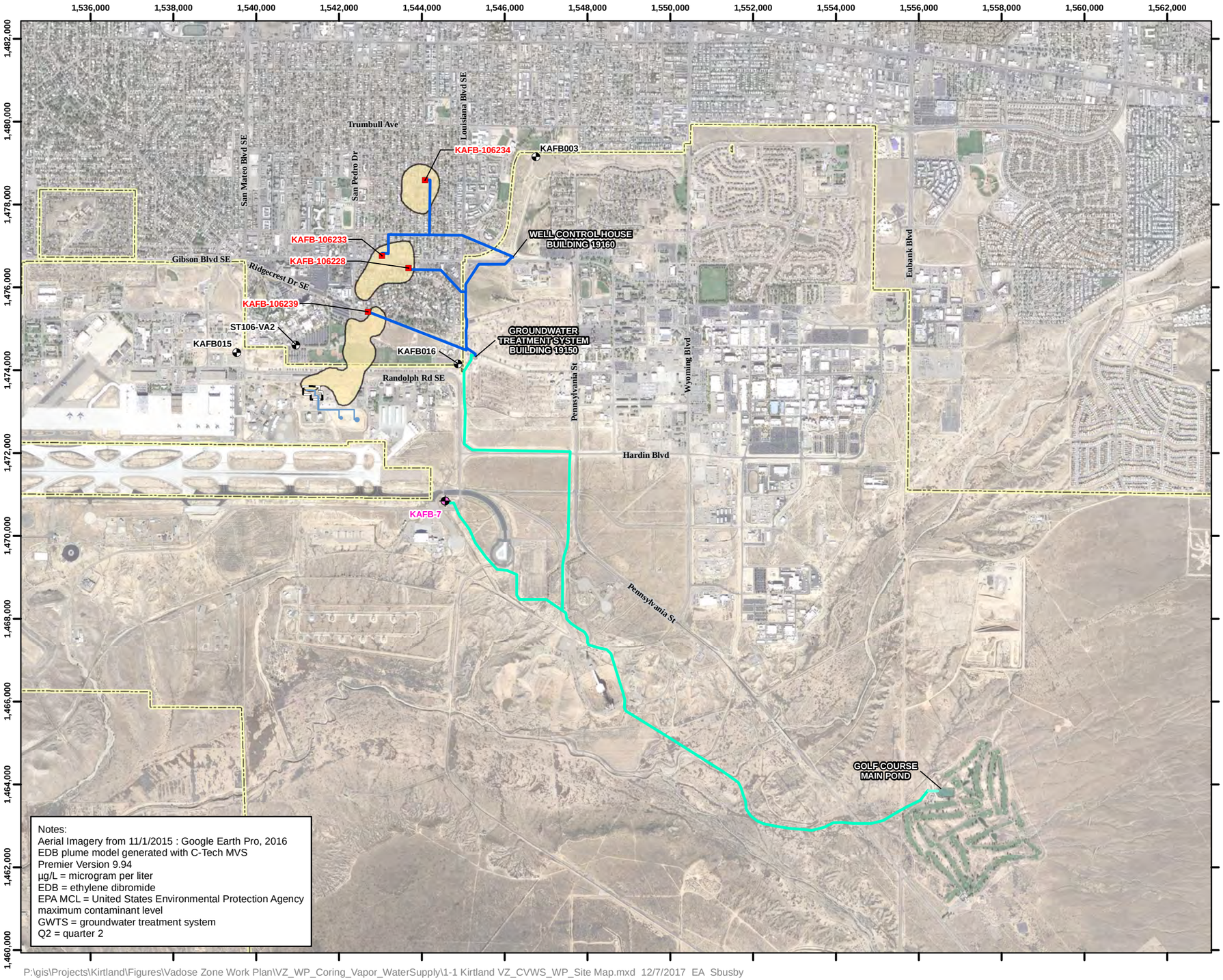
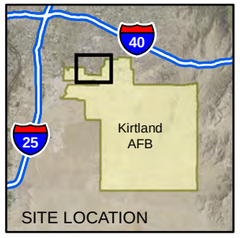
FIGURES



Notes:
Aerial Imagery from 11/1/2015 : Google Earth Pro, 2016
EDB plume model generated with C-Tech MVS Premier Version 9.94
µg/L = microgram per liter
EDB = ethylene dibromide
EPA MCL = United States Environmental Protection Agency maximum contaminant level
GWTS = groundwater treatment system
Q2 = quarter 2

Legend

- Extraction Well
- Injection Well KAFB-7
- Drinking Water Supply Well
- Former Aboveground Storage Tank
- Former Fuel Transfer Line
- GWTS Influent Piping
- GWTS Effluent Piping
- Installation Boundary
- Q2 2017 EDB Plume with Concentration > 0.05 µg/L (EPA MCL)
- Source Area



N

0 1,250 2,500 5,000

Feet

1 inch = 2,500 feet

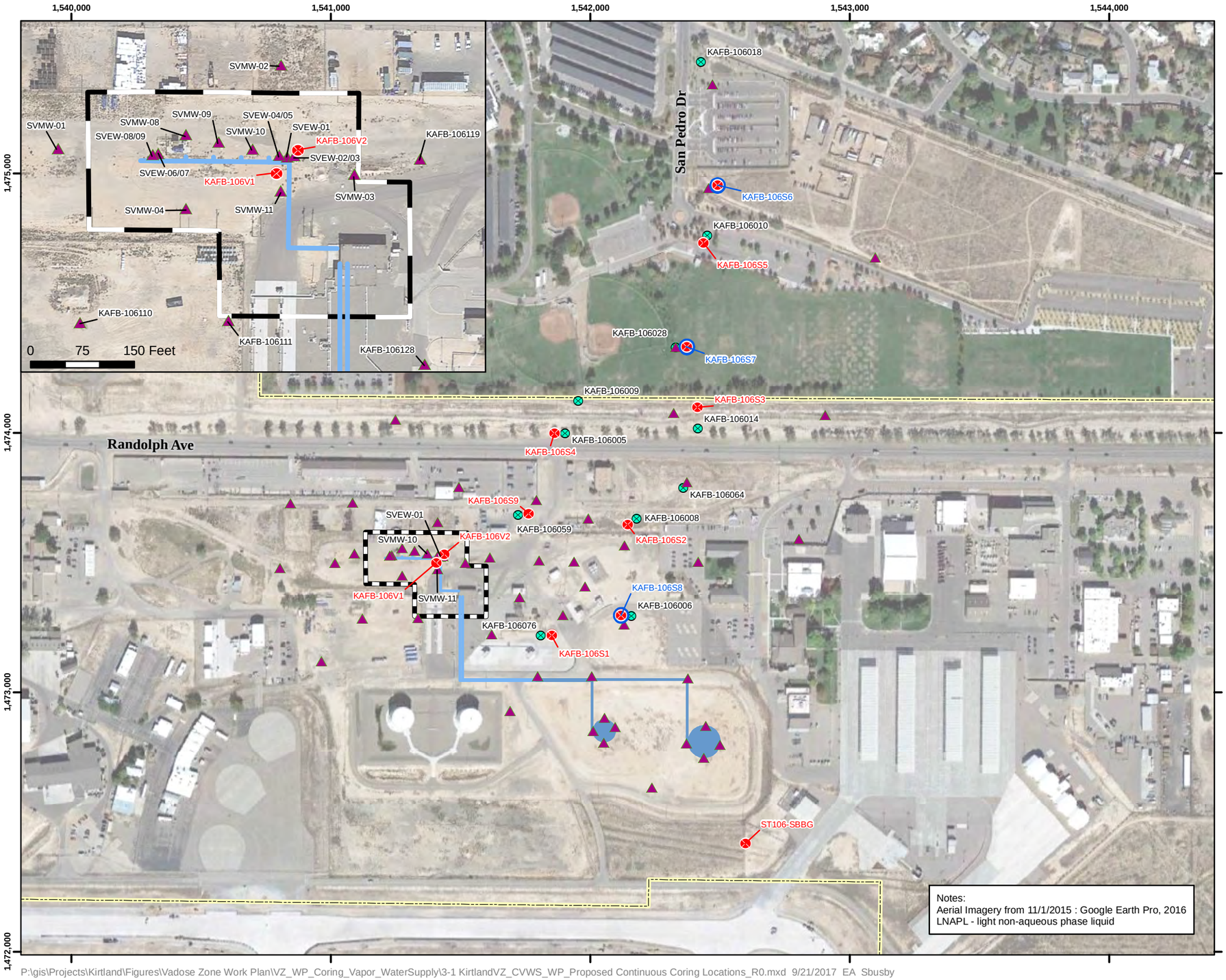
Projection: NAD83 State Plane New Mexico Central FIPS3002 Feet

WORK PLAN FOR VADOSE ZONE CORING, VAPOR MONITORING, AND WATER SUPPLY SAMPLING
BULK FUELS FACILITY
SOLID WASTE MANAGEMENT UNIT ST-106/SS-111
KIRTLAND AIR FORCE BASE, NEW MEXICO

FIGURE 1-1

SITE MAP

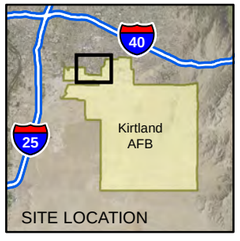
P:\gis\Projects\Kirtland\Figures\Vadose Zone Work Plan\VZ_WP_Coring_Vapor_WaterSupply\1-1 Kirtland VZ_CVWS_WP_Site Map.mxd 12/7/2017 EA Sbusby



Notes:
Aerial Imagery from 11/1/2015 : Google Earth Pro, 2016
LNAPL - light non-aqueous phase liquid

Legend

- Existing Soil Vapor Well
- Proposed Continuous Core Location
- Optional Continuous Core Location
- Monitoring Well with Historical LNAPL Observation
- Former Aboveground Storage Tank
- Former Buried Fuel Transfer Line
- Former Aboveground Fuel Transfer Line
- Installation Boundary
- Source Area



N

0 200 400 800

Feet

1 inch = 400 feet

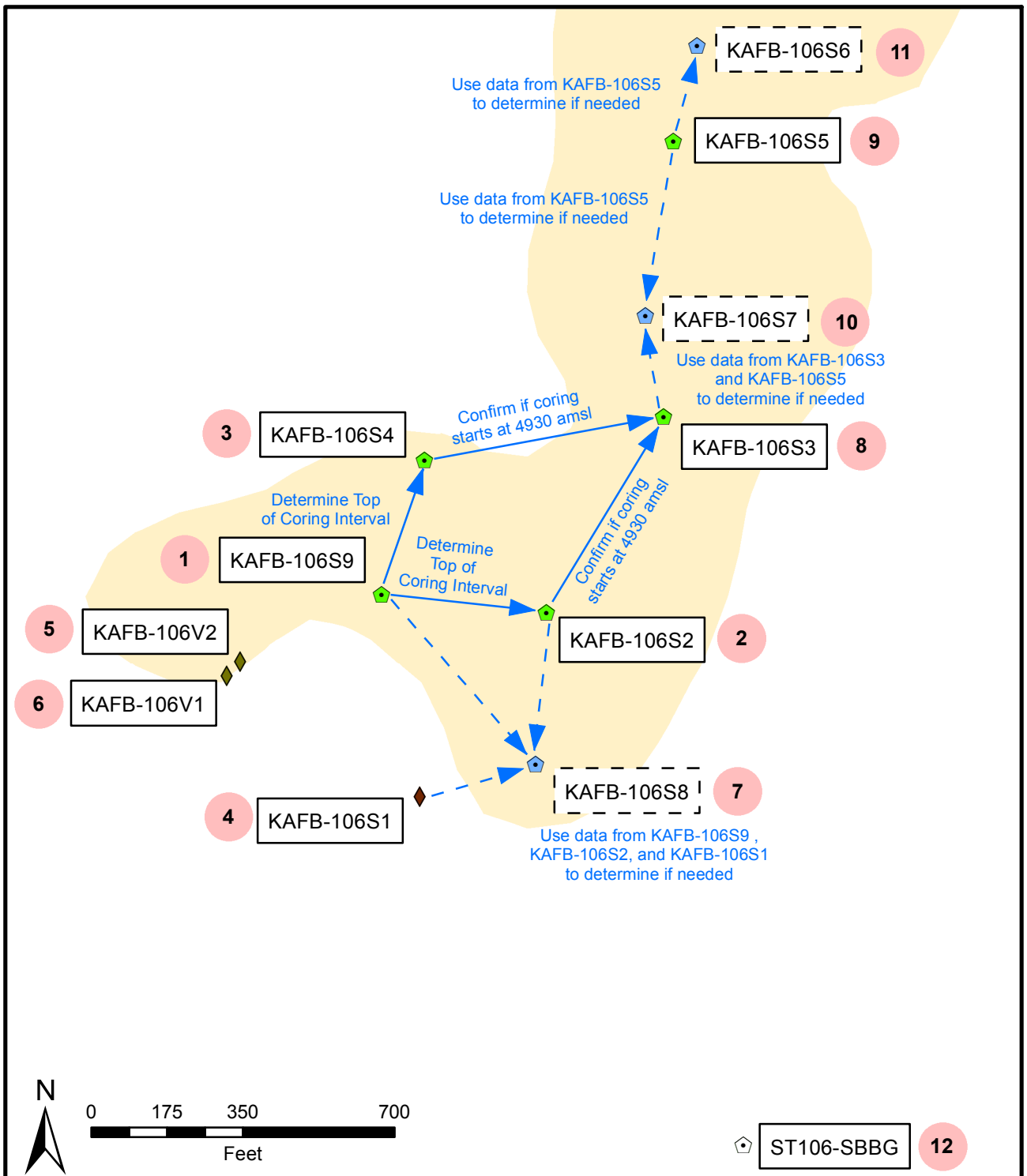
Projection: NAD83 State Plane New Mexico Central FIPS3002 Feet

WORK PLAN FOR VADOSE ZONE CORING, VAPOR MONITORING, AND WATER SUPPLY SAMPLING
BULK FUELS FACILITY
SOLID WASTE MANAGEMENT UNIT ST-106/SS-111
KIRTLAND AIR FORCE BASE, NEW MEXICO

FIGURE 3-1

PROPOSED CONTINUOUS CORING LOCATIONS

P:\gis\Projects\Kirtland\Figures\Vadose Zone Work Plan\VZ_WP_Coring_Vapor_WaterSupply\3-1 KirtlandVZ_CVWS_WP_Proposed Continuous Coring Locations_R0.mxd 9/21/2017 EA Sbusby



Legend

- Proposed Coring and Dual Completion Well
- Optional Proposed Coring and Dual Completion Well
- ST106-SBBG
- Proposed Bioventing Well
- Proposed Air-lift Well
- EDB Plume with Concentration > 0.05 µg/L, Q2 2017
- 1 Drilling Sequence

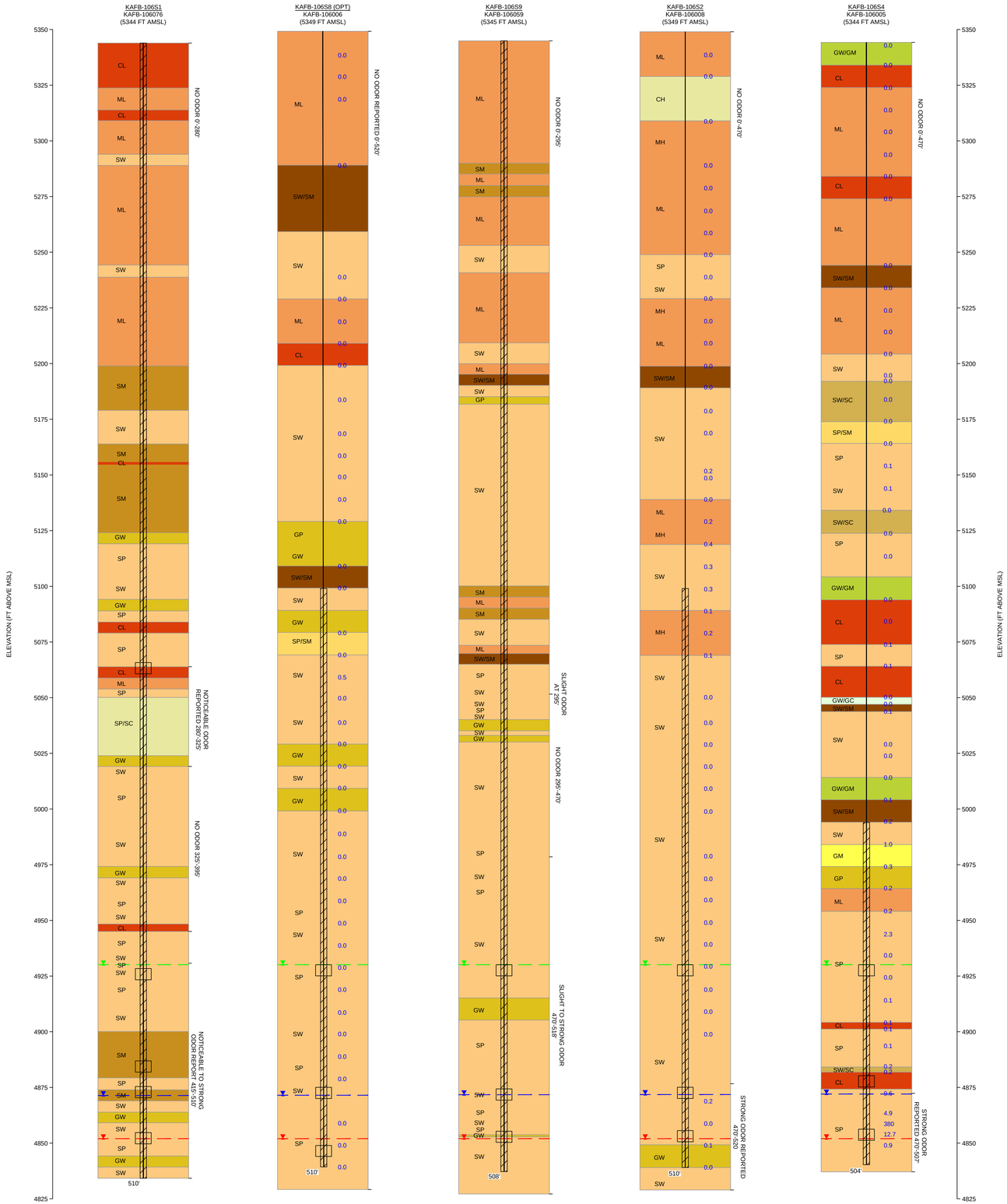
Note(s):
EDB plume model generated with C-Tech MVS Premier Version 9.94.
Dashed lines represent optional activities
AMSL = above mean sea level
EDB = ethylene dibromide
Q2 = quarter 2

WORK PLAN FOR VADOSE ZONE CORING, VAPOR MONITORING, AND WATER SUPPLY SAMPLING
BULK FUELS FACILITY
SOLID WASTE MANAGEMENT UNIT ST-106/SS-111
KIRTLAND AIR FORCE BASE, NEW MEXICO

FIGURE 3-2

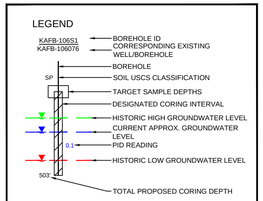
DRILLING DECISION LOGIC

P:\gis\Projects\Kirtland\Figures\Vadose Zone Work Plan\VZ_WP_Coring_Vapor_WaterSupply\3-2 Kirtland VZ_CVWS_WP_Drilling Decision Logic.mxd 9/22/2017 EA Sbusby



NOTE:
PID READINGS NOT PROVIDED ON KAFB-106076 AND 106059 BORING LOGS.

LEGEND



NOTES:
1. HISTORIC HIGH GROUNDWATER LEVEL IS APPROXIMATE GROUNDWATER ELEVATION IN 1970 AT 4,930 FT AMSL.
2. CURRENT GROUNDWATER LEVEL FROM Q3-2017 GAUGING.
3. HISTORIC LOW GROUNDWATER LEVELS FROM 2009.
4. PID READINGS IN BLUE TAKEN AT TIME OF DRILLING MONITORING WELLS IN CLOSE PROXIMITY TO PROPOSED LOCATIONS OF BOREHOLES.

USCS SOIL CLASSIFICATION

CH, SM, CL, SP, GP, SP/SC, GW, SP/SM, GW/GC, SW, GW/GM, SW/SC, MH, SW/SM, ML

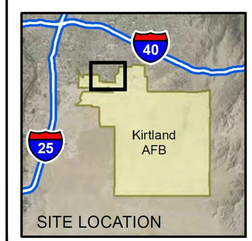
ACRONYMS

AMSL - ABOVE MEAN SEA LEVEL
CH - CLAY (LIQUID LIMIT > 50)
CL - CLAY (LIQUID LIMIT < 50)
FT OR ' - FEET
GP - POORLY GRADED GRAVEL
GW - WELL GRADED GRAVEL
GW/GC - WELL GRADED GRAVEL WITH CLAY
MH - SILT (LIQUID LIMIT > 50)
ML - SILT (LIQUID LIMIT < 50)
MSL - MEAN SEA LEVEL
OPT - OPTIONAL
SM - SILTY SAND
SP - POORLY GRADED SAND
SP/SC - POORLY GRADED SAND WITH CLAY
SP/SM - POORLY GRADED SAND WITH SILT
SW - WELL GRADED SAND
SW/SC - WELL GRADED SAND WITH CLAY
SW/SM - WELL GRADED SAND WITH SILT
USCS - UNIFIED SOIL CLASSIFICATION SYSTEM

NO HORIZONTAL SCALE

25 12.5 0 25
VERTICAL SCALE IN FEET

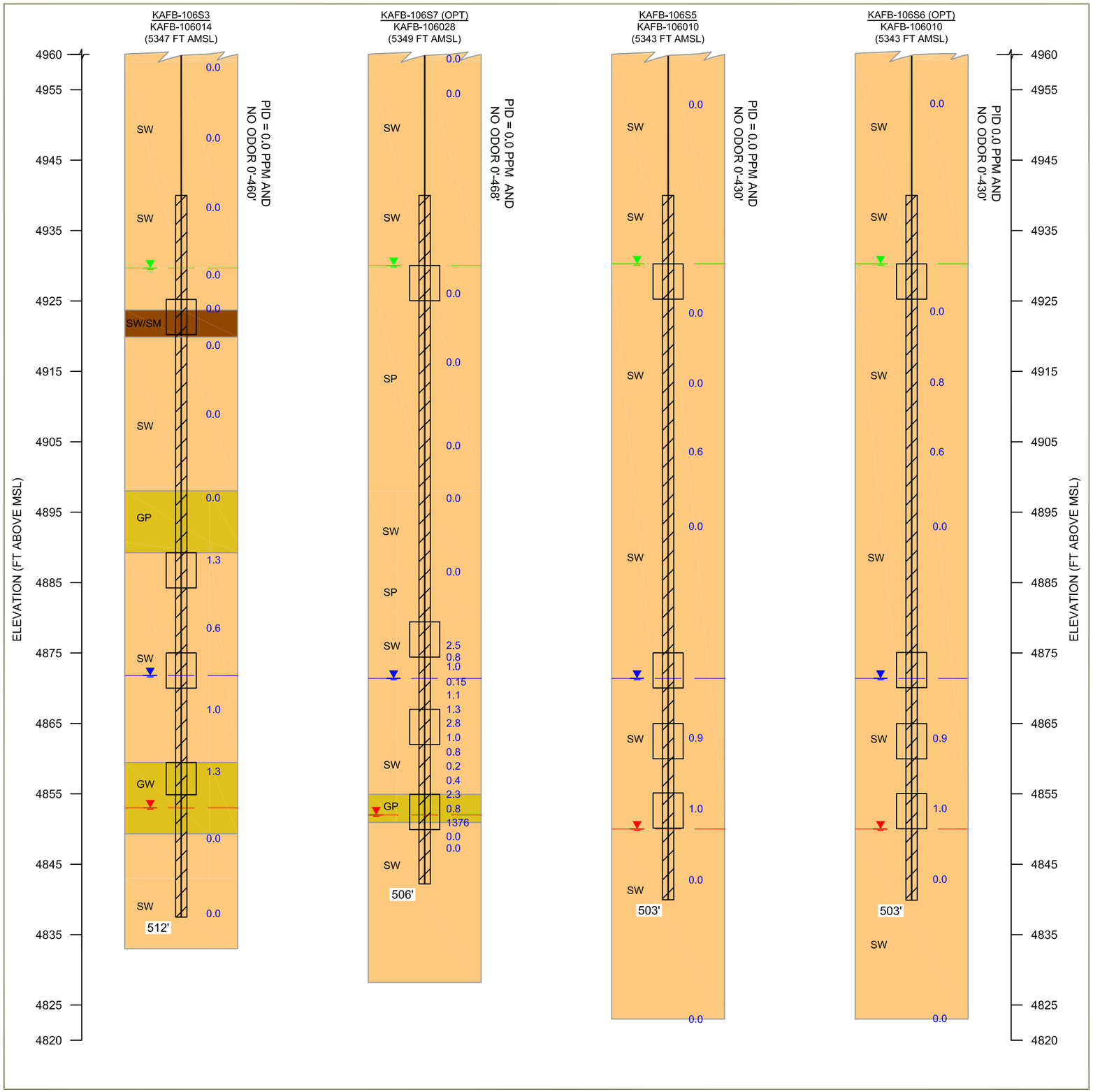
MAP INDEX



WORK PLAN FOR VADOSE ZONE CORING, VAPOR MONITORING, AND WATER SUPPLY SAMPLING
BULK FUELS FACILITY
SOLID WASTE MANAGEMENT UNIT ST-106/SS-111
KIRTLAND AIR FORCE BASE, NEW MEXICO

FIGURE 3-3

GEOLOGIC CROSS-SECTIONS OF PROPOSED CONTINUOUS CORING LOCATIONS IN THE SOURCE AREA



USCS SOIL CLASSIFICATION

- GP
- SP
- GW
- SW
- SW/SM

ACRONYMS

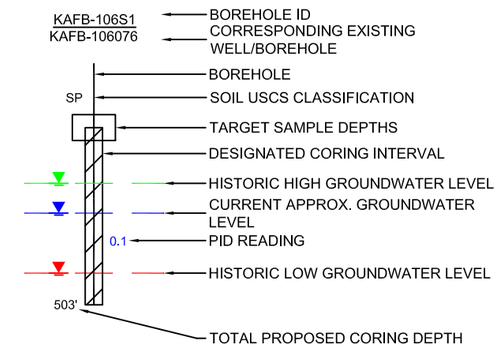
AMSL - ABOVE MEAN SEA LEVEL
FT OR ' - FEET
GP - POORLY GRADED GRAVEL
GW - WELL GRADED GRAVEL
MSL - MEAN SEA LEVEL
OPT - OPTIONAL
PPM - PARTS PER MILLION
SP - POORLY GRADED SAND
SW - WELL GRADED SAND
SW/SM - WELL GRADED SAND WITH SILT
USCS - UNIFIED SOIL CLASSIFICATION SYSTEM

NO HORIZONTAL SCALE

15 7.5 0 15

VERTICAL SCALE IN FEET

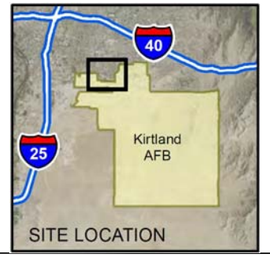
LEGEND



NOTES:

1. HISTORIC HIGH GROUNDWATER LEVEL IS APPROXIMATE GROUNDWATER ELEVATION IN 1970 AT 4,930 FT AMSL.
2. CURRENT GROUNDWATER LEVEL FROM Q3-2017 GAUGING.
3. HISTORIC LOW GROUNDWATER LEVELS FROM 2009.
4. PID READINGS IN BLUE TAKEN AT TIME OF DRILLING MONITORING WELLS IN CLOSE PROXIMITY TO PROPOSED LOCATIONS OF BOREHOLES.

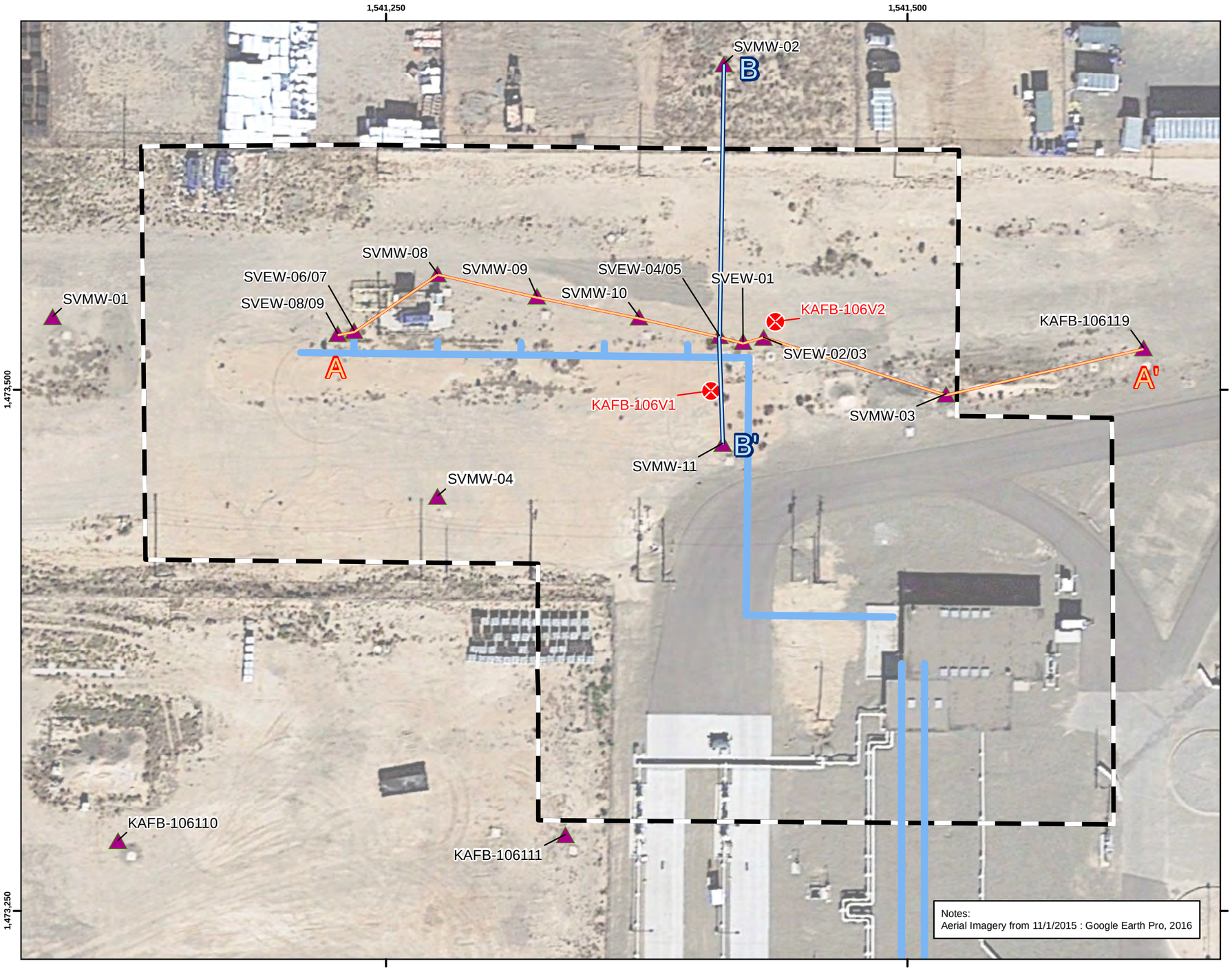
MAP INDEX



WORK PLAN FOR VADOSE ZONE CORING, VAPOR MONITORING, AND WATER SUPPLY SAMPLING
BULK FUELS FACILITY
SOLID WASTE MANAGEMENT UNIT ST-106/SS-111
KIRTLAND AIR FORCE BASE, NEW MEXICO

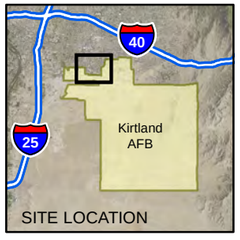
FIGURE 3-4

GEOLOGIC CROSS-SECTIONS
OF PROPOSED CONTINUOUS CORING LOCATIONS
DOWNGRADIENT OF THE SOURCE AREA



Legend

- Existing Soil Vapor Well
- Proposed Continuous Core Location
- Former Buried Fuel Transfer Line
- Installation Boundary
- Source Area
- A - A' Cross Section Transect
- B - B' Cross Section Transect



N

0 25 50 100

Feet

1 inch = 50 feet

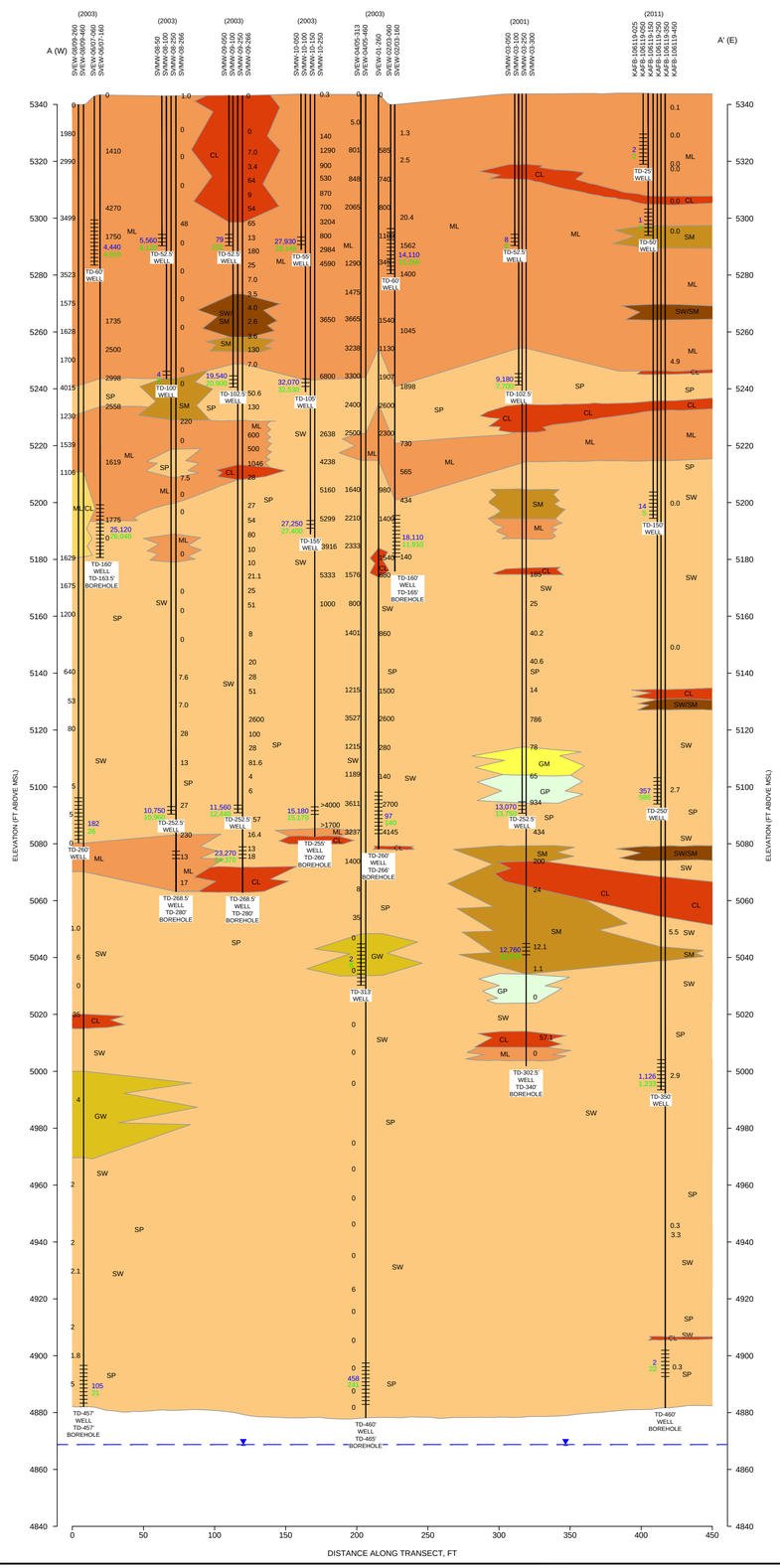
Projection: NAD83 State Plane New Mexico Central FIPS3002 Feet

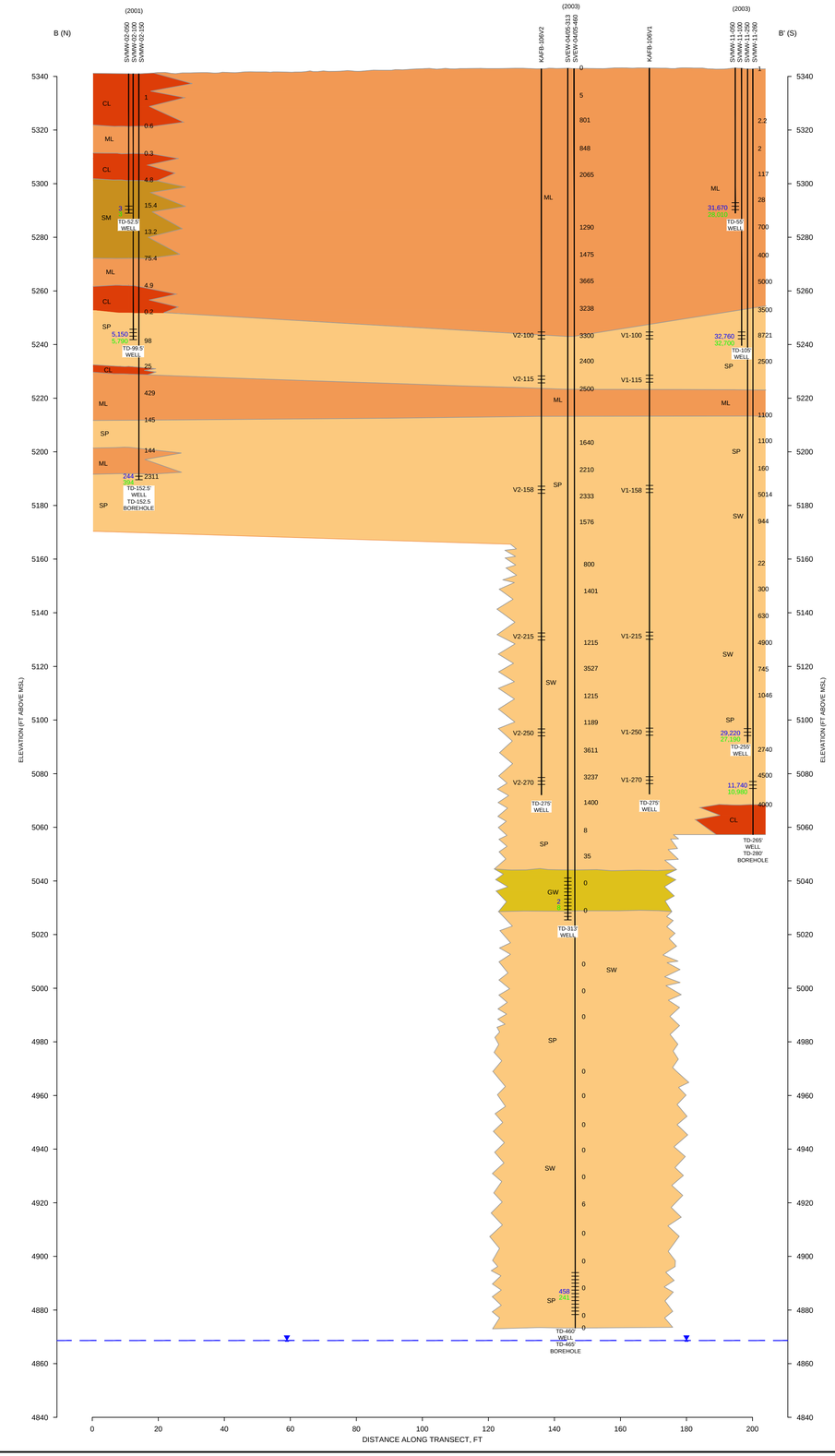
WORK PLAN FOR VADOSE ZONE CORING, VAPOR MONITORING, AND WATER SUPPLY SAMPLING
BULK FUELS FACILITY
SOLID WASTE MANAGEMENT UNIT ST-106/SS-111
KIRTLAND AIR FORCE BASE, NEW MEXICO

FIGURE 3-5

PROPOSED SOURCE AREA CONTINUOUS CORING LOCATIONS CROSS-SECTION TRANSECTS

P:\gis\Projects\Kirtland\Figures\Vadose Zone Work Plan\VZ_WP_Coring_Vapor_WaterSupply\3-5 Kirtland VZ_CVWS_WP_Cross Section Transects_R0.mxd 9/21/2017 EA Sbusby





LEGEND

- (2001) — DATE OF DRILLING
- S-VMW-03-050, S-VMW-03-150, S-VMW-03-250, S-VMW-03-350 — WELL/BORING ID
- EXISTING GROUND
- SP — SOIL USCS CLASSIFICATION
- 2.5 — PID MEASUREMENTS (ppmv)
- BOREHOLE/WELL CASING
- 458 — HYDROCARBON SOIL VAPOR READING (ppmv)
- WELL SCREEN
- TD-24' — TOTAL DEPTH IN FEET
- GROUNDWATER LEVEL

NOTES:
1. PID MEASUREMENTS TAKEN AT DATE OF DRILLING.
2. HYDROCARBON SOIL GAS VAPOR READINGS IN BLUE TAKEN DURING Q3-2016.
3. HYDROCARBON SOIL GAS VAPOR READINGS IN GREEN TAKEN DURING Q4-2016.
4. V1 AND V2 ARE PROPOSED SOIL VAPOR WELLS (PROJECTED) COMPRISED OF 6 INDIVIDUAL PORTS.
5. WATER LEVEL IS AN AVERAGE OF NEARBY WELLS KAFB-106001, 106024, 1063411, 106059, 106060, 106061, 106076, 106077, AND 106078 FROM Q3-2016 GAUGING.

USCS SOIL CLASSIFICATION

- CL
- GM
- GP
- GW
- ML
- ML/CL
- SM
- SP
- SW
- SW/SM

ACRONYMS

CL - CLAY
E - EAST
FT OR ' - FEET
GM - SILTY GRAVEL
GP - POORLY GRADED GRAVEL
GW - WELL GRADED GRAVEL
ML - SILT
ML/CL - CLAYEY SILT
MSL - MEAN SEA LEVEL
N - NORTH
S - SOUTH
SW/SM - WELL GRADED SAND WITH SILT
SM - SILTY SAND
SP - POORLY GRADED SAND
SW - WELL GRADED SAND
USCS - UNIFIED SOIL CLASSIFICATION SYSTEM
W - WEST

SECTION A-A'

50 25 0 50
HORIZONTAL SCALE IN FEET

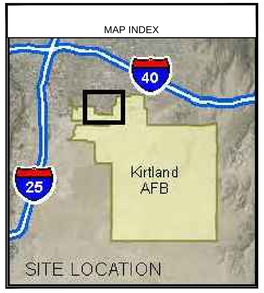
25 12.5 0 25
VERTICAL SCALE IN FEET
VERTICAL EXAGGERATION = 2x.

SECTION B-B'

20 10 0 20
HORIZONTAL SCALE IN FEET

25 12.5 0 25
VERTICAL SCALE IN FEET
VERTICAL EXAGGERATION = 1.25x.

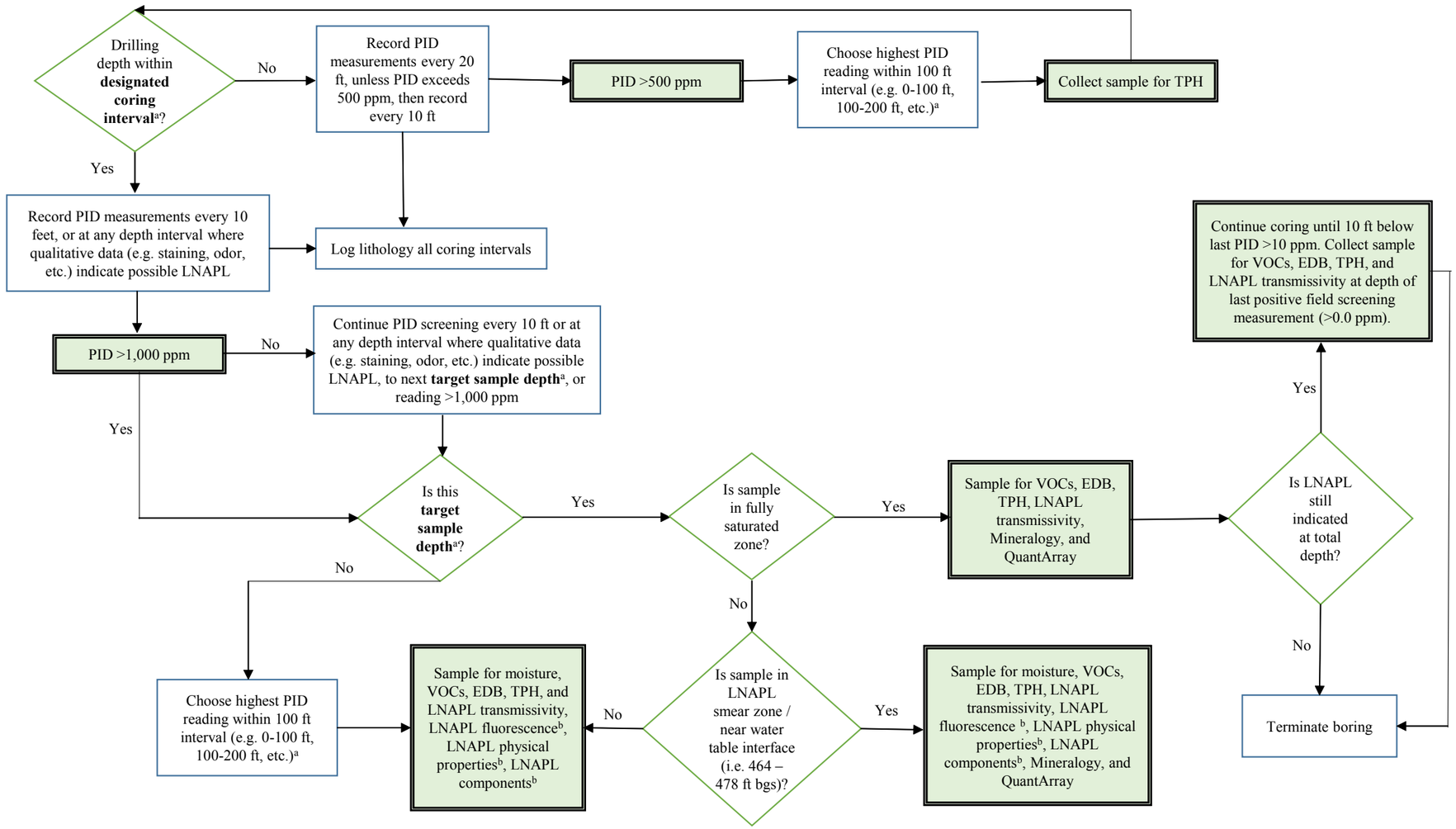
MAP INDEX



WORK PLAN FOR VADOSE ZONE CORING, VAPOR MONITORING, AND WATER SUPPLY SAMPLING
BULK FUELS FACILITY
SOLID WASTE MANAGEMENT UNIT ST-106/SS-111
KIRTLAND AIR FORCE BASE, NEW MEXICO

FIGURE 3-6

GEOLOGIC CROSS-SECTIONS
A-A' AND B-B'



Notes:
[a]Depth intervals as indicated on Table 3-3
[b]Only sample if LNAPL is present
All extracted core will be iced in the field prior to sample collection.
KAFB-SBBG is not anticipated to have LNAPL, and therefore will not be sampled for LNAPL transmissivity, LNAPL fluorescence, LNAPL physical properties, LNAPL components
bgs = below ground surface
EDB = ethylene dibromide
ft = feet
LNAPL = light non-aqueous phase liquid
PID = photoionization detector
ppm = parts per million
TPH = total petroleum hydrocarbons
VOCs = volatile organic compounds

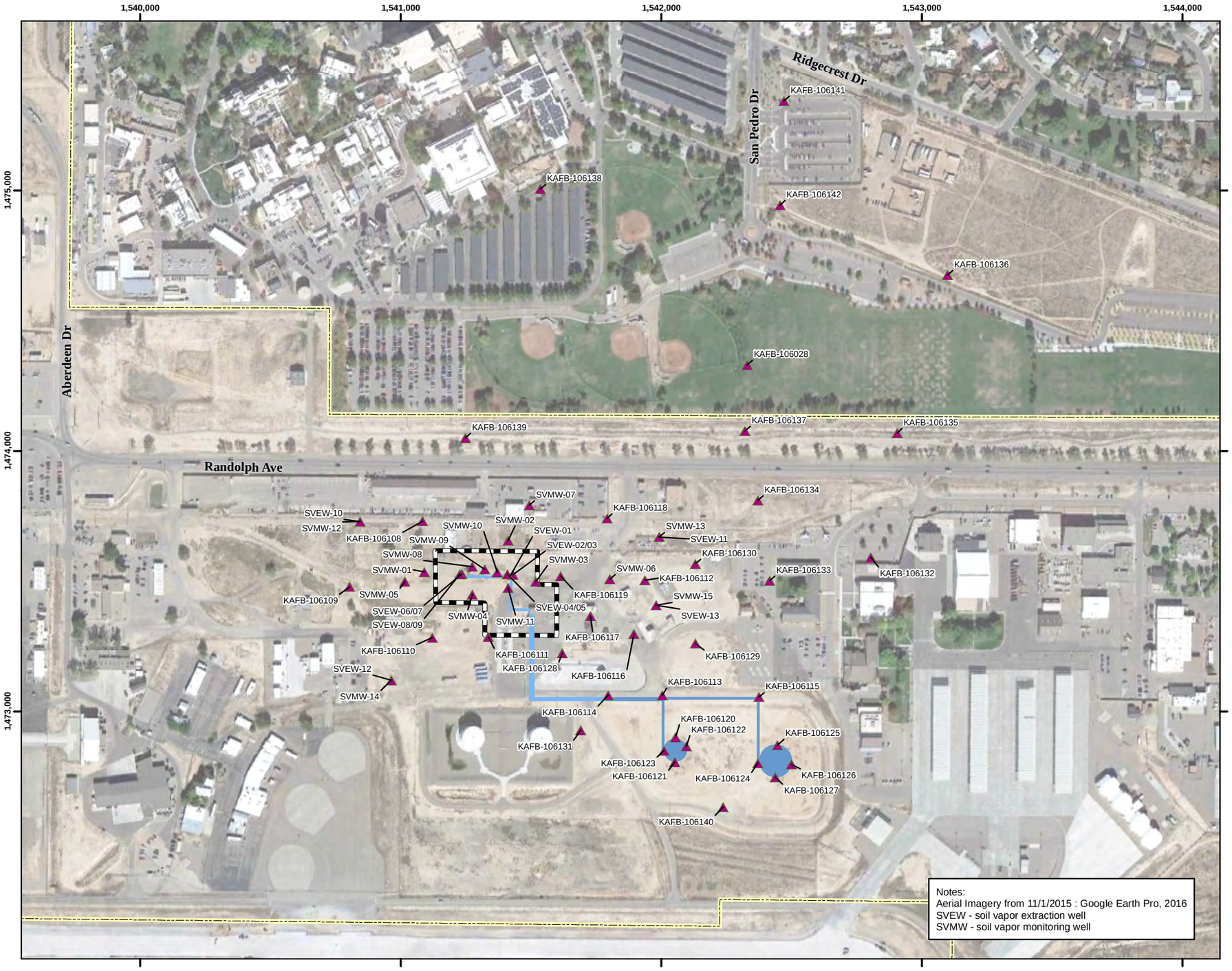
Sample Priority – will be implemented if length of LNAPL impacted soil / sample aliquot is not sufficient for all analyses:
1. LNAPL transmissivity
2. TPH
3. LNAPL components
4. LNAPL physical properties
5. VOCs
6. EDB
7. QuantArray
8. Mineralogy
9. LNAPL fluorescence
10. Moisture

WORK PLAN FOR VADOSE ZONE CORING, VAPOR MONITORING, AND WATER SUPPLY SAMPLING
BULK FUELS FACILITY
SOLID WASTE MANAGEMENT UNIT ST-106/SS-111
KIRTLAND AIR FORCE BASE, NEW MEXICO

FIGURE 3-7

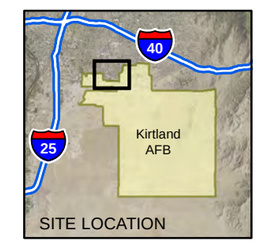
DECISION LOGIC SCHEMATIC FOR SAMPLE COLLECTION

P:\gis\Projects\Kirtland\Figures\Vadose Zone Work Plan\VZ_WP_Coring_Vapor_WaterSupply\3-7 Kirtland VZ_CVWS_WP_Decision Logic Schematic_R1.mxd 10/12/2017 EA eomalia



Legend

- Existing Soil Vapor Well
- Former Aboveground Storage Tank
- Former Buried Fuel Transfer Line
- Former Aboveground Fuel Transfer Line
- Installation Boundary
- Source Area



N

0 200 400 800

Feet

1 inch = 400 feet

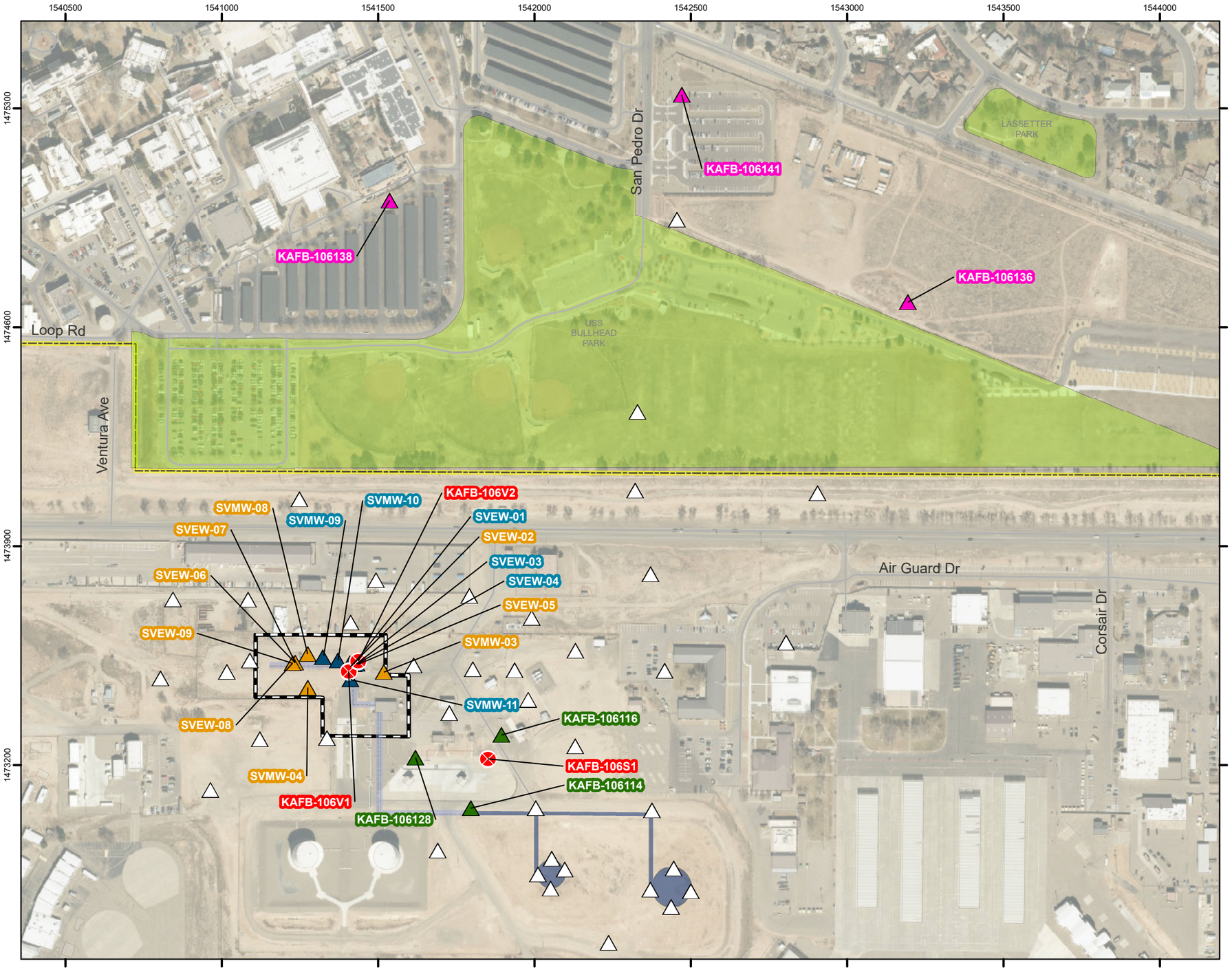
Projection: NAD83 State Plane New Mexico Central FIPS3002 Feet

WORK PLAN FOR VADOSE ZONE CORING, VAPOR MONITORING, AND WATER SUPPLY SAMPLING
BULK FUELS FACILITY
SOLID WASTE MANAGEMENT UNIT ST-106/SS-111
KIRTLAND AIR FORCE BASE, NEW MEXICO

FIGURE 3-8

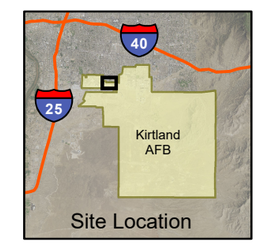
SOIL VAPOR MONITORING POINT LOCATIONS

P:\gis\Projects\Kirtland\Figures\Vadose Zone Work Plan\VZ_WP_Coring_Vapor_WaterSupply\3-8 Kirtland VZ_CVWS_WP_SVE Well Map.mxd 12/13/2017 EA Sbusby



Legend

- Soil Vapor Monitoring Location Not Designated for Data Validation
- Bioventing Injection/Observation Point
- In Source Area
- Near Airlift Location
- Closest to Residential Areas
- Proposed Bioventing/Airlift Location
- Former Aboveground Storage Tanks
- Former Buried Fuel Transfer Lines
- Former Aboveground Fuel Transfer Lines
- Kirtland Air Force Base Installation Area
- Source Area
- City of Albuquerque Parks



Data Source: NAIP, ESRI Base, USACE, Sundance, Inc, COA

N

0 150 300 600

Feet

1 inch = 50,000 feet

Projection: NAD83 State Plane New Mexico Central FIPS3002 Feet

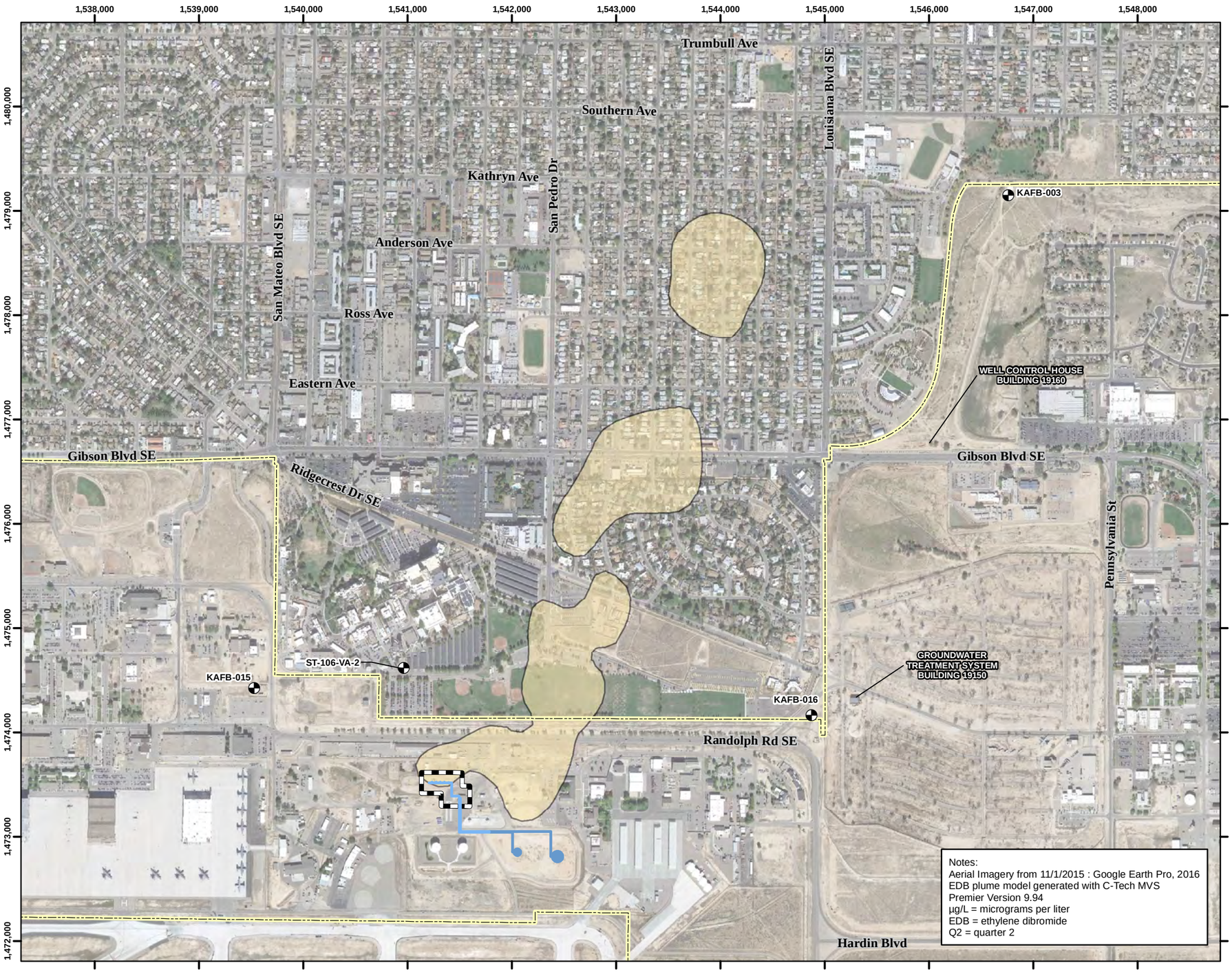
WORK PLAN FOR VADOSE ZONE CORING, VAPOR MONITORING , AND WATER SUPPLY SAMPLING
SOLID WASTE MANAGEMENT UNIT ST-106/SS-111
KIRTLAND AIR FORCE BASE, NEW MEXICO

FIGURE 3-9

SOIL VAPOR MONITORING LOCATIONS DESIGNATED FOR DATA VALIDATION

Document Path: N:\Kirtland\GIS\GIS_Projects\EA\3-9_PointsDataValidation.v2.mxd

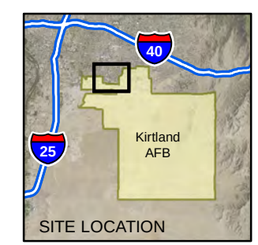
Revision Date: 10/12/2017



Notes:
Aerial Imagery from 11/1/2015 : Google Earth Pro, 2016
EDB plume model generated with C-Tech MVS
Premier Version 9.94
µg/L = micrograms per liter
EDB = ethylene dibromide
Q2 = quarter 2

Legend

- Drinking Water Supply Well
- Former Aboveground Storage Tank
- Former Buried Fuel Transfer Line
- Former Aboveground Fuel Transfer Line
- Installation Boundary
- Q2 2017 EDB Plume with Concentration > 0.05 µg/L (EPA MCL)
- Source Area



N

0 500 1,000 2,000

Feet

1 inch = 1,000 feet

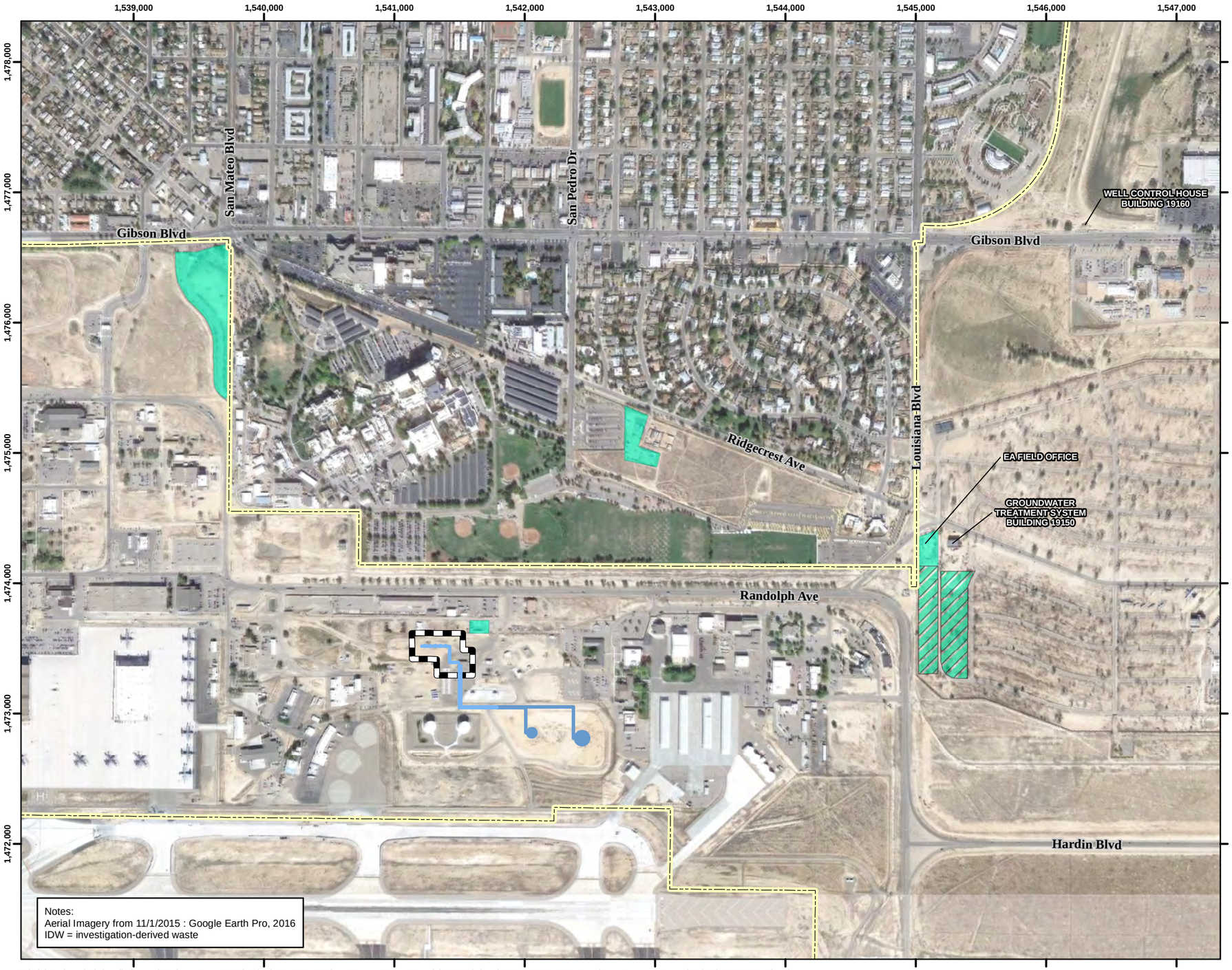
Projection: NAD83 State Plane New Mexico Central FIPS3002 Feet

WORK PLAN FOR VADOSE ZONE CORING,
VAPOR MONITORING, AND WATER SUPPLY SAMPLING
BULK FUELS FACILITY
SOLID WASTE MANAGEMENT UNIT ST-106/SS-111
KIRTLAND AIR FORCE BASE, NEW MEXICO

FIGURE 3-10

DRINKING WATER SUPPLY WELLS

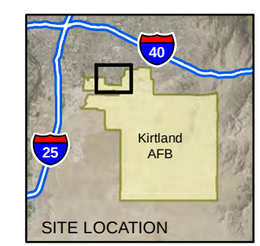
P:\gis\Projects\Kirtland\Figures\Vadose Zone Work Plan\VZ_WP_Coring_Vapor_WaterSupply\3-10 KirtlandVZ_CVWS_WP_Drinking Water Supply Wells_R0.mxd 9/21/2017 EA Sbusby



Notes:
Aerial Imagery from 11/1/2015 : Google Earth Pro, 2016
IDW = investigation-derived waste

Legend

- Laydown Area
- IDW Storage Area
- Former Aboveground Storage Tank
- Former Buried Fuel Transfer Line
- Former Aboveground Fuel Transfer Line
- Installation Boundary
- Source Area



N

0 400 800 1,600

Feet

1 inch = 800 feet

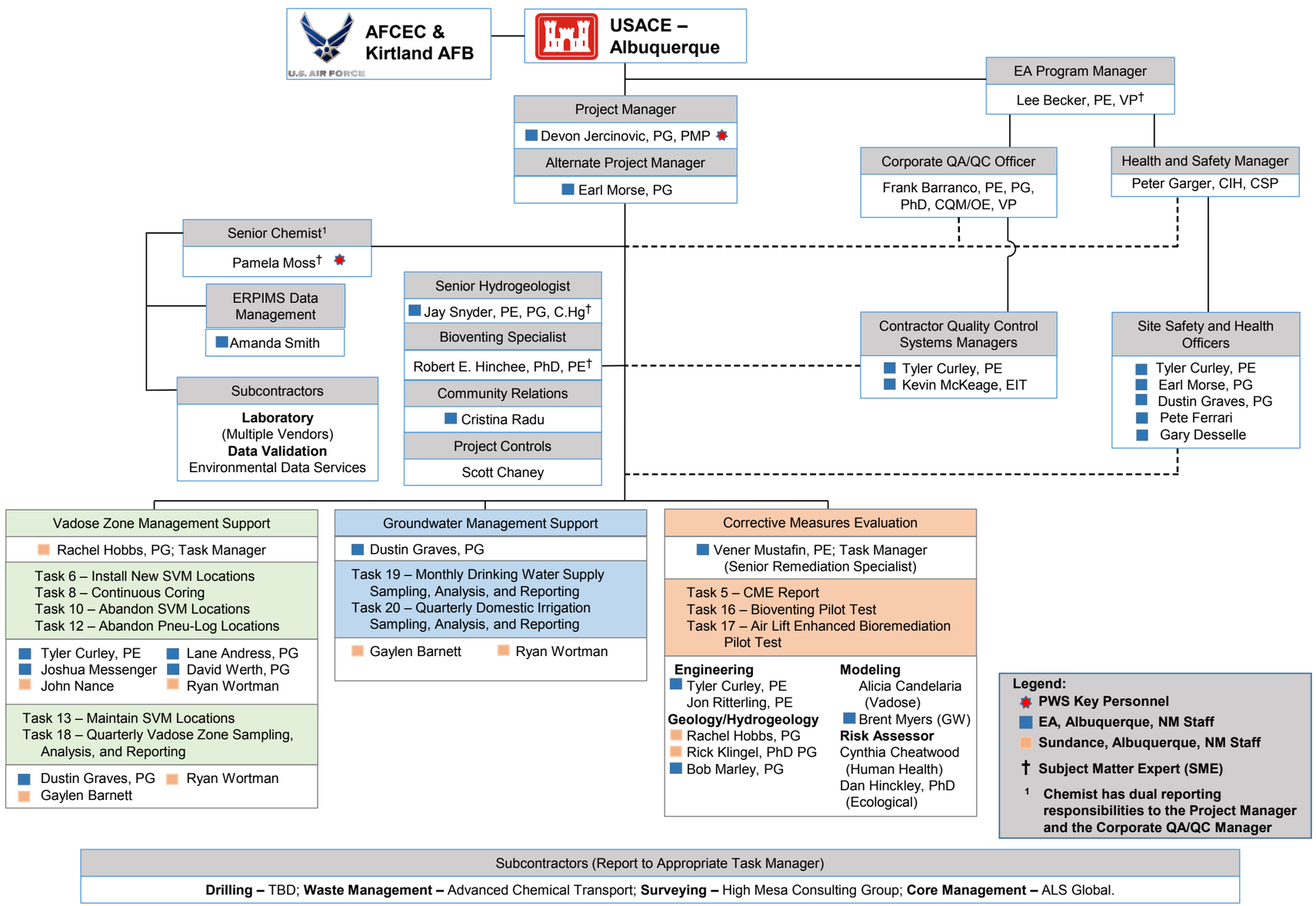
Projection: NAD83 State Plane New Mexico Central FIPS3002 Feet

WORK PLAN FOR VADOSE ZONE CORING,
VAPOR MONITORING, AND WATER SUPPLY SAMPLING
BULK FUELS FACILITY
SOLID WASTE MANAGEMENT UNIT ST-106/SS-111
KIRTLAND AIR FORCE BASE, NEW MEXICO

FIGURE 3-11

SITE LAYDOWN AREAS

P:\gis\Projects\Kirtland\Figures\Vadose Zone Work Plan\VZ_WP_Coring_Vapor_WaterSupply\3-11 Kirtland VZ_CVWS_WP_Laydown Areas_R0.mxd 9/21/2017 EA Sbusby



WORK PLAN FOR VADOSE ZONE CORING, VAPOR MONITORING, AND WATER SUPPLY SAMPLING
BULK FUELS FACILITY
SOLID WASTE MANAGEMENT UNIT ST-106/SS-111
KIRTLAND AIR FORCE BASE, NEW MEXICO

FIGURE 5-1

ORGANIZATIONAL STRUCTURE FOR VADOSE ZONE CORING, VAPOR MONITORING, AND WATER SUPPLY SAMPLING

P:\gis\Projects\Kirtland\Figures\Vadose Zone Work Plan\VZ_WP_Coring_Vapor_WaterSupply\5-1 OrgChart VZ_CVWS_WP_R1.mxd 10/12/2017 EA eomalia

TABLES

Table 3-1
Continuous Coring Location Rationale

Boring Identification	Rationale for Location	Total Maximum Borehole Depth (ft bgs)	Total Designated Coring Interval	Completed as Well
KAFB-106V1	Located in source area near SVMW-10 and SVMW-11 (high total hydrocarbons in vapor); observation well for bioventing test	275	0-275	Yes
KAFB-106V2	Located in source area near SVMW-10 and SVMW-11 (high total hydrocarbons in vapor); observation well for bioventing test	275	0-275	Yes
ST106-SBBG	Located south of the BFF in area without hydrocarbon impacts	515	415-515	No
KAFB-106S1	Located near KAFB-106076; historical LNAPL present in well	510	0-510[a]	Yes
KAFB-106S2	Located near KAFB-106008; historical LNAPL present in well	510	250-510[a]	Yes
KAFB-106S3	Located near KAFB-106014 north of ESTCP; historical LNAPL present in well	512	407-512[a]	Yes
KAFB-106S4	Located near KAFB-106005; historical LNAPL present in well	504	350-504[a]	Yes
KAFB-106S5	Located near KAFB-106010; historical LNAPL present in well	503	403-503[a]	Yes
KAFB-106S6 (Optional)	Located north of KAFB-106010; potential data gap location; well will be drilled pending results of KAFB-106S5	503	403-503[a]	Yes
KAFB-106S7 (Optional)	Located near KAFB-106028; historical LNAPL present in well; well will be drilled pending results of KAFB-106S3 and KAFB-106S5	506	409-506[a]	Yes
KAFB-106S8 (Optional)	Located near KAFB-106006; historical LNAPL present in well; will be drilled pending results of KAFB-106S1, KAFB-106S2, and KAFB-106S9	510	250-510[a]	Yes
KAFB-106S9	Located near KAFB-106059 (highest dissolved benzene in groundwater); historical LNAPL present in well; will be drilled first in sequence and data will drive decisions for subsequent cores	508	0-508	Yes

BFF = Bulk Fuels Facility
bgs = Below ground surface
ft = Foot/feet
LNAPL = liquid non-aqueous phase liquid
[a] Designated coring interval is proposed based on historical data and for planning purposes; actual coring intervals may be refined based on field observations and data collected, to follow decision logic presented in Figure 3-2.

Table 3-2
Drilling Summary for Continuous Coring Locations

Core Location	Total Planned Drilling Depth	ARCH 11-3/4 Inch Diameter Advance Drilling (ft)	ARCH 9-5/8 Inch Diameter Advance Drilling (ft)	Sonic 10-Inch Diameter Advanced Drilling (ft)	Sonic 8-Inch Diameter Drilling (ft)	Total Core Footage Planned	Designated Core Interval (ft bgs) / 4-Inch (min) Diameter Coring (ft)	ARCH 9-5/8 Inch Diameter Reaming (ft) for Well Construction	Nominal Borehole Diameter Needed for Well Construction (inch)	Plug and Abandon (ft)
Primary Continuous Core Locations										
KAFB-106V1	275	0	0	0-275	--	275	0-275	0	10	NA
KAFB-106V2	275	0	0	0-275	--	275	0-275	0	10	NA
KAFB-106S1	510	0	0	0	0-510	510	0-510	0-510	10	NA
ST106-SBBG	515	0	0	0	0-515	100	415-515	0	NA	515
KAFB-106S2	510	0	0	0	0-510	260	250-510	0-510	10	NA
KAFB-106S3	512	0-250	250-407	0	407-512	105	407-512	407-512	10	NA
KAFB-106S4	504	0-250	250-350	0	350-504	154	350-504	350-504	10	NA
KAFB-106S5	503	0-250	250-403	0	403-503	100	403-503	403-503	10	NA
KAFB-106S9	508	0	0	0	0-508	508	0-508	0-508	10	NA
Optional Continuous Core Locations										
KAFB-106S6	503	0-250	250-403	0	403-503	100	403-503	403-503	10	NA
KAFB-106S7	506	0-250	250-409	0	409-506	97	409-506	409-506	10	NA
KAFB-106S8	510	0	0	0	0-510	260	250-510	0-510	10	NA

ARCH = air-rotary casing hammer
ft = foot/feet

Table 3-3
Proposed Sampling Plan for Continuous Coring

														Continuous Coring Sampling Guide (CCSG)													
														Analysis	Core Sample Management	VOCs (SW5035A/8260C)	EDB (SW8011)	TPH-GRO/DRO/ORO (SW5035A/8015D)	LNAPL Transmissivity and Mobility - grain size, fluid properties, capillary pressure air/water drainage, free product mobility, relative permeability, and hydraulic conductivity [effective\total porosity %Vb]	LNAPL Physical Properties - gravity, hydrocarbon analysis, flashpoint, viscosity (Product)	LNAPL Components (ASTM D4052, D6733, D93, D445)	Mineralogy (XRD/EDAX)	QuantArray-Chlor (qPCR)	Moisture (ASTM D2216)	Temperature	LNAPL Fluorescence	
														Laboratory	ALS	TestAmerica	TestAmerica	TestAmerica	PTS Laboratories	Saybolt LP, Core Companies	Saybolt LP, Core Companies	IMR Metallurgical Services	Microbial Insights	DB Stephens	Field Measurement	PTS Laboratories	
			Designated Coring Interval					Target Sample Depths						Unit	NA	mg/kg	mg/kg	mg/kg	grain size (mm), fluid properties, capillary pressure (cm) air/water drainage (mD), free product mobility, relative permeability (mD), and hydraulic conductivity (cm/s)	gravity, hydrocarbon analysis, flashpoint (°C), viscosity (centipoise\centistokes) (Product)	Weight % Liq. Volume % Mole % Molecular Weight	Mineral Composition %	Bulk Cell Count (#/g), soluble MMO as Cell count	%	°C	Visual Determination	
														Container	Box and Bag Core	3 x EnCore samplers; 1 x 4-oz glass	1 x 8-oz glass	1 x 8-oz glass	2 inch x 6 inch core in sleeve sealed in ziplock bag (shipped frozen with dry ice for mobility analysis)	1 x 8-oz glass	1 x 8-oz glass	1 x 4-oz glass	1 x 8-oz glass	Double ziplock or sealed bucket (2.5 kg of soil)	--	2 inch x 6 inch core in sleeve sealed in ziplock bag (shipped frozen with dry ice for mobility analysis)	
														Preservative	--	None; Cool 6°C	None; Cool 6°C	None; Cool 6°C	--	NA None; Cool 6°C	NA None; Cool 6°C	--	None; Cool 6°C	--	--	--	
														Prep Hold Time	--	48 hours	14 days	--	--	--	--	--	--	--	--	--	
LOCID	Ground Elevation (ft amsl)	Total Proposed Coring Depth (ft bgs)	Top	Bottom	Lowest Measured Groundwater Elevation (ft amsl)	Historical High Groundwater Elevation (ft, amsl)	Expected Depth to Water (ft bgs) (July 2017)	Top of Sample Depth	Sample ID	Sample Interval (depth, bgs)	Sample Interval (elev., ft)	Anticipated Soil Media (USCS)	Anticipated Soil Media	Analytical Hold Time	--	14 days	40 days	14 days	--	--	--	--	48 hours	--	--	--	Rationale
KAFB-106V1	5342	275	0	275	NA	NA	473.22 (KAFB-106001)	0-100' highest PID reading (>1,000 ppm) will be sampled[a]							X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Highest PID reading (>1,000 ppm) within 100' depth interval
								100	KAFB-106V1-100	100-105	5242-5237	SP	Poorly Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	High PID reading in SVEW-04/05 and SVMW-11 during construction; high hydrocarbon soil vapor readings in SVMW-11 in Q3 2016; sand between silt layers
								115	KAFB-106V1-115	115-120	5227-5222	SP	Poorly Graded Sand		X	X	X	X		X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	High PID reading in SVEW-04/05 and SVMW-11 during construction; high hydrocarbon soil vapor readings in SVMW-11 in Q3 2016; sand between silt layers
								158	KAFB-106V1-158	158-163	5184-5179	SP	Poorly Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	High PID reading in SVEW-04/05 and SVMW-11 during construction
								215	KAFB-106V1-215	215-220	5127-5122	SW	Well Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	High PID reading in SVEW-04/05 and SVMW-11 during construction
								250	KAFB-106V1-250	250-255	5092-5087	SP	Poorly Graded Sand		X	X	X	X		X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	High PID reading in SVEW-04/05 and SVMW-11 during construction; high hydrocarbon soil vapor readings in SVMW-11 in Q3 2016
								270	KAFB-106V1-270	270-275	5072-5067	SP	Poorly Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	High PID reading in SVEW-04/05 and SVMW-11 during construction; high hydrocarbon soil vapor readings in SVMW-11 in Q3 2016; SVMW-11 readings directly above lean clay layer which might extend to V1 location
KAFB-106V2	5342	275	0	275	NA	NA	474.50 (KAFB-106001)	0-100' highest PID reading (>1,000 ppm) will be sampled[a]							X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Highest PID reading (>1,000 ppm) within 100' depth interval
								100	KAFB-106V2-100	100-105	5242-5237	SP	Poorly Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	High PID reading in SVEW-04/05 and SVMW-11 during construction; high hydrocarbon soil vapor readings in SVMW-11 in Q3 2016; sand between silt layers
								115	KAFB-106V2-115	115-120	5227-5222	SP	Poorly Graded Sand		X	X	X	X		X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	High PID reading in SVEW-04/05 and SVMW-11 during construction; high hydrocarbon soil vapor readings in SVMW-11 in Q3 2016; sand between silt layers
								158	KAFB-106V2-158	158-163	5184-5179	SP	Poorly Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	High PID reading in SVEW-04/05 and SVMW-11 during construction
								215	KAFB-106V2-215	215-220	5127-5122	SW	Well Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	High PID reading in SVEW-04/05 and SVMW-11 during construction
								250	KAFB-106V2-250	250-255	5092-5087	SP	Poorly Graded Sand		X	X	X	X		X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	High PID reading in SVEW-04/05 and SVMW-11 during construction; high hydrocarbon soil vapor readings in SVMW-11 in Q3 2016
								270	KAFB-106V2-270	270-275	5072-5067	SP	Poorly Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	High PID reading in SVEW-04/05 and SVMW-11 during construction; high hydrocarbon soil vapor readings in SVMW-11 in Q3 2016; SVMW-11 readings directly above lean clay layer which might extend to V2 location
ST106-SBBG	5345	515	0	515	4852	4940	478.05 (KAFB-106007)	0 - 100' [a]										X									One sample within 100' depth interval corresponding to sample depths in other boreholes
								110 - 200' [a]										X									One sample within 100' depth interval corresponding to sample depths in other boreholes
								210 - 300' [a]										X									One sample within 100' depth interval corresponding to sample depths in other boreholes
								310 - 400' [a]										X									One sample within 100' depth interval corresponding to sample depths in other boreholes
								410 - 450' [a]							X	X	X	X						X	X		One sample within depth interval corresponding to sample depths in other boreholes
								465	ST106-SBBG-465	465-470	4880-4875	SW	Well Graded Sand		X	X	X	X				X	X	X	X		Above water level
								475	ST106-SBBG-475	475-480	4870-4865	SW	Well Graded Sand		X	X	X	X				X	X	X	X		Near water table interface
								483	ST106-SBBG-483	483-488	4862-4857	SW/SM	Well Graded Sand/Silty Sand		X	X	X	X				X	X		X		Saturated zone
								493	ST106-SBBG-493	493-498	4852-4847	SW/SM	Well Graded Sand/Silty Sand		X	X	X	X				X	X		X		Saturated zone
								507	KAFB-106BG-507	507-512	4838-4833	SM/SP	Silty Sand/Poorly Graded Sand		X	X	X	X				X	X		X		Saturated zone

Table 3-3
Proposed Sampling Plan for Continuous Coring

														Continuous Coring Sampling Guide (CCSG)													
														Analysis	Core Sample Management	VOCs (SW5035A/8260C)	EDB (SW8011)	TPH-GRO/DRO/ORO (SW5035A/8015D)	LNAPL Transmissivity and Mobility - grain size, fluid properties, capillary pressure air/water drainage, free product mobility, relative permeability, and hydraulic conductivity [effective\total porosity %Vb]	LNAPL Physical Properties - gravity, hydrocarbon analysis, flashpoint, viscosity (Product)	LNAPL Components (ASTM D4052, D6733, D93, D445)	Mineralogy (XRD/EDAX)	QuantArray-Chlor (qPCR)	Moisture (ASTM D2216)	Temperature	LNAPL Fluorescence	
														Laboratory	ALS	TestAmerica	TestAmerica	TestAmerica	PTS Laboratories	Saybolt LP, Core Companies	Saybolt LP, Core Companies	IMR Metallurgical Services	Microbial Insights	DB Stephens	Field Measurement	PTS Laboratories	
			Designated Coring Interval					Target Sample Depths						Unit	NA	mg/kg	mg/kg	mg/kg	grain size (mm), fluid properties, capillary pressure (cm) air/water drainage (mD), free product mobility, relative permeability (mD), and hydraulic conductivity (cm/s)	gravity, hydrocarbon analysis, flashpoint (°C), viscosity (centipoise\centistokes) (Product)	Weight % Liq. Volume % Mole % Molecular Weight	Mineral Composition %	Bulk Cell Count (#/g), soluble MMO as Cell count	%	°C	Visual Determination	
														Container	Box and Bag Core	3 x EnCore samplers; 1 x 4-oz glass	1 x 8-oz glass	1 x 8-oz glass	2 inch x 6 inch core in sleeve sealed in ziplock bag (shipped frozen with dry ice for mobility analysis)	1 x 8-oz glass	1 x 8-oz glass	1 x 4-oz glass	1 x 8-oz glass	Double ziplock or sealed bucket (2.5 kg of soil)	--	2 inch x 6 inch core in sleeve sealed in ziplock bag (shipped frozen with dry ice for mobility analysis)	
														Preservative	--	None; Cool 6°C	None; Cool 6°C	None; Cool 6°C	--	NA None; Cool 6°C	NA None; Cool 6°C	--	None; Cool 6°C	--	--	--	
														Prep Hold Time	--	48 hours	14 days	--	--	--	--	--	--	--	--	--	
LOCID	Ground Elevation (ft amsl)	Total Proposed Coring Depth (ft bgs)	Top	Bottom	Lowest Measured Groundwater Elevation (ft amsl)	Historical High Groundwater Elevation (ft, amsl)	Expected Depth to Water (ft bgs) (July 2017)	Top of Sample Depth	Sample ID	Sample Interval (depth, bgs)	Sample Interval (elev., ft)	Anticipated Soil Media (USCS)	Anticipated Soil Media	Analytical Hold Time	--	14 days	40 days	14 days	--	--	--	--	48 hours	--	--	--	Rationale
KAFB-106S1	5344	510	0	510	4852	4940	473.52 (KAFB-106076)	0-100' highest PID reading (>1,000 ppm) will be sampled[a]							X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Highest PID reading (>1,000 ppm) within 100' depth interval
								110 - 200' highest PID reading (>1,000 ppm) will be sampled[a]							X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Highest PID reading (>1,000 ppm) within 100' depth interval
								210 - 270' highest PID reading (>1,000 ppm) will be sampled[a]							X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Highest PID reading (>1,000 ppm) within depth interval
								279	KAFB-106S1-279	279-284	5065-5060	CL	Lean Clay		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Petroleum odor reported in KAFB-106076 during construction; clay likely to retain organics
								300 - 400' highest PID reading (>1,000 ppm) will be sampled[a]							X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Highest PID reading (>1,000 ppm) within depth interval
								414	KAFB-106S1-414	414-419	4930-4925	SP	Poorly Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Petroleum odor reported in KAFB-106076 during construction; near historical high water table
								459	KAFB-106S1-459	459-464	4885-4880	SM	Silty Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Petroleum odor reported in KAFB-106076 during construction; silt likely to retain organics
								469	KAFB-106S1-469	469-474	4875-4870	SM	Silty Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)	X	X	X	X	X (If LNAPL Present)	Zone where LNAPL may be smeared; historic odor in KAFB-106076; near water table interface
								489	KAFB-106S1-489	489-494	4855-4850	SP	Poorly Graded Sand		X	X	X	X	X			X	X		X		Saturated zone; petroleum odor reported in KAFB-106076 during construction; historical low water table
KAFB-106S2[b]	5349	510	250	510	4852	4940	480.12 (KAFB-106008)	0 - 100' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								110 - 200' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								210 - 240' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within depth interval
								250 - 350' highest PID reading (>1,000 ppm) will be sampled[a]							X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Highest PID reading (>1,000 ppm) within depth interval
								360 - 410' highest PID reading (>1,000 ppm) will be sampled[a]							X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Highest PID reading (>1,000 ppm) within depth interval
								419	KAFB-106S2-419	419-424	4930-4925	SW	Well Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Zone where LNAPL may be smeared; near historical high water table
								474	KAFB-106S2-474	474-479	4875-4870	SW	Well Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)	X	X	X	X	X (If LNAPL Present)	Zone where LNAPL may be smeared; near water table interface
								499	KAFB-106S2-499	499-504	4850-4845	SW	Well Graded Sand		X	X	X	X	X			X	X		X		Saturated zone; historical low water table
KAFB-106S3[b]	5349	512	397	512	4853	4940	479.43 (KAFB-106064)[c]	0 - 100' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								110 - 200' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								210 - 300' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								310 - 400' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within depth interval
								424	KAFB-106S3-424	424-429	4925-4920	SW/SM	Well Graded Sand/Silty Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Zone where LNAPL may be smeared; near historical high water table; finer-grained lithology likely to retain organics
								459	KAFB-106S3-459	459-464	4890-4885	GP/SW	Poorly Graded Gravel/Well Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Zone where LNAPL may be smeared
								474	KAFB-106S3-474	474-479	4875-4870	SW	Well Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)	X	X	X	X	X (If LNAPL Present)	Zone where LNAPL may be smeared; near water table interface
								489	KAFB-106S3-489	489-494	4860-4855	GW	Well Graded Gravel		X	X	X	X	X			X	X		X		Saturated zone; historical low water table; highest PID reading from KAFB-106014
KAFB-106S4[b]	5344	504	350	504	4852	4940	475.11 (KAFB-106005)	0 - 100' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								110 - 200' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								210 - 300' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								310 - 340' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within depth interval
								350 - 410' highest PID reading (>1,000 ppm) will be sampled[a]							X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Highest PID reading (>1,000 ppm) within depth interval
								414	KAFB-106S4-414	414-419	4930-4925	SP	Poorly Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Zone where LNAPL may be smeared; near historical high water table
								464	KAFB-106S4-464	464-469	4880-4875	CL	Lean Clay		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)	X	X	X	X	X (If LNAPL Present)	Zone where LNAPL may be smeared, odor reported from KAFB-106005 construction; near water table interface; clay likely retain organics
								494	KAFB-106S4-494	494-499	4850-4845	SP	Poorly Graded Sand		X	X	X	X	X			X	X		X		Saturated zone; historical low water table; odor reported from KAFB-106005 construction

Table 3-3
Proposed Sampling Plan for Continuous Coring

Continuous Coring Sampling Guide (CCSG)																										
			Designated Coring Interval					Target Sample Depths						Analysis	Core Sample Management	VOCs (SW5035A/8260C)	EDB (SW8011)	TPH-GRO/DRO/ORO (SW5035A/8015D)	LNAPL Transmissivity and Mobility - grain size, fluid properties, capillary pressure air/water drainage, free product mobility, relative permeability, and hydraulic conductivity [effective\total porosity %\%b]	LNAPL Physical Properties - gravity, hydrocarbon analysis, flashpoint, viscosity (Product)	LNAPL Components (ASTM D4052, D6733, D93, D445)	Mineralogy (XRD/EDAX)	QuantArray-Chlor (qPCR)	Moisture (ASTM D2216)	Temperature	LNAPL Fluorescence	
														Laboratory	ALS	TestAmerica	TestAmerica	TestAmerica	PTS Laboratories	Saybolt LP, Core Companies	Saybolt LP, Core Companies	IMR Metallurgical Services	Microbial Insights	DB Stephens	Field Measurement	PTS Laboratories	
														Unit	NA	mg/kg	mg/kg	mg/kg	grain size (mm), fluid properties, capillary pressure (cm) air/water drainage (mD), free product mobility, relative permeability (mD), and hydraulic conductivity (cm/s)	gravity, hydrocarbon analysis, flashpoint (°C), viscosity (centipoise\centistokes) (Product)	Weight % Liq. Volume % Mole % Molecular Weight	Mineral Composition %	Bulk Cell Count (#/g), soluble MMO as Cell count	%	°C	Visual Determination	
														Container	Box and Bag Core	3 x EnCore samplers; 1 x 4-oz glass	1 x 8-oz glass	1 x 8-oz glass	2 inch x 6 inch core in sleeve sealed in ziplock bag (shipped frozen with dry ice for mobility analysis)	1 x 8-oz glass	1 x 8-oz glass	1 x 4-oz glass	1 x 8-oz glass	Double ziplock or sealed bucket (2.5 kg of soil)	--	2 inch x 6 inch core in sleeve sealed in ziplock bag (shipped frozen with dry ice for mobility analysis)	
														Preservative	--	None; Cool 6°C	None; Cool 6°C	None; Cool 6°C	--	NA None; Cool 6°C	NA None; Cool 6°C	--	None; Cool 6°C	--	--	--	
														Prep Hold Time	--	48 hours	14 days	--	--	--	--	--	--	--	--	--	
LOCID	Ground Elevation (ft amsl)	Total Proposed Coring Depth (ft bgs)	Top	Bottom	Lowest Measured Groundwater Elevation (ft amsl)	Historical High Groundwater Elevation (ft, amsl)	Expected Depth to Water (ft bgs) (July 2017)	Top of Sample Depth	Sample ID	Sample Interval (depth, bgs)	Sample Interval (elev., ft)	Anticipated Soil Media (USCS)	Anticipated Soil Media	Analytical Hold Time	--	14 days	40 days	14 days	--	--	--	--	48 hours	--	--	--	Rationale
KAFB-106S5	5343	503	393	503	4851	4940	471.86 (KAFB-106010)	0 - 100' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								110 - 200' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								210 - 300' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								310 - 390' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								413	KAFB-106S5-413	413-418	4930-4925	SW	Well Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Zone where LNAPL may be smeared, near historical high water table
								468	KAFB-106S5-468	468-473	4875-4870	SW	Well Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)	X	X	X	X	X (If LNAPL Present)	Zone where LNAPL may be smeared; near water table interface
								478	KAFB-106S5-478	478-483	4865-4860	SW	Well Graded Sand		X	X	X	X	X			X	X		X		Saturated zone; moderate PID reading in KAFB-106010 during construction
								488	KAFB-106S5-488	488-493	4855-4850	SW	Well Graded Sand		X	X	X	X	X			X	X		X		Saturated zone; moderate PID reading in KAFB-106010 during construction
KAFB-106S6 (Opt)[b]	5343	503	393	503	4851	4940	471.86 (KAFB-106010)	0 - 100' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								110 - 200' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								210 - 300' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								310 - 390' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								413	KAFB-106S5-413	413-418	4930-4925	SW	Well Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Zone where LNAPL may be smeared, near historical high water table
								468	KAFB-106S5-468	468-473	4875-4870	SW	Well Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)	X	X	X	X	X (If LNAPL Present)	Zone where LNAPL may be smeared; near water table interface
								478	KAFB-106S5-478	478-483	4865-4860	SW	Well Graded Sand		X	X	X	X	X			X	X		X		Saturated zone; moderate PID reading in KAFB-106010 during construction
								488	KAFB-106S5-488	488-493	4855-4850	SW	Well Graded Sand		X	X	X	X	X			X	X		X		Saturated zone; moderate PID reading in KAFB-106010 during construction
KAFB-106S7 (Opt)[b]	5348	506	399	506	4852	4940	477.49 (KAFB-106028)	0 - 100' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								110 - 200' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								210 - 300' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								310 - 400' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								418	KAFB-106S7-418	418-423	4930-4925	SW	Well Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Zone where LNAPL may be smeared, historical high water table
								468	KAFB-106S7-468	468-473	4880-4875	SP/SW	Poorly Graded Sand/Well Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)	X	X	X	X	X (If LNAPL Present)	Zone where LNAPL may be smeared; moderate PID reading in KAFB-106028 during construction; near water table interface
								481	KAFB-106S7-481	481-486	4867-4862	SP/SW	Poorly Graded Sand/Well Graded Sand		X	X	X	X	X			X	X		X		Saturated zone; moderate PID reading in KAFB-106028 during construction
								493	KAFB-106S7-493	493-498	4855-4850	SW/GP	Well Graded Sand/Well Graded Gravel		X	X	X	X	X			X	X		X		Saturated zone; high PID reading in KAFB-106028 during construction; historical low water table
KAFB-106S8 (Opt)[b]	5349	510	250	510	4852	4940	479.89 (KAFB-106006)	0 - 100' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								110 - 200' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								210 - 240' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								250 - 350' highest PID reading (>1,000 ppm) will be sampled[a]							X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Highest PID reading (>1,000 ppm) within depth interval
								360 - 410' highest PID reading (>1,000 ppm) will be sampled[a]							X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Highest PID reading (>1,000 ppm) within depth interval
								419	KAFB-106S8-419	419-424	4930-4925	SP	Poorly Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Zone where LNAPL may be smeared, near historical high water table
								474	KAFB-106S8-474	474-479	4875-4870	SW	Well Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)	X	X	X	X	X (If LNAPL Present)	Zone where LNAPL may be smeared; near water table interface
								499	KAFB-106S8-499	499-504	4850-4845	SP	Poorly Graded Sand		X	X	X	X	X			X	X		X		Saturated zone; historical low water table

Table 3-3
Proposed Sampling Plan for Continuous Coring

Continuous Coring Sampling Guide (CCSG)																											
													Analysis	Core Sample Management	VOCs (SW5035A/8260C)	EDB (SW8011)	TPH-GRO/DRO/ORO (SW5035A/8015D)	LNAPL Transmissivity and Mobility - grain size, fluid properties, capillary pressure air/water drainage, free product mobility, relative permeability, and hydraulic conductivity [effective\total porosity %\b]	LNAPL Physical Properties - gravity, hydrocarbon analysis, flashpoint, viscosity (Product)	LNAPL Components (ASTM D4052, D6733, D93, D445)	Mineralogy (XRD/EDAX)	QuantArray-Chlor (qPCR)	Moisture (ASTM D2216)	Temperature	LNAPL Fluorescence	
													Laboratory	ALS	TestAmerica	TestAmerica	TestAmerica	PTS Laboratories	Saybolt LP, Core Companies	Saybolt LP, Core Companies	IMR Metallurgical Services	Microbial Insights	DB Stephens	Field Measurement	PTS Laboratories	
			Designated Coring Interval					Target Sample Depths					Unit	NA	mg/kg	mg/kg	mg/kg	grain size (mm), fluid properties, capillary pressure (cm) air/water drainage (mD), free product mobility, relative permeability (mD), and hydraulic conductivity (cm/s)	gravity, hydrocarbon analysis, flashpoint (°C), viscosity (centipoise\centistokes) (Product)	Weight % Liq. Volume % Mole % Molecular Weight	Mineral Composition %	Bulk Cell Count (#/g), soluble MMO as Cell count	%	°C	Visual Determination	
													Container	Box and Bag Core	3 x EnCore samplers; 1 x 4-oz glass	1 x 8-oz glass	1 x 8-oz glass	2 inch x 6 inch core in sleeve sealed in ziplock bag (shipped frozen with dry ice for mobility analysis)	1 x 8-oz glass	1 x 8-oz glass	1 x 4-oz glass	1 x 8-oz glass	Double ziplock or sealed bucket (2.5 kg of soil)	--	2 inch x 6 inch core in sleeve sealed in ziplock bag (shipped frozen with dry ice for mobility analysis)	
													Preservative	--	None; Cool 6°C	None; Cool 6°C	None; Cool 6°C	--	NA None; Cool 6°C	NA None; Cool 6°C	--	None; Cool 6°C	--	--	--	
													Prep Hold Time	--	48 hours	14 days	--	--	--	--	--	--	--	--	--	
LOCID	Ground Elevation (ft amsl)	Total Proposed Coring Depth (ft bgs)	Top	Bottom	Lowest Measured Groundwater Elevation (ft amsl)	Historical High Groundwater Elevation (ft, amsl)	Expected Depth to Water (ft bgs) (July 2017)	Top of Sample Depth	Sample ID	Sample Interval (depth, bgs)	Sample Interval (elev., ft)	Anticipated Soil Media (USCS)	Anticipated Soil Media	Analytical Hold Time	--	14 days	40 days	14 days	--	--	--	--	48 hours	--	--	--	Rationale
KAFB-106S9	5345	508	0	508	4852	4940	476.27 (KAFB-106059)	0 - 100' highest PID reading (>1,000 ppm) will be sampled[a]							X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Highest PID reading (>1,000 ppm) within 100' depth interval
								110 - 200' highest PID reading (>1,000 ppm) will be sampled[a]							X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Highest PID reading (>1,000 ppm) within 100' depth interval
								210 - 300' highest PID reading (>1,000 ppm) will be sampled[a]							X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Highest PID reading (>1,000 ppm) within 100' depth interval
								310 - 400' highest PID reading (>1,000 ppm) will be sampled[a]							X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Highest PID reading (>1,000 ppm) within 100' depth interval
								415	KAFB-106S9-415	415-420	4930-4925	SW	Well Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Zone where LNAPL may be smeared, near historical high water table
								470	KAFB-106S9-470	470-475	4875-4870	SW	Well Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)	X	X	X	X	X (If LNAPL Present)	Zone where LNAPL may be smeared; near water table interface
								490	KAFB-106S9-490	490-495	4855-4850	SP/GW	Poorly Graded Sand/Well Graded Gravel		X	X	X	X	X			X	X		X		Saturated zone; near historical low water table
													Total Maximum Number of Samples[d] :		78	78	78	108	68	48	48	26	26	51	66	48	
													Total Minimum Number of Samples :		51	51	51	50	41	0	0	26	26	36	51	0	

[a] One sample with the highest PID reading will be collected from this depth interval, only if PID reading(s) >500 ppm (above designated coring interval), or >1,000 ppm within designated coring interval. PID readings are scheduled for every 10 ft of core length.
[b] Actual coring interval will be revised, if needed, following initial data collection. See Figure 3-2.
[c] Water level data from Q2 2017. Due to dedicated down-hole equipment, more recent water levels have not been gauged by EA.
[d] Includes an additional sample beyond the planned total planned depth, to be included if LNAPL is still indicated at this depth
Note: Historical high water table elevation adapted from Rice, et al. (2012), and is approximately 4,940 ft amsl in 1960.
Note: PID readings will be collected every 20 ft above the designated coring interval, and every 10 ft within the designed coring interval, or at any depth interval where qualitative data (e.g. staining, odor, etc.) indicate possible NAPL.
Note: All extracted core will be iced in the field prior to sample collection.

amsl = above mean sea level
bgs = below ground surface
cm = centimeter
DRO = diesel-range organics
ray
EDB = ethylene dibromide
ft = foot/feet
g = grams
GRO = gasoline-range organics
Kg = kilogram
LNAPL = light non-aqueous phase liquid
mg = milligrams
mm = millimeter
MMO = methane monooxygenase
NA = not appliable
Opt = optional
ORO = oil-range organics
oz = ounce
sat = saturated
TPH = total petroleum hydrocarbons
UNK = unkown
unsat = unsaturated
USCS = Unified Soil Classification System
VOCs = volatile organic compounds
XRD = x-ray diffraction
% = percent
°C = degrees Centigrade
= number

Table 3-4
Proposed Vapor Well Construction for Locations KAFB-106V1 and KAFB-106V2

Observation Well	Planned Screened Interval (ft bgs)	Rationale for Screen Interval Selection	Injection Wells	Screened Interval (ft bgs)	Lateral Distance Between Injection Well and Observation Well (ft)
KAFB-106V1-100	100-102.5	SVEW-04/05 PID during drilling > 3,000; SVMW-11 PID > 8,700 during drilling and hydrocarbon soil vapor > 32,000 (2016)	SVMW-11-100	100-102.5	27
			SVMW-10-100	100-102.5	49
KAFB-106V1-115	115-117.5	Top of silt unit	SVMW-11-100	100-102.5	27
			SVMW-10-100	100-102.5	49
KAFB-106V1-158	157.5-160	SVMW-11 PID >5,000 during drilling; SVEW-04/05 PID > 2,300 during drilling	SVMW-02/03-160	145-160	35
			SVMW-10-150	150-152.5	49
KAFB-106V1-215	215-217.5	SVMW-11 PID = 4,900 during drilling	SVMW-11-250	250-252.5	27
			SVEW-01-260	245-260	28
KAFB-106V1-250	250-252.5	Hydrocarbon soil vapor > 27,000 (2016); SVMW-11 PID > 2,700 during drilling	SVMW-11-250	250-252.5	27
			SVEW-01-260	245-260	28
KAFB-106V1-270	270-272.5	Top of nearby clay unit; SVMW-11 PID = 4,000 during drilling	SVMW-11-260	260-262.5	27
			SVEW-04/05-313	298-313	31
			SVEW-01-260	245-260	28
KAFB-106V2-100	100-102.5	SVEW-04/05 PID > 3,000 during drilling; directly below top silt layer	SVMW-11-100	100-102.5	65
			SVMW-10-100	100-102.5	64
KAFB-106V2-115	115-117.5	Top of clayey silt unit; SVEW-04/05 PID = 2,500 during drilling	SVMW-11-100	100-102.5	65
			SVMW-10-100	100-102.5	64
KAFB-106V2-158	157.5-160	SVEW-04/05 PID > 2,300 during drilling	SVMW-02/03-160	145-160	10
			SVMW-10-150	150-152.5	64
KAFB-106V2-215	215-217.5	SVEW-04/05 PID > 3,500 during drilling	SVEW-01-260	245-260	19
			SVEW-11-250	250-252.5	65
KAFB-106V2-250	250-252.5	SVEW-04/05 PID > 3,600 during drilling	SVEW-01-260	245-260	19
			SVEW-11-250	250-252.5	65

Table 3-4
Proposed Vapor Well Construction for Locations KAFB-106V1 and KAFB-106V2

Observation Well	Planned Screened Interval (ft bgs)	Rationale for Screen Interval Selection	Injection Wells	Screened Interval (ft bgs)	Lateral Distance Between Injection Well and Observation Well (ft)
KAFB-106V2-270	270-272.5	SVEW-04/05 PID > 3,200 during drilling	SVEW-01-260	245-260	19
			SVEW-04/05-313	298-313	32
			SVMW-11-260	260-262.5	65

bgs = below ground surface
ft = feet
PID = photoionization detector

Table 3-5
Available Vapor Wells for Injection/Observation Pairing

Injection Well	Screened Interval (ft bgs)	Observation Well	Top Screened Interval (ft bgs)	Bottom Screened Interval (ft bgs)	Planned Screened Interval (ft bgs)	Lateral Distance Between Injection Wells and Observation Well (ft)
SVMW-11-100	100-102.5	KAFB-106V1-100	100	102.5	100-102.5	27
		KAFB-106V2-100	100	102.5	100-102.5	65
		SVMW-10-100	100	102.5	Existing	72
SVMW-11-250	250-252.5	KAFB-106V1-250	250	252.5	250-252.5	27
		KAFB-106V2-250	250	252.5	250-252.5	65
		SVMW-10-250	250	252.5	Existing	72
SVMW-11-260	260-262.5	KAFB-106V1-250	250	252.5	250-252.5	27
		SVEW-01-260	245	260	Existing	50
		KAFB-106V2-250	250	252.5	250-252.5	65
		SVMW-10-250	250	252.5	Existing	72
SVEW-01-260	245-260	KAFB-106V2-250	250	252.5	250-252.5	19
		KAFB-106V1-250	250	252.5	250-252.5	28
SVMW-10-100	100-102.5	KAFB-106V1-100	100	102.5	100-102.5	49
		SVMW-09-100	100	102.5	Existing	50
		KAFB-106V2-100	100	102.5	100-102.5	64
SVMW-10-150	150-152.5	KAFB-106V1-158	157.5	160	157.5-160	49
		KAFB-106V2-158	157.5	160	157.5-160	64
SVMW-10-250	250-252.5	KAFB-106V1-250	250	252.5	250-252.5	49
		SVMW-09-250	250	252.5	Existing	50
		KAFB-106V2-250	250	252.5	250-252.5	64
SVMW-02/03-160	145-160	KAFB-106V2-158	157.5	160	157.5-160	10
		KAFB-106V1-158	157.5	160	157.5-160	35
SVEW-04/05-313	98-313	KAFB-106V1-270	270	272.5	270-272.5	31
		KAFB-106V2-270	270	272.5	270-272.5	32

Table 3-6
Soil Vapor Monitoring Point Locations and Coordinates

Location Number	SVM Location ID	SVMP ID	Easting[1]	Northing
1	KAFB-106028	KAFB-106028-150	401910.441776	1474285.009804
		KAFB-106028-250	401910.491777	1474285.239798
		KAFB-106028-350	401910.751783	1474285.259797
		KAFB-106028-450	401910.851786	1474285.409793
2	KAFB-106108	KAFB-106108-025	400664.903033	1473684.446268
		KAFB-106108-050	400664.773030	1473684.206274
		KAFB-106108-150	400664.993035	1473684.016279
		KAFB-106108-250	400665.243040	1473684.156276
		KAFB-106108-350	400665.173039	1473684.456267
		KAFB-106108-450	400665.023035	1473684.846257
3	KAFB-106109	KAFB-106109-025	400384.736587	1473432.363139
		KAFB-106109-050	400384.916591	1473432.573133
		KAFB-106109-150	400384.736587	1473432.853126
		KAFB-106109-250	400384.456580	1473432.763128
		KAFB-106109-350	400384.446580	1473432.443137
		KAFB-106109-450	400384.676586	1473432.693130
4	KAFB-106110	KAFB-106110-025	400702.613980	1473238.228342
		KAFB-106110-050	400702.373975	1473238.008348
		KAFB-106110-150	400702.523978	1473237.768354
		KAFB-106110-250	400702.783984	1473237.818353
		KAFB-106110-350	400702.833985	1473238.098345
		KAFB-106110-450	400702.033967	1473237.748355
5	KAFB-106111	KAFB-106111-025	400916.998944	1473240.918233
		KAFB-106111-050	400917.178948	1473240.698239
		KAFB-106111-150	400917.438954	1473240.808236
		KAFB-106111-250	400917.418954	1473241.068229
		KAFB-106111-350	400917.118947	1473241.148227
		KAFB-106111-450	400917.038945	1473240.748238
6	KAFB-106112	KAFB-106112-025	401517.592816	1473457.832261
		KAFB-106112-050	401517.752819	1473457.592267
		KAFB-106112-150	401518.032826	1473457.692264
		KAFB-106112-250	401518.062827	1473457.962257
		KAFB-106112-350	401517.772820	1473458.082254
		KAFB-106112-450	401517.052803	1473457.742263
7	KAFB-106113	KAFB-106113-020	401585.424459	1473016.904187
		KAFB-106113-050	401585.284456	1473016.594195
		KAFB-106113-150	401585.534462	1473016.404200
		KAFB-106113-250	401585.844469	1473016.554196
		KAFB-106113-350	401585.754467	1473016.824189
		KAFB-106113-450	401585.554462	1473016.764191

Table 3-6
Soil Vapor Monitoring Point Locations and Coordinates

Location Number	SVM Location ID	SVMP ID	Easting[1]	Northing
8	KAFB-106114	KAFB-106114-025	401377.539646	1473017.104216
		KAFB-106114-050	401377.289640	1473016.884222
		KAFB-106114-150	401377.419643	1473016.594230
		KAFB-106114-250	401377.729650	1473016.614229
		KAFB-106114-350	401377.759651	1473016.924221
		KAFB-106114-450	401377.589647	1473017.374209
9	KAFB-106115	KAFB-106115-025	401956.373050	1473009.614323
		KAFB-106115-050	401956.193046	1473009.374329
		KAFB-106115-150	401955.923040	1473009.414328
		KAFB-106115-250	401955.893039	1473009.694321
		KAFB-106115-350	401956.163045	1473009.754319
		KAFB-106115-450	401956.063043	1473009.754319
10	KAFB-106116	KAFB-106116-025	401475.631878	1473251.167863
		KAFB-106116-050	401475.951886	1473251.187862
		KAFB-106116-150	401475.521876	1473251.417856
		KAFB-106116-250	401475.741881	1473251.627850
		KAFB-106116-350	401476.021887	1473251.467854
		KAFB-106116-450	401475.051865	1473250.747874
11	KAFB-106117	KAFB-106117-025	401308.888006	1473321.085997
		KAFB-106117-050	401309.028009	1473321.305991
		KAFB-106117-150	401308.838004	1473321.555985
		KAFB-106117-250	401308.567998	1473321.445988
		KAFB-106117-350	401308.577998	1473321.165995
		KAFB-106117-450	401308.047986	1473320.746007
12	KAFB-106118	KAFB-106118-025	401372.389414	1473695.475851
		KAFB-106118-050	401372.479416	1473695.765843
		KAFB-106118-160	401372.589419	1473695.285856
		KAFB-106118-265	401372.809424	1473695.735844
		KAFB-106118-350	401372.879425	1473695.385854
		KAFB-106118-450	401372.049406	1473695.735844
13	KAFB-106119	KAFB-106119-025	401194.105322	1473474.311868
		KAFB-106119-050	401194.275326	1473474.061875
		KAFB-106119-150	401194.545332	1473474.151873
		KAFB-106119-250	401194.585333	1473474.421865
		KAFB-106119-350	401194.315327	1473474.531862
		KAFB-106119-450	401194.045321	1473474.741857
14	KAFB-106120	KAFB-106120-025	401636.035658	1472855.058560
		KAFB-106120-050	401636.135660	1472855.248555
		KAFB-106120-150	401636.015658	1472855.498549
		KAFB-106120-250	401635.685650	1472855.268555
		KAFB-106120-350	401635.855654	1472855.038561
		KAFB-106120-450	401635.915655	1472855.388552

Table 3-6
Soil Vapor Monitoring Point Locations and Coordinates

Location Number	SVM Location ID	SVMP ID	Easting[1]	Northing
15	KAFB-106121	KAFB-106121-025	401632.585594	1472760.611118
		KAFB-106121-050	401632.835600	1472760.431123
		KAFB-106121-145	401632.305587	1472760.381125
		KAFB-106121-250	401632.425590	1472760.121132
		KAFB-106121-350	401632.805599	1472760.141131
		KAFB-106121-450	401632.535593	1472760.431123
16	KAFB-106122	KAFB-106122-025	401677.386621	1472821.089473
		KAFB-106122-050	401677.326620	1472821.389465
		KAFB-106122-150	401677.046613	1472821.449464
		KAFB-106122-250	401676.936611	1472821.159472
		KAFB-106122-350	401677.156616	1472820.949477
		KAFB-106122-450	401677.146616	1472821.289468
17	KAFB-106123	KAFB-106123-025	401591.874644	1472805.169919
		KAFB-106123-050	401591.754641	1472805.439911
		KAFB-106123-150	401591.394633	1472805.419912
		KAFB-106123-250	401591.334631	1472805.109920
		KAFB-106123-350	401591.614638	1472804.929925
		KAFB-106123-450	401591.564637	1472805.319915
18	KAFB-106124	KAFB-106124-025	401951.482979	1472757.341154
		KAFB-106124-050	401951.172971	1472757.361154
		KAFB-106124-150	401951.042968	1472757.101161
		KAFB-106124-250	401951.282974	1472756.901166
		KAFB-106124-350	401951.522980	1472757.031163
		KAFB-106124-450	401951.302974	1472757.261156
19	KAFB-106125	KAFB-106125-025	402026.084695	1472824.439325
		KAFB-106125-050	402025.794688	1472824.509323
		KAFB-106125-150	402025.624684	1472824.279330
		KAFB-106125-250	402025.824689	1472824.009337
		KAFB-106125-350	402026.094695	1472824.099334
		KAFB-106125-450	402025.864690	1472824.369327
20	KAFB-106126	KAFB-106126-025	402081.045980	1472750.941306
		KAFB-106126-050	402081.015979	1472751.231298
		KAFB-106126-150	402080.725972	1472751.321296
		KAFB-106126-250	402080.555968	1472751.081302
		KAFB-106126-350	402080.735973	1472750.781310
		KAFB-106126-450	402080.795974	1472751.161300
21	KAFB-106127	KAFB-106127-025	402018.094530	1472701.832646
		KAFB-106127-050	402017.834524	1472701.972642
		KAFB-106127-150	402017.604519	1472701.792647
		KAFB-106127-250	402017.754522	1472701.472656
		KAFB-106127-350	402018.054529	1472701.512655
		KAFB-106127-450	402017.914526	1472701.832646

Table 3-6
Soil Vapor Monitoring Point Locations and Coordinates

Location Number	SVM Location ID	SVMP ID	Easting[1]	Northing
22	KAFB-106128	KAFB-106128-025	401200.655523	1473177.999889
		KAFB-106128-050	401200.545521	1473177.729897
		KAFB-106128-150	401200.765526	1473177.529902
		KAFB-106128-250	401201.025532	1473177.669898
		KAFB-106128-350	401200.965530	1473177.999889
		KAFB-106128-450	401200.045509	1473177.749896
23	KAFB-106129	KAFB-106129-025	401711.597348	1473215.518789
		KAFB-106129-050	401711.877355	1473215.378792
		KAFB-106129-150	401712.097360	1473215.618786
		KAFB-106129-250	401711.977357	1473215.878779
		KAFB-106129-350	401711.687350	1473215.848780
		KAFB-106129-450	401711.817353	1473216.128772
24	KAFB-106130	KAFB-106130-025	401711.947306	1473520.410534
		KAFB-106130-050	401712.157311	1473520.280538
		KAFB-106130-150	401712.427317	1473520.380535
		KAFB-106130-250	401712.377316	1473520.660528
		KAFB-106130-350	401712.107310	1473520.740525
		KAFB-106130-450	401712.057308	1473520.740525
25	KAFB-106131	KAFB-106131-025	401271.447212	1472881.677900
		KAFB-106131-055	401271.667217	1472881.497905
		KAFB-106131-150	401271.567214	1472881.987892
		KAFB-106131-245	401271.937223	1472881.657901
		KAFB-106131-350	401271.837220	1472881.947893
		KAFB-106131-450	401271.047202	1472881.757898
26	KAFB-106132	KAFB-106132-025	402385.372896	1473546.049729
		KAFB-106132-050	402384.882885	1473546.139727
		KAFB-106132-175	402385.202892	1473545.799736
		KAFB-106132-250	402384.892885	1473545.829735
		KAFB-106132-350	402385.152891	1473546.259724
		KAFB-106132-450	402385.072889	1473545.739738
27	KAFB-106133	KAFB-106133-025	401997.193922	1473456.332222
		KAFB-106133-050	401997.113920	1473456.612214
		KAFB-106133-170	401997.353925	1473456.832208
		KAFB-106133-250	401997.593931	1473456.672213
		KAFB-106133-350	401997.543930	1473456.362221
		KAFB-106133-450	401997.063919	1473456.742211
28	KAFB-106134	KAFB-106134-025	401952.322832	1473764.643883
		KAFB-106134-050	401952.042825	1473764.673882
		KAFB-106134-170	401952.432834	1473764.923875
		KAFB-106134-250	401952.232830	1473765.113870
		KAFB-106134-350	401951.932823	1473764.953875
		KAFB-106134-450	401952.282831	1473765.433862

Table 3-6
Soil Vapor Monitoring Point Locations and Coordinates

Location Number	SVM Location ID	SVMP ID	Easting[1]	Northing
29	KAFB-106135	KAFB-106135-025	402486.125151	1474023.666783
		KAFB-106135-050	402486.335156	1474023.456789
		KAFB-106135-150	402486.195152	1474023.146797
		KAFB-106135-250	402485.865145	1474023.256795
		KAFB-106135-350	402485.875145	1474023.556786
		KAFB-106135-450	402486.055149	1474023.526787
30	KAFB-106136	KAFB-106136-025	402775.081742	1474634.810194
		KAFB-106136-050	402775.081742	1474634.910191
		KAFB-106136-150	402775.081742	1474635.010188
		KAFB-106136-250	402775.081742	1474635.110186
		KAFB-106136-350	402775.081742	1474635.210183
		KAFB-106136-450	402775.081742	1474635.310180
31	KAFB-106137	KAFB-106137-025	401902.701639	1474032.086651
		KAFB-106137-050	401902.451633	1474032.276646
		KAFB-106137-150	401902.181627	1474032.086652
		KAFB-106137-250	401902.311630	1474031.816659
		KAFB-106137-350	401902.661638	1474031.816659
		KAFB-106137-450	401902.521634	1474034.116597
32	KAFB-106138	KAFB-106138-025	401117.783308	1474960.381655
		KAFB-106138-050	401117.443300	1474960.271658
		KAFB-106138-150	401117.413299	1474959.981666
		KAFB-106138-250	401117.693306	1474959.871669
		KAFB-106138-350	401117.913311	1474960.121662
		KAFB-106138-450	401117.613304	1474960.211660
33	KAFB-106139	KAFB-106139-025	400829.366788	1474004.577574
		KAFB-106139-050	400829.566792	1474004.137586
		KAFB-106139-150	400829.296786	1474004.027589
		KAFB-106139-250	400829.156783	1474004.327581
		KAFB-106139-350	400829.636794	1474004.477577
		KAFB-106139-450	400829.556792	1474004.807568
34	KAFB-106140	KAFB-106140-025	401817.689909	1472587.305780
		KAFB-106140-050	401818.019916	1472587.175784
		KAFB-106140-150	401817.719909	1472587.635771
		KAFB-106140-250	401818.019916	1472587.695770
		KAFB-106140-350	401818.249922	1472587.445776
		KAFB-106140-450	401817.949915	1472587.515774
35	KAFB-106141	KAFB-106141-025	402051.934886	1475298.122360
		KAFB-106141-050	402052.064889	1475298.382353
		KAFB-106141-170	402051.904885	1475298.602347
		KAFB-106141-250	402051.614878	1475298.502350
		KAFB-106141-350	402051.644879	1475298.222357
		KAFB-106141-450	402051.844884	1475298.452351

Table 3-6
Soil Vapor Monitoring Point Locations and Coordinates

Location Number	SVM Location ID	SVMP ID	Easting[1]	Northing
36	KAFB-106142	KAFB-106142-030	402036.744600	1474898.733172
		KAFB-106142-050	402036.494594	1474898.863168
		KAFB-106142-170	402036.284589	1474898.643174
		KAFB-106142-250	402036.434593	1474898.363182
		KAFB-106142-350	402036.734600	1474898.453179
		KAFB-106142-450	402036.554596	1474898.703173
37	SVEW-01	SVEW-01	401002.570886	1473477.521813
38	SVEW-02/03	SVEW-02/03-060	401012.021105	1473479.611755
		SVEW-02/03-160	401012.091107	1473478.491785
39	SVEW-04/05	SVEW-04/05-313	400990.430605	1473479.771754
		SVEW-04/05-460	400991.320625	1473479.841752
40	SVEW-06/07	SVEW-06/07-060	400815.436552	1473481.961724
		SVEW-06/07-160	400816.096568	1473481.921725
41	SVEW-08/09	SVEW-08/09-260	400807.566370	1473480.611762
		SVEW-08/09-460	400807.936379	1473480.271771
42	SVMW-01	SVMW-01-050	400671.123209	1473489.171553
		SVMW-01-100	400671.443217	1473489.531543
		SVMW-01-250	400671.423216	1473489.171553
		SVMW-01-300	400671.163210	1473489.621541
43	SVMW-02	SVMW-02-050	400993.070644	1473610.618212
		SVMW-02-100	400993.170647	1473610.478215
		SVMW-02-150	400993.220648	1473610.748208
44	SVMW-03	SVMW-03-050	401099.413133	1473452.122485
		SVMW-03-100	401099.553136	1473452.472475
		SVMW-03-250	401099.743141	1473452.272481
		SVMW-03-300	401099.633138	1473451.992488
45	SVMW-04	SVMW-04-050	400855.887502	1473403.243849
		SVMW-04-100	400855.527494	1473403.383845
		SVMW-04-250	400855.527494	1473403.113852
		SVMW-04-300	400855.697498	1473402.813860
46	SVMW-05	SVMW-05-050	400597.061500	1473453.092542
		SVMW-05-100	400596.771493	1473453.362535
		SVMW-05-230	400597.201503	1473453.422533
		SVMW-05-290	400596.971498	1473453.502531
47	SVMW-06	SVMW-06-050	401383.549711	1473462.182165
		SVMW-06-100	401384.009722	1473462.052169
		SVMW-06-252	401383.769716	1473462.402159
		SVMW-06-302	401383.689714	1473461.872174
48	SVMW-07	SVMW-07-050	401074.372504	1473745.824538
		SVMW-07-100	401074.072497	1473745.944535
		SVMW-07-150	401074.272502	1473746.164529

Table 3-6
Soil Vapor Monitoring Point Locations and Coordinates

Location Number	SVM Location ID	SVMP ID	Easting[1]	Northing
49	SVMW-08	SVMW-08-050	400855.727481	1473509.800964
		SVMW-08-100	400855.777482	1473510.000958
		SVMW-08-250	400855.807482	1473509.770965
50	SVMW-09	SVMW-09-050	400903.768595	1473499.001248
		SVMW-09-100	400903.668593	1473498.981249
		SVMW-09-250	400903.458588	1473499.251241
		SVMW-09-266	400903.188581	1473499.171244
51	SVMW-10	SVMW-10-050	400952.179718	1473488.861515
		SVMW-10-100	400952.159717	1473489.341502
		SVMW-10-150	400952.479724	1473489.071509
		SVMW-10-250	400952.069715	1473488.961512
52	SVMW-11	SVMW-11-050	400992.780668	1473428.233149
		SVMW-11-100	400992.940671	1473428.593139
		SVMW-11-250	400992.410659	1473428.593140
		SVMW-11-260	400992.560663	1473428.813134
53	SVMW-12/ SVEW-10	SVMW-12-150	400424.977477	1473683.186342
		SVMW-12-250	400425.217482	1473683.336338
		SVMW-12-350	400424.887475	1473683.766326
		SVMW-12-450	400424.627469	1473683.536333
		SVEW-10	400424.857474	1473685.086291
54	SVMW-13/ SVEW-11	SVMW-13-150	401572.894069	1473624.437741
		SVMW-13-250	401572.554061	1473624.437741
		SVMW-13-350	401572.634063	1473624.217747
		SVMW-13-450	401572.754066	1473623.977754
		SVEW-11	401572.134051	1473626.047698
55	SVMW-14/ SVEW-12	SVMW-14-150	400544.990358	1473074.172810
		SVMW-14-250	400544.730352	1473074.292806
		SVMW-14-350	400544.780353	1473073.942816
		SVMW-14-450	400545.220363	1473073.932816
		SVEW-12	400545.010358	1473076.332751
56	SVMW-15/ SVEW-13	SVMW-15-150	401560.833833	1473362.634831
		SVMW-15-250	401561.343845	1473362.704829
		SVMW-15-350	401561.013837	1473362.434836
		SVMW-15-450	401561.013837	1473362.994821
		SVEW-13	401560.863833	1473364.984767

[1] Well coordinates are provided in New Mexico State Plane (NAD27).

Table 3-7
Soil Vapor Monitoring Points Designated for Data Validation

SVMP ID	Rational
KAFB-106114-025	Near airlift location ST106-S1
KAFB-106114-050	Near airlift location ST106-S1
KAFB-106114-150	Near airlift location ST106-S1
KAFB-106114-250	Near airlift location ST106-S1
KAFB-106114-350	Near airlift location ST106-S1
KAFB-106114-450	Near airlift location ST106-S1
KAFB-106116-025	Near airlift location ST106-S1
KAFB-106116-050	Near airlift location ST106-S1
KAFB-106116-150	Near airlift location ST106-S1
KAFB-106116-250	Near airlift location ST106-S1
KAFB-106116-350	Near airlift location ST106-S1
KAFB-106116-450	Near airlift location ST106-S1
KAFB-106128-025	Near airlift location ST106-S1
KAFB-106128-050	Near airlift location ST106-S1
KAFB-106128-150	Near airlift location ST106-S1
KAFB-106128-250	Near airlift location ST106-S1
KAFB-106128-350	Near airlift location ST106-S1
KAFB-106128-450	Near airlift location ST106-S1
KAFB-106136-025	Closest to Residential Area
KAFB-106136-050	Closest to Residential Area
KAFB-106136-150	Closest to Residential Area
KAFB-106136-250	Closest to Residential Area
KAFB-106136-350	Closest to Residential Area
KAFB-106136-450	Closest to Residential Area
KAFB-106138-025	Closest to Residential Area
KAFB-106138-050	Closest to Residential Area
KAFB-106138-150	Closest to Residential Area
KAFB-106138-250	Closest to Residential Area
KAFB-106138-350	Closest to Residential Area
KAFB-106138-450	Closest to Residential Area
KAFB-106141-025	Closest to Residential Area
KAFB-106141-050	Closest to Residential Area
KAFB-106141-170	Closest to Residential Area
KAFB-106141-250	Closest to Residential Area
KAFB-106141-350	Closest to Residential Area
KAFB-106141-450	Closest to Residential Area
SVEW-01	Injection/Observation Point for Bioventing
SVEW-02/03-060	In Source Area
SVEW-02/03-160	Injection/Observation Point for Bioventing
SVEW-04/05-313	Injection/Observation Point for Bioventing
SVEW-04/05-460	In Source Area
SVEW-06/07-060	In Source Area
SVEW-06/07-160	In Source Area

Table 3-7
Soil Vapor Monitoring Points Designated for Data Validation

SVMP ID	Rational
SVEW-08/09-260	In Source Area
SVEW-08/09-460	In Source Area
SVMW-03-050	In Source Area
SVMW-03-100	In Source Area
SVMW-03-250	In Source Area
SVMW-03-300	In Source Area
SVMW-04-050	In Source Area
SVMW-04-100	In Source Area
SVMW-04-250	In Source Area
SVMW-04-300	In Source Area
SVMW-08-050	In Source Area
SVMW-08-100	In Source Area
SVMW-08-250	In Source Area
SVMW-09-050	In Source Area
SVMW-09-100	Injection/Observation Point for Bioventing
SVMW-09-250	Injection/Observation Point for Bioventing
SVMW-09-266	In Source Area
SVMW-10-050	In Source Area
SVMW-10-100	Injection/Observation Point for Bioventing
SVMW-10-150	Injection/Observation Point for Bioventing
SVMW-10-250	Injection/Observation Point for Bioventing
SVMW-11-050	In Source Area
SVMW-11-100	Injection/Observation Point for Bioventing
SVMW-11-250	Injection/Observation Point for Bioventing
SVMW-11-260	Injection/Observation Point for Bioventing

ID = identification number

SVMP = soil vapor monitoring point

Table 3-8
Drinking Water Supply Well Names and Coordinates

Well Location Name	Easting	Northing
ST106-VA2	400544.79	1474576.3
KAFB-003	406572.7	1479061.58
KAFB-015	399113.43	1474381.13
KAFB-016	404456.63	1474118.74

Table 5-1
Staff Roles, Responsibilities, and Authorities for Vadose Zone and Water Supply Sampling Tasks

Position/Staff	Qualifications	Responsibilities	Authority Level
Program Manager Lee Becker, PE	• M.S. in Civil Engineering • 25 years of program management experience for USACE • Managed over $200 million of USACE/Army projects • Over 45 years of civil engineering experience	• As EA Officer, authorized to negotiate/sign contract and commit resources • Primary point-of-contact for USACE on contractual and programmatic items • Ensures consistency in deliverables and cost/performance reporting and progress reporting/invoicing • Coordinates issue resolution as needed with Contracting Officer's Representative and/or Contracting Officer	• Coordinates corrective action at programmatic level
Project Manager Devon Jercinovic, PG, PMP	• M.S. in Geology • 35 years of RCRA experience and 28 years of experience in management and technical support for site characterization • Project Manager for $80 million+ of RCRA/CERCLA investigations and remediation at Kirtland AFB since 1997 • Past NMED environmental regulator in the former Groundwater and Hazardous Waste Bureau	• Ensures that all work is accomplished with adequate internal controls • Main point-of-contact for USACE on project-specific matters • Reviews/confirms technical approach from kickoff meeting and throughout project execution to ensure project objectives are met • Assembles and schedules resources • Ensures on-schedule and high-quality services are delivered within budget • Coordinates EA's participation in the public meeting and community relations process • Ensures work is performed in accordance with USACE/U.S. Air Force Guidelines, state/federal regulations, and within the bounds of the RCRA, COA, and New Mexico Office of the State Engineer permits • Applies lessons learned from current and past projects • Responsible for front and back end transition activities to ensure continuity on the project • Ensures public relations sensitivities are met	• Full responsibility and authority to execute Task Orders • Approves subcontractor invoices, project charges, and deliverables • Implements corrective action • Stops work for any reason related to the project

Table 5-1
Staff Roles, Responsibilities, and Authorities for Vadose Zone and Water Supply Sampling Tasks

Position/Staff	Qualifications	Responsibilities	Authority Level
Alternate Project Manager Earl Morse, PG	• M.S. in Geology • 31 years in environmental field programs (investigation and construction)	• Reports to the Project Manager • Serves as Deputy to Project Manager • Manages staffing and field resources for all field investigations • Manages subcontractors • Identifies and mitigates risks related to execution of the technical aspects of the work and ensures site safety •	• Stop work for any reasons related to any field activities
Corporate QA/QC Officer Frank Barranco, PE, PG	• Ph.D. in Environmental Science and Engineering • 27 years of engineering, environmental remediation, and construction experience • Serves as Program QA Manager on $400 million+ of federal projects	• Reports to Program Manager—independent of the Project Manager • Identifies approved senior technical reviewers and QC staff • Assists in developing and approves project quality certification programs • Monitors work, procedures, and documentation to ensure compliance with quality certification programs • Initiates/provides recommendations to improvements to the quality process • Develops and oversees corrective actions • Conducts independent QC audits	• Evaluates performance of review staff and review process and provides feedback, including recommendations, to Project Manager • Implements corrective action if the quality of the work is not acceptable
Health and Safety Manager Peter Garger, CIH, CSP	• ScM in Public Health • As Corporate Health and Safety Director, oversees health and safety activities for 450+ employees and 30 federal contracts • Prepared/reviewed over 3,000 APPs/SSHPs • Served as Chief of Industrial Hygiene for USACE–Baltimore Hazardous, Toxic, and Radioactive Waste Branch	• Oversees development of APP in accordance with Engineer Manual 385-1-1 and Occupational Safety and Health Administration regulations • Assists Project Manager and procurement staff in verification of safety performance of subcontractors • Investigates any incidents, accidents, or safety violations • Performs safety audits	• Approves APPs/SSHPs and all modifications before issuance to the USACE • Manages Health and Safety Program and directs training and required attendance • Investigates safety concerns raised by staff • Investigates any accidents • Stops work for noncompliance/safety violation

Table 5-1
Staff Roles, Responsibilities, and Authorities for Vadose Zone and Water Supply Sampling Tasks

Position/Staff	Qualifications	Responsibilities	Authority Level
Senior Chemist Pamela Moss	• B.S. in Chemistry • 25 years of chemistry experience, including developing and implementing data quality objectives in accordance with RCRA/CERCLA to ensure performance standards are achieved • Expertise in developing QAPjP, Sampling and Analysis Plan, Field Sampling Plan for Department of Defense • Performed $35 million+ of project work at Kirtland, Cannon, and Holloman AFBs in New Mexico	• Reports to both the Project Manager and the Corporate QA/QC Manager • Ensures that project implementation is performed in compliance with QA Project Plans • Overall responsibility for chemical data quality and ensures that data meet data quality objectives • Supports development of project-specific work plans and QAPjP • Monitors implementation of QAPjP, including oversight of laboratory, analytical methods, reporting limits, and data deliverables • Coordinates third-party data validation and reviews data validation results and reports • Prepares data quality reports to document that data are usable and achieve data quality objectives • Direct interface with analytical laboratory Project Manager and QC Manager	• Coordinates all communication with the analytical laboratory • Coordinates data validation and evaluation • In coordination with the Project Manager, implements corrective actions related to laboratory performance
Project Geologist Jay Snyder, PE, PG, CHg	• M.S. in Geology/Geological Engineering • 26 years geological experience, working with within New Mexico and with New Mexico regulators	• Reports to the Project Manager • Senior technical support for bioventing and bioremediation pilot tests • Reviews all work plan, geological reporting, and data deliverables associated with pilot testing • Assists with establishing project-specific data quality objectives • Responsible for providing input for the design of the corrective actions and reviews corrective elements specific to geology or well installation	• Stop drilling work or pilot testing for any reasons related to drilling activities

Table 5-1
Staff Roles, Responsibilities, and Authorities for Vadose Zone and Water Supply Sampling Tasks

Position/Staff	Qualifications	Responsibilities	Authority Level
Bioventing Specialist Robert Hinchee, PE	• Ph.D., Civil and Environmental Engineering • 35 years performing LNAPL/Petroleum Hydrocarbon Remediation on thousands of sites in North America, South America, Europe, Africa, the Middle East, and Asia. • SME for Bioventing - lead much of the early development of bioventing including serving as project manager, technical director, or technical reviewer of bioventing studies at 500 sites in the U.S. and Europe. Developed the first field treatability testing protocol that was applied at all sites, leading to scale up of the remediation systems at hundreds of sites. Co-authored the EPA's Bioventing Principals and Practice Manual	• Reports to the Project Manager • Senior subject matter expert for bioventing and bioremediation pilot tests • Participates in Vadose Zone Working Group • Reviews pilot test work plans, geological reporting, and data deliverables associated with pilot testing • Responsible for providing input for the design of the corrective actions and reviews corrective elements specific to vadose zone remediation	• Stop drilling work or pilot testing for any reasons related to drilling activities
Vadose Zone Support Rachel Hobbs, PG	• M.S. in Geology; • 5 years' experience in environmental remediation; • Past experience coordinating Kirtland BFF project tasks	• Reports to the Project Manager and serves as Task Manager for Vadose Support activities • Oversees all vadose zone drilling operations during well installations and abandonments • Manages soil sampling, lithologic logging, and vapor well construction • Conducts data analysis and reporting • Support Corrective Measures Evaluation Report	• Stop drilling work for any reasons related to drilling activities

Table 5-1
Staff Roles, Responsibilities, and Authorities for Vadose Zone and Water Supply Sampling Tasks

Position/Staff	Qualifications	Responsibilities	Authority Level
Project Remediation Engineer Vener Mustafin, PE	• M.S. in Geology/Geological Engineering • 26 years geological experience, working with within New Mexico and with New Mexico regulators	• Reports to the Project Manager and serves as Task Manager for the Corrective Measures Evaluation and all vadose zone pilot tests. • Overall responsibility for design, implementation, and management of pilot tests • Reviews all work plans, geological reporting, and data deliverables for pilot tests • Assists with establishing project-specific data quality objectives • Coordinates with Field Geologists for oversight and quality control • Responsible for the design of the corrective actions and reviews all corrective elements	• Stop drilling work or pilot testing for any reasons related to drilling activities
Groundwater Support Dustin Graves, PG, CHMM	• M.S. in Geology • 10 years of geological experience with drilling and well installation oversight and groundwater and drinking water sampling • Past experience coordinating Kirtland BFF project tasks	• Reports to the Project Manager and serves as Task Manager for Groundwater Support activities • Oversees all drilling operations during well installations and abandonments • Conducts data analysis and reporting • Manages Subcontractors	• Stop drilling work for any reasons related to drilling activities

Table 5-1
Staff Roles, Responsibilities, and Authorities for Vadose Zone and Water Supply Sampling Tasks

AFB = Air Force Base
APP = Accident Prevention Plan
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
CHg = Certified Hydrologist
CIH = Certified Industrial Hygienist
CSP = Certified Safety Professional
EA = EA Engineering, Science, and Technology, Inc., PBC
EI = Engineer Intern
NMED = New Mexico Environment Department
O&M = operation and maintenance
PE = Professional Engineer
PG = Professional Geologist
PMP = Project Management Professional
QA = quality assurance
QAPjP = Quality Assurance Project Plan
QC = quality control
RCRA = Resource Conservation and Recovery Act
SSHP = Site Safety and Health Plan
USACE = U.S. Army Corps of Engineers

Table 8-1
Summary of Investigation-Derived Waste Sampling

Analytical Method	Constituent	Frequency	Sample Location
Water Investigation-Derived Waste from Drilling and Well Testing Activities All waste profiling for IDW water generated during well development or sampling activities on new wells will be based on sample analytical results.			
EPA Method SW8011[a]	EDB	One per Baker tank/roll-off	Discharge valve
EPA Method SW 6010C/7470A	RCRA Metals and Mercury; dissolved Iron and Manganese	One per Baker tank/ roll-off	Discharge valve
EPA Method SW8021[a]	BTEX	One per Baker tank/roll-off	Discharge valve
40 CFR Part 261[b]	Ignitability	One per Baker tank/roll-off	Discharge valve
40 CFR Part 261[b]	Corrosivity/pH	One per Baker tank/roll-off	Discharge valve
40 CFR Part 261[b]	Reactivity	One per Baker tank/roll-off	Discharge valve
Soil Investigation-Derived Waste from all Coring and Installation of New Wells			
EPA Method SW8015D[a]	TPH-DRO/RRO	One per roll-off	5-point composite
EPA Method SW8015D[a]	TPH-GRO	One per roll-off	5-point composite
40 CFR Part 261[b]	Ignitability	One per roll-off	5-point composite
40 CFR Part 261[b]	Corrosivity/pH	One per roll-off	5-point composite
40 CFR Part 261[b]	Reactivity	One per roll-off	5-point composite
EPA Method SW1311/8260C[a]	TCLP VOCs	One per roll-off	5-point composite
EPA Method SW1311/8270D[a]	TCLP SVOCs	One per roll-off	5-point composite
EPA Method SW1311/6010C/7470A[a]	TCLP RCRA Metals	One per roll-off	5-point composite
EPA Method SW1311/8151A[a]	TCLP Herbicides	One per roll-off	5-point composite
EPA Method SW1311/8081B[a]	TCLP Pesticides	One per roll-off	5-point composite

[a] Analytical method per EPA SW-846 Test Methods for Evaluating Solid Waste, Third Edition and Updates, 1986
[b] Analytical methods per CFR Title 40, Chapter I, Subchapter I, Part 261, Identification and Listing of Hazardous Waste, Subpart C. Updated as of October 22, 2015.
BTEX = benzene, toluene, ethylbenzene, and total xylenes
CFR = Code of Federal Regulations
DRO = diesel-range organics
EDB = ethylene dibromide (aka 1,2-dibromoethane)
EPA = U.S. Environmental Protection Agency
GRO = gasoline-range organics
RCRA = Resource Conservation and Recovery Act
RRO = residual-range organics
SVOC = semivolatile organic compound
SW = EPA SW-846-Test Methods for Evaluating Solid Waste, 3rd Edition, 1986 and Updates
TCLP = Toxicity Characteristic Leaching Procedure
TPH = total petroleum hydrocarbons
VOC = volatile organic compound

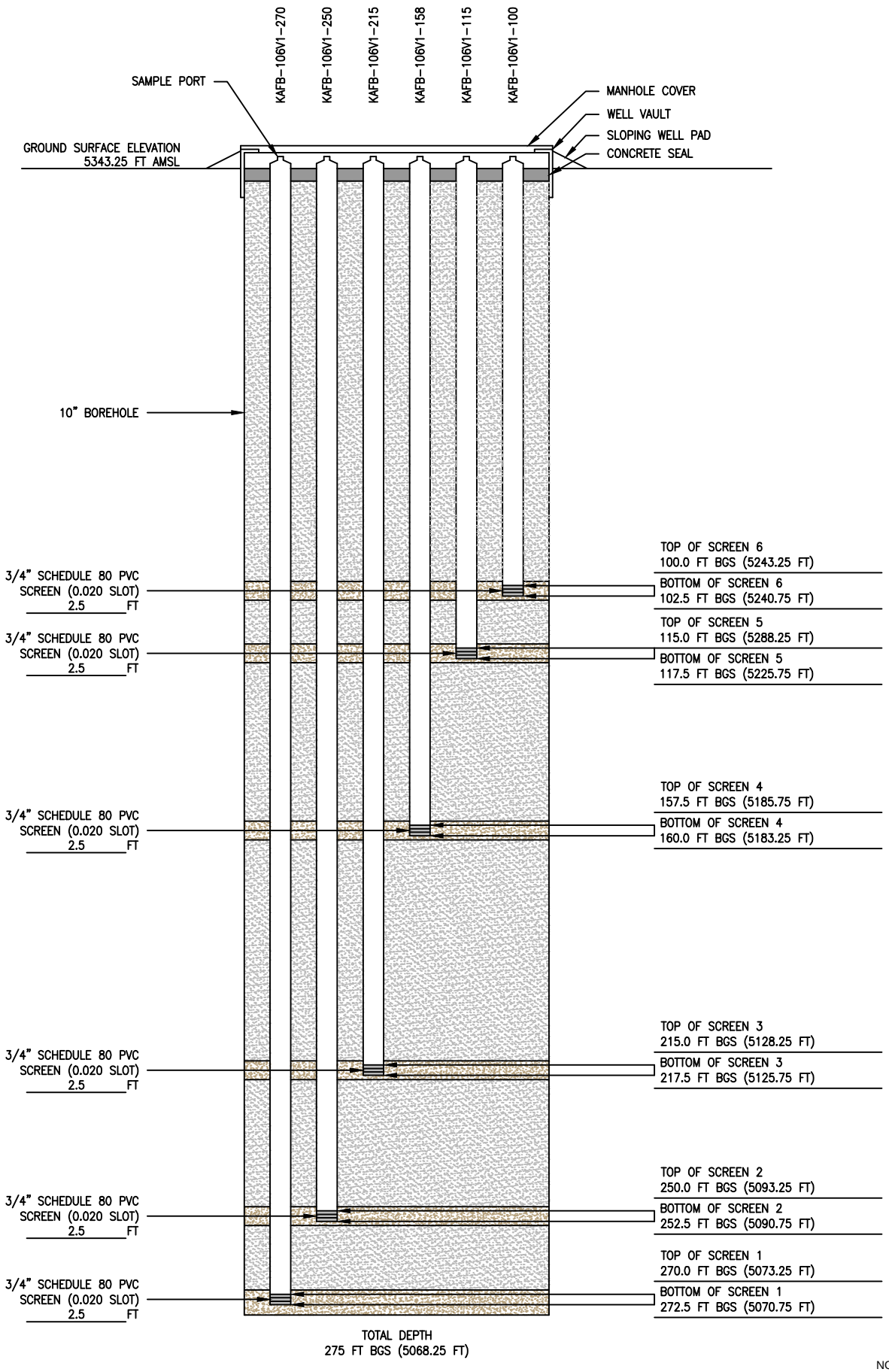
APPENDIX A

Quality Assurance Project Plan

APPENDIX B

Bioventing Well Design, Air-Lift Enhanced Bioremediation Well Design, and Dual-Completion Soil Vapor/Groundwater Wells

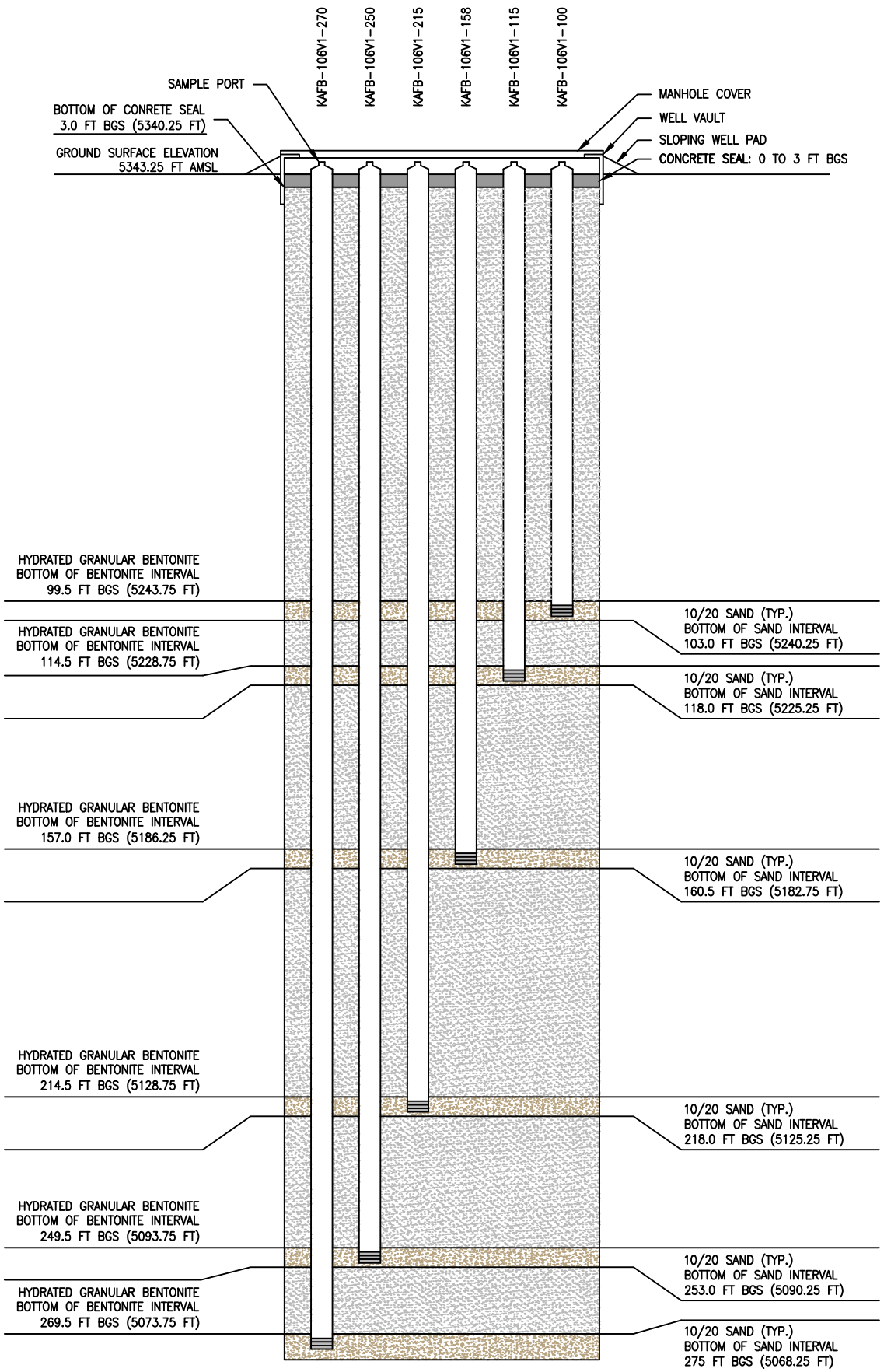
FIGURE B-1: NESTED SOIL VAPOR WELL COMPLETION DIAGRAM FOR KAFB-106V1



(ELEVATION) IS IN ABOVE MEAN SEA LEVEL
ASML = ABOVE MEAN SEA LEVEL

NOT TO SCALE
BGS = BELOW GROUND SURFACE
FT = FEET

FIGURE B-2: NESTED SOIL VAPOR WELL COMPLETION DIAGRAM FOR KAFB-106V1

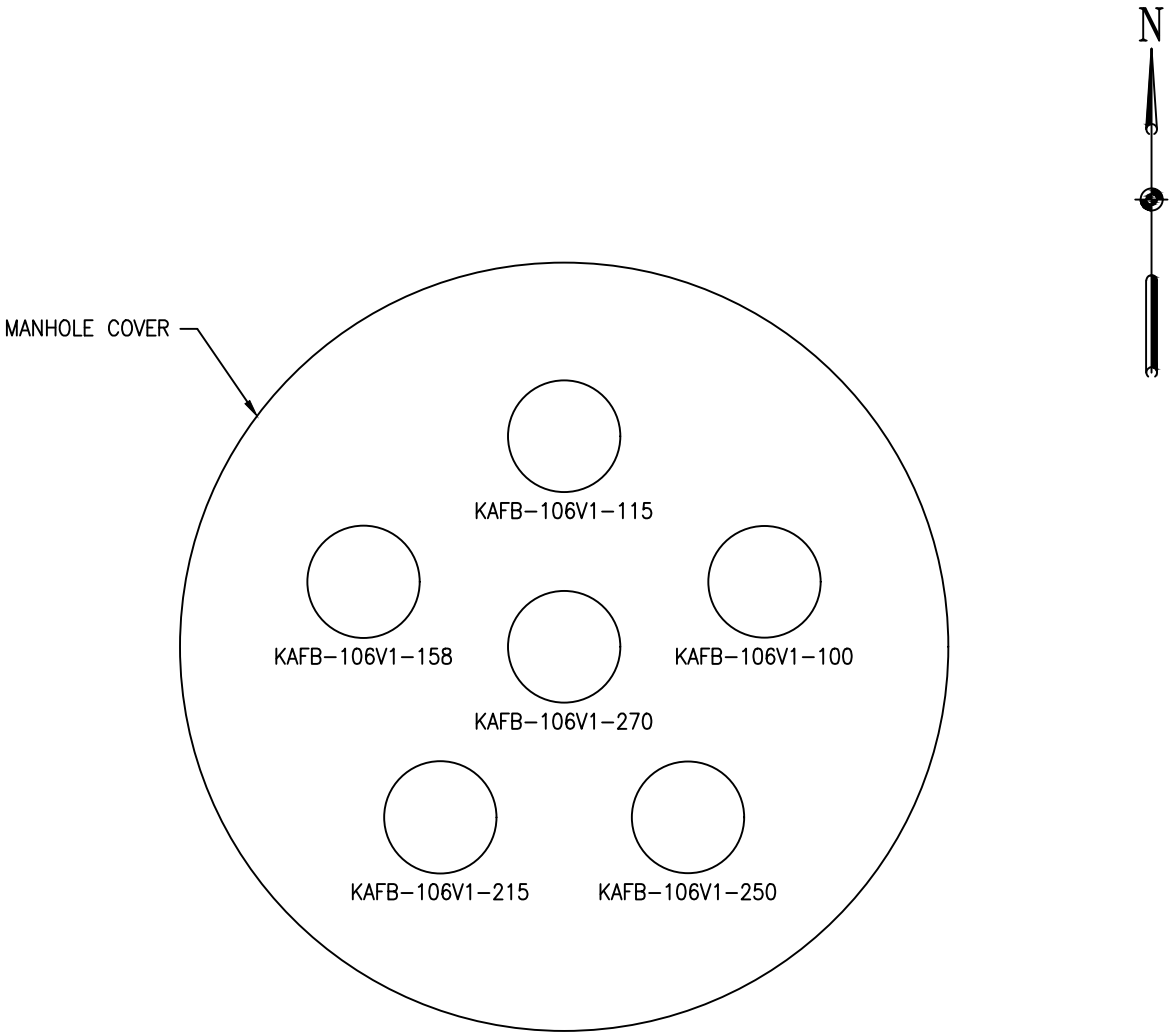


(ELEVATION) IS IN ABOVE MEAN SEA LEVEL
ASML = ABOVE MEAN SEA LEVEL

NOT TO SCALE
BGS = BELOW GROUND SURFACE
FT = FEET

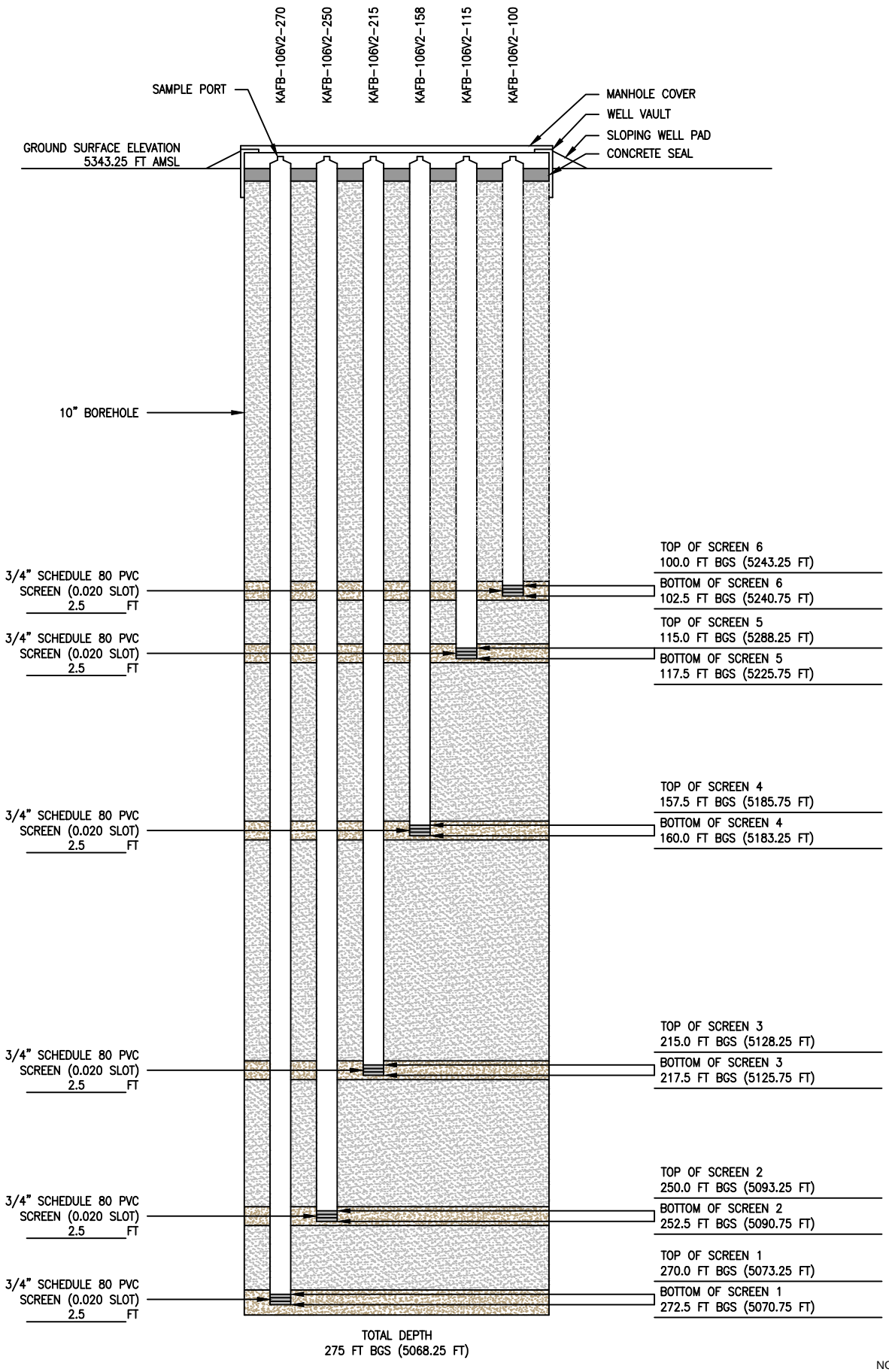
FIGURE B-3: NESTED SOIL VAPOR WELL COMPLETION DIAGRAM
MAP VIEW FOR KAFB-106V1

TOP VIEW VAULT ELEVATION: 5343.25 (FT)



WELL NUMBER	WELL DIAMETER	WELL DEPTH	SCREEN INTERVAL	ELEVATION
KAFB-106V1-100	3/4	102.5	100 - 102.5	5342.75
KAFB-106V1-115	3/4	117.5	115 - 117.5	5342.75
KAFB-106V1-158	3/4	160	157.5 - 160	5342.75
KAFB-106V1-215	3/4	217.5	215 - 217.5	5342.75
KAFB-106V1-250	3/4	252.5	250 - 252.5	5342.75
KAFB-106V1-270	3/4	272.5	270 - 272.5	5342.75

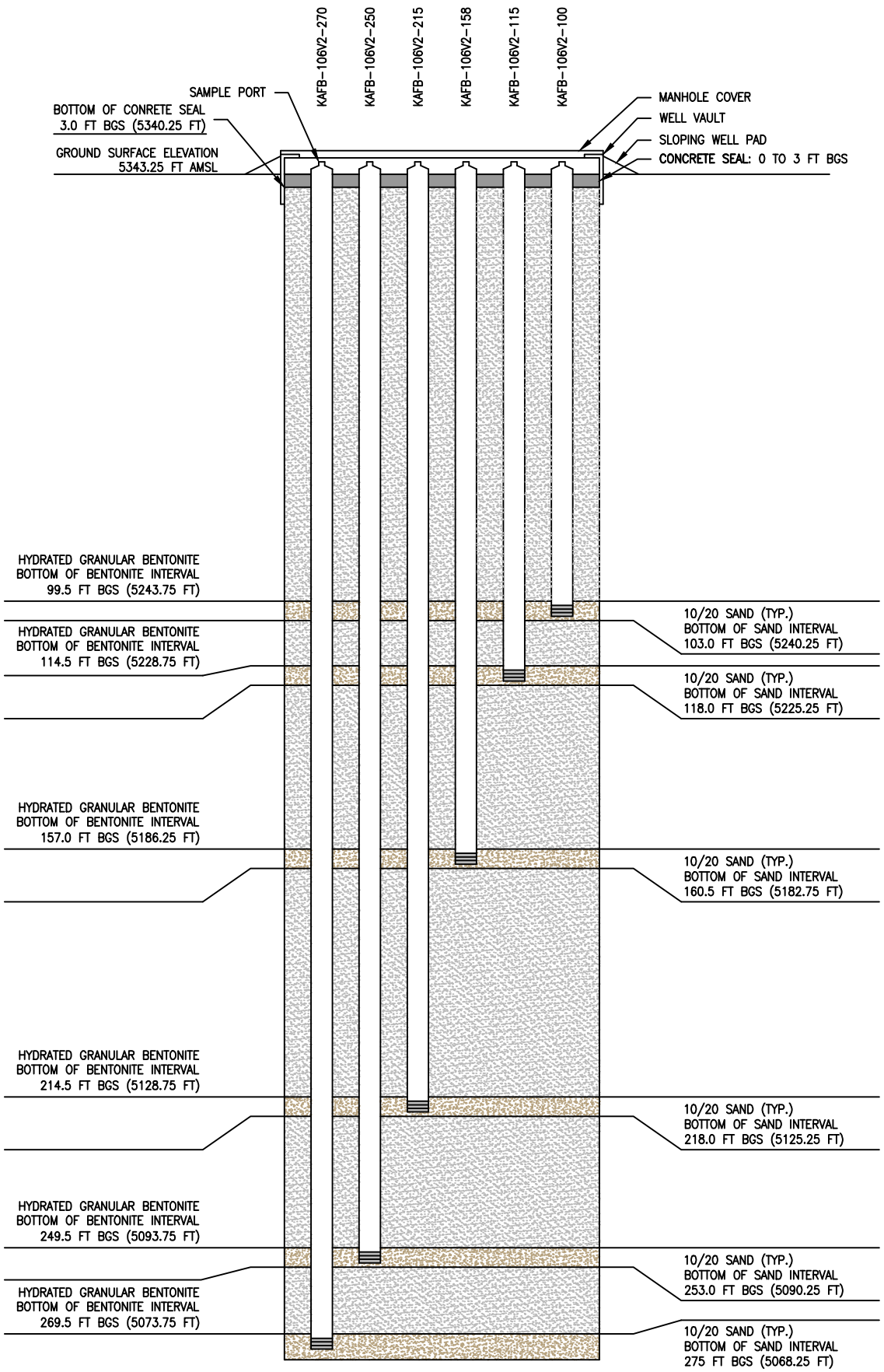
FIGURE B-4: NESTED SOIL VAPOR WELL COMPLETION DIAGRAM FOR KAFB-106V2



(ELEVATION) IS IN ABOVE MEAN SEA LEVEL
ASML = ABOVE MEAN SEA LEVEL

NOT TO SCALE
BGS = BELOW GROUND SURFACE
FT = FEET

FIGURE B-5: NESTED SOIL VAPOR WELL COMPLETION DIAGRAM FOR KAFB-106V2

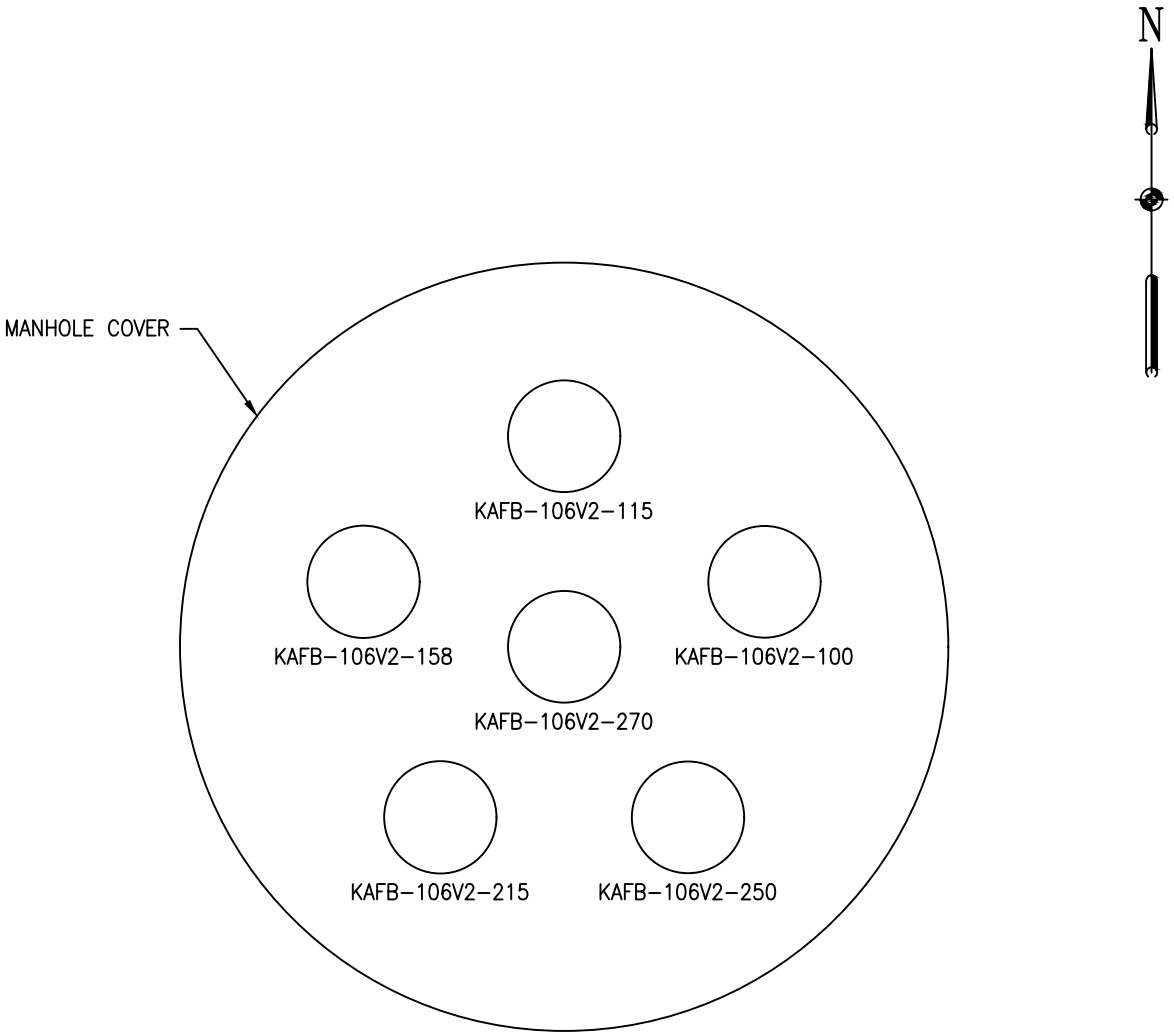


(ELEVATION) IS IN ABOVE MEAN SEA LEVEL
ASML = ABOVE MEAN SEA LEVEL

NOT TO SCALE
BGS = BELOW GROUND SURFACE
FT = FEET

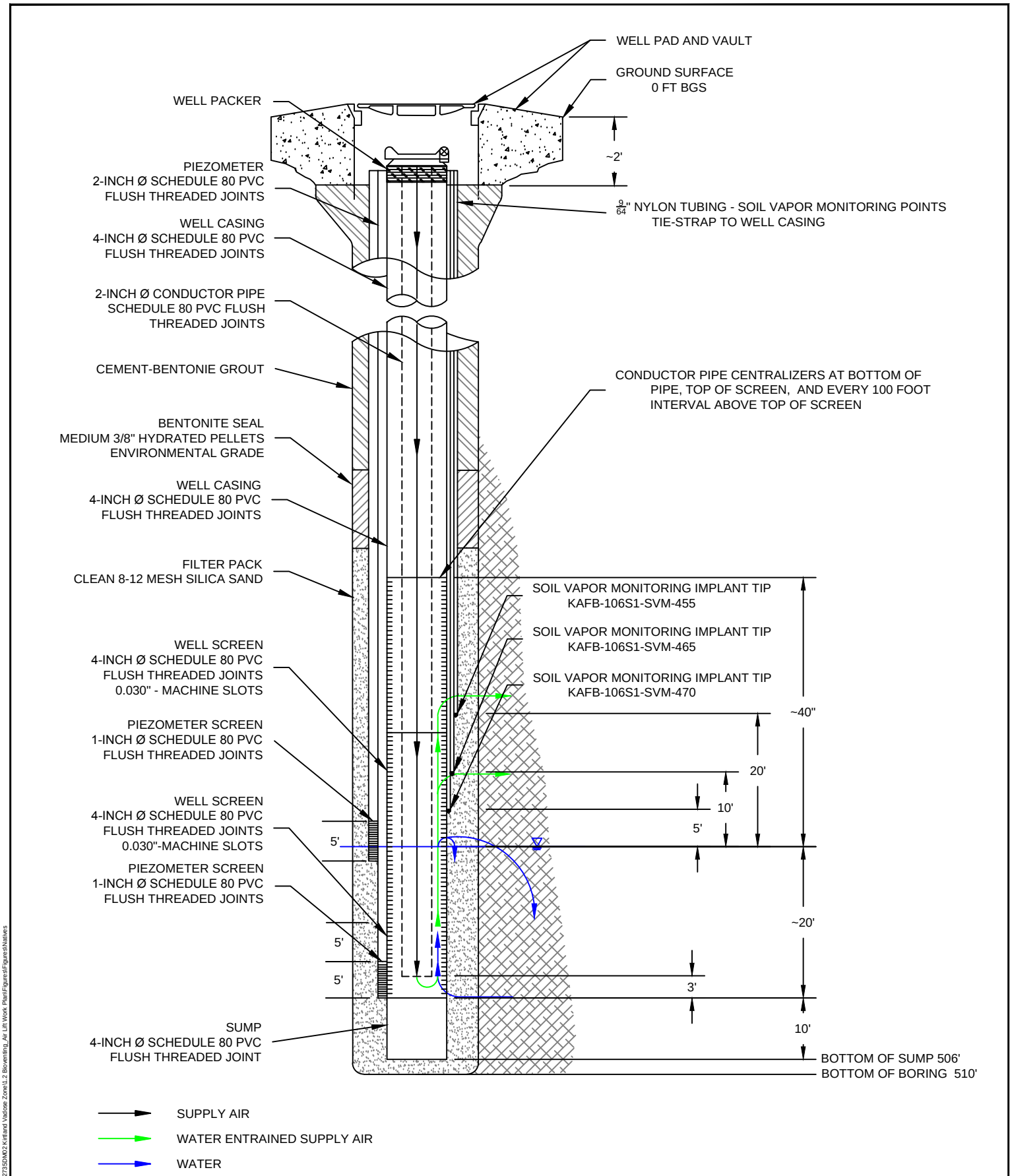
FIGURE B-6: NESTED SOIL VAPOR WELL COMPLETION DIAGRAM
MAP VIEW FOR KAFB-106V2

TOP VIEW VAULT ELEVATION: 5343.25 (FT)



WELL NUMBER	WELL DIAMETER	WELL DEPTH	SCREEN INTERVAL	ELEVATION
KAFB-106V2-100	3/4	102.5	100 - 102.5	5342.75
KAFB-106V2-115	3/4	117.5	115 - 117.5	5342.75
KAFB-106V2-158	3/4	160	157.5 - 160	5342.75
KAFB-106V2-215	3/4	217.5	215 - 217.5	5342.75
KAFB-106V2-250	3/4	252.5	250 - 252.5	5342.75
KAFB-106V2-270	3/4	272.5	270 - 272.5	5342.75

FIGURE B-7: AIR-LIFT ENHANCED BIOREMEDIATION PROCESS SCHEMATIC FOR KAFB-106S1



(ELEVATION) IS IN ABOVE MEAN SEA LEVEL
ASML = ABOVE MEAN SEA LEVEL

NOT TO SCALE
BGS = BELOW GROUND SURFACE
FT = FEET

\\ABQP\Projects\Active Projects\62735DM02 Kirtland Vadose Zone\1.2 Bioventing_Air Lift Work Plan\Figures\Figures\Natives

FIGURE B-8 DUAL COMPLETION VADOSE ZONE/GROUNDWATER MONITORING WELL CONSTRUCTION - KAFB-106S2 THROUGH KAFB-106S9

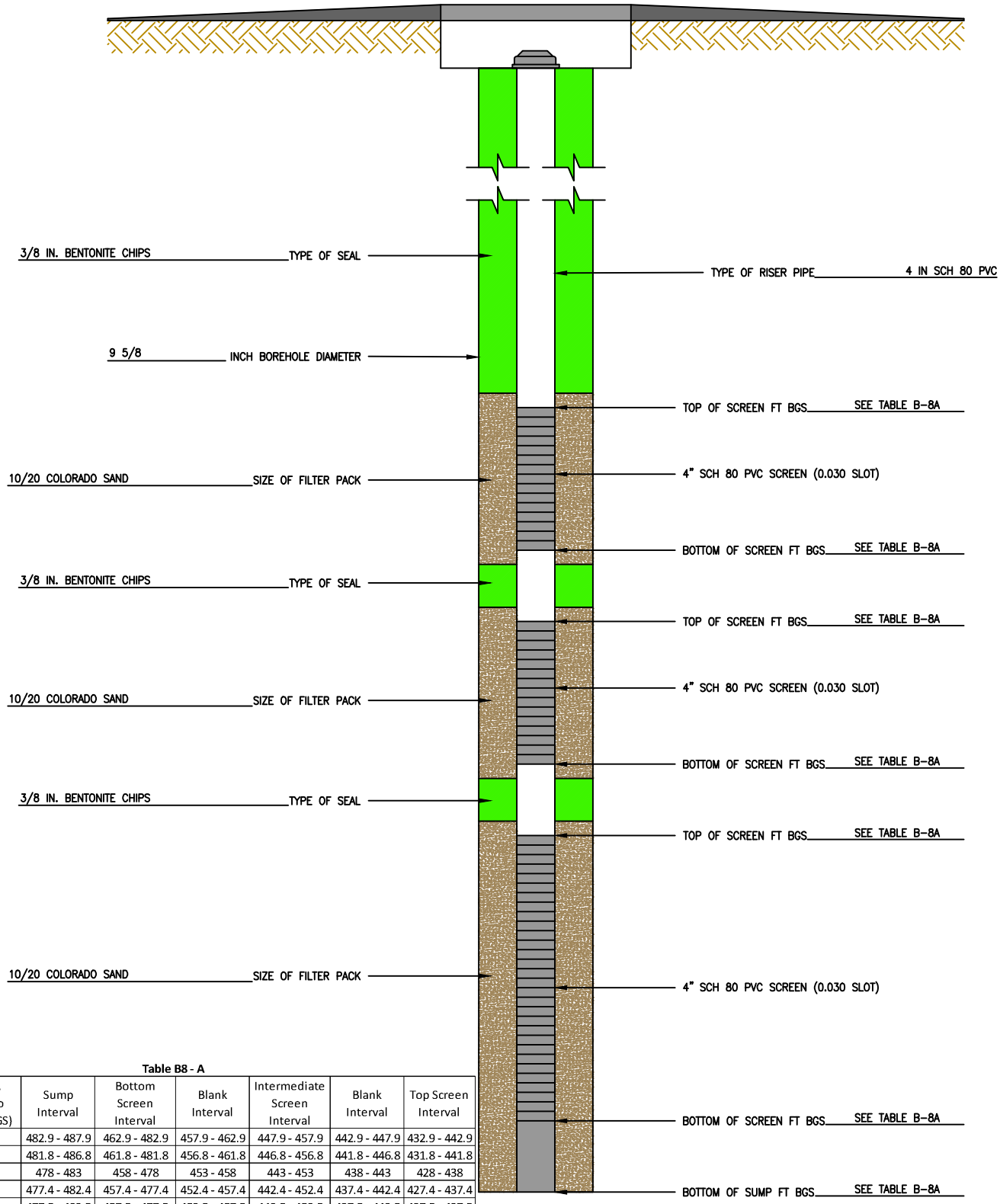


Table B8 - A

Well	Approx. Depth to Water (BGS)	Sump Interval	Bottom Screen Interval	Blank Interval	Intermediate Screen Interval	Blank Interval	Top Screen Interval
KAFB-106S2	476.9	482.9 - 487.9	462.9 - 482.9	457.9 - 462.9	447.9 - 457.9	442.9 - 447.9	432.9 - 442.9
KAFB-106S3	475.8	481.8 - 486.8	461.8 - 481.8	456.8 - 461.8	446.8 - 456.8	441.8 - 446.8	431.8 - 441.8
KAFB-106S4	472.0	478 - 483	458 - 478	453 - 458	443 - 453	438 - 443	428 - 438
KAFB-106S5	471.4	477.4 - 482.4	457.4 - 477.4	452.4 - 457.4	442.4 - 452.4	437.4 - 442.4	427.4 - 437.4
KAFB-106S6	471.5	477.5 - 482.5	457.5 - 477.5	452.5 - 457.5	442.5 - 452.5	437.5 - 442.5	427.5 - 437.5
KAFB-106S7	476.8	482.8 - 487.8	462.8 - 482.8	457.8 - 462.8	447.8 - 457.8	442.8 - 447.8	432.8 - 442.8
KAFB-106S8	476.9	482.9 - 487.9	462.9 - 482.9	457.9 - 462.9	447.9 - 457.9	442.9 - 447.9	432.9 - 442.9
KAFB-106S9	472.8	478.8 - 483.8	458.8 - 478.8	453.8 - 458.8	443.8 - 453.8	438.8 - 443.8	428.8 - 438.8

All depths and intervals listed in feet below ground surface (bgs).

NOT TO SCALE
AMSL=ABOVE MEAN SEA LEVEL
BGS=BELOW GROUND SURFACE
FT-FEET

NOTE: ALL DEPTHS REFERENCE IN FEET BELOW GROUND SURFACE

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC., PBC
320 Gold Avenue, SW Suite 1300
Albuquerque, NM 87102
Phone: (505) 224-9013

KIRTLAND AIR FORCE BASE		INSTALLATION START DATE/TIME:	INSTALLATION END DATE/TIME:
PROJECT NO.: 62735DM02	WELL ID: KAFB-106S2 - 106S9	GEOLOGIST:	DRILLER:

FILE PATH: F:\FEDERAL\DOD\AFCEC\PROJECTS\62599DM01 - KIRTLAND BFF\CADD\FIGURES\EXTRACTION WELLS-NM\FEB 2017\EXTRACTION WELL COMPLETION DIAGRAM-FIGURE B-8.DWG [FIGURE B-8] SWANSON, CHRISTOPHER 6/26/2017 5:28 PM

APPENDIX C

Relevant Standard Operating Procedures from Kirtland AFB Basewide Plan (Appendix B; 2004)

SOP B1.1 Borehole and Sample Logging

Drilling Logs and Documentation

Each boring will be fully described on a boring log similar or equivalent to that shown in Figure B1.1-1 and in accordance with ASTM D5434. The rig geologist will log the boring as it is being drilled by recording relevant data, listed below, on either the appropriate boring log or in a bound field logbook. Boring log forms may be transcribed from a field logbook, but must be completed at a minimum on a weekly basis. Data that will be included in the logs, when applicable, are:

- Identifying number and location of each boring.
- All measurements shall be accurate to one-tenth of a foot.
- Drilling logs and other scaled drawings should be drawn at a scale of 1 inch = 1 foot. (note: for wells deeper than 200', the scale may be adjusted to a more practical ratio. In addition, if sampling intervals are greater than 10 ft. apart the log can be represented with breaks in order to skip unlogged intervals)
- Soil classifications in accordance with the USCS. These classifications will be prepared in the field by the geologist and will be subject to revision based on laboratory tests or subsequent review.
- Rock classifications in accordance with the procedures and guidelines described in the below section on Rock Classification.
- A full description of soil samples. For split-spoon, thin wall, soil core, or otherwise intact samples, the description will include but not be limited to the USCS two-letter classification, plus a more complete verbal description of color, consistency, soil moisture, grain size and size distribution.
- Depth limits, type and number of each sample taken. All samples will be numbered consecutively.
- The number of blows required for each 6-inch penetration of split-spoon sampler and for each 12-inch penetration of casing; hammer weight and length of fall for split-spoon or driven samplers; hydraulic pressure used to push thin-wall tubes. If thin-wall tubes are pushed manually, that will be indicated.
- The start and finish times for all rock coring runs including a description and depth of any drilling anomalies such as voids, loss of fluids or air, odors, etc.
- Depth to water as first encountered during drilling, along with the method of determination. Any distinct water-bearing zones below the first zone also will be noted. Other observations during drilling will also be noted, such as bit chatter, rod binding, rod drops, flowing or heaving sands, bit pressure, rod rotations per minute, and water pressure.
- If drilling fluid is used, the fluid losses, interval over which they occur and the quantity losses, lost will be recorded.

- A general description of the drilling equipment used. This description, including such information as rod size, bit type, pump type, rig manufacturer, and model, may be provided in a general legend.
- Dates and times of start and completion of boring.
- Names of Contractor, driller and rig geologist.
- Size and length of casing or auger used in each borehole.
- Observations of visible contamination for each sample or from cuttings that appear contaminated.
- Field instrument readings.

As the boring is drilled, the rig geologist will evaluate adjacent samples recovered, together with observation of the drill cuttings, wash water (if any), drill performance, etc., to determine appropriate stratigraphic definitions or distinctions within the soil column. Such contacts or breaks between strata must be determined by the rig geologist and indicated on the boring log. If such information is not provided, the "log" is nothing more than a listing of individual sample descriptions. In general, a stratigraphic unit contains only similar soils which can be classified within the same two-letter USCS classification category symbol. In some cases, significant differences in soil color, grain size distribution, strength, etc., would be sufficient to classify soils having the same two-letter USCS classification category symbol into two or more distinct strata.

After the rig geologist has indicated the appropriate stratigraphic breaks on the log, he/she should develop and record an appropriate description for each defined stratigraphic unit. Each description should contain information about the color, grain size distribution, consistency, moisture, etc., and the appropriate two-letter USCS classification category symbol.

Classification of Soils

All classification data should be written directly on the boring log (if there is enough space) or in a field logbook. The method of deriving the classification should be described, or reference to this guideline or other manuals should be made. Handling of samples during soil classification should be coordinated with chemical sampling activities, if appropriate.

USCS Classification

Soils are to be classified according to the USCS (ASTM D2487). This method of classification is detailed in Figure B1.1-2. This method of classification identifies soil types on the basis of grain size and liquid limits, and categorizes them by two-letter symbols.

In the USCS system, fine-grained soils, or fines, are classified as those which will pass through a No. 200 U.S. standard sieve [0.074 millimeter (mm)] and are of two types: silt "M" and clay "C". Some classification systems define size ranges for these soil particles, but for field classification purposes, they are identified by their respective behaviors only. Organic material "O" is common component of soil but has no size range, and is recognized by its composition.

Gravely soils are identified by a "G" as the first letter in the two-letter symbol, whereas sandy soils are identified with an "S". The term "rock fragments" should be used to indicate granular materials resulting from the breakup of rock. These materials are normally angular, indicating little or no transport from their source. When the term "rock fragments" is used it should be followed by a size designation, such as ¼ to ½ diameter or "coarse-sand size" either immediately after the entry or in the remarks column. The USCS classification would not be affected by this variation in terms.

The second letter in the two-letter USCS symbol provides information about the grain size distribution of granular soils, or the plasticity characteristics of fine-grained soils. These second-letter modifiers are "P" well sorted, "W" well graded/poorly sorted, "C" clayey, "M" silty, "L" low plasticity, or "H" high plasticity. Note that the term "poorly graded" implies a uniform grain size distribution and is the same as "well sorted."

Color

Soil colors should be described utilizing a single color descriptor preceded, when necessary, by a modifier to denote variations in shade or color mixtures. A soil could therefore be referred to as "gray" or "light gray" or "blue-gray." Since color can be utilized in correlating units between sampling locations, it is important that color descriptions be kept consistent throughout field operations.

Colors must be described while the sample is still moist. Soil samples should be broken or split vertically to describe colors. Soil sampling devices tend to smear the sample surface creating color differences between the sample interior and exterior. In accordance with ASTM D1535, Munsell Color Charts or equivalent must be used based on project requirements.

Relative Density and Consistency

To classify the relative density and/or consistency of a soil, the geologist must first identify the soil type. Granular soils contain predominantly sands and gravels and are generally noncohesive (particles do not adhere well when compressed). Finer grained soils (silts and clays) are cohesive (particles will adhere together when compressed).

The density of noncohesive, granular soils is classified according to standard penetration resistances obtained from split-spoon sampling methods that are in accordance with ASTM D1586 and are detailed in SOP B2.3, Split Spoon Sampling Procedure section. Those designations are:

Standard Penetration Resistance (SPR)

Designation	Blows per ft
Very loose	0 to 4
Loose	5 to 10
Medium dense	11 to 30
Dense	31 to 50
Very dense	Over 50

Standard penetration resistance is the number of blows required to drive a split-barrel sampler with a 2-inch outside diameter 12 inches into the material using a 140-pound hammer falling freely through 30 inches. The sampler is driven through an 18- or 24-inch sample interval and number of blows is recorded for each 6-inch increment. The density designation of granular soils is obtained by adding the number of blows required to penetrate the second and third 6 inches of each sample interval. It is important to note

that if gravel or rock fragments are broken by the sampler or if rock fragments are logged in the tip, the resulting blow count will be erroneously high, reflecting a higher density than actually exists. This should be noted on the log and referenced to the sample number.

The consistency of cohesive soils is determined by performing field tests and identifying the consistency as shown in Figure B1.1-2. The consistency of cohesive soils is determined either by blow counts or most accurately by a pocket penetrometer or field Torvane device in accordance with ASTM D2573-72– *Method for Field Vane Sheer Text in Cohesive Soil.* The SPR can be applied to cohesive soils as follows:

Designation	SPR (blows per ft)
Very soft	<2
Soft	2-4
Medium soft	4-8
Stiff	8-15
Hard	>30

The pocket penetrometer method is conducted on a selected sample of the soil, preferably the lowest 0.5 ft of the sample in the split-spoon sampler. The sample should be broken in half and the penetrometer pushed into the end of the sample to determine the consistency. Do not determine consistency by attempting to penetrate a rock fragment. If the sample is decomposed rock, it is classified as a soft, decomposed rock fragment rather than a hard soil. The pocket penetrometer or Torvane may be used in the conjunction with blow counts to determine cohesive soil consistency.

Soil Component

In nature, soils are comprised of particles of varying size and shape and are combinations of the various soil types. Figure B1.1-2 lists grain size classifications to be used in describing soils or rocks. The following terms are useful in the description of soil components:

The Identifying Proportion of the Component	Defining Range of Percentages by Weight
trace	0-10 percent
little	11-20 percent
some	21-35 percent
"and"	36-50 percent

Moisture

Moisture content is estimated in the field according to four categories: dry, moist, wet, and saturated. In dry soil, there appears to be little or no water. Saturated samples obviously have all the water they can hold. Moist and wet classifications are somewhat subjective and often are determined by the individual's judgment. A suggested parameter for judging this in a fine-grained soil would be calling a soil wet if rolling it in the hand or on a porous surface liberates water, i.e., dirties or muddies the surface. Whatever method is adopted for describing moisture, it is important that the method used by an individual remains consistent throughout an entire drilling job.

Laboratory tests in accordance with ASTM D2216 or field tests for water content should be performed if the natural water content is important.

Stratification

Stratification can only be determined after the split-spoon sampler is opened. The stratification or bedding thickness for soil and rock is dependent on grain size and composition. The classification to be used for stratification description is described below:

Thickness (Metric)	Approximate English Equivalent	Classification
>1 meter	> 3.3 ft	Very thick
30 cm - 1 meter	1.0 ft - 3.3 ft	Thick Bedded
10 cm - 30 cm	4.0 in - 1.0 ft	Medium Bedded
3 cm - 10 cm	1.0 in - 4 in	Thin Bedded
1 cm - 3 cm	2/5 in - 1 in	Very Thin Bedded
3 mm - 1 cm	1/8 in - 2/5 in	Laminated
1 mm - 3 mm	1/32 in - 1/8 in	Thinly Laminated
<1 mm	<1/32 in	Micro Laminated

Classification of Rocks

Rocks are grouped into three main divisions: sedimentary, igneous and metamorphic. Sedimentary rocks are by far the most predominant type exposed at the earth's surface. The following basic names are applied to the type of rocks found in sedimentary sequences:

- ***Sandstone***—Made up predominantly of granular materials ranging between 1/16 and 2 inches diameter.
- ***Siltstone***—Made up of granular materials less than 1/16-inch diameter. Fractures irregularly.
- ***Claystone***—Very fine-grained rock made up of clay and silt-size materials. Fractures irregularly. Very smooth to touch. Generally has irregularly spaced pitting on surface of drilled cores.
- ***Shale***—A fissile, very fine-grained rock. Fractures along bedding planes.
- ***Limestone***—Rock made up predominantly of calcite. Effervesces upon the application of hydrochloric acid.
- ***Coal***—Rock consisting mainly of organic remains.
- ***Others***—Numerous other rock types are present in the geologic section. Their overall abundance is dependent upon the geographical locations.

In classifying a sedimentary rock the following characteristics should be noted:

- Rock Type
- Color

- Bedding Thickness
- Hardness
- Fracturing
- Weathering
- Mineralogy (if discernible)
- Other Characteristics

All classification data should be written directly on the boring log or in a field log book. The method of deriving the classification should be described or reference to this guideline or other manuals used should be included.

Rock Type

As described previously, there are numerous names for sedimentary rocks. In most cases a rock will be combination of several rock types, therefore a modifier such as sandy siltstone or a silty sandstone can be used. The modifier indicates that a significant portion of the rock type is composed of the modifier. Other modifiers can include carbonaceous, calcareous, siliceous, etc.

Grain diameters are used for the classification of classic sedimentary rock. The following is the Udden-Wentworth classification that will be assigned to sedimentary rocks. The individual boundaries are slightly different than the USCS subdivision for soil classification. For field determination of grain sizes, a scale can be used for the coarse grained rocks.

Particle Name	Grain Size Diameter
Cobbles	> 64 mm
Pebbles	4 - 64 mm
Granules	2 - 4 mm
Very Coarse Sand	1 - 2 mm
Coarse Sand	0.5 - 1 mm
Medium Sand	0.25 - 0.5 mm
Fine Sand	0.125 - 02.5 mm
Very Fine Sand	0.0625 - 0.125 mm
Silt	0.0039 - 0.0625 mm
Clay	< 0.0625 mm

Color

The color of a rock can be determined in the same manner as for soil samples. Rock core samples should be classified while wet, when possible, and air-cored samples should be scraped clean of cuttings prior to color classifications. Munsell Color Charts or equivalent may be used if required for the project.

Stratification

The bedding thickness designations applied to soil classification will also be used for rock classification.

Hardness

The hardness of a rock is a function of the compaction, cementation, and mineralogical composition of the rock. A relative scale for sedimentary rock hardness is as follows:

- ***Soft***—Weathered, considerable erosion of core, easily gouged by screwdriver, scratched by fingernail. Soft rock crushes or deforms under pressure of a pressed hammer. This term is always used for the hardness of the saprolite (decomposed rock which occupies the zone between the lowest soil horizon and firm bedrock).

- ***Medium soft***—Slight erosion of core, slightly gouged by screwdriver, or breaks with crumbly edges from single hammer blow.

- ***Medium hard***—No core erosion, easily scratched by screwdriver or breaks with sharp edges from single hammer blow.

Note the difference in usage here of the words "scratch" and "gouge." A scratch should be considered a slight depression in the rock (do not mistake the scraping off of rock flour from drilling with a scratch in the rock itself), while a gouge is much deeper.

Fracturing

The degree of fracturing of a rock is described by measuring the fractures of joint spacing. After eliminating drilling breaks, the average spacing is calculated and the fracturing is described by the following terms:

Very broken—Less than 2 inches

Broke—2 inches to 1 ft

Blocky—1 to 3 ft

Massive—3 to 10 ft

Artificial breaks can be distinguished from natural partings by several criteria. Drilling breaks are generally relatively sharp edged and the newly exposed rock surfaces are invariably fresher in appearance (less weathered) than natural breaks. Core pieces on each side of a drilling break usually fit perfectly back together, whereas natural breaks may exhibit gaps and clay films or seams, oxidation stains, or mineralization. Do not confuse drill cuttings or drilling mud on a fractured surface with a natural clay film or seam.

The structural integrity of the rock can be approximated by calculating the RQD of cores recovered. The RQD is determined by adding the total lengths of all pieces exceeding 4 inches and dividing by the total length of the coring run, to obtain a percentage:

$$RQD = \left(\frac{r}{l}\right) \times 100$$

where:

r = Total length of all pieces of the lithologic unit being measured, which are

greater than four inches in length, and have resulted from natural breaks. Natural breaks include slickensides, joints, compaction slicks, bedding plane partings (not caused by drilling), friable zones, etc

l = Total length of the coring run

Weathering

The degree of weathering is a significant parameter that is important in determining weathering profiles and is also useful in engineering designs. The following terms can be applied to distinguish the degree of weathering:

- ***Fresh***—Rock shows little or no weathering effect. Fractures or joints have little or no staining and rock has a bright appearance.
- ***Slight***—Rock has some staining (i.e., discoloration along joints, cracks or exposed surfaces) which may penetrate several centimeters into the rock. Clay filling of joints may occur. Feldspar grains may show some alteration.
- ***Moderate***—Most of the rock, with exception of quartz grains, is stained. Rock is weakened due to weathering and can be easily broken with hammer.
- ***Severe***—All rock, including quartz grains, is stained. Some of the rock is weathered to the extent of becoming a soil. The rock is very weak and crumbly.

Other Characteristics

The following items should be included in the rock description:

- Description of contacts between two rock units. These can be sharp or gradational.
- Description of any cavities or bugs, including fillings, if present.
- Description of any joints or fractures.
- Notation of joints or fractures with depth, any unusual staining (not weathering), approximate angle from horizontal, any mineral filling or coating, degree of weathering and interpretive, relative degree of groundwater movement through the fracture.

As an attachment to the log, additional information should be provided, including an estimation of the degree of cementation and type of cement for granular sedimentary rocks; a description of the texture and fabric of the rock (i.e., the shape and relationship of component particles or crystals); and the structure of macroscopic features of the rock mass. Generally, rock structure is best seen in the outcrop rather than the hand specimen, but some indication of structure (e.g., horizontal or dipping beds, open joints) can be obtained from core samples.

Numerous classification schemes for igneous and metamorphic rocks are available. Compton, 1962 *Manual of Field Geology*, John Wiley & Sons, Inc. New York and *Classification of Rocks*, Quarterly of the Colorado School of Mines, Volume 50, Number 1, January 1955 are preferred. Igneous and metamorphic rocks that may be encountered at Kirtland AFB will be classified according to the procedures outlined in *Classification of Rocks*.

Igneous rock classification is based on texture and mineralogy. The distinction between intrusive and extrusive (volcanic) igneous rocks is not specifically addressed by rock classification schemes but is indicated by texture, which is a function of cooling history, and is determined by field relationships. Metamorphic rock classification is based primarily on structure and mineralogy. Directional or nondirectional structure is and important attribute in determining nomenclatures. Because metamorphic rocks derive from preexisting igneous or sedimentary rocks which have undergone a chemical or physical change after their original metamorphic rocks are divided into two groups:

- those formed by regional metamorphism, and
- those formed by contact metamorphism (Hurlbut, 1971, *Dana's Manual of Mineralogy*, 18th Edition, John Wiley & Sons, Inc.).

Igneous rock will be classified based on granularity or the absence of visible grains, the relationship between grains, the proportions of essential rock-forming minerals, color, and the presence and type of visible accessory minerals.

Metamorphic rocks will be classified on the basis of directional or nondirectional structure, the type of directional structure if any, mineralogy, and color.

In addition to standard classification of igneous and metamorphic rocks, other features will be described, Physical features of crystalline rocks that may contribute to groundwater or contaminant migration will be described and characterized. Joints or fractures will be mapped, widths measure, and their aspect and degree of interconnections described. Fracture-filling minerals will be described and sampled if necessary to determine potential interactions between these minerals and potential contaminants.

The predominant local bedrock encountered at Kirtland AFB is the Tertiary Santa Fe Formation. The Santa Fe Formation consists of light brown to reddish-brown clays and mudstones, and sands and gravels which are indurated with caliche. The Santa Fe Formation should be noted and described on the boring log when encountered in core or cuttings.

References for Other Applicable ASTM Standards

ASTM D2488 – Description and Identification of Soils (Visual-Manual Procedure)

ASTM D 4318 – Liquid Limit, Plastic Limit, and Plasticity Index of Soils

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Figure B1.1-1. Typical Bore Log Form Used to Describe Split Spoon Samples

HTRW DRILLING LOG	DISTRICT	HOLE NUMBER
1.COMPANY NAME	2.DRILL SUBCONTRACTOR	SHEET 1 OF SHEETS

3.SITE	4.LOCATION
5.NAME OF DRILLER	6.MANUFACTURER'S DESIGNATION OF DRILL
7.SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT	8.HOLE LOCATION
	9.SURFACE ELEVATION
	10.DATE STARTED / 11.DATE COMPLETED
12.OVERBURDEN THICKNESS	15.DEPTH GROUNDWATER ENCOUNTERED
13.DEPTH DRILLED INTO ROCK	16.DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED
14.TOTAL DEPTH OF HOLE	17.OTHER WATER LEVEL MEASUREMENTS (SPECIFY)

18.GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19.TOTAL NUMBER OF CORE BOXES

20.SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	SVOC	Pest/PCB	Cyanide/TRPH	21.TOTAL CORE RECOVERY %
	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23.SIGNATURE OF INSPECTOR		

22.DISPOSITION OF HOLE	SCALE 1 inch = 1 foot

LOCATION SKETCH/COMMENTS

PROJECT	HOLE NO.

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Figure B1.1-1. Typical Bore Log Form Used to Describe Split Spoon Samples (Concluded)

HTRW DRILLING LOG	SITE	LOCATION	HOLE NUMBER
PROJECT #	DISTRICT	INSPECTOR PATRICIA WESTON	SHEET 2 OF SHEETS

ELEV. (a)	DEPTH (ft.) (b)	DESCRIPTION OF MATERIALS (c)	USCS CLASS. (d)	FIELD SCREEN RESULTS (e)	REMARKS (f)
	1				
	2				
	3				
	4				
	5				
	6				
	7				
	8				
	9				
	10				
	11				
	12				
	13				
	14				
	15				
	16				
	17				
	18				
	19				
	20				

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Figure B1.1-2. The Unified Soil Classification System (USCS)

Revised 07-12-02

UNIFIED SOIL CLASSIFICATION SYSTEM

UNIFIED SOIL CLASSIFICATION AND SYMBOL CHART

COARSE-GRAINED SOILS (more than 50% of material is larger than No. 200 sieve size.)			
GRAVELS More than 50% of coarse fraction larger than No. 4 sieve size	Clean Gravels (Less than 5% fines)		
		GW	Well-graded gravels, gravel-sand mixtures, little or no fines
		GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines
	Gravels with fines (More than 12% fines)		
		GM	Silty gravels, gravel-sand-silt mixtures
		GC	Clayey gravels, gravel-sand-clay mixtures
SANDS 50% or more of coarse fraction smaller than No. 4 sieve size	Clean Sands (Less than 5% fines)		
		SW	Well-graded sands, gravelly sands, little or no fines
		SP	Poorly graded sands, gravelly sands, little or no fines
	Sands with fines (More than 12% fines)		
		SM	Silty sands, sand-silt mixtures
		SC	Clayey sands, sand-clay mixtures
FINE-GRAINED SOILS (50% or more of material is smaller than No. 200 sieve size.)			
SILTS AND CLAYS Liquid limit less than 50%		ML	Inorganic silts and very fine sands, rock flour, silty of clayey fine sands or clayey silts with slight plasticity
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
		OL	Organic silts and organic silty clays of low plasticity
SILTS AND CLAYS Liquid limit 50% or greater		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
		CH	Inorganic clays of high plasticity, fat clays
		OH	Organic clays of medium to high plasticity, organic silts
HIGHLY ORGANIC SOILS		PT	Peat and other highly organic soils

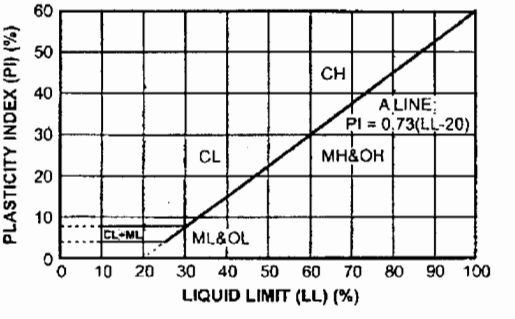
LABORATORY CLASSIFICATION CRITERIA

GW	$C_U = \frac{D_{60}}{D_{10}}$ greater than 4; $C_C = \frac{D_{30}}{D_{10} \times D_{60}}$ between 1 and 3	
GP	Not meeting all gradation requirements for GW	
GM	Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are borderline cases requiring use of dual symbols
GC	Atterberg limits above "A" line with P.I. greater than 7	
SW	$C_U = \frac{D_{60}}{D_{10}}$ greater than 4; $C_C = \frac{D_{30}}{D_{10} \times D_{60}}$ between 1 and 3	
SP	Not meeting all gradation requirements for GW	
SM	Atterberg limits below "A" line or P.I. less than 4	Limits plotting in shaded zone with P.I. between 4 and 7 are borderline cases requiring use of dual symbols.
SC	Atterberg limits above "A" line with P.I. greater than 7	

Determine percentages of sand and gravel from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows:

Less than 5 percent ..... GW, GP, SW, SP
More than 12 percent ..... GM, GC, SM, SC
5 to 12 percent ..... Borderline cases requiring dual symbols

PLASTICITY CHART



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SOP B1.4 Monitoring Well Development

General Monitoring Well Development

Monitoring well development shall be preformed within one week after installation but no sooner than 48 hours after grout installation. The following procedure should be followed for the development of all newly installed wells on Base:

- Initial development will consist of swabbing, bailing, and pumping until little or no sediment enters the well (approximately 2 hours). Contain the development and purge water in a temporary tank to be installed at each wellhead.

- Following initial development, the well will be continuously pumped using an electric submersible, or pneumatic drive positive displacement or bladder pump. Temperature, pH, specific conductivity and turbidity will be monitored during pumping, and readings will be taken after every well volume is purged. Pumping will continue until these parameters have stabilized (less than 0.2 pH units or a 10 percent change for the other parameters between 4 consecutive readings) and the water is clear and free of fines. The main goal of well development is to reduce the turbidity to less than 10 NTUs (however, under 100 NTUs is acceptable). If these parameters have not stabilized after 4 hours of continuous pumping, the well will be allowed to sit overnight and development will continue the following day for a maximum of two hours. If the turbidity still does not fall below 100 NTUs, the client project geologist will be contacted and further direction will be sought.

- Once development is complete a sample of the purge water will be collected for waste characterization purposes.

- If the addition of water is necessary to facilitate surging and bailing, only formation water previously pumped from that well into the purge tank may be used. At the completion of the well development activities at each well, a sample from the well will be collected and immediately photographed to document the results of the procedure. The photograph will be a 35-mm color photo, and submitted as part of the well installation diagram. The photograph shall be a suitably back-lit close up which shows the clarity of the water. Fines remaining in the water shall not be allowed to settle out prior to taking the photograph, the depth of any sediment which collects in the bottom of the jar after the sample is allowed to settle shall be noted on the Well Construction Diagram (USACE Geology SOS).

- The site geologist will monitor and record on the well development record form, depicted in Figure B4.1-1, and in the field log book all field parameters such as pumping rates, pH, temperature, specific conductance and pertinent information.

Monitoring Well Development using Phosphate-Free Dispersant

Phosphate-Free Dispersant (PFD) can be used during the development of wells that were drilled using mud rotary techniques. A PFD disperses mud, sediment, and clay from the producing formation and filter pack within the screened interval. The removal of these blocking agents may potentially increase well productivity and reduce the total development time. The following parameters should be known prior to treatment:

- Well diameter

- Length of screened interval
- Depths of screened intervals
- Depth to water
- Total depth of well
- Surface completion of well
- Treatment length

The above parameters will determine the size and type of injection equipment required to introduce the PFD/water solution into the well. This SOP is applicable to the use of Aqua-Clear® PFD.

Chemical mixing

Solution preparation is accomplished using the following procedures:

- To determine the amount of Aqua-Clear® PFD to use, perform this simple calculation:

  Aqua-Clear® PFD (gallons) = 0.002 x water volume in screened interval (gallons).

  The recommended concentration of Aqua-Clear® PFD is 0.2% by volume. This equates to 1 gallon of Aqua-Clear® PFD for every 500 gallons of water.

- Due to the high viscosity of the Aqua-Clear® PFD, it is necessary to pre-mix the dispersant with water (from an approved source) at the surface before injecting the solution into the well. This pre-mix solution should be of an adequate volume to allow even distribution throughout the treatment zone, and dictates the size of the injection equipment to be used. This pre-mix solution could be anywhere from 50 to 300 gallons and will be determined onsite. The concentration of the solution will be stronger than the recommended concentration to ensure there is enough Aqua-Clear® PFD in the pre-mix solution to achieve the desired concentration of 0.2% in the treatment zone when mixed with water.

- To determine the volume of water required to prepare the pre-mix solution, perform the following calculations:

  Well Volume (gallons) = $\pi r^2 h(7.48) \times 2$

Where: r = casing radius in feet (ft)

h = height of water column associated with treatment length (ft)

This calculation takes into account the screen-area casing volume, water in the filter pack, and water in the formation interface. Use this volume in the calculation to determine the amount of Aqua-Clear® PFD to be used (step 1). The manufacturer recommends doubling the calculated volume.

Chemical application

The solution will be applied in accordance with the following guidelines:

- If the dispersant is to be used for development of a shallow well, the Aqua-Clear® PFD/water solution may be poured directly into the well.
- For deeper wells the Aqua-Clear® PFD/water solution must be injected down the well using a tremie line with an isolating injection tool set at the depth of the desired screen interval to be treated. The injection tool will be flanged on both ends of the desired screened interval treatment length to isolate the area for treatment. This will ensure the solution is evenly distributed throughout the screen and that the desired concentration of the Aqua-Clear® PFD/water solution is achieved.
- Set the injection tool at the desired treatment depth.
- Inject the solution into the tremie line under enough pressure to ensure the solution is dispersed into the filter pack. This can be accomplished using a transfer pump configuration.
- Repeat the treatment until the entire occluded screen interval has been treated.

Agitation

At a minimum, the PFD solution should remain in the well for 24 hours. During this time the following agitation activities should be implemented:

- After injection of the Aqua-Clear® PFD/water solution is complete, immediately start agitation of the solution in the well. Agitation ensures the solution is thoroughly blended and dispersed into the filter pack and formation interface.
- Agitation activities using a surge and swab technique should be performed every 2 hours. The screen intervals will be agitated for approximately ½ hour and allowed to set for 1.5 hours. This will be repeated every 2 hours throughout the day. The solution will then be allowed to set overnight. The agitation activities will then resume for another full day. These steps are repeated until the operator is satisfied that maximum benefit has been obtained.

Pumping

The pumping of the well is the same as described in the General Monitoring Well Development procedure if this is for a newly installed well. However, if the treatment is used to redevelop a well to increase flow rates then the following guidelines should be considered:

1. If the well is a monitoring well then the purge water will be contained and the water quality monitored as described in the General Monitoring Well Development procedure. A test of the containerized water for parameters that are currently being monitored at the site will be performed.
2. If the well being treated is a domestic/municipal well then the purge water can be discharged to the surface with the appropriate approvals and water quality parameters monitored as described in the General Monitoring Well Development procedure.

3. If the well is a production well then the purge water could be monitored for turbidity only and the discharge water will continue to be pumped into the assigned discharge zone for the well.

4. Monitoring of the well performance should be performed to determine the success of the treatment and assess the need for any future equipment modifications.

References for Other Applicable ASTM Standards

ASTM D4750 – Determining Subsurface Liquid Levels in a Borehole or Monitoring Well

Figure B1.4-1. Well Development Record and Water Quality Field Data Sheet

Well Development Record and Water Quality Field Data Sheet

Page 1 of _____

Project: _____ Well No: _____

Project No.: _____

Date: _____ *Samplers:* _____

Time Start: _____

Time Finish: _____ Checked by: _____

Well Information

Depth to Water: _____ ft. Casing Diameter: _____ in. = _____ ft. Casing Stickup: _____ ft.

Bottom of Screen: _____ ft. Borehole Diameter: _____ in. = _____ ft. Screened Interval: _____ ft.

Sample Depth: _____ ft. Saturated Screen Well Volume: _____ gallons

Drawdown Limit: _____ ft. Calculations: Casing Volume (CV) = π (cr^2) h (7.48)

Note: All depths measured from top of casing.

Filter Pack Volume (FPV) = π ($br^2 - cr^2$)[BS-(TS or H)] P (7.48)

Saturated Screen Well Volume = CV + FPV

Calculation Notes: cr = casing radius; h = bottom of screen – depth of water in ft.; If TS>H use TS, if TS<H use H

br = borehole radius; P = estimated porosity of filter pack (35%); BS = bottom of screen

H = depth to water; TS = top of screen

Field Equipment

pH Meter: _____ Serial No.: _____ Water Level Meter: _____ Serial No.: _____

Conductivity Meter: _____ Serial No.: _____ Turbidity Meter: _____ Serial No.: _____

Temperature Meter: _____ Serial No.: _____ Bailer: _____ Size: _____

Sample Equipment *(check one)*

☐ *Submersible Pump* *Pump Type (circle one):* *Piston* *Bladder* *Impeller*

☐ *Disposable Teflon Bailer* *Pump Model:* _____

Serial No.: _____

Field Chemistry

pH _____ = @ _____ ºC pH _____ = @ _____ ºC pH _____ = @ _____ ºC Time _____

Conductivity Standard: _____ µmhos/cm @ 25ºC Reading _____ µmhos/cm @ _____ ºC Time _____

Turbidity Standard: _____ N.T.U. @ 25ºC Reading _____ N.T.U. @ _____ ºC Time _____

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Figure B1.4-1. Well Development Record and Water Quality Field Data Sheet (Concluded)

Well Development Record and Water Quality Field Data Sheet

Page 2 of _____

Project:	_____	Well No:	_____
Project No.:	_____		_____
Date:	_____	*Samplers:*	_____
Time Start:	_____		_____
Time Finish:	_____	Checked by:	_____

Field Chemistry (cont'd)

Time	Volume gallons	Temp. ºC	pH	Conductivity µmhos/cm	Turbidity N.T.U.	Comments

Was well sampled after development? ___YES ___NO

Sample Method:_____

Sample Name:_____

Analyses:_____

_____

_____

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SOP B1.11 Equipment Decontamination

The objective of field decontamination is to remove contaminants of concerns from sampling, drilling and other field equipment to concentrations that will **not** impact study objectives. This SOP was developed for use by field personnel who are responsible for cleaning sampling or other equipment in the field.

Specification for Decontamination Materials

- Use a standard brand of phosphate-free laboratory detergent, either liquid or powder, preferably Liquinox® or (Alconox®).
- Use tap water from any municipal water treatment system or use bottled drinking water. Soap and tap water will remove the gross contamination from the sampling equipment.

Handling and Containers for Cleaning Solutions

Improperly handled cleaning solutions may easily become contaminated, thereby jeopardizing the validity of the sample data. Containers should be constructed of the proper materials to ensure their integrity. The following containers should be used for storing the specified cleaning materials:

- Soap—Keep in clean containers until use. It should be poured directly from the container into the wash bucket or tub.
- Tap water—Keep in clean tanks, hand-pressure sprayers, or squeeze bottles, or apply directly from a hose.
- Deionized water—Store in clean containers that can be closed when not in use. It may be applied from squeeze bottles.

Decontamination of Large Equipment

The following procedure will be used to decontaminate large pieces of equipment, such as casings, auger flights, pipe and rods, and those portions of the drill rig that may stand directly over a boring or well location or that come into contact with casing, auger flights, pipe, or rods. This procedure shall also be employed for the decontamination of heavy machinery such as backhoes, excavators, etc.

- Wash the external surfaces of equipment with high-pressure hot water and Liquinox® or Alconox® or equivalent non-phosphate, laboratory-grade detergent. If necessary, scrub until all visible dirt, grime, grease, oil, loose paint, rust flakes, etc., have been removed. The inside surfaces of equipment which come in direct contact the media being sampled will also be washed as described above. Specific decontamination instructions will be included in the project-specific addenda.
- Rinse with potable water.
- This decontamination procedure will be performed before equipment is used and between each well or other sampling locations.

Decontamination of Sampling Equipment

The following procedure will be used to decontaminate devices such as split-spoons, bailers, sample trays, spatulas, spoons and augers that come in direct contact with the sample media:

- Wash and scrub equipment using tap water and laboratory detergent. Wire or plastic bristle brushes can be used.
- Rinse with tap water, removing all visible dirt and soap residue.
- Rinse with deionized water.
- Place onto clean plastic sheeting and allow to completely air dry.
- If not used immediately, wrap in aluminum foil.

Decontamination of sampling equipment will be kept to a minimum in the field and, whenever possible, dedicated sampling equipment will be used. Decontamination fluids will be disposed as required by the project specific addenda to the Waste Management Plan (WMP) (Appendix E of the BWP). Personnel directly involved in equipment decontamination will wear appropriate personal protective equipment as specified in the BWHSP (Appendix F of the BWP) and the SSHP.

Whenever possible, decontamination pads provided by Kirtland AFB should be used to clean large equipment. In other instances, a decontamination pad may need to be constructed at the investigation site.

Construction of a Decontamination Pad

Decontamination pads constructed in the field should meet the minimum specifications described below:

- The pad should be constructed in an area known or believed to be free of surface contamination. A temporary pad should be lined with a water impermeable material with no seams within the pad. The material should be either easily replaced (disposable) or repairable.
- The location of the pad should be out of the work zone and situated not to interfere with other work in progress.
- The pad should not leak excessively. Any sump or pit should be lined.
- Sawhorses or racks constructed to hold equipment while being cleaned should be high enough above the ground surface to prevent equipment for being splashed and re-contaminated.
- Water collected on the pad will be containerized and disposed of as per the IDW Disposal Plan. Small amounts of water will be left to evaporate.

Personal Protective Equipment

Personnel directly involved in equipment decontamination shall wear appropriate PPE as specified in the BWHSP (Appendix F of the BWP) and the SSHP. The appropriate PPE is selected based on the level of contamination present or suspected at the site. Care should be taken so the selected PPE protects decontamination workers from unnecessary contact with soils or decontamination fluids. The following is a list of the minimum PPE required to perform decontamination activities:

- Safety glasses with splash shields or goggles and latex gloves will be worn during all cleaning operations. For decontamination activities involving large amounts of water, rain suits or aprons and rubber over-boots should also be worn.

No eating, smoking, drinking, chewing, or any hand-to-mouth contact should be permitted during cleaning operations.

References for Other Applicable ASTM Standards

ASTM D5088 – Decontamination of Field Equipment Used at Nonradioactive Waste Sites

ASTM D5608 – Decontamination of Field Equipment Used at Low Level Radioactive Waste Sites

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SOP B2.3 Subsurface Soil Sampling

The following elements regarding soil borings should be considered when developing project-specific plans:

- All drilling will conform to state and local regulations. Permits, applications, and other documents required by state and local authorities will be obtained.

- The location of all borings will be approved in writing by the base before drilling commences.

- The drill rig will be decontaminated in accordance with SOP B1.10. Use of disposable equipment is preferred. If disposable equipment is unavailable, use of decontaminated equipment is allowed. Equipment shall be decontaminated per the requirements of SOP B1.10. All sampling equipment which may not be decontaminated should be disposed of in accordance with the project-specific addenda to the WMP (Appendix E of the BWP).

- The drill rig will not leak any fluids that may enter the hole or contaminate equipment that is placed in the hole. The use of rags or diapers to absorb leaking fluids is unacceptable. All leaking fluids will be caught in a proper container until the leak is repaired. If sample integrity could be comprised by leaking drill rig fluids, then sample operation may be shut down until the leak is repaired.

- No fluids will be used to advance soil borings.

- A standard penetration test will be performed each time a split spoon sample is taken. The test will be performed in accordance with ASTM D-1586. Sampling for lithologic logging should be continuous especially near ground surface in the area of potential contamination sources. The depth to which continuous lithologic sampling is completed will be determined on a site-by-site basis after review of site specific stratigraphic data collected during previous investigations. In most cases, the collection of continuous lithologic samples should begin at the ground surface and continue until the water table is encountered.

  NOTE: If soil samples are being collected for VOC or total organic carbon (TOC) analysis, those samples should be collected from the sampler prior to lithologic logging and any disturbance to the sample core.

  The method of continuous sample collection is dependent on the drilling method used. Common sampling methods include split-spoon samplers, thin-walled samplers, and core barrels. All of these sampling devices can be used with minimal disturbance of the sample.

- Sample collection for VOC and TOC analyses will be in accordance with U.S. EPA SW-846 Method 5035 and NMED requirements. Samples will be collected using EnCore® (or similar) samplers. If conditions exist that make the use of this type of sampler impractical (collection of samples from soil cuttings or dry or gravelly conditions), another method may be used and should be addressed in the project-specific work plan. If another method is used, such as a discrete grab sample collected in a 4-ounce jar, the sample should be collected prior to homogenization with as little disturbance as possible.

- Surface water and extraneous materials will not enter the boring.

- Boreholes will be abandoned as specified in project-specific addenda.

- All trash and drill cuttings will be disposed as dictated in project-specific addendum to the WMP (Appendix E of the BWP).

- Subsurface soil samples may also be collected using a stainless steel hand auger or split-spoon sampler. Project-specific addenda will specify the method to be used on the basis of field requirements.

- Lithologic logging is necessary to determine the physical characteristics of the subsurface. This information will be used in conjunction with contaminant chemical and physical data to determine how the contaminant will move from its source to potential receptors. This data will also be used for evaluating the feasibility of various remediation technologies for cleanup of subsurface contamination. The stratigraphy at Kirtland AFB is complex with lateral variation of highly heterogeneous alluvial fan and axial ancestral Rio Grande lithofacies. Small lenses of clay or sand present in these lithofacies can determine how a contaminant is transported from the source site. These lenses may be missed if lithologic sampling is not continuous.

- Before digging begins a digging permit, "*Base Civil Engineering Work Clearance Request*" form, needs to be completed and approved by the Chief of Operations or Chief of Engineering and Environmental Planning at the base in accordance with Appendix H, Permitting Plan. The work clearance request is processed just prior to the start of work and is valid for 30 days. If delays are encountered and the conditions at the job site change (or may have to be changed) or the project extends past 30 days, this work clearance request must be reprocessed. The type of information that must accompany this permit includes:

  — Location

  — Work order/job number

  — Contract number

  — If the area has been staked/clearly marked or not

  — A sketch of the excavation

  — Type of facility work involved, i.e. Pavements, drainage systems, railroad tracks, overhead or underground utility or communications, aircraft or vehicular traffic flow, security, etc.

  — Date clearance requested and terminated

  — Requesting official, phone number, and organization

Hand Auger Sampling

The following procedure will be used for hand auger sampling:

- Wear appropriate PPE as specified in the BWHSP (Appendix F of the BWP) and the SSHP. In addition, samplers will don new sampling gloves at each location.

- Use a decontaminated hand-driven 6-inch stainless steel bucket auger. The diameter of the auger may be modified to suit site-specific conditions and shall be specified in the project-specific addendum.

- Begin turning the auger in a clockwise direction and continue until the desired sampling depth is obtained.

- Remove the auger and collect samples for VOC and total organic carbon (TOC) analyses in accordance with U.S. EPA SW-846 Method 5035 and NMED requirements. Samples will be collected directly from the soil in the auger with as little disturbance as possible, using EnCore® (or similar) samplers. If conditions exist that make the use of this type of sampler impractical (such as dry or gravelly soil conditions), another method may be used and should be addressed in the project-specific work plan. If another method is used, such as a discrete grab sample collected in a 4-ounce jar, the sample should be collected prior to homogenization with as little disturbance as possible.

- Empty remaining contents of the auger into a decontaminated stainless steel pan. Homogenize samples according to the procedures specified in SOP B2.5, Sample Homogenization. Fill jars using a stainless steel spatula or spoon.

- If it is determined that the sample volume is insufficient to satisfy the analytical requirements, another sample must be obtained from a location immediately adjacent to the first sample.

- Decontaminate according to the procedures outlined in SOP B1.10.

- Place analytical samples into the shipping cooler and chill on ice to 4°C, if required. Prepare sample(s) for delivery to the laboratory for analysis within 24 hours of collection.

- Fill out field log book, sample log sheet, custody seals, labels, and C-O-C forms. Example copies of these forms are included in the QAPP (Appendix C of the BWP).

Split-Spoon Sampling Procedure

The following procedure will be used for split-spoon sampling:

- Wear appropriate PPE as outlined in the BWHSP (Appendix F of the BWP) and the SSHP. In addition, samplers will don new sampling gloves at each location.

- Drill borehole to the desired sampling depth. Drive split-spoon into the undisturbed soil, which is to be sampled.

- A stainless steel 2-inch (or 3-inch) outside diameter split-spoon sampler will be driven with blows from a 140-lb (or 300-lb) hammer falling 30 inches until either approximately 2 ft has been penetrated or 100 blows within a 6-inch interval have been applied. This process is referred to as the Standard Penetration Test (ASTM D 1586-74). A decontaminated split-spoon will be used for each sample collected for chemical analyses.

- Soil borings designated for engineering parameters such as Atterberg limits, permeability, sieve analysis, etc., will be obtained using a Shelby tube according to ASTM 1557. Shelby tubes can be used when cohesive materials are encountered, and when an undisturbed sample is required for testing.

- Record the number of blows required for each 6 inches of penetration or fraction thereof. The first 6 inches is considered to be a seating drive. The sum of the number of blows required for the second and third 6 inches of penetration is termed the penetration resistance. If the sampler is driven less than 2 ft, the penetration resistance is still the blows encountered for the second and third 6-inch intervals. If more than 50 blows have been counted for a particular 6-inch interval, then refusal shall be entered on the log.

- Bring the sampler to the surface and remove both ends and one-half of the split-spoon so that the recovered soil rests in the remaining half of the barrel. Place split-spoon on clean polyethylene sheeting. Describe thoroughly the approximate recovery (length), Unified Soil Classification System (USCS) classification, composition, color, moisture, etc., of the recovered soil. A copy of a typical bore log form is depicted in Figure B1.1-1.

  NOTE: If soil samples are being collected for VOC or total organic carbon (TOC) analysis, those samples should be collected from the sampler prior to lithologic logging and any disturbance to the sample core.

- Sample collection for VOC and total organic carbon (TOC) analyses will be in accordance with U.S. EPA SW-846 Method 5035 and NMED requirements. Samples will be collected prior to homogenization from the split-spoon core, using EnCore® (or similar) samplers. If conditions exist that make the use of this type of sampler impractical (such as dry or gravelly soil conditions), another method may be used and should be addressed in the project-specific work plan. If another method is used, such as a discrete grab sample collected in a 4-ounce jar, the sample should be collected prior to homogenization with as little disturbance as possible.

- Empty remaining contents of the split-spoon into a disposable sample tray/pan or decontaminated stainless steel pan. Homogenize samples according to the procedures specified in SOP B2.5, Sample Homogenization. Fill remaining jars with soil using stainless steel spatulas or spoons.

- Decontaminate split-spoon sampler according to the procedures outlined in SOP B1.10.

- Place analytical samples in sample cooler and chill to 4°C. Samples will be shipped to the laboratory within 24 hours.

- Fill out field log book, sample log sheet, labels, custody seals, and C-O-C forms for analytical samples. Example copies of these forms are included in the QAPP (Appendix C of the BWP).

Rock Core Sampling

After rock coring has been completed and the core recovered, the rock core will be carefully removed from the barrel, placed in a core tray (previously labeled "top" and "bottom" to avoid confusion), classified, and measured for percentage of recovery as well as the rock quality designation (RQD). See

the Classification of Rocks section in SOP B1.1 for a description of how to measure the RQD of a core. Each core will be described and classified in the field log book or on appropriate forms described in SOP B1.1, Borehole and Sample Logging.

After sampling, rock cores must be placed in the sequence of recovery in well-constructed wooden boxes or manufactured plastic core boxes provided by the drilling contractor. Rock cores from two different borings will not be placed in the same core box unless accepted by the Field Geologist. The core boxes should be constructed to accommodate at least 20 linear ft of core in rows of approximately 5 ft each and should be constructed with hinged tops secured with screws and a latch to keep the top securely fastened down. Wood partitions will be placed at the end of each core run and between rows. The depth from the surface of the boring to the top and bottom of the drill run and run number will be marked on the wooden partitions with indelible ink. Any core loss areas will be spaced with wooden blocks, polyvinyl chloride (PVC) pipe, or other sturdy material so that the entire core run is represented. The order of placing cores will be the same in all core boxes. The top of each core obtained should be clearly and permanently marked on each box. The width of each row must be compatible with the core diameter to prevent lateral movement of the core in the box. Similarly any empty space in a row will be filled with an appropriate filler material or spacers to prevent longitudinal movement of the core in the box.

The inside and outside of the core-box lid will be marked by indelible ink to show all pertinent data on the box's contents. At a minimum, the following information must be included:

- Project name
- Project number
- Boring number
- Footage (depths)
- Run number(s)
- Recovery
- Box number (x of y)

It is also useful to draw a large diagram of the core in the box, on the inside of the box top. This provides more room for elevations, run numbers, recoveries, comments, etc., than could be entered on the upper edges of partitions or spaces in the core box.

For easy retrieval when core boxes are stacked, the sides and ends of the box should also be labeled and include project number, boring number, top and bottom depths of core, and box number.

A photograph of the recovered core and the labeling on the inside cover will be taken. If moisture content is not critical, the core should be wetted with potable tap water and wiped clean for the photograph (This will help to show true colors and bedding features in the cores).

Due to the weight of the core, two people should always handle a filled core box. Core boxes temporarily stored onsite should be protected from the weather. The core boxes should be removed from the site in a careful manner as soon as possible.

Thin Wall (Shelby Tube) Sampling

When it is desired to take undisturbed samples of soil, thin-walled seamless tube samplers (Shelby tubes) will be used. These samples are not recommended by the EPA for environmental samples. Tube samplers, whether of carbon steel or stainless steel, should not be used for taking VOC samples. The following method applies:

- Clean out the hole to the sampling elevation being careful to minimize the chance for disturbance or contamination of the material to be sampled. In saturated materials, withdraw the drill bit slowly to prevent loosening of the soil around the hole and maintain the water level, if present, in the hole at or above groundwater level.

- The use of bottom discharge bits or jetting through an open-tube sampler to clean out the hole will not be allowed. Any side discharge bits are permitted.

- The sampler must be of a stationary piston-type to limit sample disturbance and aid in retaining the sample. Either the hydraulically operated or control rod-activated type of stationary piston sampler may be used. Prior to inserting the tube sampler in the hole, check to insure that the sampler head contains a check valve. The check valve is necessary to keep water in the rods from pushing the sample out of the tube sampler during sample withdrawal and to maintain suction within the tube to help retain the sample.

- With the sampling tube resting on the bottom of the hole and any water level in the boring at the natural groundwater level or above, push the tube into the soil by a continuous and rapid motion, without impacting or twisting. In no case will the tube be pushed further than the length provided for the soil sample. Allow a free space in the tube for cuttings and sludge. Data to be recorded on the sampling tube when sampling with Shelby Tubes include the maximum pressure exerted for the push, and duration in seconds of the push.

- After pushing the tube, the sampler should sit from 5 to 15 minutes in the borehole prior to removal. Immediately before removal, the sample must be sheared by rotating the rods with a pipe wrench a minimum of two revolutions.

- Upon removal of the sampler tube from the hole, measure the length of sample in the tube and also the length penetrated. Remove disturbed material at both ends of the tube and measure the length of sample again. After removing at least 1-inch of soil from the lower end and after inserting an impervious disk, seal both ends of the tube with at least ½-inch of wax applied in a way that will prevent the wax from entering the sample. Newspaper or other types of filler must be placed in voids at either end of the sampler prior to sealing with wax. Place plastic caps on the ends of the sampler, tape them into place, and dip the ends in wax to seal them.

- Affix labels to the tubes, as required, and record sample number, depth, penetration, and recovery length on the label. Mark the same information and "'up" direction on the tube with indelible ink, and mark the end of the sample. Complete C-O-C and other required forms. Do not allow tubes to freeze, and store the samples vertically (with the same orientation they had in the ground, i.e., top of sample is up) in a cool place out of the sun at all times. Ship samples protected with suitable resilient packing material to reduce shock, vibration, and disturbance.

- Using soil removed from the ends of the tube, carefully describe the sample using the methods presented in SOP B1.1.

- When thin-wall tube samplers are used to collect soil for certain chemical analyses, it may be necessary to avoid using wax, newspaper, or other fillers. Project-specific addendum will address specific materials allowed dependent on analytes being tested.

Thin-walled undisturbed sampling are sometimes difficult to collect because thin-walled tube samplers are restricted in their usage by the consistency of the soil to be sampled. Often very loose and/or wet samples cannot be retrieved by the samplers, and soils with a consistency in excess of very stiff cannot be penetrated by the sampler. Devices such as Dension or Pitcher cores can be used in conjunction with the tube samplers to obtain undisturbed samples of stiff soils. Using these devices normally increases sampling costs and therefore their use should be weighed against the increased cost and the need for an undisturbed sample. In any case, if a sample cannot be obtained with a tube sampler, an attempt should be made with a split-spoon sampler at the same depth so that at least a sample can be obtained for classification purposes.

Direct Push Sampling for Soil and Groundwater

Direct push technology (DPT) will be used to rapidly collect soil and water samples whenever possible. This technique provides for collection of undisturbed samples and does not generate soil cuttings. This section discusses the DPT method only.

The contractor will need a copy of the DPT subcontractor work plan, waste containers, and appropriate health and safety gear. All additional equipment and materials will be provided by the DPT subcontractor. The DPT subcontractor should be equipped with a rig capable of pushing 30 ft and collecting soil and groundwater samples from any interval within that depth. Equipment should include at minimum the following items:

- Hydraulic ram with hammer assembly

- 1- to 1.5-inch diameter drill rods

- Stainless steel piston-type, split-spoon, or equivalent soil sampling device that allows for lithologic characterization and retrieval of at least 400 milliliters (mL) of sample volume

- Geoprobe®, Hydrocone®, bailer, Teflon® tubing and peristaltic pump, or equivalent water sampling device

- Small diameter PVC riser and screen to make temporary wells if recovery is too slow

- Decontamination equipment

- Health and safety equipment

If a situation arises in which the groundwater recharge is too slow to allow for efficient sampling, a temporary PVC well can be installed for sampling at a later time. This well, however, must be installed according to the following specifications:

- The well will be narrower in diameter than the DPT borehole, leaving annular space around the casing
- The well will be installed between 2 and 5 ft into the water table
- New PVC casing and screen will be used, decontaminated with a stream cleaner and rinsed with copious quantities of deionized water
- Installation of well materials will occur with clean decontaminated gloves
- The well will be sampled and removed within 48 hours of installation
- If left unattended or overnight, locking well caps should be used, or a seal should be used that can indicate tampering
- One volume of the sampling device will be purged prior to sampling

General Methodology

- Verify that the subcontractor has the necessary drilling and sampling equipment, as well as proper decontamination supplies.
- Confirm that sampling locations are staked and that the clearances from all on-Base and off-Base utilities have been obtained. Do not begin the sampling until proper digging permits have been obtained and all of the utilities have been marked.
- Locate the sample location and position the DPT rig. If the sample point is on thick asphalt or concrete, the DPT subcontractor will use a hammer-drill or equivalent to drill a hole through the pavement.
- Verify that the sampling tip has been properly decontaminated, as specified in SOP B1.10 before beginning penetration.

Soil Sampling Methodology

- For soil sampling, hydraulically advance the sampler to above the target sample interval, unlock the piston point, and advance the sampling device through the sampling interval.

  — Pull the rods using the hydraulic apparatus and remove the sample insert or split spoon.

  — Log the soil and collect the required samples as specified in the project specific addendum.

- Continue sampling at additional depth intervals or abandon the borehole, as appropriate for the location

Groundwater Sampling Methodology

- If groundwater sampling is necessary, advance the sampler into the water table and collect a sample with the sampling device as specified in SOP B4.1.

- Collect and manage all wastes as specified in the project-specific addenda to the WMP (Appendix E of the BWP).

- Abandon all boreholes and repair pavement before moving to a new site as specified in SOP B1.4.

Comments

- If a buried object impedes the DPT sampler or if an insufficient sample volume is recovered, reposition the rig in a location to satisfy the intent of the original sample point and try again. Note this on the borehole logging form.

- If the total recovered sample volume is insufficient for both screening and laboratory analysis, a second hole will be pushed as close as possible to the original hole and an additional sample will be taken from the same depth interval. The two samples will be composited prior to sampling for chemical analysis.

References for Other Applicable ASTM Standards

ASTM D1452 – Soil Investigation and Sampling by Auger Borings

ASTM D1586 – Penetration Test and Split-Barrel Sampling of Soils

ASTM D4220 – Preserving and Transporting Soil Samples

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SOP B3.1 Photoionization Detectors and Organic Vapor Analyzers

A photoionization detector (PID) is used to detect the concentration of organic gases in air. During field investigations, this particular instrument, along with an organic vapor analyzer (OVA) serves several functions. First, and most importantly, it is used to protect the health and safety of the field personnel by providing information concerning the presence and concentration of contaminants encountered. Second, the information gained from the instrument is often used to dictate whether or not to continue the field investigation (i.e., drilling and sampling vertically or horizontally to delineate the extent of contamination). In addition, the field screening capabilities of the instrument can be used to determine which samples will be selected for laboratory analysis. The use of this instrument for health and safety considerations is described in the BWHSP (Appendix F of the BWP) and the SSHP.

The PID and the OVA have some important limitations. The instruments can only monitor certain vapors and gases in air. Many nonvolatile liquids, toxic solids, particulates and other toxic gases and vapors cannot be detected. Because the types of compounds that the PID and OVA can potentially detect are only a fraction of the chemicals possibly present at an incident, a zero reading does not necessarily signify the absence of air contaminants.

The instruments are also non-specific, and their responses to different compounds are relative to the calibration settings. In addition, the reading shown on the meter represents the total volatile organic concentrations rather than any one compound. The PID cannot detect methane, and neither instrument can be used as an indicator for combustible gases or oxygen deficiency. In the presence of methane, the PID will register lower levels for organic contaminants that are present due to the interference caused by the methane.

The operating instructions for the actual field instruments to be used onsite (such as PIDs and OVAs) should be described in the project-specific addenda.

The PID or OVA must be calibrated daily, at a minimum, before work commences. The instrument should be recalibrated after prolonged periods of downtime (such as a shutdown of drilling activities). Extreme temperatures (< 40°F or > 85°F) can sometimes cause the instrument to behave erratically and in error. If a malfunction occurs the instrument shall be recalibrated. When possible, the PID or OVA should be sheltered from extreme temperatures and foul weather conditions.

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SOP B3.3 Headspace Screening

When headspace screening is specified, soil samples will be screened for VOCs in the field at the time of sample collection. Field screening will utilize an OVA equipped with either PID or a FID. If a high humidity condition exists during the time period when field activity is to be performed, the FID is recommended since a PID is not a reliable screening instrument under these conditions. The ionization potential of the lamp for the PID will be optimum for the contaminants of concern. Field screening will be performed in accordance with the following procedures.

Soil Samples

- Immediately upon opening the split-spoon (or other sample retrieval device) and after collecting the volatile organic sample (if required), a representative portion of the sample will be collected and placed in a clean, contaminate-free jar. The sample may be placed in a new, clean, plastic sandwich bag inside a jar to minimize the number of new jars required. If the plastic bag method is utilized, readings will be taken inside empty bags to ensure no external contamination is being introduced.

- If the volume of sample recovered is insufficient for all analytical requirements, then the material used in the headspace readings could be utilized for any non-volatile sampling requirements (i.e., the headspace material could be used to fulfill geotechnical testing requirements). If due to insufficient sample volume an additional sample was retrieved immediately below the initial attempt, an additional headspace reading is not required.

- Seal each jar with at least one continuous sheet of aluminum foil, using the jar lid to secure the foil.

- Vigorously agitate the sample jar for at least 15 seconds and then allow a minimum of 10 minutes (or as the environmental conditions dictate) for the sample to adequately volatilize.

- During cold weather the samples will be warmed to room temperature prior to taking the headspace measurement. Since a temporary shelter (i.e. van) is generally used to protect the field instruments, especially during inclement weather, warming the samples to room temperature should not be a problem.

- Re-shake the jar and then remove the jar lid. Quickly insert the vapor sampling probe through the aluminum foil and record the maximum meter response (which should be within the first 2 to 5 seconds). Erratic responses should be evaluated in terms of high organic vapor concentrations or conditions of elevated headspace moisture.

- Record headspace screening data on the boring log and any other appropriate documentation (e.g., sample transmittals, field logbooks, etc.), as appropriate.

- The screening instrument will be calibrated according to the appropriate standard span gas and will be calibrated a minimum of twice daily and before use after a long shut-down period (i.e., lunch breaks, equipment breakdowns, weather-related breaks, etc.).

- If sample jars are to be re-used in the field, jars must be cleaned according to the field decontamination procedures for cleaning of sampling equipment. In addition, headspace readings must be taken to ensure no residual organic vapors exist in the cleaned sample jars.

- Any deviation(s) from the approved procedures must be noted on the drill logs and the DQCR and a basis stated for the deviation(s). DQCRs are discussed in the QAPP (Appendix C of the BWP).

Water Sample

For volatile organic compound screening of water samples, the same general procedures apply as for soil sample screening. However, only new glass jars should be used to contain the sample during the screening operation. Each empty jar must be pre-screened to assure that no extraneous substances are contained in the sample container which might affect the screening results.

SOP B4.4 Field Filtration

The rationale for collecting the filtered samples will be clearly defined in the project-specific addenda. Filter apparatus must be made of polyethylene, polypropylene, or borosilicate glass. The filter used will be a cellulose-based membrane filter of 0.45-micron nominal pore size. The sample must be filtered immediately after collection to minimize changes in the concentration of the substance of interest. Samples are only passed through the filtration apparatus once. Samples are then preserved immediately as required. All paperwork accompanying the samples to the laboratory should clearly state that the samples have been field-filtered, in order to avoid second filtration at the laboratory. Field filtering of water samples should be conducted as follows:

- The filter apparatus will be decontaminated and clean.
- Pour the sample into the filter apparatus and filter sample through a cellulose-based membrane filter of 0.45-micron nominal size. Samples are only passed through the filter once.
- Preserve sample immediately as required.
- Place analytical samples in cooler and chill to 4°C. Samples will be shipped to the appropriate laboratory within 24 hours.
- Fill out field log book, sample log sheet, labels, custody seals, and C-O-C forms. Example copies of these forms are included in the QAPP (Appendix C of the BWP).

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SOP B5.1 pH

The following procedure is used for measuring groundwater pH with a pH meter:

- The instrument and batteries should be checked and calibrated in the laboratory prior to initiation of the field effort.
- The accuracy of the buffer solutions used for field and laboratory calibration should be checked. Buffer solutions need to be changed due to degradation upon exposure to the atmosphere. The date of preparation of each buffer should be included on the bottle label.
- Immerse the tip of the electrodes in water overnight. If this is not possible due to field conditions, immerse the electrode tip in water for at least an hour before use. The electrode tip may be immersed in a rubber or plastic sack containing buffer solution for field transport or storage. This is not applicable for all electrodes as some must be stored dry.
- Make sure all electrolyte solutions within the electrode(s) are at their proper levels and that no air bubbles are present within the electrode(s).
- Immerse the electrode(s) in a pH-7 buffer solution.
- Adjust the temperature compensator to the proper temperature (on models with automatic temperature adjustment, immerse the temperature probe into the buffer solution). Alternately, the buffer solution may be immersed in the sample and allowed to reach temperature equilibrium before equipment calibration. It is best to maintain buffer solution at or near expected sample temperature before calibration.
- Adjust the pH meter to read 7.0.
- Remove the electrode(s) from the buffer and rinse well with deionized water. Immerse the electrode(s) in pH-4 (for water with pH of 1 to 7) or pH-10 (for water with pH of 7 to 12) buffer solution and adjust the slope control to read the appropriate pH. At least three successive readings during calibration, one minute apart, should be within +0.1 pH unit. For best results, the standardization and slope adjustments should be repeated at least once daily before use.
- Immerse the electrode(s) in the unknown solution, slowly stirring the probe until the pH stabilizes. Stabilization may take several seconds to minutes. If the pH continues to drift, the sample temperature may not be stable, a chemical reaction (e.g., degassing) may be taking place in the sample, or the meter or electrode may be malfunctioning. This must be clearly noted in the log book.
- Read and record the pH of the solution, after adjusting the temperature compensator to the sample temperature. pH should be recorded to the nearest 0.1 pH unit. Also record the sample temperature.
- Rinse the electrode(s) with deionized water.
- Keep the electrode(s) immersed in water when not in use.

The sample used for pH measurement should never be saved for subsequent conductivity or chemical analysis. All pH electrodes leak small quantities of electrolytes (e.g., sodium or potassium chloride) into the solution. Precipitation of saturated electrolyte solution, especially at colder temperatures, or in cold water, may result in slow electrode response. Any visual observation of conditions that may interfere with pH measurement, such as oily materials, or turbidity, should be noted in the field log book.

SOP B5.2 Specific Conductance

The steps involved in taking specific conductance measurements are listed below:

- Check batteries and calibrate instrument before going into the field.
- Immerse the electrode in water overnight. If this is not possible due to field conditions, immerse the electrode at least one hour before use.
- Calibrate the instrument between each measurement or groups of closely spaced measurements. Potassium chloride standard solutions with a specific conductance closest to the values expected in the field should be used.
- Rinse the electrode with one or more portions of the sample to be tested.
- Immerse the electrode in the sample and measure the conductivity.
- Read and record the results in a field log book. Report the results to the nearest ten units for readings under 1000 micromhos per centimeter (μmhos/cm) and the nearest 100 units for readings over 1000 μmhos/cm. Adjust the temperature setting to the sample temperature.
- Repeat the procedure with fresh sample until reproducible (i.e., ± 5 percent) results are obtained.

If the specific conductance measurements become erratic, or inspection shows that any platinum black has flaked off the electrode, replatinization of the electrode is necessary. See the manufacturer's instructions for details.

Note that specific conductance is occasionally reported at temperatures other than ambient.

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SOP B5.3 Water Temperature

Water temperature may be measured with either a thermometer or temperature meter. The following procedure is applicable to both instruments:

- Rinse the thermometer or temperature probe with a portion of the collected sample.
- Immerse the thermometer or probe in the sample until temperature equilibrium is obtained (1- to 3-minutes). To avoid the possibility of contamination, the thermometer should not be inserted into samples which will undergo subsequent chemical analysis.
- Record values in a field log book to the nearest 0.5°C.
- If a temperature meter or probe is to be used, the instrument should be calibrated according to the manufacturer's recommendations and a National Bureau of Standards (NBS) certified thermometer or one that is traceable to NBS certification before field use. Cross-checking and duplicate field analyses should agree within ± 0.5°C. A cross-check with a calibrated NBS certified thermometer will be made at least semiannually.
- Rinse the thermometer or probe with distilled water.

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SOP B5.4 Dissolved Oxygen

Probes differ as to specifics of use. Follow the manufacturer's instructions to obtain an accurate reading. The following general steps should be used to measure the dissolved oxygen concentration:

- The equipment should be calibrated and its batteries checked in the laboratory before going to the field.
- The probe should be conditioned in a water sample for as long a period as practical before its use in the field. Long periods of dry storage followed by short periods of use in the field may result in inaccurate readings.
- The instrument should be calibrated in the field before each measurement or group of closely spaced measurements by placing the probe in a water sample of known dissolved oxygen concentration (i.e., determined by Winkler method) or in a freshly air-saturated water sample of known temperature. Dissolved oxygen values for air-saturated water can be determined by consulting a table listing oxygen solubility as a function of temperature and salinity.
- The instrument probe should be immersed in a flow-through cell or directly into the water column of the well for the most accurate measurement.
- Record the dissolved oxygen content and temperature of the sample in a field log book. Read the dissolved oxygen dial to the nearest 0.1 milligram per liter (mg/L).
- Recalibrate the probe when the membrane is replaced, or as needed. Follow the manufacturer's instructions. Duplicate analyses should agree within ± 0.1 mg/L.

Note that although *in-situ* placement of the probe is preferable, since sample handling is not involved,. thismay not always be practical. Be sure to record whether the liquid was analyzed *in-situ*, or if a sample was taken. If a sample is taken special care should be taken during collection to avoid turbulence, which can lead to increased oxygen solubility and positive test interference.

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SOP B5.5 Oxidation-Reduction Potential

The following procedure is used for measuring oxidation-reduction potential:

- The equipment should be calibrated and its batteries checked in the laboratory before going to the field.
- Check that the platinum probe is clean and the platinum bond or tip is unoxidized. If dirty, polish with emery paper or, if necessary, clean the electrode using aquaregia, nitric acid, or chromic acid, in accordance with manufacturer's instructions.
- Thoroughly rinse the electrode with distilled water.
- Verify the sensitivity of the electrodes in accordance with the manufacturer's instructions.
- After the assembly has been checked for sensitivity, wash the electrodes with three changes of deionized water or with a flowing stream of water from a wash bottle. Place the sample in a clean glass beaker or sample cup and insert the electrodes. Set temperature compensator to the sample temperature. Provide adequate agitation throughout the measurement period. Read the millivolt (mV) potential of the solution, allowing sufficient time for the system to stabilize and reach temperature equilibrium. Measure successive portions of the sample until readings on two successive portions differ by no more than 10 mV. A system that is very slow to stabilize properly will not yield a meaningful oxidation-reduction potential. Record all results in a field log book, including oxidation-reduction potential (to nearest 10 mV), sample temperature, and pH at the time of measurement.

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APPENDIX D

Soil Vapor Sampling SOP

Standard Operating Procedure

SWMU ST-106/SS-111 Soil Vapor Monitoring

This standard operating procedure (SOP) describes requirements for soil vapor monitoring (SVM) at solid waste management unit (SWMU) ST-106/SS-111 at Kirtland Air Force Base (AFB). All field personnel collecting soil vapor samples are required to be trained and fully understand the sampling procedure outlined in this document. Any and all questions will be addressed prior to the start of sampling via a field sampling orientation led by the Project Field Lead.

During sampling, the condition of each well port will be examined by the field personnel to confirm the integrity of each fitting and to immediately address and mitigate any problems or replace any defective parts.

1.1 Pre-Sampling Steps

1.1.1 Horiba Model MEXA 584L Calibration

During sampling of each soil vapor well, field parameters including total hydrocarbons (HC), oxygen (O_2), and carbon dioxide (CO_2) will be measured using a Horiba Mexa 584L auto emissions analyzer (Horiba) or equivalent.

The Horiba manufacturer's calibration procedure, which was developed for engine exhaust monitoring, has been modified to better calibrate the instrument for measuring soil vapor petroleum HC, O_2 and CO_2 concentrations. The modified calibration method includes a more representative calibration gas, more frequent calibration than specified by the manufacturer, frequent calibration checks (HC, O_2 and CO_2) during daily Horiba usage, and real-time data analysis to look for indicators of potential calibration deviations.

At the beginning of every work day, the Horiba will be calibrated for air-phase petroleum HC and CO_2 against a calibration standard of known concentrations in a premixed gas cylinder. The Horiba will also be calibrated for O_2 against atmospheric concentrations. At the middle of each work day (or no more than 5 hours after the start of work), a calibration check will be performed on the Horiba to determine whether the calibration of any of the parameters has drifted since the morning calibration. If the calibration check results are outside of 5% of the calibration gas standards, then the Horiba will be recalibrated prior to additional sampling.

The same calibration gas cylinder will be used to calibrate every Horiba instrument and calibration will be completed at the beginning of each day to ensure consistent calibrations. The calibration gas consists of 1,600 parts per million by volume (ppmv) propane, 13.0% (percent) CO_2, and the remaining volume will consist of nitrogen. This calibration gas mixture was selected to accurately calibrate the Horiba for the gases that are present in the vadose zone during soil vapor sampling and respiration/rebound testing, specifically, CO_2 and HC (calibrated as propane).

The initial daily calibration of the instrument will be performed by applying the pre-mixed gas into the calibration port located on top of the instrument. The calibration steps listed in the Horiba manual for applying the calibration gas and the sequence of key strokes listed will be followed to complete calibration. After calibration, HC and CO_2 concentrations should be within 5% of the known calibration gas values.

The Horiba Instruction Manual goes through the calibration of each compound. During the calibration of

HC, the Horiba will display three numbers as shown in the Horiba Instruction Manual. The top number is the known value of the calibration gas (propane at 1,600 ppmv). The middle number will be constant for a particular instrument, but will vary from instrument to instrument; this number is the factory calibration setting for that instrument that corresponds to the input value of the calibration gas. The bottom number will change as the calibration gas is applied and read by the instrument. Both the middle and bottom numbers are reporting the gas as hexane rather than propane; hexane is the standard for HC for the Horiba instrument. The conversion between hexane and propane for the Horiba is approximately one half the concentration. Thus, a reading of 800 ppmv reported as hexane by the detector is the equivalent of 1,600 ppmv as propane. Once the gas is applied, the bottom HC number on the display should read within 5% of the middle number. A value of approximately 800 ppmv HC is expected after the Horiba instrument is calibrated.

After calibration is confirmed, the same calibration gas will be used to fill a 3 liter Tedlar® vapor collection bag. The customized sampling system will be used to complete the calibration as follows:

Step 1. Disconnect all fittings from sampling system with the exception of the hose. This ensures the system is sealed from all points except through the hose.

Step 2. Visually check that the red drain separator O-ring (approximately 2-inches in diameter) is visible at the opening of the sample inlet port, which is located on the front of the Horiba and to the right of the screen display. Insert the male pneumatic fitting on the end of the Horiba sampling tube to the female quick connect on the sampling system and ensure a secure fit.

Step 3. Ensure that the sampling system is purged according to the steps listed below under Section 1.1.2- Cross Contamination Purging for Sampling System.

Step 4. Once within the given values, attach the Tedlar® bag to the fitting at the end of the braided stainless steel tubing.

Step 5. Open the Tedlar® bag valve to allow the calibration gas to be pulled through the sampling system.

Step 6. Record the instrument read-outs when the instrument has stabilized and compare the results to the calibration gas concentrations.

The mid-day calibration check will be performed using the same technique as the “flow through” portion of initial calibration described in steps one through six above.

If the values for HC, O_2 and CO_2 are within 5% of the calibration values made using the calibration port, the calibration process is complete. As stated previously, the Horiba reports HC as hexane. A value of approximately 800 ppmv HC is expected. All other gas composition values should match the calibration gas values. If values are outside of this range, perform a leak check as described below and follow the calibration process again.

If at any point during sampling, a reading for HC, O_2 or CO_2 reaches an unreasonable value (e.g., an O_2 concentration greater than 22%) or if a data value falls outside the trend indicated by previous readings at a given SVMP, a calibration check will be triggered. The expected range of values are: for HC - from 0 to 40,000 ppmv, for percent O_2 from 0 % to 22%, and for percent CO_2 from 0% to 15%. If any readings are outside of these ranges, a calibration check must be made and if necessary, the instrument will be recalibrated.

1.1.2 Cross Contamination Purging for Sampling System

The sampling system must be purged with ambient air before being attached to a SVMP sample port to minimize the potential for cross contamination between sample collections. To ensure the entire sample train is thoroughly purged, attach the pump to the setup and flush atmospheric air through the quick connect port and the nylon tubing. All fittings are to be opened during this process to allow for flow. Monitor the purging effectiveness using the Horiba to ensure no contaminants are still present and only ambient air is being read. Correct values for ambient air must be less than 5 ppmv HC, between 20% to 22% for percent O_2, and 0% for percent CO_2. Complete instrument purging must be performed after sampling each SVMP.

1.1.3 Leak Check of Sample System

At the beginning of each day, the sampling system will be leak checked by using the pump to apply vacuum to the sampling system as follows:

Step 1. Cap the male pneumatic fitting on the end of the nylon tubing with a spare female quick disconnect fitted to a vacuum/pressure gauge.

Step 2. Connect the SVMP purging/sampling pump to one of the quick disconnect fittings on the sample system and evacuate the air from the sample system to establish a vacuum.

Step 3. Disconnect the pump and immediately record the vacuum reading from the pressure/vacuum gauge.

Step 4. After 10 minutes have elapsed, check and record the vacuum reading on the gauge.

Step 5. Verify that the starting and ending vacuum readings are within 10% to ensure that the sampling system is not leaking.

Step 6. If the two vacuum readings are not within 10% of each other, check the conditions of the seals and repeat the leak test until the sampling system is confirmed to be air tight.

1.2 Soil Vapor Sampling Procedures

1.2.1 Sample Train Setup

The Horiba analyzer must be turned on, warmed up, and calibrated according to the steps stated above and then attached to the sampling system. The Horiba analyzer is turned on for the first time at the beginning of the day and remains in the on position throughout the day. The Horiba analyzer is plugged into the 12V DC outlet in the project vehicle using an AC inverter. All other equipment is gas powered or will be powered by generator, and can be powered off between sampling at each well. The pump is attached and sealed to the setup by a quick connect fitting. It is important that no pneumatic fittings besides the tubing to the soil vapor well port are attached prior to turning on the pump.

1.2.2 Static Pressure Measurement

Before taking the static pressure reading, the manometer instrument must be zeroed to atmospheric pressure. The screen should read 0.00 inches of water column (in WC). After confirming that the manometer is zeroed, the following procedure is used to connect the sampling system to the SVMPs

and measure the static (also called baseline) pressure, to assure readiness for purging and sampling:

Step 1. Connect the manometer to the the side of the sampling system opposite of the SUMMA® sample collection port.

Step 2. Verify that the manometer reads 0.00 in WC.

Step 3. Connect nylon tubing to the SVMP and ensure a secure connection.

Step 4. Monitor the change in manometer readings over time and record the pressure/vacuum reading when the meter stabilizes.

Note: Static pressure readings have typically ranged from +2.00 in (pressure) to -12.00 in WC (vacuum) at each soil vapor well port.

1.2.3 Well Purging

Stagnant soil vapor is purged from the SVMP as follows:

Step 1. Turn on the SVMP sampling pump, verify the operation of the flow rotameter, and check for potential leaks as necessary.

Step 2. Consult the Purge Table (Table 1) for the initial purge volume.

Step 3. Connect the female quick disconnect on the terminal end of the sampling system to the male quick connect on the vacuum side of the soil vapor monitoring sampling pump and start timing the purge cycle. (Note: Use the flow rate on the rotameter and the pre-calculated purge volume to quickly calculate the purge time. The purge time is determined by the well port diameter, well depth, and rate of the pump; all of which are known before sampling with the exception of the flowrate. The amount of vapor needed to be removed is based on one well casing volume.)

Step 4. After adequately purging for the appropriate time, quickly disconnect the sampling system from the vacuum pump. (Note: The sampling system is to remain connected to the SVMP for the duration of sampling.)

Step 5. Allow the manometer reading to return to within 0.10 in. WC of the static pressure reading before moving to the next step in the sampling procedure.

1.2.4 Horiba Readings

Once the SVMP has been purged, the following procedure is used to take and record HC, O_2 and CO_2 measurements using the calibrated Horiba:

Step l. Ensure that the Horiba is turned on and functioning properly.

Step 2. Record the manometer reading.

Step 3. Insert the male quick connect fitting into the female quick connect fitting on the terminal side of the sampling system and ensure a tight connection.

Step 4. Observe the Horiba O_2 reading for stability or for a maximum of one minute, whichever comes first.

Step 5. Record the O_2, CO_2, and HC readings and quickly disconnect the Horiba. Photograph the Horiba reading for quality control (QC) reference. Include the well number in the picture.

1.2.5 Soil Vapor Sampling

The following procedure will be used when collecting soil vapor samples for laboratory analyses:

Step 1. Check the vacuum in the SUMMA® canister prior to sampling by taking a vacuum reading using a lab-supplied vacuum gauge or equivalent.

- Confirm the valve is closed.
- Remove the brass cap.
- Attach the gauge. Take care to not cross thread the gauge onto the canister. The gauge should be snug with no apparent rattles prior to collecting the initial vacuum reading.
- Attach brass cap to side of gauge tee fitting to ensure a closed train.
- Open and close valve quickly (a few seconds)
- Read vacuum on gauge. (Note: canisters are required to be within --25 to -29.9 inches of mercury (in Hg) of vacuum. If the measured vacuum is outside of this tolerance, do not use the canister for sample collection).
- Record initial vacuum reading on chain-of-custody, verify valve is closed, and remove gauge.
- Replace the brass cap.

Step 2. With the nylon tubing still connected to the well port, record the static pressure indicated on the manometer read-out.

Step 3. Connect the SUMMA® canister to the connection on the sample system.

- Confirm the valve is closed.
- Remove the brass cap.
- Attach the particulate filter.
- Connect the SUMMA® canister to the connection on the sampling system
- Open valve ½ turn – fill canister.
- Disconnect the SUMMA® canister after two minutes or once the manometer reads -5 inches of mercury, whichever comes first (Note: it is the intent to leave some vacuum in the canister for the laboratory to determine sample integrity upon receiving samples)
- Close valve by hand tightening knob clockwise.
- Repeat Step 1 to determine vacuum / pressure.
- Replace brass cap.

SUMMA® canisters will be shipped to the specified laboratory, and analyzed for the appropriate analytical methods listed in the Work Plan.

1.2.6 Sample Packaging and Shipping

Sample packaging and shipping requirements are designed to maintain sample integrity from the time a sample is collected until it is received at the analytical laboratory. All chain-of-custody forms, sample tags, custody seals, and other sample documents will be completed as specified in the QAPjP. Specific procedures for packaging and shipping of environmental samples are presented below:

- A sample tag, completed with indelible ink, will be attached to the canister.
- The filled SUMMA® canisters will be placed in the cardboard box in which the canisters were received from the laboratory. The sample number will be written on the top of the box. Each individual box will be boxed in groups of four or eight in the larger boxes in which they were shipped.
- A copy of the chain-of-custody form will be placed inside the box.
- The box will be closed and taped shut with strapping tape (filament-type).
- Custody seals will be placed on the box. Clear tape will be placed over the custody seals to help prevent them from being accidentally torn or ripped off.
- The box of samples will be shipped via Fed Ex ground. A copy of the shipping bill will be retained for the field records and sent electronically to the project chemist.

Table 1. Soil Vapor Monitoring Point Construction Parameters and Pre-Calculated Purge Volumes
Bulk Fuels Facility Area
Kirtland Air Force Base, Albuquerque, New Mexico

SVM Location ID	SVMP ID	Screened Interval (ft)		Well Diameter (in)	Casing Area (sq ft)	Filter Pack Volume (cu ft)[1]	Purge Volume (cu ft)
		Top	Bottom				
SVMW-01	SVMW-01-050	50	52.5	0.5	0.00136	0.409	0.481
	SVMW-01-100	100	102.5	0.5	0.00136	0.409	0.549
	SVMW-01-250	250.7	253.2	0.5	0.00136	0.409	0.754
	SVMW-01-300	308.5	310	0.5	0.00136	0.245	0.668
SVMW-02	SVMW-02-050	50	52.5	0.5	0.00136	0.409	0.481
	SVMW-02-100	97	99.5	0.5	0.00136	0.409	0.545
	SVMW-02-150	150	152.5	0.5	0.00136	0.409	0.617
SVMW-03	SVMW-03-050	50	52.5	0.5	0.00136	0.409	0.481
	SVMW-03-100	100	102.5	0.5	0.00136	0.409	0.549
	SVMW-03-250	250	252.5	0.5	0.00136	0.409	0.753
	SVMW-03-300	300	302.5	0.5	0.00136	0.409	0.822
SVMW-04	SVMW-04-050	50	52.5	0.5	0.00136	0.409	0.481
	SVMW-04-100	98	100.5	0.5	0.00136	0.409	0.546
	SVMW-04-250	250	252.5	0.5	0.00136	0.409	0.753
	SVMW-04-300	297.5	300	0.5	0.00136	0.409	0.818

Table 1. Soil Vapor Monitoring Point Construction Parameters and Pre-Calculated Purge Volumes
Bulk Fuels Facility Area
Kirtland Air Force Base, Albuquerque, New Mexico

SVM Location ID	SVMP ID	Screened Interval (ft)		Well Diameter (in)	Casing Area (sq ft)	Filter Pack Volume (cu ft)[1]	Purge Volume (cu ft)
		Top	Bottom				
SVMW-05	SVMW-05-050	50	52.5	0.5	0.00136	0.409	0.481
	SVMW-05-100	100	102.5	0.5	0.00136	0.409	0.549
	SVMW-05-230	229.5	231	0.5	0.00136	0.245	0.560
	SVMW-05-290	287.5	290	0.5	0.00136	0.409	0.804
SVMW-06	SVMW-06-050	50	52.5	0.5	0.00136	0.409	0.481
	SVMW-06-100	99.5	102	0.5	0.00136	0.409	0.548
	SVMW-06-252	252	254.5	0.5	0.00136	0.409	0.756
	SVMW-06-302	302.5	305	0.5	0.00136	0.409	0.825
SVMW-07	SVMW-07-050	49.5	52	0.5	0.00136	0.409	0.480
	SVMW-07-100	95.5	98	0.5	0.00136	0.409	0.543
	SVMW-07-150	147.5	150	0.5	0.00136	0.409	0.614
SVMW-08[2]	SVMW-08-050	50	52.5	0.5	0.00136	0.379	0.451
	SVMW-08-100	100	102.5	0.5	0.00136	0.379	0.519
	SVMW-08-250	250	252.5	0.5	0.00136	0.379	0.723
SVMW-09	SVMW-09-050	50	52.5	0.5	0.00136	0.379	0.451
	SVMW-09-100	100	102.5	0.5	0.00136	0.379	0.519
	SVMW-09-250	250	252.5	0.5	0.00136	0.379	0.723
	SVMW-09-266	266	268.5	0.5	0.00136	0.379	0.745

Table 1. Soil Vapor Monitoring Point Construction Parameters and Pre-Calculated Purge Volumes
Bulk Fuels Facility Area
Kirtland Air Force Base, Albuquerque, New Mexico

SVM Location ID	SVMP ID	Screened Interval (ft)		Well Diameter (in)	Casing Area (sq ft)	Filter Pack Volume (cu ft)[1]	Purge Volume (cu ft)
		Top	Bottom				
SVMW-10	SVMW-10-050	50	52.5	0.5	0.00136	0.379	0.451
	SVMW-10-100	100	102.5	0.5	0.00136	0.379	0.519
	SVMW-10-150	150	152.5	0.5	0.00136	0.379	0.587
	SVMW-10-250	250	252.5	0.5	0.00136	0.379	0.723
SVMW-11	SVMW-11-050	50	52.5	0.5	0.00136	0.379	0.451
	SVMW-11-100	100	102.5	0.5	0.00136	0.379	0.519
	SVMW-11-250	250	252.5	0.5	0.00136	0.379	0.723
	SVMW-11-260	260	262.5	0.5	0.00136	0.379	0.737
SVMW-12	SVMW-12-150	150	152.5	0.5	0.00136	0.379	0.587
	SVMW-12-250	250	252.5	0.5	0.00136	0.379	0.723
	SVMW-12-350	350	352.5	0.5	0.00136	0.379	0.860
	SVMW-12-450	450	452.5	0.5	0.00136	0.379	0.996
SVMW-13	SVMW-13-150	150	152.5	0.5	0.00136	0.379	0.587
	SVMW-13-250	250	252.5	0.5	0.00136	0.379	0.723
	SVMW-13-350	350	352.5	0.5	0.00136	0.379	0.860
	SVMW-13-450	450	452.5	0.5	0.00136	0.379	0.996
SVMW-14	SVMW-14-150	150	152.5	0.5	0.00136	0.379	0.587
	SVMW-14-250	250	252.5	0.5	0.00136	0.379	0.723
	SVMW-14-350	350	352.5	0.5	0.00136	0.379	0.860
	SVMW-14-450	450	452.5	0.5	0.00136	0.379	0.996

Table 1. Soil Vapor Monitoring Point Construction Parameters and Pre-Calculated Purge Volumes
Bulk Fuels Facility Area
Kirtland Air Force Base, Albuquerque, New Mexico

SVM Location ID	SVMP ID	Screened Interval (ft)		Well Diameter (in)	Casing Area (sq ft)	Filter Pack Volume (cu ft)[1]	Purge Volume (cu ft)
		Top	Bottom				
SVMW-15	SVMW-15-150	150	152.5	0.5	0.00136	0.379	0.587
	SVMW-15-250	250	252.5	0.5	0.00136	0.379	0.723
	SVMW-15-350	350	352.5	0.5	0.00136	0.379	0.860
	SVMW-15-450	450	452.5	0.5	0.00136	0.379	0.996
KAFB-106028	KAFB-106028-150	148.75	151.25	0.5	0.00136	0.379	0.585
	KAFB-106028-250	248.75	251.25	0.5	0.00136	0.379	0.722
	KAFB-106028-350	348.75	351.25	0.5	0.00136	0.379	0.858
	KAFB-106028-450	448.75	451.25	0.5	0.00136	0.379	0.994
SVEW-01	SVEW-01-260	245	260	4	0.08727	2.274	24.963
SVEW-02/03	SVEW-02-060	45	60	2	0.02182	2.274	3.583
SVEW-02/03	SVEW-03-160	145	160	2	0.02182	2.274	5.764
SVEW-04/05	SVEW-04-313	298	313	2	0.02182	2.274	9.102
SVEW-04/05	SVEW-05-460	445	460	2	0.02182	2.274	12.309
SVEW-06/07	SVEW-06-060	45	60	2	0.02182	2.274	3.583
SVEW-06/07	SVEW-07-160	145	160	2	0.02182	2.274	5.764
SVEW-08/09	SVEW-08-260	245	260	2	0.02182	2.274	7.946
SVEW-08/09	SVEW-09-460	443	457	2	0.02182	2.122	12.092
SVEW-10	SVEW-10-410	400	410	2	0.02182	1.516	10.461
SVEW-11	SVEW-11-410	400	410	2	0.02182	1.516	10.461
SVEW-12	SVEW-12-410	400	410	2	0.02182	1.516	10.461
SVEW-13	SVEW-13-410	400	410	2	0.02182	1.516	10.461

Table 1. Soil Vapor Monitoring Point Construction Parameters and Pre-Calculated Purge Volumes
Bulk Fuels Facility Area
Kirtland Air Force Base, Albuquerque, New Mexico

SVM Location ID	SVMP ID	Screened Interval (ft)		Well Diameter (in)	Casing Area (sq ft)	Filter Pack Volume (cu ft)[1]	Purge Volume (cu ft)
		Top	Bottom				
KAFB-106108	KAFB-106108-025	15.3	25.3	0.75	0.00307	2.259	2.337
	KAFB-106108-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106108-150	140.2	150.2	0.75	0.00307	1.517	1.978
	KAFB-106108-250	240.3	250.3	0.75	0.00307	1.517	2.285
	KAFB-106108-350	340.3	350.3	0.75	0.00307	1.517	2.592
	KAFB-106108-450	440	450	3	0.04909	1.517	23.607
KAFB-106109	KAFB-106109-025	15.2	25.2	0.75	0.00307	2.259	2.336
	KAFB-106109-050	40.1	50.1	0.75	0.00307	2.259	2.413
	KAFB-106109-150	140	150	0.75	0.00307	1.517	1.978
	KAFB-106109-250	240.2	250.2	0.75	0.00307	1.517	2.285
	KAFB-106109-350	340.6	350.6	0.75	0.00307	1.517	2.593
	KAFB-106109-450	440	450	3	0.04909	1.517	23.607
KAFB-106110	KAFB-106110-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106110-050	40.1	50.1	0.75	0.00307	2.259	2.413
	KAFB-106110-150	140.3	150.3	0.75	0.00307	1.517	1.979
	KAFB-106110-250	240	250	0.75	0.00307	1.517	2.284
	KAFB-106110-350	340.2	350.2	0.75	0.00307	1.517	2.592
	KAFB-106110-450	440	450	3	0.04909	1.517	23.607

Table 1. Soil Vapor Monitoring Point Construction Parameters and Pre-Calculated Purge Volumes
Bulk Fuels Facility Area
Kirtland Air Force Base, Albuquerque, New Mexico

SVM Location ID	SVMP ID	Screened Interval (ft)		Well Diameter (in)	Casing Area (sq ft)	Filter Pack Volume (cu ft)[1]	Purge Volume (cu ft)
		Top	Bottom				
KAFB-106111	KAFB-106111-025	15.2	25.2	0.75	0.00307	2.259	2.336
	KAFB-106111-050	40.1	50.1	0.75	0.00307	2.259	2.413
	KAFB-106111-150	140.3	150.3	0.75	0.00307	1.517	1.979
	KAFB-106111-250	240.3	250.3	0.75	0.00307	1.517	2.285
	KAFB-106111-350	340.4	350.4	0.75	0.00307	1.517	2.592
	KAFB-106111-450	440.3	450.3	3	0.04909	1.517	23.621
KAFB-106112	KAFB-106112-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106112-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106112-150	140	150	0.75	0.00307	1.517	1.978
	KAFB-106112-250	240	250	0.75	0.00307	1.517	2.284
	KAFB-106112-350	339	349	0.75	0.00307	1.517	2.588
	KAFB-106112-450	439	449	3	0.04909	1.517	23.558
KAFB-106113	KAFB-106113-020	10	20	0.75	0.00307	2.259	2.320
	KAFB-106113-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106113-150	140	150	0.75	0.00307	1.517	1.978
	KAFB-106113-250	240	250	0.75	0.00307	1.517	2.284
	KAFB-106113-350	340	350	0.75	0.00307	1.517	2.591
	KAFB-106113-450	440	450	3	0.04909	1.517	23.607

Table 1. Soil Vapor Monitoring Point Construction Parameters and Pre-Calculated Purge Volumes
Bulk Fuels Facility Area
Kirtland Air Force Base, Albuquerque, New Mexico

SVM Location ID	SVMP ID	Screened Interval (ft)		Well Diameter (in)	Casing Area (sq ft)	Filter Pack Volume (cu ft)[1]	Purge Volume (cu ft)
		Top	Bottom				
KAFB-106114	KAFB-106114-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106114-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106114-150	140	150	0.75	0.00307	1.517	1.978
	KAFB-106114-250	235	245	0.75	0.00307	1.517	2.269
	KAFB-106114-350	340	350	0.75	0.00307	1.517	2.591
	KAFB-106114-450	439.6	449.6	3	0.04909	1.517	23.587
KAFB-106115	KAFB-106115-025	14.6	24.6	0.75	0.00307	2.259	2.335
	KAFB-106115-050	39.6	49.6	0.75	0.00307	2.259	2.411
	KAFB-106115-150	144.6	154.6	0.75	0.00307	1.517	1.992
	KAFB-106115-250	239.6	249.6	0.75	0.00307	1.517	2.283
	KAFB-106115-350	339.6	349.6	0.75	0.00307	1.517	2.590
	KAFB-106115-450	439.6	449.6	3	0.04909	1.517	23.587
KAFB-106116	KAFB-106116-025	10	19.45	0.75	0.00307	2.135	2.194
	KAFB-106116-050	40	49.45	0.75	0.00307	2.135	2.287
	KAFB-106116-150	140	149.45	0.75	0.00307	1.434	1.892
	KAFB-106116-250	240	249.45	0.75	0.00307	1.434	2.199
	KAFB-106116-350	340	349.45	0.75	0.00307	1.434	2.506
	KAFB-106116-450	440	448.95	3	0.04909	1.358	23.396

Table 1. Soil Vapor Monitoring Point Construction Parameters and Pre-Calculated Purge Volumes
Bulk Fuels Facility Area
Kirtland Air Force Base, Albuquerque, New Mexico

SVM Location ID	SVMP ID	Screened Interval (ft)		Well Diameter (in)	Casing Area (sq ft)	Filter Pack Volume (cu ft)[1]	Purge Volume (cu ft)
		Top	Bottom				
KAFB-106117	KAFB-106117-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106117-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106117-150	140	150	0.75	0.00307	1.517	1.978
	KAFB-106117-250	240	250	0.75	0.00307	1.517	2.284
	KAFB-106117-350	340	350	0.75	0.00307	1.517	2.591
	KAFB-106117-450	440	450	3	0.04909	1.517	23.607
KAFB-106118	KAFB-106118-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106118-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106118-160	150	160	0.75	0.00307	1.517	2.008
	KAFB-106118-265	255	265	0.75	0.00307	1.517	2.330
	KAFB-106118-350	340	350	0.75	0.00307	1.517	2.591
	KAFB-106118-450	440	450	3	0.04909	1.517	23.607
KAFB-106119	KAFB-106119-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106119-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106119-150	140	150	0.75	0.00307	1.517	1.978
	KAFB-106119-250	240	250	0.75	0.00307	1.517	2.284
	KAFB-106119-350	340	350	0.75	0.00307	1.517	2.591
	KAFB-106119-450	440	450	3	0.04909	1.517	23.607

Table 1. Soil Vapor Monitoring Point Construction Parameters and Pre-Calculated Purge Volumes
Bulk Fuels Facility Area
Kirtland Air Force Base, Albuquerque, New Mexico

SVM Location ID	SVMP ID	Screened Interval (ft)		Well Diameter (in)	Casing Area (sq ft)	Filter Pack Volume (cu ft)[1]	Purge Volume (cu ft)
		Top	Bottom				
KAFB-106120	KAFB-106120-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106120-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106120-150	140	150	0.75	0.00307	1.517	1.978
	KAFB-106120-250	240	250	0.75	0.00307	1.517	2.284
	KAFB-106120-350	340	350	0.75	0.00307	1.517	2.591
	KAFB-106120-450	434	444	3	0.04909	1.517	23.312
KAFB-106121	KAFB-106121-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106121-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106121-145	135	145	0.75	0.00307	1.517	1.962
	KAFB-106121-250	240	250	0.75	0.00307	1.517	2.284
	KAFB-106121-350	340	350	0.75	0.00307	1.517	2.591
	KAFB-106121-440	434	444	3	0.04909	1.517	23.312
KAFB-106122	KAFB-106122-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106122-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106122-150	140	150	0.75	0.00307	1.517	1.978
	KAFB-106122-250	240	250	0.75	0.00307	1.517	2.284
	KAFB-106122-350	340	350	0.75	0.00307	1.517	2.591
	KAFB-106122-450	434	444	3	0.04909	1.517	23.312

Table 1. Soil Vapor Monitoring Point Construction Parameters and Pre-Calculated Purge Volumes
Bulk Fuels Facility Area
Kirtland Air Force Base, Albuquerque, New Mexico

SVM Location ID	SVMP ID	Screened Interval (ft)		Well Diameter (in)	Casing Area (sq ft)	Filter Pack Volume (cu ft)[1]	Purge Volume (cu ft)
		Top	Bottom				
KAFB-106123	KAFB-106123-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106123-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106123-150	140	150	0.75	0.00307	1.517	1.978
	KAFB-106123-250	240	250	0.75	0.00307	1.517	2.284
	KAFB-106123-350	340	350	0.75	0.00307	1.517	2.591
	KAFB-106123-450	432	442	3	0.04909	1.517	23.214
KAFB-106124	KAFB-106124-025	15.1	25	0.75	0.00307	2.236	2.313
	KAFB-106124-050	40.1	50	0.75	0.00307	2.236	2.390
	KAFB-106124-150	140.1	150	0.75	0.00307	1.502	1.962
	KAFB-106124-250	240.1	250	0.75	0.00307	1.502	2.269
	KAFB-106124-350	340.1	350	0.75	0.00307	1.502	2.576
	KAFB-106124-450	440.1	450	3	0.04909	1.502	23.592
KAFB-106125	KAFB-106125-025	15.2	25	0.75	0.00307	2.214	2.291
	KAFB-106125-050	40.2	50	0.75	0.00307	2.214	2.367
	KAFB-106125-150	140.2	150	0.75	0.00307	1.487	1.947
	KAFB-106125-250	240.2	250	0.75	0.00307	1.487	2.254
	KAFB-106125-350	340.2	350	0.75	0.00307	1.487	2.561
	KAFB-106125-450	440.2	450	3	0.04909	1.487	23.576

Table 1. Soil Vapor Monitoring Point Construction Parameters and Pre-Calculated Purge Volumes
Bulk Fuels Facility Area
Kirtland Air Force Base, Albuquerque, New Mexico

SVM Location ID	SVMP ID	Screened Interval (ft)		Well Diameter (in)	Casing Area (sq ft)	Filter Pack Volume (cu ft)[1]	Purge Volume (cu ft)
		Top	Bottom				
KAFB-106126	KAFB-106126-025	15.1	25	0.75	0.00307	2.236	2.313
	KAFB-106126-050	40.1	50	0.75	0.00307	2.236	2.390
	KAFB-106126-150	140.1	150	0.75	0.00307	1.502	1.962
	KAFB-106126-250	240.1	250	0.75	0.00307	1.502	2.269
	KAFB-106126-350	340.1	350	0.75	0.00307	1.502	2.576
	KAFB-106126-450	440.2	450	3	0.04909	1.487	23.576
KAFB-106127	KAFB-106127-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106127-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106127-150	140	150	0.75	0.00307	1.517	1.978
	KAFB-106127-250	240	250	0.75	0.00307	1.517	2.284
	KAFB-106127-350	340	350	0.75	0.00307	1.517	2.591
	KAFB-106127-450	440	450	3	0.04909	1.517	23.607
KAFB-106128	KAFB-106128-025	15.04	25.04	0.75	0.00307	2.259	2.336
	KAFB-106128-050	40.07	50.07	0.75	0.00307	2.259	2.413
	KAFB-106128-150	140.19	150.19	0.75	0.00307	1.517	1.978
	KAFB-106128-250	240.29	250.29	0.75	0.00307	1.517	2.285
	KAFB-106128-350	340.39	350.39	0.75	0.00307	1.517	2.592
	KAFB-106128-450	440.06	450.06	3	0.04909	1.517	23.610

Table 1. Soil Vapor Monitoring Point Construction Parameters and Pre-Calculated Purge Volumes
Bulk Fuels Facility Area
Kirtland Air Force Base, Albuquerque, New Mexico

SVM Location ID	SVMP ID	Screened Interval (ft)		Well Diameter (in)	Casing Area (sq ft)	Filter Pack Volume (cu ft)[1]	Purge Volume (cu ft)
		Top	Bottom				
KAFB-106129	KAFB-106129-025	15.1	25.1	0.75	0.00307	2.259	2.336
	KAFB-106129-050	39.7	49.7	0.75	0.00307	2.259	2.412
	KAFB-106129-150	140.2	150.2	0.75	0.00307	1.517	1.978
	KAFB-106129-250	240.1	250.1	0.75	0.00307	1.517	2.285
	KAFB-106129-350	337.4	347.4	0.75	0.00307	1.517	2.583
	KAFB-106129-450	440.7	450.7	3	0.04909	1.517	23.641
KAFB-106130	KAFB-106130-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106130-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106130-150	150	160	0.75	0.00307	1.517	2.008
	KAFB-106130-250	240	250	0.75	0.00307	1.517	2.284
	KAFB-106130-350	340	350	0.75	0.00307	1.517	2.591
	KAFB-106130-450	440	450	3	0.04909	1.517	23.607
KAFB-106131	KAFB-106131-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106131-055	45	55	0.75	0.00307	2.259	2.428
	KAFB-106131-150	140	150	0.75	0.00307	1.517	1.978
	KAFB-106131-245	235	245	0.75	0.00307	1.517	2.269
	KAFB-106131-350	340	350	0.75	0.00307	1.517	2.591
	KAFB-106131-450	430	440	3	0.04909	1.517	23.116

Table 1. Soil Vapor Monitoring Point Construction Parameters and Pre-Calculated Purge Volumes
Bulk Fuels Facility Area
Kirtland Air Force Base, Albuquerque, New Mexico

SVM Location ID	SVMP ID	Screened Interval (ft)		Well Diameter (in)	Casing Area (sq ft)	Filter Pack Volume (cu ft)[1]	Purge Volume (cu ft)
		Top	Bottom				
KAFB-106132	KAFB-106132-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106132-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106132-175	164	174	0.75	0.00307	1.517	2.051
	KAFB-106132-250	240	250	0.75	0.00307	1.517	2.284
	KAFB-106132-350	340	350	0.75	0.00307	1.517	2.591
	KAFB-106132-450	440	450	3	0.04909	1.517	23.607
KAFB-106133	KAFB-106133-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106133-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106133-170	160	170	0.75	0.00307	1.517	2.039
	KAFB-106133-250	240	250	0.75	0.00307	1.517	2.284
	KAFB-106133-350	339	349	0.75	0.00307	1.517	2.588
	KAFB-106133-450	439	449	3	0.04909	1.517	23.558
KAFB-106134	KAFB-106134-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106134-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106134-170	160	170	0.75	0.00307	1.517	2.039
	KAFB-106134-250	240	250	0.75	0.00307	1.517	2.284
	KAFB-106134-350	340	350	0.75	0.00307	1.517	2.591
	KAFB-106134-450	440	450	3	0.04909	1.517	23.607

Table 1. Soil Vapor Monitoring Point Construction Parameters and Pre-Calculated Purge Volumes
Bulk Fuels Facility Area
Kirtland Air Force Base, Albuquerque, New Mexico

SVM Location ID	SVMP ID	Screened Interval (ft)		Well Diameter (in)	Casing Area (sq ft)	Filter Pack Volume (cu ft)[1]	Purge Volume (cu ft)
		Top	Bottom				
KAFB-106135	KAFB-106135-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106135-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106135-150	140	150	0.75	0.00307	1.517	1.978
	KAFB-106135-250	240	250	0.75	0.00307	1.517	2.284
	KAFB-106135-350	340	350	0.75	0.00307	1.517	2.591
	KAFB-106135-450	440	450	3	0.04909	1.517	23.607
KAFB-106136	KAFB-106136-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106136-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106136-150	140	150	0.75	0.00307	1.517	1.978
	KAFB-106136-250	240	250	0.75	0.00307	1.517	2.284
	KAFB-106136-350	340	350	0.75	0.00307	1.517	2.591
	KAFB-106136-450	440	450	3	0.04909	1.517	23.607
KAFB-106137	KAFB-106137-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106137-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106137-150	140	150	0.75	0.00307	1.517	1.978
	KAFB-106137-250	240.1	250.1	0.75	0.00307	1.517	2.285
	KAFB-106137-350	340.5	350.5	0.75	0.00307	1.517	2.593
	KAFB-106137-450	440	450	3	0.04909	1.517	23.607

Table 1. Soil Vapor Monitoring Point Construction Parameters and Pre-Calculated Purge Volumes
Bulk Fuels Facility Area
Kirtland Air Force Base, Albuquerque, New Mexico

SVM Location ID	SVMP ID	Screened Interval (ft)		Well Diameter (in)	Casing Area (sq ft)	Filter Pack Volume (cu ft)[1]	Purge Volume (cu ft)
		Top	Bottom				
KAFB-106138	KAFB-106138-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106138-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106138-150	140	150	0.75	0.00307	1.517	1.978
	KAFB-106138-250	240	250	0.75	0.00307	1.517	2.284
	KAFB-106138-350	340	350	0.75	0.00307	1.517	2.591
	KAFB-106138-450	440	450	3	0.04909	1.517	23.607
KAFB-106139	KAFB-106139-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106139-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106139-150	140	150	0.75	0.00307	1.517	1.978
	KAFB-106139-250	240	250	0.75	0.00307	1.517	2.284
	KAFB-106139-350	340	350	0.75	0.00307	1.517	2.591
	KAFB-106139-450	440	450	3	0.04909	1.517	23.607
KAFB-106140	KAFB-106140-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106140-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106140-150	141.8	151.8	0.75	0.00307	1.517	1.983
	KAFB-106140-250	240	250	0.75	0.00307	1.517	2.284
	KAFB-106140-350	340	350	0.75	0.00307	1.517	2.591
	KAFB-106140-450	440	450	3	0.04909	1.517	23.607

Table 1. Soil Vapor Monitoring Point Construction Parameters and Pre-Calculated Purge Volumes
Bulk Fuels Facility Area
Kirtland Air Force Base, Albuquerque, New Mexico

SVM Location ID	SVMP ID	Screened Interval (ft)		Well Diameter (in)	Casing Area (sq ft)	Filter Pack Volume (cu ft)[1]	Purge Volume (cu ft)
		Top	Bottom				
KAFB-106141	KAFB-106141-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106141-050	50	60	0.75	0.00307	2.259	2.443
	KAFB-106141-170	160	170	0.75	0.00307	2.259	2.781
	KAFB-106141-250	240	250	0.75	0.00307	2.259	3.026
	KAFB-106141-350	340	350	0.75	0.00307	2.259	3.333
	KAFB-106141-450	440	450	3	0.04909	2.259	24.348
KAFB-106142	KAFB-106142-030	20	30	0.75	0.00307	2.259	2.351
	KAFB-106142-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106142-170	160	170	0.75	0.00307	2.259	2.781
	KAFB-106142-250	240	250	0.75	0.00307	2.259	3.026
	KAFB-106142-350	340	350	0.75	0.00307	2.259	3.333
	KAFB-106142-450	440	450	3	0.04909	2.259	24.348

[1]borehole casing factor = (((10 inch diameter/12 inches)^2)(3.14159/4))(0.3 porosity) = 0.1636

[2]SVMW-08-266 is clogged and cannot be sampled

APPENDIX E

Water Supply Well Monitoring SOP

Standard Operating Procedure

SWMU ST-106/SS-111 Water Supply Well Monitoring

This standard operating procedure (SOP) describes requirements for drinking water supply well and private water supply well monitoring at solid waste management unit (SWMU) ST-106/SS-111 at Kirtland Air Force Base (AFB). All field personnel collecting groundwater samples from these locations are required to be trained and fully understand the sampling procedure outlined in this document.

1.1 Pre-Sampling Steps

1.1.1 Preparation for Water Supply Well Sampling

The following procedures apply to the preparation before purging of water supply wells:

- Don appropriate personal protective equipment, as outlined in the SSHP. In addition, samplers will don new sampling gloves at each individual well before beginning sampling.

- Visually examine the exterior of the well for signs of damage or tampering and record on the Sampling Log (Appendix A).

1.2 Water Supply Wells Sampling Procedures

1.2.1 Sampling of Water Supply Wells

Four drinking water supply wells will be sampled monthly as part of the ST-106/SS-111 investigation to confirm that they have not been impacted by groundwater contaminants. These wells include ST106-VA2 on VA Medical Center property, and KAFB-003, KAFB-015 and KAFB-016 on Kirtland AFB property.

In addition, private water supply well sampling will be performed quarterly on all private water supply wells within the vicinity of the ethylene dibromide (EDB) plume with consent of the well owner(s). Sampling procedures for private water supply wells will be the same as the sampling procedures for drinking water supply wells unless noted otherwise.

These existing drinking water supply wells at Kirtland AFB and the VA Medical Center actively provide drinking water to the facilities' employees and inhabitants. The private water supply wells actively supply water for domestic irrigation. Because the wells will be actively producing water during sampling, water levels at these wells will not be measured prior to sampling. In addition, one well volume will not be purged prior to sampling. Sampling at the drinking water supply wells will be performed in accordance with the following steps:

Step 1. A water quality instrument(s) will be used to collect field readings for dissolved oxygen (DO), pH, oxidation reduction potential (ORP), conductivity, turbidity, and temperature during sampling. Calibrate the multi-parameter instrument per the manufacturer's instructions for pH, ORP, conductivity, turbidity, and DO. Record the readings in a calibration log.

Step 2. Decontamination of the multi-parameter instrument will take place before use at each water supply well location. As described in the Work Plan.

Step 3. Place a bucket underneath the sample port at the wellhead, and open the sample port. Purge any water in the sample port for thirty seconds to ensure that any accumulated sediment is removed.

Step 4. For drinking water supply wells, fill the water quality instruments(s) from the sample port and take a baseline reading of DO, pH, ORP, conductivity, turbidity and temperature. Record these parameters on the sample collection log. For private water supply wells connect a flow through cell to the well head and record water quality parameters until three consecutive readings are taken within 10% of each other for DO, pH, ORP, conductivity, turbidity and temperature. Record all readings on sample collection logs.

Step 5. Fill the water sample containers in accordance with requirements of the Quality Assurance Project Plan (QAPjP). Samples for volatile organic analysis will be collected first. The sample bottles will be carefully filled to avoid overflow and potential loss of preservative, and tapped so entrapment of air is minimized and no head space exists. If bubbles appear, the vial will be refilled or a new vial will be used if a sample preservative (e.g., hydrochloric acid) is used.

Step 6. Place analytical samples in a cooler and chill to 4 degrees Celsius (°C). Samples must be shipped to the appropriate laboratory within the appropriate holding time as listed in the project QAPP. The sample cooler must be shaded from direct sunlight immediately after collection.

Step 7. The field logbook, sample log sheet, labels, custody seals, and chain-of-custody forms will be filled out during sample collection.

Drinking water supply well and private water supply well samples will be shipped to TestAmerica laboratory in Savannah, GA, where they will be analyzed for the analytical parameters listed in the Work Plan.

1.2.2 Decontamination

Final decontamination of all equipment will take place in designated decontamination areas specific to the work activity and approved by Kirtland AFB. Water from decontamination will be managed as per the Work Plan.

The objective of field decontamination is to remove contaminants of concern from sampling, drilling, and other field equipment to concentrations that will not impact study objectives. Specifications for decontamination materials are as follows:

- Use a standard brand of phosphate-free laboratory detergent, preferably either liquid Liquinox® or powder Alconox®.

- Use tap water from a municipal water treatment system or use bottled drinking water for the wash. Soap and tap water will remove the gross contamination from the sampling equipment.

- Use deionized water for the final rinse of sampling equipment that has direct contact to the sampling medium (e.g., the non-dedicated pumps used to sample monitoring wells).

1.2.3 Sample Packaging and Shipping

Sample packaging and shipping requirements are designed to maintain sample integrity from the time a sample is collected until it is received at the analytical laboratory. All chain-of-custody forms, sample

labels, custody seals, and other sample documents will be completed as specified in the QAPjP. Specific procedures for packaging and shipping of environmental samples are presented below:

- A sample label, completed with indelible ink, will be attached to the sample bottle.
- A cooler will typically be used as a shipping container.
- In preparation for shipping samples, the drain plug will be taped shut so that no fluids, such as melted ice, will drain out of the cooler during shipment. A large plastic bag may be used as a liner for the cooler. Packing material, such as bubble wrap, will be placed in the bottom of the liner. Ice will be placed at the bottom of the cooler.
- The containers will be placed in the lined cooler. Cardboard separators or bubble wrap may be placed between the containers at the discretion of the shipper.
- All samples for chemical analysis must be shipped cooled to ≤ 6 degrees Celsius with ice. All samples will require icing before shipment. A temperature blank will be included in each shipment of water and soil samples.
- The liner will be taped closed, if used, and sufficient packing material will be used to prevent sample containers from making contact or rolling around during shipment.
- A copy of the chain-of-custody form will be placed inside the cooler.
- The cooler will be closed and taped shut with strapping tape (filament-type).
- Custody seals will be placed on the cooler. Clear tape will be placed over the custody seals to help prevent them from being accidentally torn or ripped off.
- The cooler of samples will be shipped via an overnight carrier. A copy of the shipping bill will be retained for the field records and sent electronically to the project chemist.

APPENDIX F

Field Forms

BORING/WELL CONSTRUCTION LOG

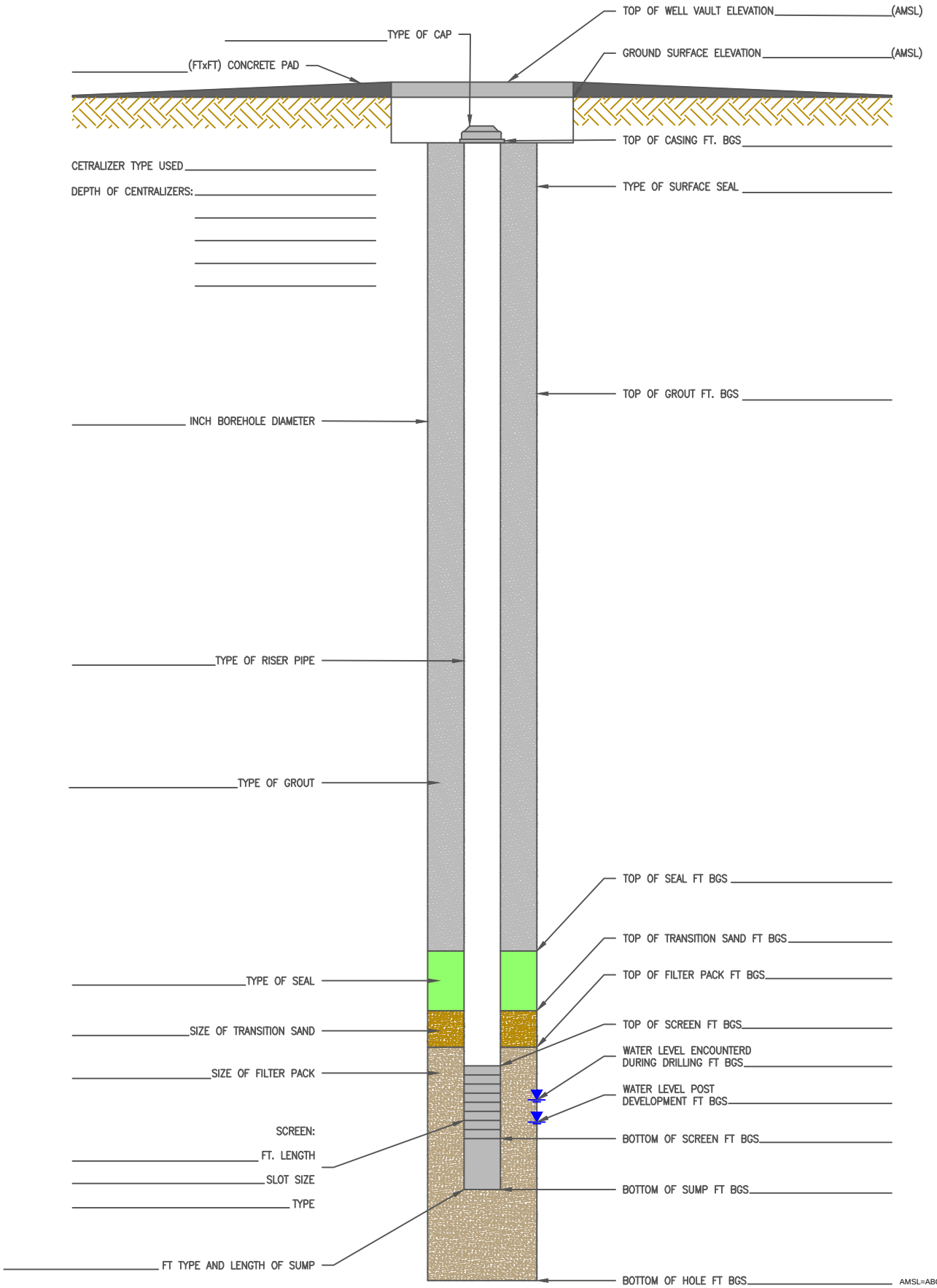
Project: **Kirtland BFF**	Project Number: **62599DM01.1017.04**
Drilling Company:	Start Time/Date:
Lead Driller:	Completion Time/Date:
Drilling Method:	Final Depth:
Casing Diameter OD:	Bit Type and Outer Diameter
Boring/Well ID:	Logged By: Page ___ of ____

		SAND		GRAVEL				
USCS Soil Type	**PID Reading (ppm)**	**Grain Size %(fine, medium, coarse)**	**Mineralogy %(Quartz, Feldspar, Lithic)**	**Angularity, Roundness (R,SR,SA,A)**	**Mineralogy %(Quartz, Feldspar, Lithic)**	**Depth, ft bgs**	**Soil Description** (sample interval, soil type, color, plasticity, moisture, other)	**Well Details**

Additional Comments:

R=Rounded, SR=Subrounded, SA=Subangular, A=Angular

FILE PATH AND NAME:



NOT TO SCALE
AMSL=ABOVE MEAN SEA LEVEL
BGS=BELOW GROUND SURFACE
FT=FEET

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC., PBC	**WELL COMPLETION DIAGRAM**	KIRTLAND AIR FORCE BASE	INSTALLATION START DATE/TIME:	INSTALLATION END DATE/TIME:
		PROJECT NO.:	WELL ID:	GEOLOGIST:	DRILLER:

FIELD RECORD OF WELL DEVELOPMENT

Project Name:	Project No:	Date/Time:
EA Personnel:	Development Method:	
Equipment Used:		Equipment Calibrated: Y N
Weather/Temperature/Barometric Pressure:		Date/Time:

Well No.:	Well Condition:
Well Diameter:	Measurement Reference:
Well Volume Calculations	
A. Depth To Water (ft):	D. Well Volume/ft:
B. Total Well Depth (ft):	E. Total Well Volume (gal)[C*D]:
C. Water Column Height (ft):	F. Five Well Volumes (gal):

Parameter	Beginning	1 Volume	2 Volumes	3 Volumes	4 Volumes	5 Volumes
Time (min)						
Depth to Water (ft)						
Purge Rate (gpm)						
Volume Purged (gal)						
pH (Δ<0.2)						
Temperature (°F) (Δ<10%)						
Conductivity (µmhos/cm) (Δ<10%)						
Turbidity (NTU) (<10 NTU*)						

Parameter	6 Volumes	7 Volumes	8 Volumes	9 Volumes	10 Volumes	End
Time (min)						
Depth to Water (ft)						
Purge Rate (gpm)						
Volume Purged (gal)						
pH (Δ<0.2)						
Temperature (°F) (Δ<10%)						
Conductivity (µmhos/cm) (Δ<10%)						
Turbidity (NTU) (<10 NTU*)						

NOTE: NTU = Nephelometric turbidity unit.
ORP = Oxidation-reduction potential.
* = If <10 NTU is not able to be achieved, <100 NTU is acceptable

Parameter stabilization requires four consecutive readings [four consecutive differences (Δ)] to meet parameter stabilization requirements listed.

COMMENTS AND OBSERVATIONS: _____

Kirtland AFB BFF Expansion Project # 62599DM01
Groundwater Well Inspection Form

Well ID: _____ **PID:** _____ ppm **Date:** _____

Stick up: ☐ **Flush Mount**: ☐

Well Pad Condition:	Below Grade ☐	Functional ☐	Repair Required ☐
Bollards:	Not Applicable ☐	Functional ☐	Repair Required ☐
Protective Casing:	Not Applicable ☐	Functional ☐	Repair Required ☐
Lock/Cover Bolt:	Not Applicable ☐	Functional ☐	Replacement Required ☐
Vault Threads:	Not Applicable ☐	Functional ☐	Cleaning Required ☐
Vault Cover:	Not Applicable ☐	Functional ☐	Repair Required (Excessive Corrosion on Threads) ☐
Vault Seal:	Missing ☐	Functional ☐	Replacement Required (Excessive Corrosion at Seal Surface) ☐
Water in Vault:	Yes ☐	No ☐	***If yes, Depth of Water***: _____ Ft.
Debris in Vault:	Yes ☐	No ☐	***If yes, Type of Debris***: _____
Pump Present:	Yes ☐	No ☐	***If no pump, J-Plug Present:*** Yes ☐ No ☐

Bennett Pump Inventory:

Drop Pipe Plug:	Missing ☐	Functional ☐	Replacement Required ☐
Exhaust Line Plug:	Missing ☐	Functional ☐	Replacement Required ☐
Pump Line Plug:	Missing ☐	Functional ☐	Replacement Required ☐
Well Sounder Plug:	Missing ☐	Functional ☐	Replacement Required ☐

Additional Comments: _____

_____

_____

_____

_____

Work Performed: _____

_____

_____

Photographs of Damaged/Missing Parts Taken: Yes ☐

Recorded By: _____

For serious problems, contact Earl Morse at (505) 238-4410

Well Gauging Form Team 1

2016

Project: Kirtland AFB BFF ST-106/SS-111

Quarter : 3rd

Well ID	Previous DTW 2016 Q2 (ft MRP)		Date	Depth to NAPL (ft MRP)	DTW (ft MRP)	Initials	Barricades	Reference Point
	Depth to NAPL	DTW (ft MRP)						
KAFB-106231*	-	459.50					Barricades by SWSS	TWV
KAFB-106232*	-	458.94					Barricades by SWSS	TWV
KAFB-106029*	-	442.80					Barricades by SWSS	TWV
KAFB-106030*	-	442.95					Barricades by SWSS	TWV
KAFB-106031*	-	443.01					Barricades by SWSS	TWV
KAFB-106021*	-	446.31					Barricades by SWSS	TWV

*** Gauge while sampling** ***SWSS (George Thompson 505-873-0044)**

Well Gauging Form Team 2

7/11/2016

Project: Kirtland AFB BFF ST-106/SS-111

Quarter : 3rd

Well ID	Previous DTW 2016 Q2 (ft MRP)		Date	Depth to NAPL (ft MRP)	DTW (ft MRP)	Initials	Contact	Reference Point
	Depth to NAPL	DTW (ft MRP)						
KAFB-106032	-	449.27					Gibson Med. Ctr.	TWV
KAFB-106033	-	449.43					Gibson Med. Ctr.	TWV
KAFB-106034	-	450.26					Gibson Med. Ctr.	TWV
KAFB-106105	-	454.26						TWV
KAFB-106106	-	454.13						TWV
KAFB-106107	-	455.35						TWV
KAFB-106042	-	456.22						TWV
KAFB-106043	-	456.49						TWV
KAFB-106219	-	472.25					Barricades by SWSS	TWV
KAFB-106220	-	472.08					Barricades by SWSS	TWV
KAFB-106221	-	471.78					Barricades by SWSS	TWV
KAFB-106222	-	465.47						TWV
KAFB-106223	-	466.11						TWV
KAFB-106224	-	467.20						TWV
KAFB-106204	-	464.75						TWV
KAFB-106205	-	464.87						TWV
KAFB-106206	-	465.25						TWV
KAFB-106207	-	475.49						TWV
KAFB-106208	-	475.11						TWV
KAFB-106209	-	474.46						TWV
KAFB-106230	-	456.88						TWV
KAFB-106225	-	459.04						TWV
KAFB-106226	-	459.60						TWV
KAFB-106227	-	460.36						TWV

***Gibson Med. Ctr. (Nadine Martinez-Daskalos 505-270-6801) *SWSS (George Thompson 505-873-0044)**

Well Gauging Form Team 2

7/12/2016

Project: Kirtland AFB BFF ST-106/SS-111

Quarter : 3rd

Well ID	Previous DTW 2016 Q2 (ft MRP)		Date	Depth to NAPL (ft MRP)	DTW (ft MRP)	Initials	Barricades	Reference Point
	Depth to NAPL	DTW (ft MRP)						
KAFB-106013	-	482.13					Call VA Police	TOPC
KAFB-106097	-	479.07					Call VA Police	TWV
KAFB-106098	-	479.16					Call VA Police	TWV
KAFB-106020	-	472.55					Call VA Police	TWV
KAFB-106004	-	476.95					EA Barricade	TOPC
KAFB-106099	-	474.94					EA Barricade	TWV
KAFB-106100	-	474.02					EA Barricade	TWV
KAFB-106091	-	447.37						TWV
KAFB-106092	-	447.78						TWV
KAFB-106093	-	447.18						TWV
KAFB-106212	-	454.51					Church	TWV
KAFB-106035	-	454.18					(Church)	TWV
KAFB-106036	-	454.53					(Church)	TWV
KAFB-106037	-	454.99					(Church)	TWV
KAFB-106055	-	457.23						TWV
KAFB-106057	-	457.60						TWV
KAFB-106058	-	458.10						TWV
KAFB-106052	-	451.03						TWV
KAFB-106053	-	450.93						TWV
KAFB-106054	-	450.50						TWV
KAFB-106025	-	449.22						TWV
KAFB-106049	-	448.18						TWV
KAFB-106050	-	447.40						TWV
KAFB-106051	-	447.68						TWV

***VA Police (LT. Butts 505-991-6504)** *** Church- enter church office through east side of building and ask**

Well Gauging Form Team 2

7/13/2016

Project: Kirtland AFB BFF ST-106/SS-111

Quarter : 3rd

Well ID	Previous DTW 2016 Q2 (ft MRP)		Date	Depth to NAPL (ft MRP)	DTW (ft MRP)	Initials	Barricades	Reference Point
	Depth to NAPL	DTW (ft MRP)						
KAFB-106216	-	466.21						TWV
KAFB-106217	-	465.86						TWV
KAFB-106218	-	466.01						TWV
KAFB-106213	-	457.87						TWV
KAFB-106214	-	457.70						TWV
KAFB-106215	-	457.76						TWV
KAFB-106022	-	450.40						TWV
KAFB-106085	-	449.31						TWV
KAFB-106086	-	449.63						TWV
KAFB-106087	-	448.85						TWV
KAFB-106070	-	450.82						TWV
KAFB-106071	-	453.01						TWV
KAFB-106072	-	451.31						TWV
KAFB-106088	-	456.49						TWV
KAFB-106089	-	456.21						TWV
KAFB-106090	-	455.02						TWV
KAFB-106103	-	460.96						TWV
KAFB-106104	-	460.40						TWV
KAFB-106023	-	460.69						TWV
KAFB-106038	-	483.61						TOPC
KAFB-106039	-	483.43						TOPC
KAFB-106040	-	482.38						TOPC

Well Gauging Form Team 3

7/11/2016

Project: Kirtland AFB BFF ST-106/SS-111

Quarter : 3rd

Well ID	Previous DTW 2016 Q2 (ft MRP)		Date	Depth to NAPL (ft MRP)	DTW (ft MRP)	Initials	Barricades	Reference Point
	Depth to NAPL	DTW (ft MRP)						
KAFB-106007	-	481.34						TOPC
KAFB-106027	-	480.05						TOPC
KAFB-106044	-	480.18						TOPC
KAFB-106045	-	479.88						TOPC
KAFB-106016	-	473.76						TOPC
KAFB-3411	-	475.23						TOPC
KAFB-106001	-	476.45						TWV
KAFB-106024	-	475.13						TWV
KAFB-106002	-	473.50						TWV
KAFB-106003	-	471.70						TWV
KAFB-106101	-	471.70						TOPC
KAFB-106102	-	471.81						TOPC
KAFB-106015	-	474.56						TOPC
KAFB-106201	-	488.47						TOPC
KAFB-106202	-	489.15						TOPC
KAFB-106203	-	489.19						TOPC

Well Gauging Form Team 3

7/12/2016

Project: Kirtland AFB BFF ST-106/SS-111

Quarter : 3rd

Well ID	Previous DTW 2016 Q2 (ft MRP)		Date	Depth to NAPL (ft MRP)	DTW (ft MRP)	Initials	Barricades	Reference Point
	Depth to NAPL	DTW (ft MRP)						
KAFB-106073	-	471.39					Call VA Police	TWV
KAFB-106074	-	472.14					Call VA Police	TWV
KAFB-106075	-	472.07					Call VA Police	TWV
KAFB-106082	-	467.07					Call VA Police	TWV
KAFB-106083	-	466.78					Call VA Police	TWV
KAFB-106084	-	469.60					Call VA Police	TWV
KAFB-106018	-	467.94						TOPC
KAFB-106046	-	484.73					EA Barricade	TWV
KAFB-106047	-	484.79					EA Barricade	TWV
KAFB-106048	-	484.51					EA Barricade	TWV
KAFB-106017	-	474.55						TOPC
KAFB-106019	-	486.60						TOPC
KAFB-106094	-	476.73						TWV
KAFB-106095	-	476.10						TWV
KAFB-106096	-	476.71						TWV
KAFB-106067	-	479.28						TWV
KAFB-106068	-	479.04						TWV
KAFB-106069	-	478.87						TWV
KAFB-106065	-	480.52						TWV
KAFB-106066	-	480.69						TWV
KAFB-106012-R	-	476.61						TOPC
KAFB-106009	-	479.97						TWV

***VA Police (LT. Butts 505-991-6504)**

Well Gauging Form Team 3

7/13/2016

Project: Kirtland AFB BFF ST-106/SS-111

Quarter : 3rd

Well ID	Previous DTW 2016 Q2 (ft MRP)		Date	Depth to NAPL (ft MRP)	DTW (ft MRP)	Initials	Barricades	Reference Point
	Depth to NAPL	DTW (ft MRP)						
KAFB-106080	-	480.01						TOPC
KAFB-106081	-	481.15						TOPC
KAFB-106011	-	484.88						TOPC
KAFB-106062	-	483.82						TOPC
KAFB-106063	-	483.56						TOPC
KAFB-106060	-	476.93						TWV
KAFB-106061	-	476.91						TWV
KAFB-106006	-	482.97						TOPC
KAFB-106077	-	477.74						TWV
KAFB-106078	-	476.91						TWV
KAFB-106005	478.26	478.27						TOPC
KAFB-106079	-	481.40						TOPC
KAFB-106014	-	481.90						TOPC
KAFB-106064	-	482.73						TOPC
KAFB-106008	483.29	483.34						TOPC
KAFB-106059	-	479.31						TWV
KAFB-106076	476.80	476.81						TWV
KAFB-106010	-	474.98						TWV
KAFB-106028	-	480.58						TWV

HAZ Well Sounder

Passive Diffusion Water Sampling Data Sheet

Well Location ID: _____ ***Deployment***

Year:
Quarter:
Sample ID:

Well Information

Screen Interval Length (ft):

Well Depth: _____ ft MRP
Top of Screen: _____ ft MRP
Bottom of Screen: _____ ft MRP

Deployment Team: _____

Date Deployed: _____ **Time Deployed:** _____

PID: MiniRAE 3000 **Serial No:** _____

Water Level Meter: Solinst 500 ft **Serial No:** _____

PID Reading: _____ **ppm**

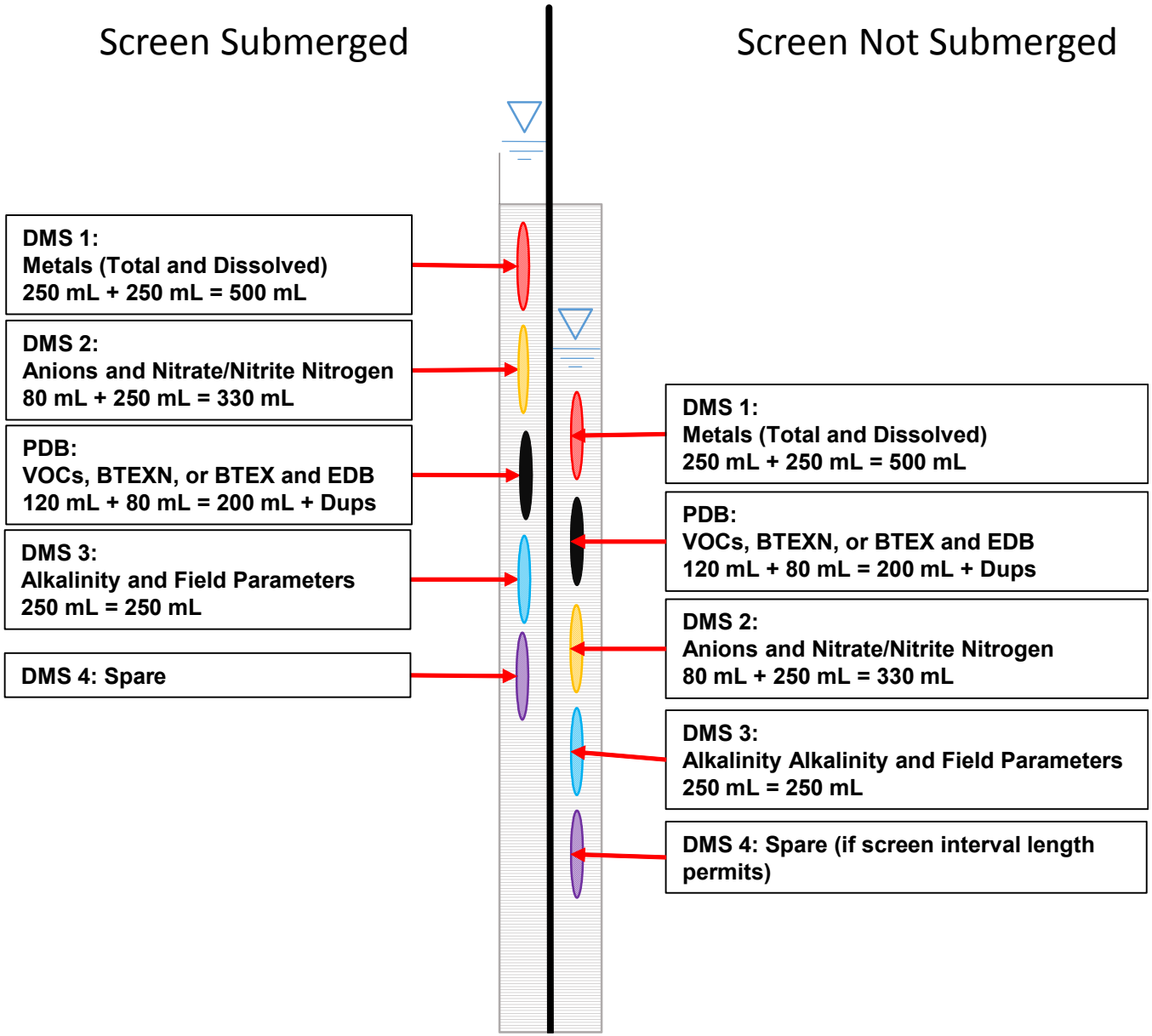
Depth to Water: _____

Notes: _____

Sampler Number: (shallow to deep)	Type of Sampler: (circle one type)	
1	DMS	PDB
2	DMS	PDB
3	DMS	PDB
4	DMS	PDB
5	DMS	PDB
6	DMS	PDB
7	DMS	PDB
8	DMS	PDB
9	DMS	PDB
10	DMS	PDB
11	DMS	PDB
12	DMS	PDB

Reviewed by: _____ Initials: _____

Review Date: _____



Reviewed by: _____ Initials: _____

Review Date: _____

Passive Diffusion Water Sampling Data Sheet

Well Location ID: _____ ***Sampling***

Year:
Quarter:
Sample ID:

Date Sampled: _____ **Time Sampled:** _____ **Sampling Team:** _____

Sampler Number:
(shallow to deep)

Type of Analysis (circle appropriate)

										Document in notes	
										Dup?	MS/MSD?
1	Metals (Total)	Metals (Dissolved)	Anions	Nitrate / Nitrite	VOCs	EDB	BTEX (N)	Alkalinity	Field Parameters	☐	☐
2	Metals (Total)	Metals (Dissolved)	Anions	Nitrate / Nitrite	VOCs	EDB	BTEX (N)	Alkalinity	Field Parameters	☐	☐
3	Metals (Total)	Metals (Dissolved)	Anions	Nitrate / Nitrite	VOCs	EDB	BTEX (N)	Alkalinity	Field Parameters	☐	☐
4	Metals (Total)	Metals (Dissolved)	Anions	Nitrate / Nitrite	VOCs	EDB	BTEX (N)	Alkalinity	Field Parameters	☐	☐
5	Metals (Total)	Metals (Dissolved)	Anions	Nitrate / Nitrite	VOCs	EDB	BTEX (N)	Alkalinity	Field Parameters	☐	☐

pH, Conductivity, ORP, DO, Temperature: YSI Professional Plus Serial No: _____ Water Level Meter: Solinst 500 ft Serial No: _____

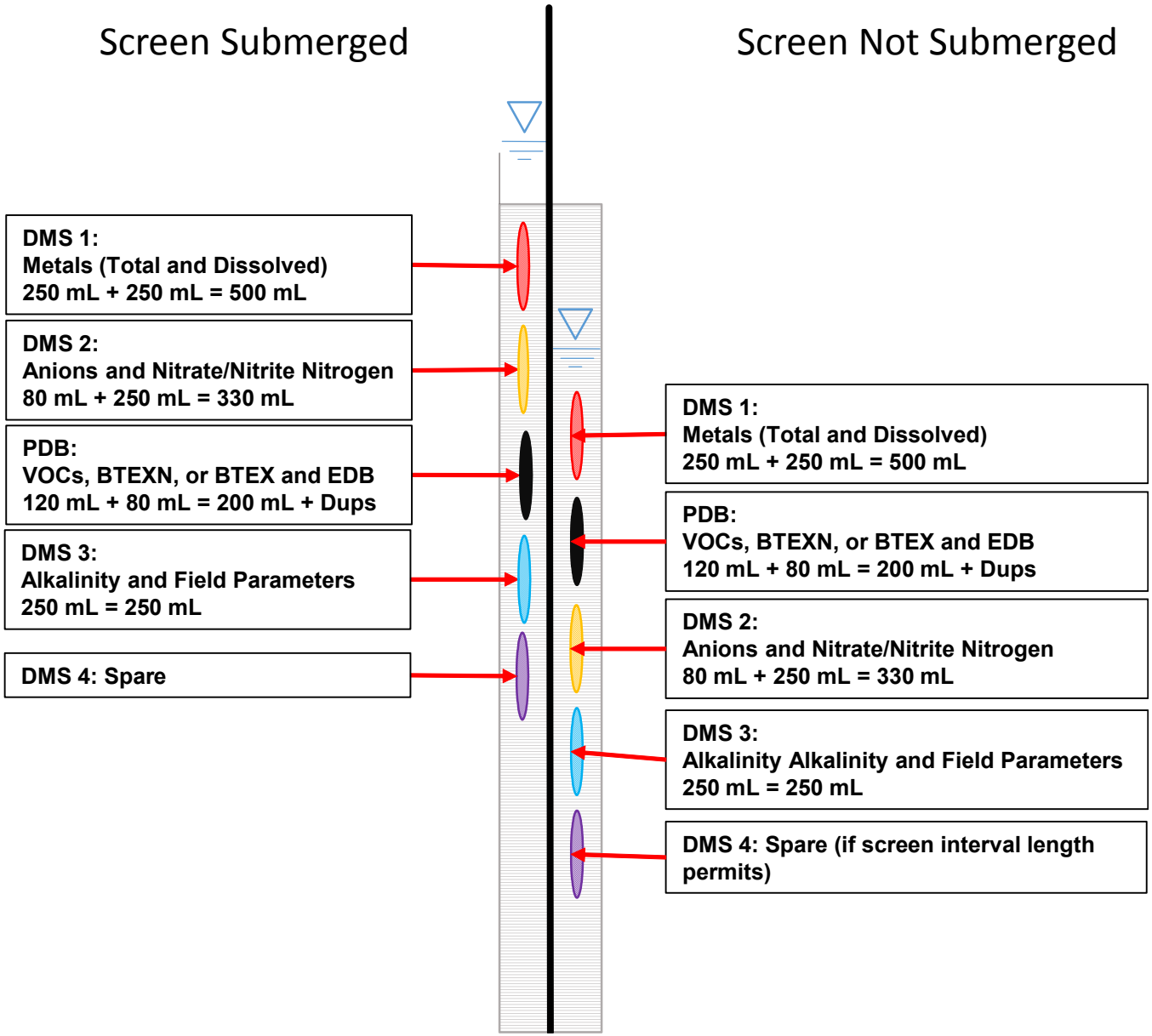
PID: MiniRAE 3000 Serial No: _____ Turbidity Meter: Hach 2100Q Serial No: _____

Time	Turbidity (NTU)	Temp. (°C)	Saturated DO (%)	DO (mg/L)	Specific Conductance (µS/cm)	pH	ORP (mV)
Historical Data:							

Notes: _____

Sample ID: _____
Duplicate ID: (if applicable) _____
COC#: _____

Reviewed by: _____ Initials: _____ Review Date: _____



Reviewed by: _____ Initials: _____

Review Date: _____

YSI Professional Plus Log

Serial # **15K101396** **(WH0001)**

Year: 2016

Project: Kirtland AFB BFF ST-106/SS-111

Quarter : 3rd

Date	Cal or Bump	pH 4.00	pH 7.00	pH 10.00	ORP (220 mV)	Conductivity (1413 µS/cm)	Measured DO (% Sat)	Barometer (mm Hg)	100% DO Sat Adjusted for Barometric Pressure	Initials
Calibration Tolerances:		+/- 0.2 pH Units			+/- 20 mV Standard	+/- 0.5% of Standard	+/- 2% of the Adjusted DO Value	N/A	N/A	N/A

* Calibrate all parameters weekly. Bump check all parameters daily and re-calibrate if values are out of tolerance.

* 100% DO Sat =100 x (Barometric Pressure in mmHg/760)

YSI Professional Plus Log

Serial # **15L100541** **(WH0002)**

Year: 2016

Project: Kirtland AFB BFF ST-106/SS-111

Quarter : 3nd

Date	Cal or Bump	pH 4.00	pH 7.00	pH 10.00	ORP (220 mV)	Conductivity (1413 µS/cm)	Measured DO (% Sat)	Barometer (mm Hg)	100% DO Sat Adjusted for Barometric Pressure	Initials
Calibration Tolerances:		+/- 0.2 pH Units			+/- 20 mV Standard	+/- 0.5% of Standard	+/- 2% of the Adjusted DO Value	N/A	N/A	N/A

* Calibrate all parameters weekly. Bump check all parameters daily and re-calibrate if values are out of tolerance.

* 100% DO Sat =100 x (Barometric Pressure in mmHg/760)

YSI Professional Plus Log

Serial # **15K101398** **(WH0003)**

Year: 2016

Project: Kirtland AFB BFF ST-106/SS-111

Quarter : 3rd

Date	Cal or Bump	pH 4.00	pH 7.00	pH 10.00	ORP (220 mV)	Conductivity (1413 µS/cm)	Measured DO (% Sat)	Barometer (mm Hg)	100% DO Sat Adjusted for Barometric Pressure	Initials
Calibration Tolerances:		+/- 0.2 pH Units			+/- 20 mV Standard	+/- 0.5% of Standard	+/- 2% of the Adjusted DO Value	N/A	N/A	N/A

* Calibrate all parameters weekly. Bump check all parameters daily and re-calibrate if values are out of tolerance.

* 100% DO Sat =100 x (Barometric Pressure in mmHg/760)

Rae Systems MiniRAE 3000 PID Log

Serial # 592-915790 (WH0004)

Year: 2016

Project: Kirtland AFB BFF ST-106/SS-111

Quarter : 3rd

Date	Cal or Bump	0 ppm	100 ppm	Initials
Calibration Tolerances:		+/- 3% of standard value		N/A

* Calibrate all parameters weekly. Bump check all parameters daily and re-calibrate if values are out of tolerance.

Rae Systems MiniRAE 3000 PID Log

Serial # 592-915778 (WH0005)

Year: 2016

Project: Kirtland AFB BFF ST-106/SS-111

Quarter : 3rd

Date	Cal or Bump	0 ppm	100 ppm	Initials
Calibration Tolerances:		+/- 3% of standard value		N/A

* Calibrate all parameters weekly. Bump check all parameters daily and re-calibrate if values are out of tolerance.

Rae Systems MiniRAE 3000 PID Log

Serial # 592-915579 (WH0006)

Year: 2016

Project: Kirtland AFB BFF ST-106/SS-111

Quarter : 3rd

Date	Cal or Bump	0 ppm	100 ppm	Initials
Calibration Tolerances:		+/- 3% of standard value		N/A

* Calibrate all parameters weekly. Bump check all parameters daily and re-calibrate if values are out of tolerance.

Hach 2100Q Portable Turbidimeter Log

Serial # **15100C045025** **(WH0007)**

Year: 2016

Project: Kirtland AFB BFF ST-106/SS-111

Quarter : 3rd

Date	Bump or Cal	20 NTU	100 NTU	800 NTU	10 NTU	Initials
Calibration Tolerance:		+/- 10% of Standard Value				N/A

*Calibrate Instrument every three months, bump check weekly and re-calibrate if values are out of tolerance.

Hach 2100Q Portable Turbidimeter Log

Serial # **15100C045034** **(WH0008)**

Year: 2016

Project: Kirtland AFB BFF ST-106/SS-111

Quarter : 3rd

Date	Bump or Cal	20 NTU	100 NTU	800 NTU	10 NTU	Initials
Calibration Tolerance:		+/- 10% of Standard Value				N/A

*Calibrate Instrument every three months, bump check weekly and re-calibrate if values are out of tolerance.

Hach 2100Q Portable Turbidimeter Log

Serial # **15100C044633** **(WH0009)**

Year: 2016

Project: Kirtland AFB BFF ST-106/SS-111

Quarter : 3rd

Date	Bump or Cal	20 NTU	100 NTU	800 NTU	10 NTU	Initials
Calibration Tolerance:		+/- 10% of Standard Value				N/A

*Calibrate Instrument every three months, bump check weekly and re-calibrate if values are out of tolerance.

QRAE II Multi-Gas Detector Log

Serial # **181-217279** **(WH0027)**

Year: 2016

Project: Kirtland AFB BFF ST-106/SS-111

Quarter : 3rd

Date	Test	O_2 (18%)	CH_4 (2.5% [50% LEL])	H_2S (10 ppm)	CO (50 ppm)	Initials

Test: Mark if calibration or bump test was performed.

Refridgerator Temperature Log

Year: 2016

Project: Kirtland AFB BFF ST-106/SS-111

Quarter : 3rd

Date/Time	Temperature 1 (Internal 1)	Temperature 2 (Internal 2)	Date/Time	Temperature 1 (Internal 1)	Temperature 2 (Internal 2)

Test: Mark if calibration or bump test was performed.

Groundwater Purge and Sampling Log

Year: _____

Quarter: _____

Project: Kirtland AFB BFF ST-106/SS-111

Well ID: _____

Project No: 62599DM01

Samplers: _____

Date: _____

Crew Signature: _____

Well Information

Prior Well Status: Non-Hazardous Hazardous

Well Depth: _____ ft MRP

Prior Screen Status: Submerged Not Submerged

Top of Screen: _____ ft MRP

Barricade/Notification: ☐

Bottom of Screen: _____ ft MRP

Measurement Reference Point (MRP):

Water Bearing Zone: _____

IDW will be taken to:

IDW Label:

Protective Casing/Vault: Intact Damaged

Well Locked/Security Bolt Present: Yes No

Well ID Marked: Yes No

Photoionization Measurements at Wellhead: _____ ppm

LNAPL Present (circle one)? Yes No

LNAPL Thickness: _____ ft

Previous Depth to water: _____ ft MRP

Depth to Water (DTW): _____ ft MRP

Pump Information

Bennett Pump Serial No.: _____

Non-Dedicated Pump Depth: _____ ft MRP

* - if screen is submerged, place pump 2 ft below top of screen; if not submerged, place pump 2 ft above bottom of screen.

Field Instrumentation

pH, Conductivity, ORP, DO, Temperature: YSI Professional Plus — Serial No: _____

PID: MiniRAE 3000 — Serial No: _____

Water Level Meter: Solinst 500 ft — Serial No: _____

Turbidity Meter: Hach 2100Q — Serial No: _____

Sample Information

Sample ID: _____

Sampling Method: Low-flow

Duplicate ID: (if applicable) _____

Sampling Medium: Water

COC#: _____

Reviewed by: _____ Initials: _____ Review Date: _____

Groundwater Purge and Sampling Log

Year: _____

Quarter: _____

Project: Kirtland AFB BFF ST-106/SS-111 Well ID: _____

Purge Information and Field Parameter

Date: _____

Purge Start Time: _____ Purge Rate: _____ L/min X 0.265 = _____ gal/min

Description of first water purged: _____

Drawdown Limit: _____ ft (based on previous water level)

Time	Volume Purged (gal)	DTW (ft)	Turbidity (NTU)	Temp. (°C)	Saturated DO (%)	DO (mg/L)	Specific Conductance (µS/cm)	pH	ORP (mV)
Stabilization Requirements		-------	If >10,±10%	±10%	-------	±10%	±10%	±0.5	-------
Historical Data:									

Sample Time: _____ Sample Date: _____

Purge End Time: _____

Bubbles in the vials? ☐ Yes ☐ No Where? _____ Amount _____ Size _____

Sampled by: _____ Sampler Signature: _____

IDW Management

Drum No.	Estimated volume per IDW drum (gal)
1	
2	
Total	

IDW will be taken to: _____

IDW Label: _____

Comments: _____

Reviewed by: _____ Initials: _____ Review Date: _____

225 Schiling Circle Suite
400 Hunt Valley MD
Tel No: (410) 584-7000
Fax No. (410) 771-1625

CHAIN-OF-CUSTODY RECORD

COC NUMBER

PROJECT NAME: **Kirtland AFB Bulk Fuels Facility**	PROJECT NUMBER: **62599DM01**	LABORATORY NAME AND CONTACT: **Eurofins Lancaster Laboratories 2425 New Holland Pike Lancaster PA 17601**	FAX AND MAIL REPORTS/EDD TO: Tara Lamond: tlamond@eaest.com EA Amanda Smith: asmith@eaest.com EA FAX AND MAIL REPORTS/EDD TO: Pam Moss: pmoss@eaest.com EA
YEAR:	QUARTER:		
PROJECT SITE AND PHASE: ST106/SS110		LAB PO NUMBER: 14800	LAB CONTACT: Kay Hower KayHower@eurofinsUS.com Eurofins 1 (717) 556-7258

ANALYSIS REQUIRED (Specify number of bottles)

ITEM	SAMPLE IDENTIFIER	DATE COLLECTED	TIME COLLECTED	Total Number of Bottles	(8260C) VOCs	(8260C) BTEX	(8260C) BTEXN	(8011) EDB	(6020A/6010C) Total As,Pb,Ca,K,Na,Mg	(6010C) Dissolved Fe, Mn	(300.0) Chloride, bromide, sulfate	(353.2) Nitrate-Nitrite	(SM2320B) Alkalinity	COMMENTS
1										*				
2														
3														
4														
5														
6														

COMMENTS: *Dissolved Fe, Mn aliquot was field filtered.

SAMPLER(S):

COURIER AND SHIPPING NUMBER:

RELINQUISHED BY:	DATE	TIME	RECEIVED BY:	DATE	TIME
Printed Name and Signature:			Printed Name and Signature:		
Printed Name and Signature:			Printed Name and Signature:		
Printed Name and Signature:			Printed Name and Signature:		
Printed Name and Signature:			Printed Name and Signature:		

SAMPLE COOLER

SHIPPING CHECKLIST

Site Name: Kirtland BFF (62599DM01) **Date: _____**

Fedex Tracking Number: _____

Matrix: Groundwater **Lab:** Eurofins (Lancaster, PA)

Cooler Sealed: _____ (Time) **Delivered to FedEx:_____(Time)**

Sampler 1 (Initials)		Sampler 2 (Initials)
☐	**Two (2) Plastic Bag Liners Included**	☐
☐	**Temperature Blank Included at Bottom of Cooler Surrounded by Ice**	☐
☐	**Trip Blank Included (2 for EDB, 2 for BTEX if present)**	☐
☐	**Samples Checked Against Chain of Custody**	☐
☐	**Chain of Custody Originals Included**	☐
☐	**All Void Space in Cooler filled with Ice**	☐
☐	**Custody Seals On Plastic Bag Liner And Outside Of Cooler**	☐

(Print)Name:_____ **(Print)Name:_____**

Signature:_____ **Signature:_____**

Date/Time:_____ **Date/Time:_____**

COC's in Cooler:

_____

_____

_____

_____

Field Activity Log

Job Number:	Task Description:	Date:

Weather:	Important notes:	Sundance Employes on site	Visitors

Name:	Signature:	Date:

Field Activity Log (Continuation)

Page_____of_____

Job Number:	Task Description:	Date:

SVM Well Integrity Checklist

Well ID: _____ Inspector's Name: _____
Date: _____
Time: _____ Inspector's Signature:_____

Before opening well

1. Is well cement Pad in good condition? _____
2. Is lid securely tightened to vault?_____
3. Is well clearly labeled? _____
4. Do wells outside of BFF have security bolts?_____
5. Photograph well

After removing lid before sampling well

1. Is gasket worn or damaged? _____
2. Is vault flooded? _____
3. Are ports capped/labeled? _____
4. Are ports angled correctly? _____
5. Are all fittings and quick connects intact and operational?

   _____
6. Can you hear well breathing? _____
7. Photograph well with lid off

During sampling

1. Do all quick connects fit securely to sample system? _____
2. Does static pressure after purging return to initial static pressure within one minute?

   _____
3. Is well clogged? _____

Comments:_____

_____

Horiba Calibration Sheet

Horiba ID #:

	Know Gas Mixture			Initial Horiba Reading			Post Cal. Horiba Readings			Flow through readings			
Date/time	C3H8(ppm)	% CO2	% O2*	HC(ppm)	% CO2	% O2*	HC(ppm)	% CO2	% O2*	HC(ppm)	% CO2	% O2*	Initals
	1600	13	20.9										
	1600	13	20.9										
	1600	13	20.9										
	1600	13	20.9										
	1600	13	20.9										
	1600	13	20.9										
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	1600	13	20.9										
	1600	13	20.9										
	1600	13	20.9										

* = Atmosphric %O2 consentrations

Leak Test log

Date	Intital Vacuum reading	Time	Vacuum reading after 10 min.	Time	Initials

SVM Purge Log

Project Name: Bulk Fuels Facility

Project Location: Kirtland Air Force Base

Well ID/Port Depth: _____

Samplers: _____

Sampler Signature/Date :_____

Screened Interval: Top:_____(ft. b.g.s)
Bottom:_____(ft. b.g.s)

Is Well damaged/Flooded: Yes - No

If yes, describe: _____

Weather Observations _____

Pump ID:_____ Horiba ID: _____ Sample System ID: _____ Manometer ID: _____

Was the sample system purged of hydrocarbons before connection with well port: Yes - No

Initial Static Pressure (inWC) _____

A. Pre- Calculated purge volume (cu. ft) Located on well data sheet	(Ft^3)
B. Flow Rate (SCFM) On flowmeter for air pump	(SCFM)
C. Purge time (Min. and Sec.) 1. Equals A/B 2. Write down whole number as minute 3. Multiple decimal by 60 for seconds	

Post Purge Static Pressure (inWC) _____

Sample Date/Time	CO2 %	O2%	Actual Purge Time	Hydrocarbons (ppmv)

Comments: _____

Bottle Vac. Number:_____

Initial B.V. Pressure:_____

Sample ID: _____

Final B.V. Pressure: _____

Reviewed by (Name): _____

Reviewer (Signature/Date): _____

Soil Vapor Sample Collection Log

Date: _____

Time: _____

Project No.: __US01-023_____

C0C #: _____

Project Name: ___KAFB_Bulk Fuels Facility_____

Sample No.: _____

Sample Location: ___Kirtland AFB _____

Sample Type: ____GRAB_____

Composite: (Y/N) _____No_____

Sample Team: _____

Trip Blank: _____

Sample:

Analytical Suite	Preservative	Container	TAT	Initials
VOCs by TO-15, EDB by CARB 422, Air-Phase Petroleum Hydrocarbons by MA APH 1.0, and Fixed Gases (H2, CO, CO2, N2, CH4 and O2/Ar) by E3C.	None	One Liter Amber Glass	15 Days	

Comments:

_____

_____

_____

_____

Logged By: _____ **Reviewed By**: _____

TestAmerica Sacramento
880 Riverside Parkway

West Sacramento, CA 95605-1500
phone 916.373.5600 fax 303.467.7248

Canister Samples Chain of Custody Record

TestAmerica Laboratories, Inc. assumes no liability with respect to the collection and shipment of these samples.

TestAmerica THE LEADER IN ENVIRONMENTAL TESTING

TestAmerica Laboratories, Inc.

Client Contact Information	**Project Manager:**	**Samples Collected By:**	COC No:
Company Name:	**Phone:**		_______ of ______ COCs
Address:	**Email:**		
City/State/Zip			**For Lab Use Only:**
Phone:	**Site Contact:**		Walk-in Client:
FAX:	**TA Contact:**		Lab Sampling:
Project Name:	**Anaylsis Turnaround Time**		
Site/Location:	Standard (Specific):_________________		Job / SDG No.:
P O #	Rush (Specifiy):____________________		(See below for Add'l Items)

Sample Identification	**Sample Date(s)**	**Time Start**	**Time Stop**	**Canister Vacuum in Field, 'Hg (Start)'**	**Canister Vacuum in Field, 'Hg (Stop)'**	**Flow Controller ID**	**Canister ID**	**TO-15 (Med / Std / Low / SIM)**	**MA-APH**	**EPA 3C**	**EPA 25C / 25.3**	**ASTM D-1946 / 1945 / 3588**	**EPA 15/16**	**TO-3**	**Other** (Please specify in notes section)	***Sample Type***	**Indoor Air**	**Ambient Air**	**Soil Gas**	**Landfill Gas**	**Other** (Please specify in notes section)	**Sample Specific Notes:**

Temperature (Fahrenheit)			
Start	**Interior**	**Ambient**	
Stop			

Temperature (Fahrenheit)			
Start	**Interior**	**Ambient**	
Stop			

Special Instructions/QC Requirements & Comments:

Samples Shipped by:	**Date / Time:**	**Samples Received by:**
Samples Relinquished by:	**Date / Time:**	**Received by:**
Relinquished by:	**Date / Time:**	**Received by:**
Lab Use Only: **Shipper Name:**	**Opened by:**	**Condition:**

APPENDIX G

Definition of Land Survey Objective/Measuring Points and Land Survey Campaign among the Kirtland Air Force Base Monitoring Well Network

Definition of Land Survey Objective / Measuring Points and Land Survey Campaign among the Kirtland Air Force Base Monitoring Well Network

Prepared for:

Kirtland AFB Fuel Leak Remediation Project: Hydrogeology Working Group

Prepared by:

Paul H. Rydlund, PLS
Supervisory Hydrologist
U.S. Geological Survey – WMA

Stuart Norton, PhD
Hydrologist
U.S. Geological Survey – NMWSC

In collaboration with:

Devon E. Jercinovic, PG, PMP
Program Manager I
EA Engineering, Science and Technology, Inc., PBC

Richard P. Wells
Project Manager /Principal Environmental Scientist
AECOM

DRAFT

Introduction

At the request of the Air Force, the U.S. Geological Survey (USGS) has prepared the following standard operating procedure (SOP) and preliminary work plan for completing a survey of 400 monitoring wells within and nearby the Kirtland Air Force base in southeastern Albuquerque. Reconnaissance, field investigations, and Base-Wide Plans for the Environmental Restoration Program (USACE, 2004) reveal two (2) monitoring well platforms:

Stick-up

Stick-up platforms represent an 8-inch by 5-ft protective round steel casing and a 4-ft by 4-ft by 4-inch concrete pad mounded in such a way as to direct surface runoff from the casing (USACE, 2004). Steel bollards filled with concrete (4-inch by 5-ft) exist on the outside of the concrete pad. The stick-up configuration maintains 3-ft of exposed casing and protective steel bollards above ground and 2-ft of casing and protective steel bollards below ground.

Due to long-term potential for frost heave or movement of the shallow mounted casing or mounded concrete platform, the primary land survey objective point (PLSOP) will reside at the top of the casing pipe (TOC). Location of the PLSOP will be a notch or mark at the north end of the TOC. Subsequent land-survey objective point (LSOP) elevations will be measured by a fixed rule and a standard 3-ft level (or differential level survey equipment) as follows (fig.1):

1. Rule up to a notch or mark on the north side of the top of the protective casing (TOPC) or top of protective casing collar (TOPCC).

2. Rule down from the TOPC or TOPCC to an installed small metal concrete marker (fig.2) representing the top of the concrete pad (TCP). Installation of this marker should be offset a minimum radius of 6" from the protective casing. Marker should be installed on the northern-most side.

3. Level and rule down from the TCP to the ambient land surface (ALS) at (3) sides (northern-most/eastern-most/western-most) of the concrete pad. An average will be used as this measurement.

Figure 1. Stick-up monitoring well, land-survey objective point locations and measurement identification.

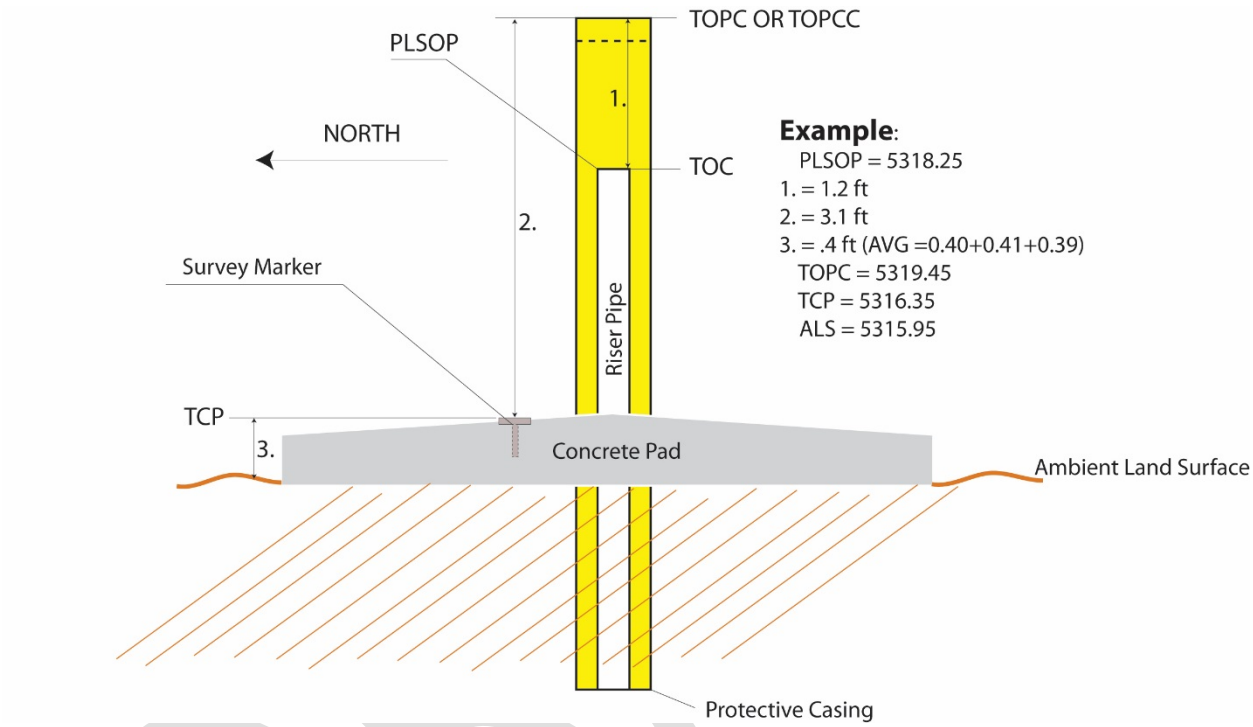


Figure 2a. Monument installation variations for independent origin per category I well cluster.

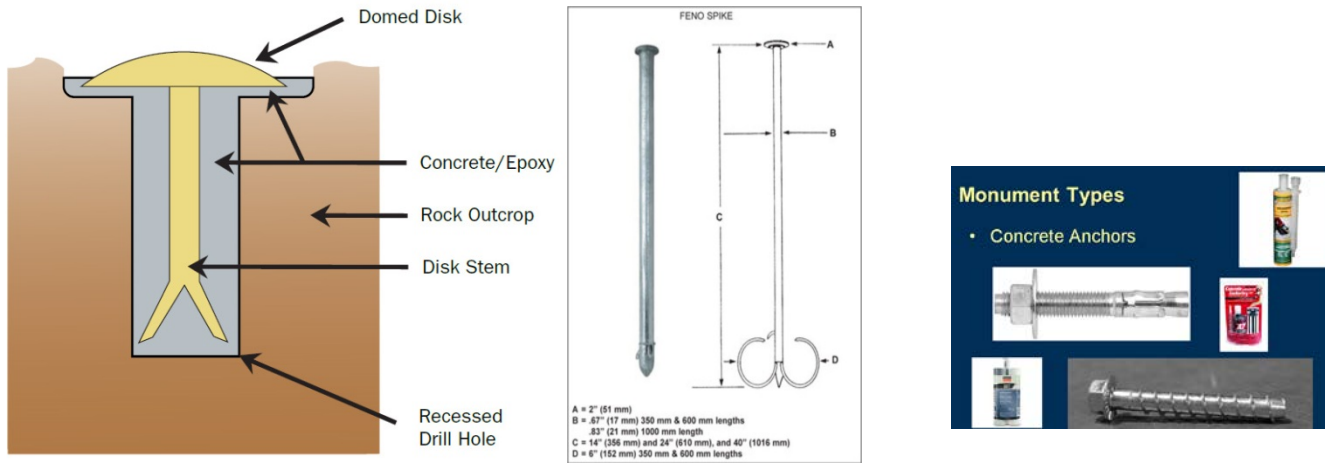
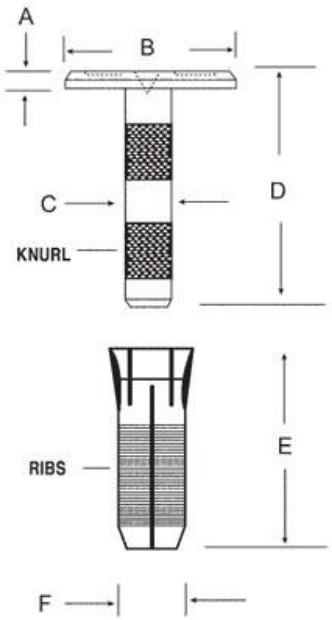


Figure 2b. Marker recommendation for top of concrete pad (TCP) installation. Bernsten, Inc., BP1-SM



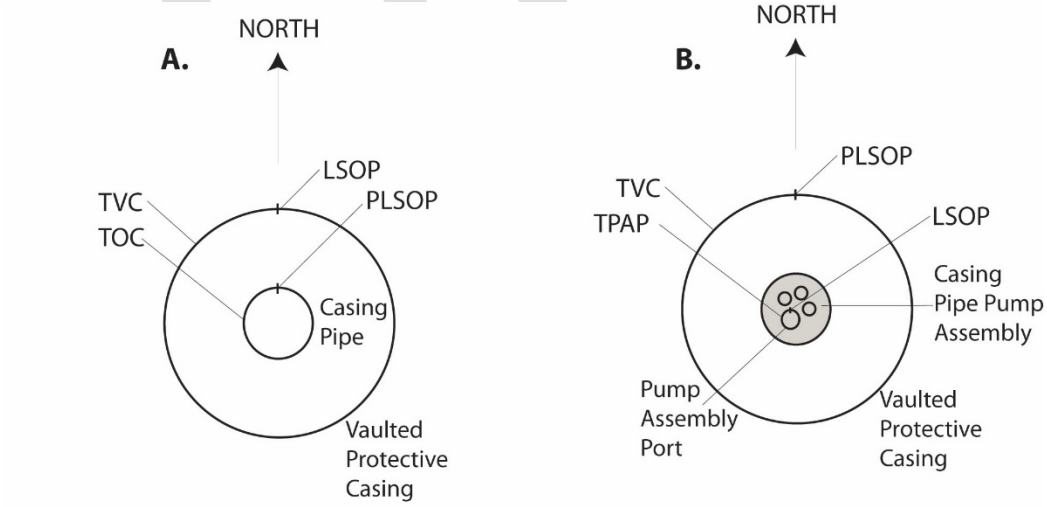
A = 1/8" (3 mm)
B = 1 5/32" (30 mm)
C = 21/64" (8 mm)
D = 1 11/16" (43 mm)
E = 1 7/16" (37 mm)
F = 29/64" (12 mm)

Flush Mount

Flush mount monitoring well platforms typically represent a 5-inch casing pipe inside of a 1-ft. vaulted casing. As a result of potential surface damage surrounding the flush mount well, the PLSOP will reside as a notch or mark on the north side of the top of the casing pipe (TOC) and a secondary LSOP will represent a notch or mark on the north end of the top of the vault casing (TVC) (fig.3). If a pump assembly is revealed in the casing pipe, a 1-inch threaded PVC cap is removed to reveal the pump assembly port. A notch or mark on the top (north side) of the pump assembly port (TPAP) will serve as the secondary LSOP and the TVC will serve as the PLSOP (fig.3).

For the flush mount configuration, the ALS elevation will be equal to the elevation of the TVC.

Figure 3. Flush mount monitoring well, land survey objective point identification for (A) casing pipe without a pump assembly and (B) casing pipe with pump assembly.

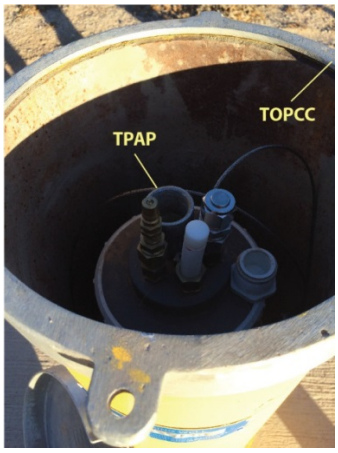


DRAFT

Special Case Monitoring Wells

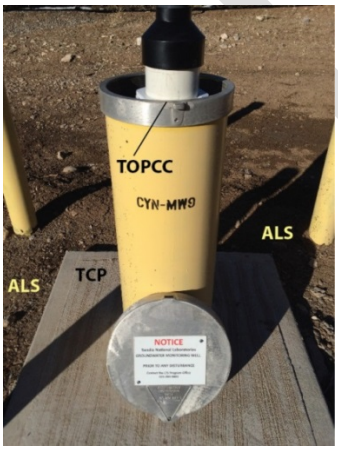
Stick-up wells with pump assemblies exist within the network at Kirtland AFB (fig.4). For this configuration, it is recommended the pump assembly be removed if possible prior to any survey campaign to expose the TOC and PLSOP thereof. If this is not feasible, the TOPC or TOPCC will provide the PLSOP. It is cautioned that potential long-term movement of the casing (TOPC) and/or independent movement of the collar (TOPCC) are not ideal for the PLSOP. Measurements made with fixed rule and level (or differential leveling equipment) are used to perpetuate elevation down to the TPAP in the well casing and installed marker serving as the TCP outside the casing. Similar to stick-up wells, the ALS (average) will be achieved by level and rule down (or differential leveling equipment) from the TCP to three (3) sides (northern-most/eastern-most/western-most) of the concrete pad.

Figure 4. Stick-up well with pump assembly



Another stick-up well with pump assembly configuration was recovered, ownership by Sandia National Laboratories within the network at Kirtland AFB (fig.5). For this configuration, it is recommended the pump assembly be removed if possible prior to any survey campaign to expose the TOC and PLSOP thereof. If this is not feasible, the TOPC or TOPCC will provide the PLSOP. Once again it is cautioned that potential long-term movement of the casing (TOPC) and/or independent movement of the collar (TOPCC) are not ideal for the PLSOP. Similar to the case demonstrated in fig.4, measurements made with fixed rule and level (or differential leveling equipment) are used to perpetuate elevation down to the installed marker serving as the TCP outside the casing. The ALS (average) will be achieved by level and rule down (or differential leveling equipment) from the TCP to three (3) sides (northern-most/eastern-most/western-most) of the concrete pad.

Figure 5. Stick-up well with pump assembly by Sandia



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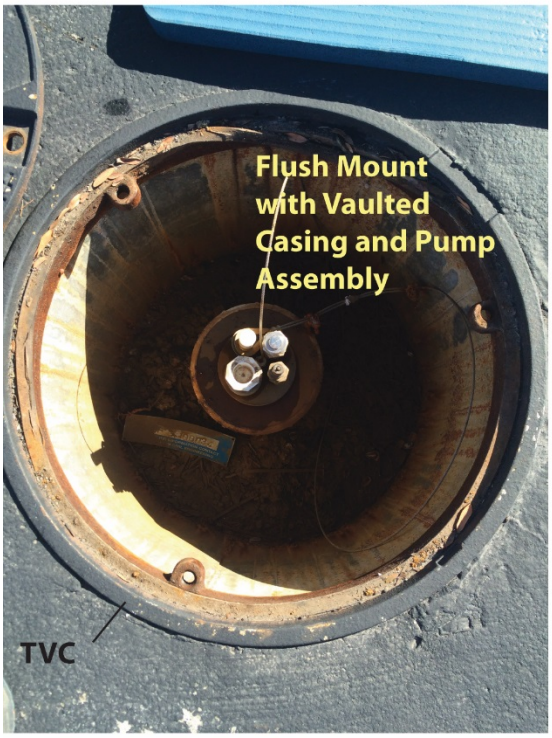
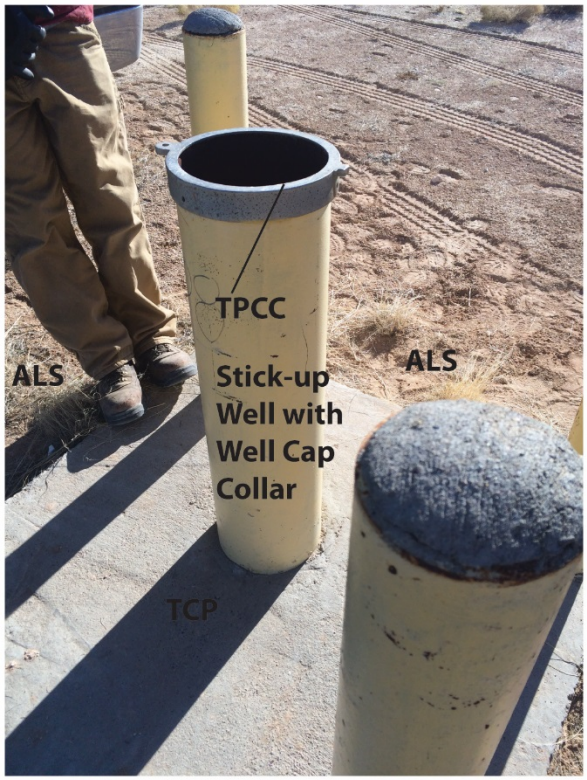
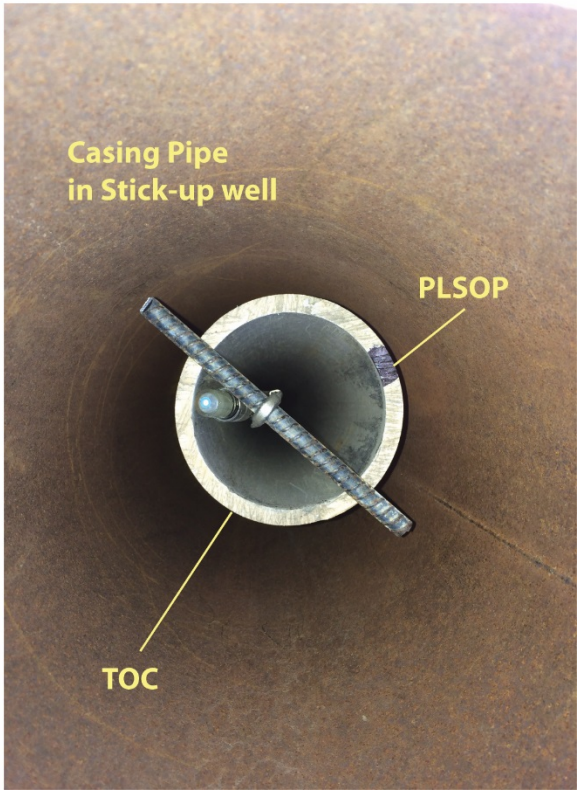
Appendix I. Example well configurations and LSOPs

Flush mount and stick up well examples with identified nomeclature







Acronyms

ERPIMS	Environmental Restoration Program Information Management System
ALS	Ambient land surface (also known within the USGS as the Land Surface Datum (LSD))
LSOP	Land-survey objective point
PLSOP	Primary land-survey objective point
TOPC	Top of protective casing
TOPCC	Top of protective casing collar
TOC	Top of casing pipe
TCP	Top of concrete pedestal
TVC	Top of vault casing
TPAP	Top of pump assembly port

Well Survey Campaign

Objective:

To establish accurate altitude among 400 monitoring wells within the Kirtland Air Force Base (KAFB), monitoring wells have been categorized based on their proximity to other wells and the expected groundwater potentiometric surface gradient. Monitoring wells have, therefore, been categorized into two representations. Category I wells includes groups or clusters of wells within close proximity and which, therefore, represent minimal groundwater potentiometric surface gradients. Category II wells represent wells that are more distal to one another with larger groundwater potentiometric surface gradients.

For the purpose of this survey, 328 wells have been grouped into 63 well clusters, identified herein as Category I wells (Table 1). The remaining 72 wells represent "stand alone" wells, identified herein as Category II wells. As a result of these two representations, the survey effort will be accomplished in two phases:

Phase I – Global Navigation Satellite System (GNSS)

Phase I includes the establishment of an estimated 135 benchmarks (monuments, rebar rods similar to that shown in fig. 2a), with 63 of these placed within the Category I well clusters and 72 of these located at the distal Category II wells. For each of the Category I well clusters and the distal Category II wells, one benchmark will be established with altitude derived by GNSS observation at an existing monument, a survey mark, or a newly established monument. Five (5) GNSS survey teams will approach this campaign with a Level II quality specification for altitude (Rydlund and Densmore, 2012). The grouping of wells into clusters will, in part, be based on findings in the field at the time of the GNSS survey.

Phase I efforts among the five teams will also include survey mark installations (fig.2b) at the TCP exclusively for stick-up platforms among the Category II wells (72) targeted for altitude. Level and fixed rule (or differential leveling equipment) measurements for both stick-up and flush mount platforms will occur at the category II (72) wells identified with altitude.

The location and placement of the benchmark monuments and survey markers, described above, will be based upon findings in the field. Benchmark monuments (fig. 2a) will only be installed within areas where below ground utilities have previously been cleared and, when working on the Kirtland Air Force base, a dig permit has been issued. Therefore, during Phase I, the GNSS crews will limit installation of new monuments to within the area included within the bollards located at the monitoring wells, as a dig permit has been issued for this area. If new monuments cannot be installed within the area included within the bollards located at the monitoring well, a survey mark (fig. 2b) will be installed at the monitoring well pad (or in other nearby concrete) and will be used as the benchmark, in lieu of a rebar rod monument. In the event that a suitable location for a benchmark monument or survey mark isn't identified during the Phase I field

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effort, the field crew may flag or mark a location outside the bollards for monument installation during Phase II, such that utilities may be cleared and a dig permit issued.

Required metadata for this effort is outlined in Rydlund and Densmore, 2012 for GNSS RT or Static surveys. All data will be stored electronically.

Phase II – Differential Leveling

Three hundred twenty eight (328) Category I wells, grouped into 63 well clusters, will have relative altitudes established by differential levels (Appendix I, Table 1). Monuments established within the 63 well clusters during Phase I, discussed above, will be used to perpetuate altitude with specifications outlined by Kenney, 2010.

Phase II efforts among these teams will also include survey mark installations (fig.2b) at the TCP exclusively for stick-up platforms among the category I (328) wells. Level and fixed rule (or differential leveling equipment) measurements for both stick-up and flush mount platforms will occur at all remaining wells to be leveled.

Required metadata for this effort is outlined in Kenny, 2010 and will be stored electronically.

A third phase will occur that includes processing, analysis, and summation of all survey data. Phase III will involve error analysis outlined by Rydlund and Densmore, 2012, for GNSS surveys and Kenny, 2010, for differential leveling. Results will be submitted to the Air Force in electronic (spreadsheet format).

Datum Specification:

- New Mexico State Plane Coordinate System, Central Zone, North American Datum of 1983
- Category I and II horizontal uncertainty at the PLSOP = <0.03'
- North American Vertical Datum 1988 (NAVD88)
- Category I altitude uncertainty at the PLSOP = < 0.01'
- Category II altitude uncertainty at the PLSOP = < 0.15'

A survey of horizontal positions (x-y coordinates) will be completed in future years (FY2017) under subsequent authorizations. Analysis and summary tables will be included in a USGS Scientific Investigations Report (SIR) that outlines objective, approach, and error analysis with summary tables. The USGS SIR will be completed in FY2017.

Staffing and Schedule – see Appendix II

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Appendix I. Table 1. Category I well groups identified with effort (may change based on findings in the field).

Well Group	Estimated Turns	Overall Uncertainty	Time (Day)	UNIQUE_DB_	CASING_DIA	CASING_TYP
1	1	0.003	0.1	KAFB-106207	5	PVC
				KAFB-106208	5	PVC
				KAFB-106209	5	PVC
2	4	0.006	0.3	KAFB-3	5	PVC
				KAFB-106201	5	PVC
				KAFB-106202	5	PVC
				KAFB-106203	5	PVC
3	5	0.007	0.3	KAFB-106204	5	PVC
				KAFB-106205	5	PVC
				KAFB-106206	5	PVC
				KAFB-106231	5	PVC
				KAFB-106232	5	PVC
4	16	0.012	1.0	KAFB-106042	5	PVC
				KAFB-106043	5	PVC
				KAFB-106049	5	PVC
				KAFB-106050	5	PVC
				KAFB-106051	5	PVC
				KAFB-106052	5	PVC
				KAFB-106053	5	PVC
				KAFB-106054	5	PVC
				KAFB-106105	5	PVC
				KAFB-106106	5	PVC
				KAFB-106107	5	PVC
5	8	0.008	0.5	KAFB-106026	5	PVC
				KAFB-106225	5	PVC
				KAFB-106226	5	PVC
				KAFB-106227	5	PVC
				KAFB-106230	5	PVC
6	9	0.009	0.6	KAFB-106219	5	PVC
				KAFB-106220	5	PVC
				KAFB-106221	5	PVC
				KAFB-106222	5	PVC
				KAFB-106223	5	PVC
				KAFB-106224	5	PVC
7	16	0.012	1.0	KAFB-106025	4	PVC
				KAFB-106029	5	PVC
				KAFB-106030	5	PVC
				KAFB-106031	5	PVC

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				KAFB-106055	5	PVC
				KAFB-106057	5	PVC
				KAFB-106058	5	PVC
				KAFB-106091	5	PVC
				KAFB-106092	5	PVC
				KAFB-106093	5	PVC
8	7	0.008	0.4	KAFB-106015	4	PVC
				KAFB-106216	5	PVC
				KAFB-106217	5	PVC
				KAFB-106218	5	PVC
9	6	0.007	0.4	KAFB-106022	4	PVC
				KAFB-106035	5	PVC
				KAFB-106036	5	PVC
				KAFB-106037	5	PVC
				KAFB-106212	5	PVC
				KAFB-106213	5	PVC
				KAFB-106214	5	PVC
				KAFB-106215	5	PVC
10	8	0.008	0.5	KAFB-106021	4	PVC
				KAFB-106032	5	PVC
				KAFB-106033	5	PVC
				KAFB-106034	5	PVC
				KAFB-106085	5	PVC
				KAFB-106086	5	PVC
				KAFB-106087	5	PVC
11	30	0.016	1.9	KAFB-106023	4	PVC
				KAFB-106070	5	PVC
				KAFB-106071	5	PVC
				KAFB-106072	5	PVC
				KAFB-106088	5	PVC
				KAFB-106089	5	PVC
				KAFB-106090	5	PVC
				KAFB-106103	5	PVC
				KAFB-106104	5	PVC
12	16	0.012	1.0	KAFB-106017	4	PVC
				KAFB-106018	4	PVC
				KAFB-106020	4	PVC
				KAFB-106038	5	PVC
				KAFB-106039	5	PVC
				KAFB-106040	5	PVC
				KAFB-106073	5	PVC
				KAFB-106074	5	PVC
				KAFB-106075	5	PVC
				KAFB-106082	5	PVC
				KAFB-106083	5	PVC

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				KAFB-106084	5	PVC
13	13	0.011	0.8	KAFB-106010	5	PVC
				KAFB-106013	5	PVC
				KAFB-106019	5	PVC
				KAFB-106067	5	PVC
				KAFB-106068	5	PVC
				KAFB-106069	5	PVC
				KAFB-106094	5	PVC
				KAFB-106095	5	PVC
				KAFB-106096	5	PVC
				KAFB-106097	5	PVC
				KAFB-106098	5	PVC
14	13	0.011	0.8	KAFB-106005	4	PVC
				KAFB-106009	4	PVC
				KAFB-106011	4	PVC
				KAFB-106014	4	PVC
				KAFB-106028-510	4	PVC
				KAFB-106065	5	PVC
				KAFB-106066	5	PVC
				KAFB-106079	5	PVC
				KAFB-106080	5	PVC
				KAFB-106081	5	PVC
15	17	0.012	1.1	KAFB-106002	4	PVC
				KAFB-106003	4	PVC
				KAFB-106004	4	PVC
				KAFB-106012R	5	PVC
				KAFB-106099	5	PVC
				KAFB-106100	5	PVC
				KAFB-106101	5	PVC
				KAFB-106102	5	PVC
16	27	0.016	1.7	KAFB-106001	4	PVC
				KAFB-106006	4	PVC
				KAFB-106007	4	PVC
				KAFB-106016	4	PVC
				KAFB-106024	4	PVC
				KAFB-106027	4	PVC
				KAFB-106044	5	PVC
				KAFB-106045	5	PVC
				KAFB-106076	5	PVC
				KAFB-106077	5	PVC
				KAFB-106078	5	PVC
				KAFB3411	5	PVC
17	20	0.013	1.3	KAFB-106008	4	PVC
				KAFB-106046	5	PVC

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				KAFB-106047	5	PVC
				KAFB-106048	5	PVC
				KAFB-106059	5	PVC
				KAFB-106060	5	PVC
				KAFB-106061	5	PVC
				KAFB-106062	5	PVC
				KAFB-106063	5	PVC
				KAFB-106064	5	PVC
18	12	0.010	0.8	KAFB-0510	5	PVC
				KAFB-0519	5	PVC
				KAFB-16	5	PVC
19	53	0.022	3.3	KAFB-0213	5	PVC
				KAFB-0216	5	PVC
				KAFB-0219	5	PVC
				KAFB-0220	5	PVC
				KAFB-0221	5	PVC
				KAFB-0222	5	PVC
				KAFB-0223	5	PVC
				ST105MW001	5	PVC
				KAFB-0214	5	PVC
				KAFB-0217	5	PVC
				KAFB-0218	5	PVC
20	22	0.014	1.4	KAFB-0514	5	PVC
				KAFB-0516	5	PVC
				ST105MW011	5	PVC
				ST105MW022	5	PVC
21	8	0.008	0.5	KAFB-0525	5	PVC
				ST105MW018	5	PVC
22	15	0.012	0.9	KAFB-0517	5	PVC
				KAFB-0518	5	PVC
				ST105MW017	5	PVC
23	26	0.015	1.6	KAFB-0504	5	PVC
				KAFB-0506	5	PVC
				KAFB-2625	5	PVC
				KAFB-2629	5	PVC
				KAFB-2630	5	PVC
				KAFB-2631	5	PVC
				KAFB-2632	5	PVC
				KAFB-504	5	PVC
				KAFB-4	5	PVC
24	22	0.014	1.4	KAFB-0505	5	PVC
				KAFB-0509	5	PVC
				KAFB-2623	5	PVC
				KAFB-2624	5	PVC

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				KAFB-2627	5	PVC
				KAFB-2628	5	PVC
25	30	0.016	1.9	KAFB-0507	5	PVC
				KAFB-0512	5	PVC
				KAFB-2602A	5	PVC
				KAFB-2622	5	PVC
				KAFB-2626	5	PVC
				KAFB-507R	5	PVC
				KAFB-512R	5	PVC
26	28	0.016	1.8	KAFB-0508	5	PVC
				KAFB-0521A	5	PVC
				KAFB-0521B	5	PVC
				KAFB-0521C	5	PVC
				KAFB-0523	5	PVC
				KAFB-0524	5	PVC
				KAFB-7	5	PVC
27	3	0.005	0.2	KAFB-8281	5	PVC
				KAFB-8282	5	PVC
28	1	0.003	0.1	TA1-W-05	5	PVC
				TA1-W-08	5	PVC
29	7	0.008	0.4	TA1-W-02	5	PVC
				TA1-W-06	5	PVC
				KAFB-6	5	PVC
30	21	0.014	1.3	KAFB-3391	5	PVC
				KAFB-3392	5	PVC
				TA1-W-01	5	PVC
				TA1-W-07	5	PVC
31	1	0.003	0.1	WYO-3	5	PVC
				WYO-4	5	PVC
32	18	0.013	1.1	TA2-NW1-325	5	PVC
				TA2-NW1-595	5	PVC
				TA2-SW1-320	5	PVC
				TA2-W-01	5	PVC
				TA2-W-28	5	PVC
33	30	0.016	1.9	KAFB-0307	5	PVC
				KAFB-0311	5	PVC
				TA2-W-19	5	PVC
				TA2-W-24	5	PVC
				TA2-W-27	5	PVC
				TJA-2	5	PVC
34	1	0.003	0.1	TJA-3	5	PVC
				TJA-7	5	PVC
35	17	0.012	1.1	KAFB-0901	5	PVC
				KAFB-0903	5	PVC

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				ST105MW012	5	PVC
				TA2-W-25	5	PVC
				TA2-W-26	5	PVC
36	16	0.012	1.0	KAFB-8351	5	PVC
				KAFB-12	5	PVC
37	22	0.014	1.4	Burn Site Well	5	PVC
				CYN-MW10	5	PVC
				CYN-MW11	5	PVC
				CYN-MW12	5	PVC
				CYN-MW14A	5	PVC
				CYN-MW15	5	PVC
				CYN-MW3	5	PVC
				CYN-MW6	5	PVC
				CYN-MW9	5	PVC
38	10	0.009	0.6	CYN-MW13	5	PVC
				CYN-MW7	5	PVC
				CYN-MW8	5	PVC
39	8	0.008	0.5	KAFB-0904	5	PVC
				ST105MW002	5	PVC
40	24	0.015	1.5	KAFB-0613	5	PVC
				KAFB-0614	5	PVC
				ST105MW013	5	PVC
41	12	0.010	0.8	KAFB-0602	5	PVC
				KAFB-0608	5	PVC
				KAFB-0610	5	PVC
				RG-1589-S-4	5	PVC
				RG-1598-S-4	5	PVC
42	1	0.003	0.1	KAFB-0611	5	PVC
				KAFB-0612	5	PVC
43	50	0.021	3.1	AVN-1	5	PVC
				AVN-2	5	PVC
				TAV-MW10	5	PVC
				TAV-MW11	5	PVC
				TAV-MW12	5	PVC
				TAV-MW14	5	PVC
				TAV-MW3	5	PVC
				TAV-MW4	5	PVC
				TAV-MW6	5	PVC
				TAV-MW7	5	PVC
44	14	0.011	0.9	LWDS-MW1	5	PVC
				LWDS-MW2	5	PVC
				TAV-MW13	5	PVC
				TAV-MW2	5	PVC
				TAV-MW5	5	PVC

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				TAV-MW8	5	PVC
				TAV-MW9	5	PVC
45	12	0.010	0.8	KAFB-2007	5	PVC
				KAFB-2008	5	PVC
				KAFB-2004	5	PVC
				KAFB-2006	5	PVC
46	4	0.006	0.3	KAFB-2005	5	PVC
				KAFB-2009	5	PVC
				KAFB-7201	5	PVC
				KAFB-7202	5	PVC
47	12	0.010	0.8	KAFB-6241	5	PVC
				KAFB-6301	5	PVC
48	14	0.011	0.9	MWL-BW2	5	PVC
				MWL-MW4	5	PVC
				MWL-MW5	5	PVC
				MWL-MW6	5	PVC
				MWL-MW7	5	PVC
				MWL-MW8	5	PVC
				MWL-MW9	5	PVC
49	1	0.003	0.1	NWTA3-MW2	5	PVC
				NWTA3-MW3D	5	PVC
50	1	0.003	0.1	PL-2	5	PVC
				PL-4	5	PVC
51	6	0.007	0.4	CWL-BW5	5	PVC
				CWL-MW10	5	PVC
				CWL-MW11	5	PVC
				CWL-MW9	5	PVC
52	2	0.004	0.1	MW-1	5	PVC
				MW-2	5	PVC
				MW-3	5	PVC
				MW-4	5	PVC
				MW-5	5	PVC
				MW-6	5	PVC
				MW-7	5	PVC
				RW-1	5	PVC
				RW-2	5	PVC
				RW-3	5	PVC
				RW-4	5	PVC
				RW-5	5	PVC
53	1	0.003	0.1	OBS-MW1	5	PVC
				OBS-MW2	5	PVC
				OBS-MW3	5	PVC
54	4	0.006	0.3	KAFB-1901	5	PVC
				KAFB-1902	5	PVC

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				KAFB-1904	5	PVC
55	1	0.003	0.1	MRN-2	5	PVC
				MRN-3D	5	PVC
56	1	0.003	0.1	SWTA3-MW3	5	PVC
				SWTA3-MW4	5	PVC
57	1	0.003	0.1	KAFB-1007	5	PVC
				KAFB-1007R	5	PVC
58	2	0.004	0.1	SFR-3D	5	PVC
				SFR-3P	5	PVC
				SFR-3S	5	PVC
				SFR-3T	5	PVC
59	1	0.003	0.1	SFR-4P	5	PVC
				SFR-4T	5	PVC
60	11	0.010	0.7	KAFB-0118	5	PVC
				KAFB-0119	5	PVC
				KAFB-0121	5	PVC
61	8	0.008	0.5	ST105MW015	5	PVC
				KAFB-0110	5	PVC
62	2	0.004	0.1	KAFB-0623	5	PVC
				KAFB-0626A	5	PVC
				KAFB-0626B	5	PVC
				KAFB-0626C	5	PVC
				KAFB-0626D	5	PVC
63	1	0.003	0.1	KAFB-0618	5	PVC
				KAFB-0619	5	PVC

Appendix I. Table 2. Monument installation by phase.

	Monument Installation (Figure 2a)	**Survey Point Installation (Figure 2b)**	**'At well' Level-Fixed Rule or Diff Leveling to other LSOPs (Figures 1 or 3)**
Phase I	135 installations	72 stick-up wells	72 wells
Phase II		328 stick-up wells	328 wells

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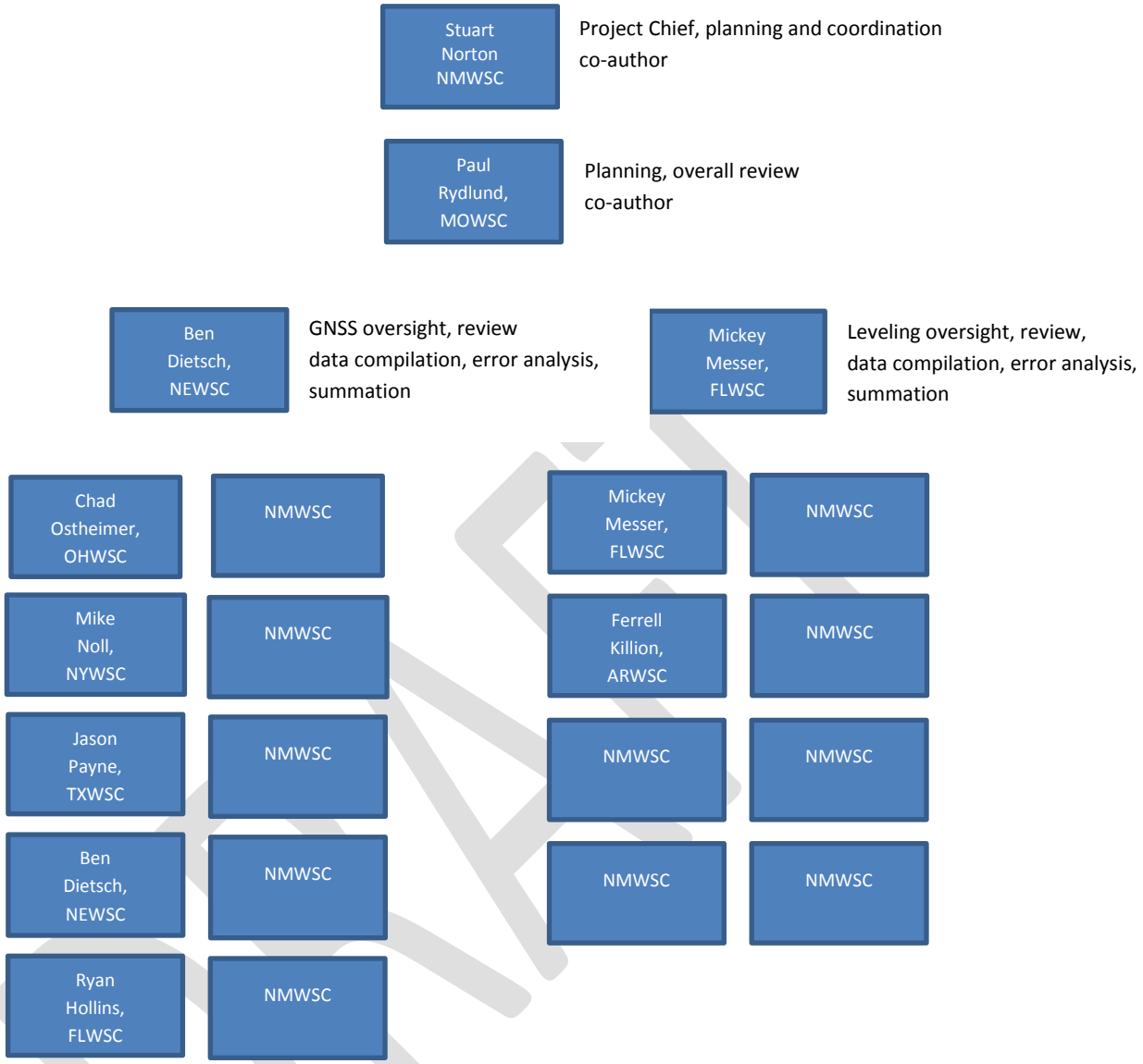
Appendix II. Staffing and responsibilities



Appendix II. Tentative Schedule (current authorization)

October 2015 – April 2016 – Develop SOP and Preliminary Work Plan

April 2016 – July 2016 – Complete Phase I, GNSS, and Phase II, Differential Level surveys

July 2016 – September 2016 – Complete Phase III, data reduction, review and submission to Air Force

Future phases (future authorization):

FY2017 – Survey horizontal (x,y) coordinates and complete SIR

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Rydlund, P.H., Jr., and Densmore, B.K., 2012, Methods of practice and guidelines for using survey-grade global navigation satellite systems (GNSS) to establish vertical datum in the United States Geological Survey: U.S. Geological Survey Techniques and Methods, book 11, chap. D1, 102 p. with appendixes.

USACE, 2004, Kirtland Air Force Base : Base-Wide Plans for the Environmental Restoration Program 2004 Update, TERC Contract No. DACW45-0003. Delivery Order 39, Work Authorization Directive 7.

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APPENDIX H

Project Schedule

Schedule for Vadose Zone Coring, Vapor Monitoring, and Water Supply Sampling

Continuous Coring Boreholes Planning Documents	Fall 2017
Continuous Coring Boreholes	Spring 2018
Bioventing Pilot Test Planning Documents	Fall 2017
Enhanced Air-Lift Bioremediation Pilot Test Planning Documents	Fall 2017
Semiannual Vadose Zone Monitoring and Reporting (2018 – 2021)	Beginning Q2 2018
Monthly Water Supply Wells Monitoring and Reporting	Beginning January 2018

KIRTLAND AIR FORCE BASE
ALBUQUERQUE, NEW MEXICO

WORK PLAN FOR VADOSE ZONE CORING, VAPOR MONITORING, AND WATER SUPPLY SAMPLING
BULK FUELS FACILITY
SOLID WASTE MANAGEMENT UNIT ST-106/SS-111

Revision 1

December 2017

377 MSG/CEI
2050 Wyoming Boulevard Southeast
Kirtland Air Force Base, New Mexico 87117-5270

KIRTLAND AIR FORCE BASE
ALBUQUERQUE, NEW MEXICO

WORK PLAN FOR VADOSE ZONE CORING, VAPOR MONITORING, AND WATER SUPPLY SAMPLING BULK FUELS FACILITY SOLID WASTE MANAGEMENT UNIT ST-106/SS-111

Revision 1

December 2017

~~**June 2017**~~

Prepared for
U.S. Army Corps of Engineers
Albuquerque District
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Contract No. W9128F-13-D-0006/Delivery Order DM02

NOTICE

This Work Plan was prepared for the U.S. Army Corps of Engineers by EA Engineering, Science, and Technology, Inc., PBC for the purpose of performing vadose zone characterization and monitoring activities in addition to water supply sampling associated with the Kirtland Air Force Base (AFB) Bulk Fuels Facility, Solid Waste Management Unit ST-106/SS-111. This work is performed under the U.S. Air Force Environmental Restoration Program, under requirements set forth in the Resource Conservation and Recovery Act permit issued to Kirtland AFB, with the New Mexico Environment Department serving as the lead regulatory agency. Addressed are the tasks related to the installation of soil vapor monitoring wells for future pilot testing; soil vapor monitoring, continuous coring, and sampling water supply wells.

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14. ABSTRACT

This Work Plan describes specific vadose zone treatability studies to be conducted under the Resource Conservation and Recovery Act for the Bulk Fuels Facility leak at Solid Waste Management Unit ST-106/SS-111 at Kirtland Air Force Base, New Mexico. The Work Plan includes the technical approach for continuous coring of soil borings to investigate the distribution and characteristics of petroleum hydrocarbons submerged by increasing aquifer elevations. This Work Plan also includes the technical approach for installation of soil vapor monitoring wells for future pilot testing in three of the coring locations, dual-completion soil vapor/groundwater monitoring wells in eight coring locations, performance of vadose zone network monitoring and maintenance, and sampling of water supply wells.

15. SUBJECT TERMS

Work Plan, Kirtland AFB, Bulk Fuels Facility; continuous coring; soil vapor monitoring wells installation; soil vapor monitoring, water supply well sampling, Solid Waste Management Unit ST-106/SS-111, Interim Measure; LNAPL

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377th Air Base Wing Public Affairs

PREFACE

This Work Plan is prepared by EA Engineering, Science, and Technology, Inc., PBC for the U.S. Army Corps of Engineers (USACE), under Contract Number W9128F-13-D-0006, Delivery Order DM02. This Work Plan pertains to the conductance of vadose zone treatability studies to address a leak at the Kirtland Air Force (AFB) Base Bulk Fuels Facility (BFF) (site), Solid Waste Management Unit ST-106/SS-111. The site is located in Albuquerque, New Mexico. This Work Plan was prepared in accordance with the permit issued to Kirtland AFB under the Resource Conservation and Recovery Act (RCRA) and applicable federal, state, and local laws and regulations.

The objective of the Work Plan is to describe specific vadose zone field activities to be performed in the source area of the BFF as well as water supply sampling. The Work Plan provides the technical approach for the continuous coring for subsurface sample collection, installation of soil vapor monitoring wells for future pilot testing at three of the coring locations, dual-completion soil vapor/groundwater monitoring wells in eight of the coring locations, soil vapor network monitoring and maintenance, and sampling of water supply wells.

This Work Plan is prepared for work to be performed between ~~July~~December 1, 2017 and September 22, 2021. Mr. Trent Simpler, PE, is the USACE–Albuquerque District Project Manager. The Environmental Restoration Section Chief for this program is Mr. Scott Clark of Kirtland AFB. The Work Plan was prepared by Devon Jercinovic, PG, CPG, PMP; Theresa McMillan, PG; Dustin Graves, PG, CHMM; Pamela Moss; Joshua Messenger; and Denise Wilt of EA, as well as Rachel Hobbs and Ryan Wortman of Sundance Consulting, Inc. and Dr. Robert Hinchee of Integrated Science & Technology, Inc. Devon Jercinovic is the EA Project Manager.

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ACRONYMS AND ABBREVIATIONS

ºC	degrees Celsius
%	percent
AFB	Air Force Base
AFCEC	Air Force Civil Engineer Center
APP	Accident Prevention Plan
ARCH	air-rotary casing hammer
bgs	below ground surface
BFF	Bulk Fuels Facility
BTEX	benzene, toluene, ethylbenzene, and total xylenes
C&D	construction and demolition
CFR	Code of Federal Regulations
COA	City of Albuquerque
DO	dissolved oxygen
DoD	Department of Defense
EA	EA Engineering, Science, and Technology, Inc., PBC
EDB	ethylene dibromide (also known as 1,2-dibromoethane)
EDD	electronic data deliverable
ELAP	Environmental Laboratory Accreditation Program
ELLE	Eurofins Lancaster Laboratories Environmental, LLC
EPA	U.S. Environmental Protection Agency
ERPIMS	Environmental Resources Program Information Management System
GWM	groundwater monitoring
GWTS	groundwater treatment system
IDW	investigation-derived waste
LNAPL	light non-aqueous phase liquid
mg/kg	milligram(s) per kilogram
NMED	New Mexico Environment Department
No.	number
NTU	nephelometric turbidity unit
O&M	operation(s) and maintenance
ORP	oxidation reduction potential
PDF	portable document format
PID	photoionization detector
PLSOP	primary land survey objective point
QA	quality assurance

ACRONYMS AND ABBREVIATIONS (CONCLUDED)

QAPjP	Quality Assurance Project Plan
QC	quality control
RCRA	Resource Conservation and Recovery Act
Site	Bulk Fuels Facility site
SOP	Standard Operating Procedure
SSHP	Site Safety and Health Plan
SVE	soil vapor extraction
SVEW	soil vapor extraction well
SVM	soil vapor monitoring
SVMP	soil vapor monitoring point
SWMU	Solid Waste Management Unit
USACE	U.S. Army Corps of Engineers
USAF	U.S. Air Force
VA	Veterans Affairs
VOC	volatile organic compound

EXECUTIVE SUMMARY

This Work Plan has been prepared by EA Engineering, Science, and Technology, Inc., PBC (EA) with support from Sundance Consulting, Inc. and Integrated Science & Technology, Inc. to address activities to be performed at Solid Waste Management Unit (SWMU) ST-106/SS-111, the Bulk Fuels Facility (BFF) at Kirtland Air Force Base (AFB), New Mexico. The Work Plan demonstrates the U.S. Air Force's commitment to continue addressing fuel contamination resulting from the BFF fuel leaks. This Work Plan outlines activities to be performed in support of vadose studies that will advance the remediation in the BFF leak source area. In conjunction with the Quality Assurance Project Plan (QAPjP) provided in Appendix A, this Work Plan will become the procedural guidance document for conducting these activities. These documents meet the most recent requirements of the Department of Defense (DoD) regarding planning documents for DoD facilities. The Work Plan was written in accordance with Kirtland AFB's Resource Conservation and Recovery Act Permit Number NM9570024423.

The objective of the Work Plan is to detail the activities to be implemented performing vadose zone treatability studies to support a future corrective measures evaluation, and continued monitoring of water supply wells in proximity to the BFF plume. The work to be completed is presented under each of the tasks listed below:

- Perform continuous coring and sample collection from up to 12 borehole locations
- Install soil vapor monitoring (SVM) points for future pilot testing in ~~three~~ two continuous coring locations, and an air-lift enhanced well in an additional coring location
- Install dual-completion soil vapor/groundwater monitoring wells for future pilot testing in up to eight of the continuous coring locations
- Perform vadose zone monitoring, maintenance, and reporting of the existing SVM network
- Perform sampling and reporting of water supply wells.

1. INTRODUCTION

Under Contract Number (No.) W9128F-13-D-0006, Delivery Order DM02, EA Engineering, Science, and Technology, Inc., PBC (EA) was contracted to perform tasks associated with vadose zone treatability studies at Solid Waste Management Unit (SWMU) ST-106/SS-111, at Kirtland Air Force Base (AFB), New Mexico. This SWMU is known as the Bulk Fuels Facility (BFF) site. Environmental restoration efforts at the BFF site are being conducted under requirements set forth in Resource Conservation and Recovery Act (RCRA) Permit No. NM9570024423 (RCRA Permit) with the New Mexico Environment Department (NMED) serving as the lead regulatory agency (NMED, 2010).

This Work Plan addresses tasks supporting vadose zone treatability studies and water supply sampling and is the procedural guidance document for activities to be executed as part of the RCRA Corrective Action Process. Additionally, the work to be performed in accordance to this plan will also address outstanding data gaps in the delineation of the nature and extent of residual light non-aqueous phase liquid (LNAPL) in the vadose zone and groundwater. This Work Plan meets the most recent requirements of the Department of Defense (DoD) regarding planning documents for DoD facilities.

The requirements for the protection of health and attaining safety on the job sites are addressed in the companion *Accident Prevention Plan (APP) for the Kirtland AFB BFF Expansion of the Groundwater Treatment System (GWTS) and Vadose Zone Treatability Studies (Revision 4)* (EA, 2017). The APP also incorporates the Site Safety and Health Plan (SSHP). The APP is a dynamic document that will be revised to cover all activity-specific concerns and will be updated as necessary.

1.1 Scope of Activities

The BFF site is located in Albuquerque, New Mexico (Figure 1-1). This Work Plan covers activities required to meet the performance objectives associated with supporting vadose zone treatability studies as well as sampling water supply wells. The work associated with the vadose zone treatability studies includes continuous coring at up to 12 locations in the vadose zone to characterize contaminant zones; installation of soil vapor monitoring (SVM) wells for future pilot tests at three of the coring locations; installation of dual-completion soil vapor/groundwater monitoring wells in up to eight of the coring locations; SVM network sampling, maintenance, and reporting; and water supply sampling. This Work Plan was prepared in accordance with the RCRA Permit for Kirtland AFB (NMED, 2010) and applicable federal, state, and local laws and regulations. For completeness, this Work Plan includes the required elements of a Sampling and Analysis Plan/Field Sampling Plan including soil sampling associated with drilling activities, water supply well sampling, soil vapor sampling, data management, and waste management.

1.2 Work Plan Organization

The Work Plan is divided into the following sections:

- ***Section 1***—Presents an introduction to the plan and the scope of activities and organization of the Work Plan.
- ***Section 2***—Presents the site description and operational history.

- ***Section 3***—Summarizes the project tasks with sufficient detail on how the objectives will be accomplished. To avoid repetitiveness, activities that are common to more than one project task are presented only once, in Section 3.2.

- ***Section 4***—Presents the project schedule.

- ***Section 5***—Provides information on the organizational plan for the execution of work.

- ***Section ~~5~~6***—Refers to the data management requirements.

- ***Section ~~6~~7***—Refers to the quality assurance (QA) and quality control (QC) requirements that are further detailed in the QAPjP provided in Appendix A.

- ***Section ~~7~~8***—Presents information on the management and disposal of the waste generated during this project.

- ***Section ~~8~~9***—Refers to the safe work practices to be employed while executing this project, which are further detailed in the APP (EA, 2017).

- ***Section ~~9~~10***—Provides references cited in the Work Plan.

Figures and tables follow the main body of the Work Plan. Appendices provided at the end of this Work Plan include:

- Appendix A—QAPjP

- Appendix B— Bioventing Well Design, Air-Lift Enhanced Bioremediation Well Design, and Dual-Completion Soil Vapor/Groundwater Wells

- Appendix C—Relevant Standard Operating Procedures from Kirtland AFB Basewide Plan (Appendix B; 2004)

- Appendix D—Soil Vapor Sampling Standard Operating Procedure (SOP)

- Appendix E—Water Supply Well Monitoring SOP

- Appendix F—Field Forms

- Appendix G—Definition of Land Survey Objective/Measuring Points and Land Survey Campaign among the Kirtland AFB Monitoring Well Network

- ~~Appendix H—PetroFLAG™ Soil Analyses~~

- Appendix ~~I~~H—Project Schedule

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2. BACKGROUND INFORMATION

2.1 Site Description

Kirtland AFB is located in Bernalillo County, in central New Mexico, southeast of and adjacent to the City of Albuquerque (COA) and the Albuquerque International Sunport (Figure 1-1). The approximate area of the base is 52,287 acres. The BFF site is located in the northwestern portion of Kirtland AFB.

2.2 Site History

The BFF and associated infrastructure operated from 1953 until 1999. During this time, the fueling area was separated into a tank holding area where bulk shipments of fuel were received and a fuel loading area where individual fuel~~s~~ trucks were filled. Kirtland AFB removed the underground piping at the facility from service in 1999 due to discovery of underground leakage. Even though the fuel leak was identified by Kirtland AFB, the exact history of the leaks or releases is unknown. Releases could have occurred when fuel was transferred from railcars to the pump house. Initially, it was thought that the leak only affected surface soil around the identified source area; however, Kirtland AFB learned through characterization activities that the leaked fuel had reached the groundwater and ~~that~~ the dissolved-phase fuel contamination migrated northeast and north of Kirtland AFB.

To comply with NMED Hazardous Waste Bureau requirements, Interim Measures were implemented for both groundwater and soil. The goals of the groundwater Interim Measure are to protect drinking water supply wells and collapse the distal ethylene dibromide (EDB) plume. The soil vapor extraction (SVE) system addressing light non-aqueous phase liquid (LNAPL) in the source area was shut down in Quarter 2 of 2015 (U.S. Army Corps of Engineers [USACE], 2017a).

2.3 Ongoing Soil Vapor Monitoring

Semiannual SVM has been ongoing as part of the ST-106/SS-111 investigation to monitor the nature and extent of soil vapor contamination in the vadose zone. A total of 284 soil vapor monitoring points (SVMPs) at 56 SVM locations are sampled. Future sampling activities will be conducted under this work plan beginning in January 2018.

2.4 Ongoing Water Supply Monitoring

Three drinking water production wells have been sampled monthly as part of the ST-106/SS-111 investigation to confirm that they have not been impacted by groundwater contaminants. These wells include ST106-VA2 on Raymond G. Murphy Veterans Affairs (VA) Medical Center property, and KAFB-003, ~~and~~ KAFB-015, and KAFB-016 on Kirtland AFB property. ~~A fourth well, KAFB-016, is currently not operational due to ongoing maintenance; however, future sampling is planned when the well becomes operational (projected late summer 2017).~~ Monthly sampling of these wells under this work plan will be conducted beginning in ~~January 2~~018. In addition, at least one private water supply well will be sampled quarterly.

3. TASKS AND ACTIVITIES

Section 3.1 describes the tasks that will be performed under this project. Section 3.2 provides detail of activities that are common to more than one task.

3.1 Project Tasks

3.1.1 Continuous Coring

~~The horizontal extent of LNAPL on the water table has been defined by detection of LNAPL in Site groundwater monitoring (GWM) wells as discussed in Section 5.3.1 of the *RCRA Facility Investigation Report* (USACE, 2017a).~~ One of the principal drivers for the completion of continuous coring near the BFF source area is to address the data gaps of horizontal and vertical extent of LNAPL. Due to capillary forces and the physical properties of LNAPL, and after over 10 years of active SVE, residual fuel may remain in pore spaces and sorbed to soil particles in both the vadose zone and in the smear zone near the groundwater and vadose zone interface. Soil vapor hydrocarbon measurements as high as 30,000 parts per million by volume, suggest the hold up of free-phase fuel hydrocarbons in the vadose zone; however, the amount and chemical composition of the residual are not known. The objectives of the continuous coring are to provide supplemental data on the nature and extent of the residual fuels, and to characterize the subsurface biogeochemical conditions relative to residual hydrocarbon and EDB treatment potential.

When the fuel leak began, the water table was approximately ~~10~~ 60 feet higher than ~~it is today~~current elevations (Rice et al., 2014). Water levels began dropping due to the development of the COA well fields, and reached their lowest level at the end of 2009. Groundwater fluctuations created a smear zone located from the maximum height of the LNAPL layer above the highest historical water table elevation to the minimum height of LNAPL-water interface at the lowest water table elevation (USACE, 2017a).

~~Eight~~Nine continuous core locations (Figure 3-1) including one background location, were selected to characterize residual hydrocarbon within the vadose zone and saturated zone. ~~Four~~Three additional locations are optional, and will be cored if field observations dictate a need for additional data in between the ~~eight~~nine planned coring locations. Specific data objectives for the coring include:

- Provide supplemental information on the nature and thickness of the smeared LNAPL zone
- Collect data to support future intrinsic biodegradation pilot tests
- Accommodate well construction for future bioventing wells (KAFB-106V1 and KAFB-106V2)
- Accommodate well construction as air-lift enhanced well (KAFB-106S1) to support the future air-lift enhanced bioremediation pilot test
- Accommodate dual-completion of soil vapor/groundwater monitoring wells to support future vadose zone pilot tests and soil vapor and groundwater monitoring.

3.1.1.1 Drilling Approach and Methodology

Each proposed borehole location is referenced to an existing logged borehole; the closest existing borehole present that is believed to afford the best idea of the underlying geology at the location of the

proposed coring locations. Table 3-1 provides a summary of the coring locations and rationale for each location.

Table 3-2 summarizes the drilling methodology and depths for each ~~e~~boring location. Figure 3-2 provides a decision logic and borehole sequence that is discussed in more detail below. The designated coring intervals (Table 3-3) at all borehole locations will be drilled using an 8-inch diameter sonic drilling rig with 4-inch diameter core barrel. Figures 3-3 and 3-4 show a cross sectional view of the lithology, historical data, and anticipated coring intervals for KAFB-106S1 through KAFB-106S9. Figures 3-5 and 3-6 show cross sectional transects, and cross sections, respectively, for the area near KAFB-106V1 and KAFB-106V2.~~Except for~~

KAFB-106V1 and KAFB-106V2~~, continuous coring will be accomplished using a combination of air-rotary casing hammer (ARCH) drilling to the desired coring depths, followed by sonic drilling to obtain undisturbed cores from the target intervals~~ will be cored continuously from ground surface to total depth. Due to the relatively shallow depths for KAFB-106V1 and KAFB-106V2, these borings will be completed entirely with sonic drilling to 10-inch nominal diameter. KAFB-106S1 and KAFB-106S9 will also be cored continuously from ground surface to total depth, and these borings will be over-reamed via air-rotary casing hammer (ARCH) technique to the nominal 10-inch diameter. All other borings will be accomplished using a combination of ARCH drilling to the designated coring depth, followed by sonic drilling to obtain undisturbed cores from the designated coring intervals. Upon achieving the ~~target coring~~ top of the designated coring interval depth, the ARCH rig will be moved off each location while leaving the casing downhole, and the sonic rigs will be positioned at the cased holes to core the prescribed ~~sampling~~ designated coring intervals~~. For KAFB-106V1 and KAFB-106V2, which are relatively shallow, the coring locations will be sonic drilled over the entire borehole depth, and~~ and then subsequently reamed with a 9 ⅝-inch bit with the ARCH drilling rig to provide a large enough borehole for ~~bioventing~~ well construction. Figure 3-2 provides a decision logic and borehole sequence that will be followed to allow for modifications of the designated coring intervals, target depth intervals, and selection of optional borings to be completed. ~~The designated coring intervals (Table 3-3) at all borehole locations will be drilled using an 8-inch diameter sonic drilling rig with 4-inch diameter core barrel.~~

Heating during continuous core collection can impact contaminant, geochemical and microbial properties and adversely affect sample representativeness. In addition to advancing the borehole to the designated coring depth ~~core depth~~ with the ARCH rig, to minimize the heating potential, heating of the sonic drilling core barrels in the unsaturated zone can be controlled by any one or combination of the following:

- Advancing shorter sampling runs (5-10 feet versus 20 feet)
- Allowing the core barrel to cool (or pre-cooling the core barrel) before tripping back into the borehole
- Changing the vibration level and rotation speed
- Injecting small quantities of potable water between the override casing and the core barrel without compromising sample integrity as described in ASTM International D6914/D6914M-16.

Temperature inside the core will be monitored when returned to the surface to ensure that heating of the core barrel is not impacting sample selection or integrity. Background soil vapor temperatures in the vadose zone have historically averaged from 20 to 22 degrees Celsius (ºC). Average groundwater temperatures at the site are 19ºC. Any core heating over 20ºC will require mitigation steps as outlined above. If water is injected, the bottom few inches of the core intervals that are possibly in contact with

water accumulating in the bottom of borehole will be discarded prior to collection of samples. Sonic core barrels in the saturated zone are naturally cooled by the presence of formation water; however, similar steps will be implemented as described above to ensure sample representativeness.

Table 3-3 summarizes the ~~target~~ designated coring intervals and target sample depths for each borehole based on historical lithology, noted presence of hydrocarbons, and maximum and minimum depth to groundwater since the historical release.
~~For cores that extend into groundwater, t~~For borings that are not continuously cored from ground surface to total depth, the ~~target depth of the~~ top of the ~~sampling~~ designated coring intervals ~~represents the current water level (from Quarter 1 2017) with an additional 15 feet of vadose zone in anticipation of the groundwater elevation increase in the next seven years~~was selected based on historical data, anticipated lithology (from nearby boreholes), or as 10-feet above the historical high water elevation (approximately 4930 feet amsl). The ~~target depth of the~~ bottom of the ~~sampling~~ designated coring intervals extends approximately 10 - 20 feet below the lowest historic recorded water level (2009) to ensure that the deepest vertical LNAPL migration elevation is evaluated. Target sample depths have been prescribed within each designed coring interval, as discussed in detail in Section 3.1.1.2. The ~~target~~ designated coring intervals and target sample depths ~~will~~may be modified based on field observations and field screening measurements, and will be collaboratively coordinated with NMED and the project team. The target sample depths are intended as a baseline minimum (that maybe modified based on field conditions) that will not be eliminated or replaced, but may be supplemented with additional samples as outlined in the Decision Logic (Figure 3-7), and summarized on Table 3-3 ~~as described below~~.

3.1.1.2 Rationale for Sampling Depth Intervals

KAFB-106S9 will be drilled first (Figure 3-2) and will be continuously cored to total depth. Designated coring intervals on subsequent borings may be adjusted based on field observations and data from KAFB-106S9 (with exception of KAFB-106S1 which will also be cored continuously to total depth), and other borings as the work progresses. Prescribed designated coring intervals were established from site data, as discussed below, and to serve as a baseline for planning purposes.

The probable underlying geology present at the location of the selected boreholes is inferred from borehole logs created during the construction of nearby monitoring wells. Photoionization detector (PID) measurements and qualitative data (e.g., presence of petroleum odor) recorded during the construction of these wells, and historic water level measurements ~~from Quarter 1 2017 gauging~~ were considered. The compilation of information was used to construct a cross-section of each proposed coring, and assisted in the determination of the number and location of ~~sampling sites~~target samples (Figures 3-~~2~~3 ~~through~~ and 3-4). Ultimately, the selected target sampling depths are located where changes in lithology were noted (e.g., lean clay to poorly graded sand) that could have influenced vertical hydrocarbon migration, ~~or~~ where historical high PID readings or notable odor were recorded (from drilling or ~~in~~ soil vapor monitoring in Quarter 4 2016 (USACE, 2017b)), or at historical or current water elevations. Target ~~S~~sample depths are generally prescribed in fine-grained lithologic units that might retain organics (i.e., silt and clay), or locations where the contaminants might have become perched ~~on,~~ or smeared ~~in, such units~~. As discussed in Section 3.1.1.3, additional sample locations may be selected within each boring based on field screening (i.e. PID measurements).

3.1.1.3 Field Screening for Hydrocarbons

When advancing the borehole to ~~the target~~the designated coring interval with ARCH, all cuttings will be logged and PID measurements will be taken at a minimum of every 20 feet as described in Section 3.2.10. If any PID measurements exceed 500 ppm, the material with the highest PID reading within the

prescribed 100-foot depth interval(s) will be sampled for total petroleum hydrocarbons (TPH) (Table 3-3 and Figure 3-7), and PID measurements will subsequently be recorded for every 10 feet to the top of the designated coring interval depth.

Within the ~~target sampling~~designated coring interval, PID readings will be collected every 10 ft. Additional measurements will be collected ~~if lithologic changes are noted~~if qualitative data (e.g., staining, odor, etc.) indicate possible LNAPL (Figure 3-~~5~~7). If any PID measurements exceed 1,000 ppm, the material with the highest PID reading within the prescribed 100-foot depth interval(s) will be sampled for multiple analytes, as discussed in Section 3.1.1.4 and shown on Table 3-3 and Figure 3-7. Historical PID measurements in the source area on split-spoon samples collected in advance of ARCH were on the magnitude of 4,000-6,000 ppm in fine grained units and directly above fine-grained units where LNAPL is indicated (Figure 3-6). PID measurements were not recorded on ~~Review of~~ boring logs for wells that ~~have~~ had historical LNAPL present, or ~~have~~ had core samples/LNAPL fluorescence collected (2011)~~, did not reveal recorded PID measurements~~. Although references that correlate PID readings to the presence of LNAPL were not readily found, at least one reference provided an approximation that 1,000 ppm could potentially indicate NAPL presence (Golder Associates, 2011).~~Field screening for hydrocarbons will also be performed for cores within the target sampling intervals of each borehole utilizing PetroFLAG™ (U.S. Environmental Protection Agency [EPA] Method 9074).~~

~~PetroFLAG™ (EPA Method 9074) detects a broad spectrum of hydrocarbons and is therefore considered a screening technique for total hydrocarbons. The field screening method is used to determine the total amount of recoverable petroleum hydrocarbon contamination is soil (fuels, oils, and greases). This method cannot be used to determine specific hydrocarbon compounds or groups of compounds that may be part of a larger hydrocarbon mixture. The procedure for sample preparation and analysis are as follows.~~

~~Calibrate the analyzer using a blank and a single calibration standard. This should be done with each batch of samples, or at least daily.~~

~~Select the appropriate *response factor* for the particular hydrocarbon or class of hydrocarbons present at the site.~~

~~A 10 ± 0.1 gram sample of soil is extracted with a solvent mixture composed primarily of methanol. Shake sample for 15 seconds to ensure that the soil sample is fully wet. Resulting mixture is allowed to settle (1 minute) and the free liquid is decanted into the barrel of a filter syringe assembly.~~

~~The liquid is filtered through a 0.2 µm filter into a vial containing an aqueous emulsifier development solution. The filtered sample is allowed to develop for 10 minutes (hydrocarbons present precipitate out and become suspended in solution).~~

~~Developed sample is placed in the calibrated turbidimeter for analysis.~~

~~A beam of yellow light at 585 nm is passed through the sample and the scattering of light through the suspension at 90˚ is measured. The concentration of total recoverable petroleum hydrocarbons present is calculated relative to the standard curve.~~

~~Record the reading.~~
~~Soil samples may be contaminated with residual methanol, and will be handled as suspect hazardous waste until final laboratory analyses are received. A summary of the screening method and complete field manual for the testing is provided in Appendix H.~~

3.1.1.4 Laboratory Analyses for Selected Core Samples

Samples for laboratory analyses will be selected based on PID measurements~~, PetroFLAG™ concentrations, lithology,~~ (augmented by lithologic and qualitative data) and ~~other relevant field observations~~the prescribed sampling and analytical methodology outlined in Table 3-3. Selection of target sample depths will follow~~ing~~ the decision logic presented in Figure 3-~~5~~7, or may be modified based on field observations and data. Table 3-3 summarizes the laboratory analyses for selected samples, and provides information for each of the analyses regarding sample containers, required sample volumes, and sample preservation methods, and includes the laboratories to which specific samples should be shipped. Analyses are detailed in the QAPjP and include:

- Volatile organic compounds (VOCs) (EPA Method 8260C); EDB (EPA Method 8011), total petroleum hydrocarbons-gasoline range organics/diesel range organics/oil range organics (EPA Method 8015D); TestAmerica, Inc., Arvada, Colorado.

- LNAPL transmissivity and mobility, grain size, fluid properties, capillary pressure air/water drainage, free product mobility, relative permeability, and hydraulic conductivity; PTS Laboratories~~, Inc.~~, Santa Fe Springs, California.

- LNAPL physical properties including gravity, hydrocarbon component analysis, flash point, and viscosity; Saybolt LP, Core Companies, Deer Park, Texas.

- Mineralogy using x-ray diffraction and energy dispersive x-ray spectrometry; IMR Metallurgical Services, Louisville, Kentucky.

- Microbial analysis using QuantArray-Chlor to identify and quantify halorespiring bacteria; Microbial Insights, Inc., Knoxville, Tennessee.

- Moisture analyses (ASTM D2216); Daniel B. Stephens & Associates Soil Testing Laboratory, Albuquerque, New Mexico.

3.1.2 Soil Vapor Monitoring Point Installation in Boreholes KAFB-106V1 and KAFB-106V2

KAFB-106V1 and KAFB-106V2 SVMPs will be completed in 10-inch diameter boreholes for use as observation SVMPs in the Bioventing Pilot Test, and will be a nested construction using Schedule 80 ¾-inch polyvinyl chloride from ground surface to deepest well depth of approximately 275 feet below ground surface (bgs). Screened intervals for both nested SVMP locations, and the rationale for the depth selections, are summarized on Table 3-4 and are shown on diagrams B-1 through B-6 (Appendix B).

The screened intervals for each SVMP are 2.5 feet in length with 20-slot screen and 10-20 filter pack. A schematic of the KAFB-106V1 and KAFB-106V2 completions are provided in Appendix B. The final construction diagrams will be submitted to NMED following installation, in the first post-construction report, to accurately document as-built conditions.

Table 3-4 also identifies possible future injection SVMPs and their paired screened intervals with these observation SVMP screened intervals. Table 3-5 summarizes possible injection SVMPs and the available observation SVMPs (including the new KAFB-106V1 and KAFB-106V2) that could be utilized in a

future test and includes the lateral distances between the injection SVMPs and the available observation SVMPs.

3.1.3 Air-Lift Well Completion ~~in Borehole S1~~ KAFB-106S1

KAFB-106S1 will be completed in a 10-inch diameter borehole for use in the Air-Lift Enhanced Bioremediation Pilot Test, and will be constructed using Schedule 80, 4-inch polyvinyl chloride. The air-lift enhanced bioremediation well will include a 4-inch diameter, continuous 60-foot screen (30-slot), with approximately 20 feet of screen below the water table, and approximately 40 feet of screen above the water table. ~~from ground surface to a depth of 510 feet bgs (i.e., 30 feet above water table). The screened interval will be placed from 435 to 505 feet deep (70 feet of screen total) with 30-slot screen and 8-12 filter pack.~~ A general schematic of the KAFB-106S1 completion is provided as diagram B-7 (Appendix B). ~~The final construction diagram will be submitted to NMED for approval prior to construction.~~

The pilot test Work Plan for bioventing has been submitted to NMED under separate cover. The Air-Lift Enhanced Bioremediation Pilot Test will be conducted using the 4-inch well installed in soil coring KAFB-106S1. ~~A schematic diagram of the proposed air-lift process is provided in Appendix B.~~ The proposed air lift mechanism will consist of an air diffuser installed in a 2-inch diameter conductor pipe. The conductor pipe will be open near the base of the ~~pilot test~~ well and the air-lift diffuser installed inside the conductor pipe on a ¾-inch diameter airline pipe. The conductor pipe will serve as the "stripping reactor" in the air-lift process and will be open above the anticipated high water level to facilitate outflow of air-lifted oxygenated groundwater to the impacted aquifer at the water table. This oxygenated groundwater will then flow outward through the ~~4-inch~~well screen setting up a vertical "recirculation" cell.

~~The conductor pipe will be tested with and without packers. When packers are used, they will be low-pressure packers installed top and bottom to isolate the process (i.e., the air-lift intake at the base to the outflow at the top). Groundwater will be entrained by the air-lift in the conductor casing and "lifted" to an upper screen open to the vadose zone and water table where the stripped, oxygenated groundwater and the lift-air flow out into the water table and the lower vadose zone, respectively.~~

~~A~~Two piezometers will be installed in the annulus of the air-lift pilot test well to allow placement of downhole multi-parameter probe to record water levels and geochemical parameters (e.g., dissolved oxygen [DO], oxidation reduction potential [ORP], pH, temperature, and specific conductance). Air supply to the system will be via air compressor and pressure regulator to ensure adjustable, constant air flow rates during the test.

Further ~~D~~details of the ~~in-well air-lift apparatus~~well and apparatus completion ~~and monitoring devices will be detailed~~are documented in the ~~Interim Measures Work Plan to be provided in the future~~Work Plan for Bioventing and Air-lift Enhanced Bioremediation Pilot Tests, to be submitted to NMED under separate cover.

3.1.4 Dual-Completion Vadose Zone/Groundwater Monitoring Wells

KAFB-106S2 through KAFB-106S9 will be completed in ~~a~~ 10-inch diameter boreholes for use in future vadose zone pilot tests and monitoring, and will be constructed using Schedule 80, 4-inch polyvinyl chloride from ground surface to a depth approximately six feet below the current water table ~~(Table 3-2)~~. Multiple 30-slot screened intervals will be installed with five feet of blank casing between each screened interval~~s~~. The deepest screen will be 20 feet in length and the two screened intervals above will be 10

feet in length. The annulus will be completed with a~~nd 8-12~~ 10/20 Colorado sand silica filter pack with bentonite seals placed across ~~from~~ each interval of blank casing. A general schematic of the KAFB-106S2-KAFB-106S9 completion is provided as diagram B-8 (Appendix B). The design of the wells is intended to allow for options of future monitoring, for both soil vapor and/or groundwater, including possible retrofitting in the future with the anticipation of continued water level rise. The final construction diagrams will be submitted to NMED ~~for approval prior to~~following construction.

3.1.5 Vadose Zone Monitoring and Reporting

The current SVM network consists of a total of 284 SVMPs installed at 56 SVM locations (Figure 3-~~6~~8). Table 3-6~~5~~ describes the SVM network including each SVM location, its associated SVMPs, and their associated easting and northing coordinates. In Summary, the SVM network includes:

- One SVM location contains four SVMPs co-located in the same vault as a GWM well in Bullhead Park (KAFB-106028~~-510~~; see location number one in Table 3-6).

- Thirty-five locations installed in 2010 and 2011, each with six SVMPs, are located throughout the BFF, on base property north of the BFF, on COA property in Bullhead Park and its open space area, and on VA property. These locations are named using the convention KAFB-106XXX to signify that they were installed as part of the investigation at SWMU ST-106/SS-111. Numbering at these 35 SVM locations ranges from KAFB-106108 through KAFB-106142 (see locations 2 through 36 in Table 3-6). Individual SVMPs at each location are further identified using the bottom of the screen depth of each point (e.g., KAFB-106108-050).

- Twenty locations installed inside the BFF named using the convention "soil vapor extraction well (SVEW)-XX" or "soil vapor monitoring well (SVMW)-XX" (see locations 37 through 56 in Table 3-6).

  — Four of these 20 locations have both SVMW and SVEW type SVMPs at a single location. For example, SVM Location Number 54 includes SVMW-13 (comprised of four SVMPs screened between 150 and 450 feet deep) and SVEW-11 (with one SVMP) all located together in a single well vault.

Semiannual monitoring of the SVM network was approved for ST-106/SS-111 on January 4, 2017 (NMED, 2017a), and will include sampling of the entire 284 SVMP network beginning in Quarter 2 2018. All field personnel collecting soil vapor samples are required to be trained and fully understand the sampling SOP provided in Appendix D. The Horiba Model MEXA 584L (or equivalent) will be used to measure total hydrocarbons, oxygen, and carbon dioxide.

Samples will be shipped to ~~ALS Environmental~~TestAmerica~~-~~, Inc. ~~Laboratories~~ in ~~Simi Valley~~West Sacramento, California, where they will be analyzed for an optimized list of VOCs in air by modified Method TO-15 (NMED, 2017a, 2017b).

Data validation will be performed at the SVM locations listed in Table 3-7 and shown on Figure 3-~~7~~9. A total of 21 locations (68 SVMPs) were chosen for data validation based on their location in relation to residential neighborhoods, or planned interim measures. The rationale for each location chosen is listed in Table 3-7. The SVM locations listed in Table 3-7 represent 23 percent (%) data validation, which exceeds the industry standard of 10%, and meets EPA guidance and the requirements of Section 6.5.1.8.3

of the RCRA permit. A 100% data validation will be performed at any new SVM locations until four events of baseline sampling have been established.

3.1.6 Maintenance of the Soil Vapor Monitoring Well Network

Maintenance for the SVM network will be performed during the sampling events. Prior to the first sampling event in 2018, the SVM network will be retrofitted to accommodate a transition to SUMMA® canister sampling (versus the previously utilized Bottle Vac™ samplers). During each sampling event, the condition of each well port will be examined by the field personnel to confirm the integrity of each fitting and to immediately address and mitigate any problems or replace any defective parts. Wellheads will be inspected for integrity and necessary repairs will be performed as soon as possible. The findings of the inspections and any repairs made will be documented by photographs and on the appropriate field forms (Appendix F), which will be included in the corresponding Quarterly Monitoring Reports.

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3.1.7 Water Supply Sampling and Reporting

Four drinking water supply wells (ST-106-VA-2 on the VA Medical Center property and KAFB-003, KAFB-015, and KAFB-016 at Kirtland AFB) will be sampled monthly beginning in January 2018 to confirm that they have not been impacted by groundwater contaminants (Figure 3-~~8~~10). Table 3-8 lists the coordinates of each of these four wells. Samples will be analyzed for volatile organic compounds including EDB and benzene, toluene, ethylbenzene, and xylene (BTEX). Under another contract, additional analyses are performed semiannually for select total metals (total arsenic, calcium, lead, magnesium, potassium, and sodium), and select dissolved metals (iron and manganese), anions (ammonia nitrogen, bromide, chloride, nitrite/nitrate nitrogen, sulfate, and sulfide), and alkalinity. Field parameters will be recorded during sampling. These analytical requirements may also be revised in the future based on Technical Working Group recommendations and NMED agreement.

These existing drinking water supply wells at Kirtland AFB and the VA Hospital actively provide drinking water to the facilities' employees and inhabitants. Because the wells will be actively producing water during sampling, water levels at these wells will not be measured prior to sampling. In addition, one well volume will not be purged prior to sampling.

The drinking water supply well analytical data will be provided monthly in a technical memorandum. Analytical results will also be reported in the Quarterly Monitoring reports for Solid Waste Management Unit (SWMU) ST-106/SS-111.

In addition to the drinking water supply well sampling, private water supply wells within the vicinity of the EDB plume will be sampled on a quarterly basis with the consent of the well owner. Samples will be analyzed for volatile organic compounds including EDB and BTEX. Field parameters will be recorded during sampling. Production of a one-page technical memorandum with a summary of the quarterly analytical results will also be prepared and provided to USACE and Air Force Civil Engineer Center (AFCEC) for approval prior to sending to the homeowner(s) and NMED. ~~Analytical data will be provided to the owner(s) of the private water supply wells~~. Sampling and reporting will be performed in accordance with the Water Supply Well SOP (Appendix E). The private water supply wells are used for irrigation purposes, not for drinking water.

~~These existing drinking water supply wells at Kirtland AFB and the VA Hospital actively provide drinking water to the facilities' employees and inhabitants. The private water supply wells are used for irrigation purposes, not for drinking water. Because the wells will be actively producing water during sampling, water levels at these wells will not be measured prior to sampling. In addition, one well volume will not be purged prior to sampling.~~

TestAmerica, Inc., Savannah, Georgia, will provide analytical testing services in support of this task for the EDB and BTEX analyses using EPA drinking water methods EPA 504.1 and 524.2, respectively. TestAmerica, Inc. maintains State of New Mexico drinking water certification for these methods. The metals and anions will be analyzed at Eurofins Lancaster Laboratories Environmental (ELLE), Lancaster, Pennsylvania. ELLE maintains current DoD Environmental Laboratory Accreditation Program (ELAP) certification and has the analytical expertise to perform the analyses required for this task in accordance with DoD Quality Systems Manual Version 5.0 (DoD, 2013) and EPA or other industry standard analytical methodologies. ELLE is also analyzing the quarterly groundwater samples associated with the BFF monitoring wells. TestAmerica, Inc. and ELLE reporting limits will achieve the EPA maximum contaminant levels and the New Mexico Water Quality Control Commission standards.

3.2 Activities Common to More than One Task

This section details the activities that are pertinent to more than one project task outlined in Section 3.1. The activities involve field implementation, and are described herein to avoid repetitiveness. Overall, the activities presented herein conform to the requirements of the Base-Wide Plans for the Environmental Restoration Program at Kirtland AFB (U.S. Air Force [USAF], 2004) ensuring that the data will be appropriate for the decision-making process. The following Kirtland AFB SOPs (USAF, 2004) are applicable to the work performed under this project, unless otherwise indicated in this Work Plan:

- B1.1, Borehole and Sample Logging
- B1.4, Monitoring Well Development
- B1.11, Equipment Decontamination
- B2.3, Subsurface Soil Sampling
- B3.1, PIDs and Organic Vapor Analyzers
- B5.1, pH
- B5.2, Specific Conductance
- B5.3, Water Temperature
- B5.4, DO
- B5.5, ORP.

The SOPs listed above are included in Appendix C.

3.2.1 Site Clearance and Utilities Location/Relocation

A utilities clearance will be conducted to locate all underground and suspended utilities both on Kirtland AFB property and off-base. On-base, utilities clearance activities will be conducted as prescribed by and in accordance with the Kirtland AFB site representative policies and procedures. Clearances will be renewed if they expire. No intrusive work will be initiated unless all locations are staked, the clearances from all on-base and off-base utilities have been obtained, and digging permits have been obtained. Utilities clearance activities at adjacent off-Base locations and COA right-of-ways will be prescribed by

and in accordance with state of New Mexico utilities regulations. All underground utilities will be clearly marked before the start of any intrusive activities. All intrusive activities will take into account any existing utilities. The state of New Mexico's "New Mexico One Call" utility excavation clearance system will be used for all off-base drilling and excavation locations. Pot-holing will be performed to physically observe all utilities (using an approach adequately protective of the utility [e.g., hydro-vacuuming, air knife, hand digging, etc.]).

3.2.2 Permitting, Right-of-Way Agreements, and Right-of-Entry Agreements

Prior to any mobilization, copies of the right-of-way and right-of-entry agreements will be obtained for the location where work will be performed and documentation will be onsite with the field crew so that it is available in case inspections are being performed. In addition to access and site clearance, the appropriate permits will be obtained for the various field activities. The representative list of permits is presented below. ~~The permit documentation will be on file with the field crew so that it is available in case inspections are being performed.~~ Special attention will be taken for those permits that have an expiration date. The permitting process will be timed such that permit approvals will be received in time to maintain the schedule, but not too early in the process so that they expire before work is initiated. Permit renewals will be initiated such that the work will proceed with no interruption. Depending on the timing, permits may be combined. The list of permits/plans applicable to this project include:

- USACE~~EA~~ Work Plan Vadose Zone Coring, Soil Vapor Monitoring, and Water Supply Sampling (when approved by NMED Hazardous Waste Bureau).
- USACE Work Plan for Bioventing and Air-Lift Enhanced Bioremediation Pilot Tests (in progress)
- New Mexico Office of the State Engineer Well Drilling Permits for each of the coring locations, SVM well locations, and GWM well locations with no consumptive use of water.
- COA Right-of-Way Licenses for SVM and GWM wells: these are already in place and will be kept on file to be available in case of inspections.
- COA specific plans:
  - ~~Fugitive Dust Permit for extraction wells, vaults, observation wells, and conveyance lines, if required~~
  - Noise Control Plan/Permit for drilling.
  - Excavation/Barricade Permits for each drilling location off-Base.
- Kirtland AFB specific permits:
  - Erosion and Sediment Control Plan
  - 813 Request for Environmental Impact Analysis
  - Civil Engineer Digging Permit Request.

- Right-of-Entry Agreements and Licenses for accessing off-base locations for coring and SVM monitoring:
  - COA
  - Department of VA Health Care System
  - Private property owners of private irrigation wells.

3.2.3 Readiness Review Meetings

Readiness review meetings will be conducted with USACE and USAF a minimum of one week in advance of any new field activities. The meeting will be conducted to ensure that all pre-mobilization elements (e.g., approved plans, permits, right-of-way agreements, Kirtland AFB badging, and community notification) and mobilization elements (e.g., required staffing, equipment, and materials) have been completed.

3.2.4 Mobilization/Demobilization

Subject to USACE and USAF approval, EA (and our subcontractors) will maintain four laydown areas to support field activities. A BFF field office location has been located at Kirtland AFB, proximal to the BFF and a second field office near the GWTS and existing investigation-derived waste (IDW) storage yard. A secure fenced equipment yard has been established near the Truman gate for both heavy machinery and materials; this yard will also hold materials and supplies meant for use on the project at locations outside of Kirtland AFB, as required. Roll-off containers filled with solid waste (soil cuttings and mud) may be stored at the IDW storage area near the GWTS. Due to the large number of roll-off containers required for delivery and transfer during daily drilling activities, waste management support is a key element of mobilization. Laydown site locations are presented on Figure 3-~~9~~11.

3.2.5 Site Security

A safe and secure construction site will be maintained during the execution of all activities taking place inside or outside of Kirtland AFB. EA site and safety personnel will coordinate with USACE, USAF point of contact, and the current contractor to gain insight into site security precautions (i.e., after hours security guards) that are ~~in~~ currently in progress. Based on lessons learned, a plan to control public access and reduce interference with the surrounding area (traffic control, noise control, and site security) will be implemented and a safe work environment for the field teams and the surrounding community will be established. On-Base, all critical laydown yards will be secured by fencing and locked gates and the office trailer will be locked.

3.2.6 Barricading/Traffic Control

Work areas for coring, SVM, or GWM well drilling, installation, or abandonment will be protected from pedestrian and vehicular access. Barricades, temporary traffic control measures, and detour routes will be established where necessary in accordance with COA Construction Services Division requirements. EA will comply with the COA's Construction Coordination Section for work within the public right-of-way, including barricade and excavation permits and fees, and providing data for traffic reports.

3.2.7 Erosion and Sediment Control

All construction subcontractor(s) will obtain the necessary National Pollutant Discharge Elimination System Construction General Permit and submit any required Notice of Intent to the local agencies if required to support tasks on this project. A Stormwater Pollution Prevention Plan will be developed and posted at the work site. Stormwater Pollution Prevention Plan inspections will be completed in compliance with the permit and after rain events. Best management practices for sediment control (i.e., silt fences) will be implemented and maintained to manage stormwater and sediment discharge from work areas.

3.2.8 Decontamination

Final decontamination of all equipment will take place in designated decontamination areas specific to the work activity and approved by Kirtland AFB. Water from decontamination will be managed as per Section 8.

The objective of field decontamination is to remove contaminants of concern from sampling, drilling, and other field equipment to concentrations that will not impact study objectives. Specifications for decontamination materials are as follows:

- Use a standard brand of phosphate-free laboratory detergent, preferably either liquid Liquinox® or powder Alconox®.
- Use tap water from a municipal water treatment system or use bottled drinking water for the wash. Soap and tap water will remove the gross contamination from the sampling equipment.
- Use deionized water for the final rinse of sampling equipment that has direct contact to the sampling medium (e.g., the non-dedicated pumps used to sample monitoring wells).

3.2.9 Borehole Logging

During drilling, each boring will be fully described on the boring log form (Appendix F) in accordance with ASTM International D5434 and will include the following, when applicable:

- Identification number and location of each boring
- A general description of the drilling equipment used that includes such information as rod size, bit type, pump type, rig manufacturer, and model
- Date and time of start and completion of boring
- Name of contractor, driller, and drill site geologist
- Size and length of casing used in each borehole
- Soil classification in accordance with the United Soil Classification System, color, relative density and consistency, soil components, soil moisture, stratification, hardness, grain size and size distribution, and odor

- Mineralogical content of the core (for correlation)
- Depth to water as first encountered during drilling, along with method of determination
- Observations during drilling will be noted, such as bit chatter, rod binding, rod drops, and flowing or heaving sands (if drilling fluid is used, the fluid losses, interval over which they occur, and the quantity lost will be recorded)
- Depth limits, type, and number of each sample taken
- Observations of visible contamination for each sample or from cuttings that appear to be contaminated.

3.2.10 Photoionization Detector

PIDs will be used to determine the location of soil samples, if any soil samples will be collected for chemical analysis. The need for a PID for soil sampling will be determined once the drilling techniques are selected. The PID will be calibrated and tested as required in the QAPjP.

3.2.11 Headspace Screening

Headspace field screening will be performed in accordance with the following procedures.

1. Take PID measurements from cuttings/core with the frequency described in future revisions of this Work Plan.
2. Immediately upon the retrieval, collect a representative portion of the sample and place in a clear, dedicated (e.g., single sample) 1-gallon press-and-seal plastic food storage bag~~clean contaminant-free jar~~.

~~3. Seal the jar with at least one continuous sheet of aluminum foil, using the jar lid to secure the foil.~~

~~4.~~3. Vigorously agitate the sample ~~jar~~ for at least 15 seconds ~~and~~ then allow a minimum of 10 minutes for the sample to adequately volatilize.

~~5.~~4. During cold weather, warm the samples to room temperature prior to taking the headspace measurement.

~~6.~~5. Re-shake the ~~jar~~bag and quickly insert the vapor sampling probe ~~through the aluminum foil~~ and record the maximum meter response (this should be within the first 2-5 seconds).

~~7.~~6. Record headspace screening data on the boring log.

~~8. Decontaminate sample jars between uses.~~

PID measurements will be recorded at a minimum of every 20 feet of core following the process below. Note that specific drilling tasks may have additional monitoring requirements.

1. Immediately upon the retrieval of the 2-4 feet of core, cut a small hole in the plastic core sleeve and insert the PID and record the highest reading.

2. Seal hole in a plastic core sleeve with tape.

3. Record headspace screening data on the boring log and core sleeve.

3.2.12 Sonic Core Handling and Photography

Core from sonic drilling will be extruded into plastic core sleeves at 2- to 4-foot increments over a 10-foot interval. Core sleeves will be labeled with the depth interval and the top of the core will be indicated. Once PID measurements and soil samples have been collected and the core has been logged by the geologist, the core will be placed in core boxes and photographed using a high resolution digital camera. The core boxes will be secured at the end of the project to the designated Kirtland AFB facility currently used to store project cores.

3.2.13 Well Construction Diagrams

Construction diagrams will be completed for the SVMP's KAFB-106V1, KAFB-106V2, and the air-lift well KAFB-106S1, as well as the dual completion vadose zone/groundwater monitoring wells. Well design will be approved in advance by NMED, and well construction will be documented on forms such as the one provided in Appendix B. Each form will include:

- Project and site names, well number, and total depth of the well
- Depth of any grouting or sealing, the amount of cement and/or bentonite used, and the total depth of the boring
- Depth and type of well casing
- Static water level upon completion of the well and after well development (except for SVMP's KAFB-106V1 and KAFB-106V2) ~~(KAFB-106S1)~~
- Installation date or dates, and name of the driller and the geologist installing the well; each installation diagram will be signed by the preparer
- All pertinent construction details of the wells, such as depth to and description of backfill materials installed (i.e., gravel pack, bentonite, and grout); gradation of gravel pack, length, location, diameter, slot size, material and manufacturer of well screen(s); position of centralizers; and location of any blank pipe installed in the well
- Description of surface completion, including protective steel casing, protective pipes, and concrete surface seal
- A description of any difficulties encountered during well installation
- Survey coordinates and the elevation of the top of ground and top of well riser.

3.2.14 Soil Sampling

Soil samples will be collected to characterize the distribution of LNAPL in the identified subsurface target zones as related to the objectives of the borehole drilling. Soil samples will be collected as described below.

3.2.14.1 Soil Sampling for Chemical Analysis

Soil samples may be collected for chemical analysis during drilling of the continuous coring locations (Table 3-~~2~~3). Once the sample depths have been determined, soil samples will be collected using EnCore® samplers for analysis of volatile-type compounds. –Analyses performed for physical testing and/or biological testing have sampling specific container and handling requirements as outlined in Table 3-4 of the QAPjP.

3.2.14.2 Investigation-Derived Waste Sampling for Chemical Analysis

Samples submitted for solid IDW profiling will be collected as a five-point composite from each roll-off bin. A sampling scoop with a long handle will be used to collect each aliquot for homogenization from below the waste surface. The soil will be homogenized with a stainless steel sampling tool in a disposable container and aliquots will be collected to fill containers as per the QAPjP. Section 8 provides additional information for the chemical analyses to be performed on IDW samples.

3.2.14.3 Soil Sampling for Geotechnical Testing

Moisture content will be performed on selected core samples, when retrieved core represents different lithologic intervals. The samples will be sent to Daniel B. Stephens & Associates soil testing laboratory

~~3.2.14.3 Soil Sampling for Geotechnical Testing~~

~~Geotechnical tests~~~~Moisture content will be conducted~~ performed ~~on selected core samples, when retrieved core represents different lithologic intervals. The geotechnical samples will be sent to Daniel B. Stephens & Associates soil testing laboratory~~ in Albuquerque, New Mexico for ~~expedited analyses of particle size wet sieve analysis including hydrometer~~ analysis by~~(~~ASTM ~~International D2487~~D2216~~)~~. The soil will be collected by field staff donning nitrile gloves and using a stainless steel trowel and placed in 1-gallon plastic baggies. Samples will be collected, labeled, and handled as outlined in the QAPjP.

3.2.15 Well Development

KAFB-106S1 will be installed as a groundwater monitoring well, and KAFB-106S2 through KAFB-106S9 will be completed as dual-completion vadose zone/groundwater monitoring wells. KAFB-106S1 will be developed within 1 week after installation but no sooner than 48 hours after grout installation by bailing and surging. Wells KAFB-106S2 through KAFB-106S9 will be developed when there is sufficient water column available in the wells. Well development details are as follows:

- Initial development will consist of swabbing and bailing until little or no sediment enters the well (approximately 2-4 hours). Development and purge water will be contained in a temporary tank. If the addition of water is necessary to facilitate surging and bailing, only clean potable water will be used.

- A bailer fitted with a toggle valve will be lowered into the well and used to gently surge the screen interval to remove any accumulated sand, silt, and debris accumulated in the well bore. When the bailer is brought to the surface, an Imhoff cone will be used to collect water

from the first bailer run to evaluate the amount of silt and sediment in the water. This process will be repeated after each cycle of surging development.

- A minimum of five casing volumes of water will be developed from the well.
- At the completion of well development, a sample will be collected and immediately photographed to document the results of the procedure.

The main goal of well development is to reduce the turbidity to less than 10 Nephelometric Turbidity Units (NTUs) (under 100 NTUs is acceptable). The site geologist will monitor field parameters including pH, temperature, and specific conductance, and record the results and other pertinent information on the well development record form (Appendix F).

3.2.16 Groundwater Gauging and Sampling

Following well development, groundwater and LNAPL (top and bottom) will be measured in KAFB-106S1, and all boreholes completed as dual- completion vadose zone/groundwater monitoring wells. The wells will be allowed to recover a minimum of 24-hours following development prior to gauging, or water sampling. A baseline groundwater sample will be collected from the well utilizing a portable pump and dedicated tubing. Groundwater sampling will be performed in accordance with the procedures outlined in the Work Plan for Bulk Fuels Facility Expansion of the Dissolved-Phase Plume Groundwater Treatment System Design (USACE, 2017c). The new wells installed in this work plan will be incorporated into the groundwater monitoring program as soon as available (i.e. following proper development), and sampled as "newly-installed" wells~~, will be sampled~~ quarterly during the one year baseline period. Following the baseline sampling, the wells will be proposed for a sampling frequency consistent with plume monitoring in each well location. If additional data are required, nearby ~~Surrounding~~ wells ~~that~~ may ~~require~~ be ~~sampling~~ sampled more frequently than the monitoring program ~~outside of~~in ~~the normal~~ frequency ~~of quarterly groundwater monitoring, as~~ provided in the Work Plan for Bulk Fuels Facility Expansion of the Dissolved-Phase Plume Groundwater Treatment System Design (USACE, 2017c)~~, will be sampled in accordance with that approved Work Plan~~. Future sampling and sample frequency of the air lift well, and any wells used in the pilot tests, will be described in the air-lift test plan. KAFB-106S1 will not be incorporated into the GWM network until completion of the air-lift pilot test and removal of downhole equipment.

3.2.17 Sample Packaging and Shipping

Sample packaging and shipping requirements are designed to maintain sample integrity from the time a sample is collected until it is received at the analytical laboratory. All chain-of-custody forms, sample labels, custody seals, and other sample documents will be completed as specified in the QAPjP. Specific procedures for packaging and shipping of environmental samples are presented below:

1. Complete sample label with indelible ink and attach to the sample bottle. Place sample bottles in a cooler for shipping.
2. In preparation for shipping samples, tape the drain plug shut so that no fluids, such as melted ice, will drain out of the cooler during shipment. A large plastic bag may be used as a liner for the cooler. Place packing material, such as bubble wrap, in the bottom of the liner. Place ice at the bottom of the cooler.

3. Place the containers in the lined cooler. Place cardboard separators or bubble wrap between the containers at the discretion of the shipper.

4. All samples for chemical analysis must be shipped cooled to ≤6 degrees Celsius with ice. Include a temperature blank in each sample container prior to shipment.

5. Tape the liner closed, if used, and use sufficient packing material to prevent sample containers from making contact or rolling around during shipment.

6. Place a copy of the chain-of-custody form inside the cooler.

7. Close and tape the cooler shut with strapping tape (filament-type).

8. Place custody seals on the cooler. Place clear tape over the custody seals to help prevent them from being accidentally torn or ripped off.

Ship the cooler of samples via an overnight carrier. A copy of the shipping bill will be retained with the field records and sent electronically to the project chemist.

3.2.18 Site Restoration

Site restoration will consist of backfilling and compaction, surface restoration/resurfacing, and landscaping restoration. Work areas will be restored to original conditions; and, in the residential areas, pavement of the type and thickness meeting COA Department of Municipal Development requirements will be replaced.

3.2.19 Survey

Land surveying activities will occur before, during, and after well installation activities. The surveys will be conducted at locations on Kirtland AFB, adjacent residential neighborhoods, and COA right-of-ways, as required. The surveys will establish northings, eastings, and elevations at all locations. All survey points will be verified, determined, marked, and documented per the provisions specified in the Definition of Land Survey Objective/Measuring Points and Land Survey Campaign among the Kirtland AFB Monitoring Well Network, which is included in draft form as Appendix G. This draft documentation includes an SOP and preliminary work plan for completing a survey of 400 existing monitoring wells within and nearby the Kirtland AFB in southeastern Albuquerque. For the purpose of the resurvey, wells have been divided into two categories, as follows: Category I wells include groups or clusters of wells within close proximity and which, therefore, represent minimal groundwater potentiometric surface gradients; and Category II wells include wells that are more distal to one another with larger groundwater potentiometric surface gradients. Datum specifications (refer to Appendix G for additional detail) are as follows for the two categories:

- New Mexico State Plane Coordinate System, Central Zone, North American Datum of 1983

- Category I and II horizontal uncertainty at the primary land survey objective point (PLSOP) = <0.03 feet

- North American Vertical Datum 1988

- Category I altitude uncertainty at the PLSOP = < 0.01 feet

- Category II altitude uncertainty at the PLSOP = < 0.15 feet.

A survey of horizontal positions (x-y coordinates) for existing wells will be completed in future years under a separate contract. For the survey of new wells to be installed under this Work Plan, the same procedures will be followed by a state of New Mexico-registered professional land surveyor or licensed Professional Engineer. Applicable requirements for uncertainty will also be used for excavation extents, temporary benchmarks as required for site controls, and as-built determination surveys.

Daily reports will consist of the following: a tabulation of the location, identification, coordinates, and elevations of each point surveyed that day. The elevations at junctions for all conveyance lines will be inverted.

As the documentation provided in Appendix G is still in draft form and further revisions are anticipated, survey work will be conducted throughout the duration of the project according to the version of these specifications current at the time work is being performed.

3.2.20 Analytical Services

Groundwater, drinking water, soil vapor, soil, and LNAPL samples will be collected, labeled, packaged, and shipped to the subcontractor laboratory as indicated below:

- ***Eurofins Lancaster Laboratories Environmental, LLC (ELLE), Lancaster, Pennsylvania***—Groundwater monitoring samples and well installation soil samples. ELLE maintains a current DoD ELAP certification for the analyses required under this contract (Appendix A, Attachment 1).

- ***TestAmerica, Inc., Arvada, Colorado***—Soil samples associated with the coring activities. Test America, Inc. maintains current DoD ELAP certification (Appendix A, Attachment 2).

- ***TestAmerica, Inc., Savannah, Georgia***—Drinking water samples from supply wells and domestic irrigation wells. TestAmerica, Inc., Savannah maintains current State of New Mexico drinking water analysis certification (Appendix A, Attachment 2).

- ***~~ALS Environmental~~TestAmerica, Inc., West Sacramento, California*** — ***~~Simi Valley, California~~*** —Soil vapor samples associated with semiannual SVE monitoring~~ and pilot testing~~. ~~ALS Environmental~~TestAmerica, Inc. -maintains current DoD ELAP certification (Appendix A, Attachment 3).

- ***PTS Laboratories, Inc., Santa Fe Springs, California***—Soil coring samples for LNAPL transmissivity and mobility (Appendix A, Attachment 4).

- ***Saybolt LP, Core Companies, Deer Park, Texas***—LNAPL component testing associated with continuous coring activities (Appendix A, Attachment 5).

- ***IMR Metallurgical Services, Louisville, Kentucky***—Soil sample testing for x-ray diffraction and energy dispersive x-ray spectrometry associated with continuous coring activities (Appendix A, Attachment 6).

- ***Microbial Insights, Inc., Knoxville, Tennessee***—Soil samples for halorespiring bacteria to support vadose zone treatability studies (Appendix A, Attachment 7).

- ***Daniel B. Stephens & Associates***—Soil samples collected for geotechnical analyses to determine soil properties associated with well installations (Appendix A, Attachment 8).

3.2.21 Data Validation

Analytical data generated in support of this contract will undergo data validation by the project chemist and an independent third party validation subcontractor to ensure compliance with data quality and project objectives per the QAPjP (Appendix A). All project data will undergo data verification by the project chemist or designee. For new data collection activities, 100% ~~percent~~ of the coring data and new well groundwater data ~~will undergo~~ will undergo EPA Stage 3 (formerly EPA Level 3) data validation for the criteria specified in the QAPjP. Due to the robust data set associated with SVM, 23 percent of analytical data for soil vapor is proposed for EPA Stage 3 data validation. Data qualifiers will be uploaded to the project database prior to finalizing data for use in project reports. Results of the data verification and validation efforts will be documented in the data validation report to be included with the Periodic Monitoring Reports. Data validation will be conducted in accordance with the requirements presented in the QAPjP.

3.2.22 Environmental Resources Program Information Management System Data Upload

Analytical and field data associated with the coring, drilling, and sampling activities will be managed and stored using EQuIS® Environmental Data Management System (Version 6.0). In addition to the EQuIS electronic deliverable, EA will receive Environmental Resources Program Information Management System 6.0 (ERPIMS) formatted deliverables from the laboratory for processing and submittal to the USAF Data Management ERPIMS support contractor on a semiannual basis for upload to the USAF Data Repository. ERPIMS submittals will include all soil vapor and groundwater data in addition to the chemical analysis of soil samples. IDW data will not be submitted to ERPIMS.

3.2.23 Public Notification

The public will be informed through door-to-door notifications at least seven days prior to mobilizing off-Base for intrusive activities, such as drilling.

4. PROJECT SCHEDULE

The project schedule is provided in Appendix H~~I~~.

5. ORGANIZATIONAL PLAN

5.1 Organizational Structure

The organizational structure for this project is shown in Figure 5-1.

5.2 Responsibilities, Qualifications, and Authority of Key Personnel

Table 5-1 summarizes roles and responsibilities, qualifications, and authorities of project team members for the vadose zone treatability studies.

6. DATA MANAGEMENT

This section provides the data management process and procedures to be implemented for the field data and analytical laboratory data generated from work activities in support of the BFF pilot tests. The data management will satisfy the requirements of the QAPjP~~,~~ (Appendix A) ~~of the *Work Plan for Vadose Zone Coring, Vapor Monitoring, and Water Supply Sampling, Bulk Fuels Facility, Solid Waste Management Unit ST-106/SS-111* (pending NMED approval)~~~~This section provides the data management process and procedures to be implemented for the field and for handling laboratory data generated from work activities in support of the BFF vadose zone treatability studies. The data management will satisfy the Base-wide Data Management Plan for Kirtland AFB (USAF, 2004) as well as the requirements of EA SOP No. 063 Chemical Data Management.~~

6.1 Personnel Roles and Responsibilities Specific to Data Management

Specific data management roles and responsibilities for the Data Management Lead and Field Team Lead are discussed below:

- ***Data Management Lead***—Responsible for oversight of transfer of field data to electronic data deliverable (EDD) format for loading to the project database, loading of laboratory EDDs, updating the database as required with current data pulls from the Environmental Resources Program Information Management System (ERPIMS) data repository, and running reports to provide current and historical data from the database. Also responsible for uploading the database with data validation qualifiers following validation, edits resulting from data validation, and delivering the ERPIMS data deliverable to the USAF data management contractor.

- ***Field Team Lead (responsibility will be assigned for each task to qualified staff)***—Responsible for the accuracy of all field activity-related documentation and records collected in support of project plan implementation including all information related to field sample collection; field instrumentation and measurements; equipment decontamination; and sample management and shipping documentation, field variance, and corrective action.

~~Specific data management roles and responsibilities are held by the Data Management Lead and Field Team Lead and are discussed below:~~

- ~~***Data Management Lead***—Responsible for transcription of field data to electronic data deliverable (EDD) format, loading of field and laboratory analytical EDDs, updating the database as required with current data pulls from the ERPIMS data repository, and running reports to provide current and historical data from the database. Also responsible for uploading the database with data validation qualifiers, edits resulting from data validation, and delivering the ERPIMS data deliverable to the Air Force Civil Engineer Center.~~

- ~~***Field Team Lead***—Responsibility will be assigned for each task to qualified staff: Responsible for the accuracy of all field activity-related documentation and records collected in support of project plan implementation including all information related to field sample collection; field instrumentation and measurements; equipment decontamination; and sample management and shipping documentation, field variance, and corrective action.~~

6.2 Project Data Types and Records

Field and analytical data will be collected as appropriate in support of activities associated with the BFF vadose zone treatability studies including coring, long-term SVM, well drilling and installation, ~~and~~ drinking water supply well sampling, and irrigation well sampling. The following section describes the types of records and documentation that will be included for current and historical datasets, databases that will be used, database input requirements, and how data will be maintained and archived.

6.2.1 Project Data and Records

Project data will be documented and recorded using various methods as applicable. The following is a list of the various field and laboratory documentation and records that may be generated during project data gathering activities as applicable.

- Air bills and sample shipping documentation
- Analytical laboratory reports
- Chain-of-custody records
- Communication logs/e-mails
- Corrective action reports
- Documentation of corrective action results
- Documentation of deviations from methods (variances)
- Documentation of internal QA reviews
- Laboratory EDDs
- Field data collection forms, including boring logs, well construction logs, and field parameter logs
- Sampling notes in bound, waterproof field logbooks or on designated field forms
- Field instrumentation calibration logs
- Survey files for well location
  - ~~Global Positioning System files~~
- Identification of QC samples
- Photographs
- Sampling equipment decontamination records
- Sampling location figures (based on targeted and actual coordinates)
- Field variance request forms.

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These records will be created in either written (e.g., sampling notes) or electronic formats (e.g., Global Positioning System files, measurement instrument/data-logger files, field databases, etc.). All records will undergo an independent review either at the laboratory or in the field by the technical leads, QA Officer, or the Project Manager. Additional information is provided in the QAPjP (Appendix A).

6.2.2 ~~Laboratory Testing~~ Laboratory Analytical Testing
~~6.2.2 Chemical Analytical Data~~

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Laboratory samples to be collected in support of the project include soil, soil vapor, and water for chemical analysis data and geotechnical soil testing data. Data deliverables to be provided by laboratories will be project- and data-type specific. Laboratory data will include:

- ***Chemical Analytical Data***—EPA Level IV-type data report (in portable document format [PDF]) and electronic data files in EQuIS® format and ERPIMS Version 6.0.

- ***Geotechnical Soil Data***—Electronic data file in Microsoft® Excel and summary report PDF.

6.2.3 Chemical Analytical Data

Chemical analytical data will include sample results from soil, soil vapor, and groundwater samples generated by the laboratory subcontractors. These data may include both routine and non-routine analytical testing. For all chemical analytical data, the laboratory will provide level 4 type data reports as defined in the QAPjP, EQuIS® 6 EDD for validation and loading into the project database and ERIPMS version 6.0 EDDs for processing and submittal of validated analytical data to the AFCEC data management contractor,~~an EQuIS® EDD, ERPIMS EDD, and a Level IV type data package (unless otherwise specified)~~. The PDF data deliverable will be consistent with the requirements specified in the project-specific subcontractor statement of work.

The laboratories are responsible for ensuring that all analytical data reported in the electronic copy and level 4 type data report are consistent, accurate and complete in accordance with their scope. Verification of EDD formatting and completeness will be performed by the EA data management personnel during data review and upload of electronic data files. EDDs and data reports received from the laboratory that contain errors will be returned to the laboratory for correction and resubmittal. All chemical analytical data will be uploaded to the USAF data repository.
~~The laboratories are responsible for ensuring that all analytical data reported in the electronic copy and PDF data report are consistent and accurate in accordance with their scope. Verification of EDD formatting and completeness will be performed by the EA project chemist and data management personnel during data review and upload. EDDs and data reports received from the laboratory that contain errors will be returned to the laboratory for correction and resubmittal. All chemical analytical data will be uploaded to the USAF data repository.~~

6.2.4 Geotechnical Data

~~Geotechnical~~ Moisture content data will ~~include soil testing data~~be generated by the subcontractor geotechnical testing laboratory. ~~Geotechnical t~~Testing results will be provided in Microsoft® Excel format and in a PDF data report. Geotechnical data results are not required to be submitted in ERPIMS format and will not be uploaded to the USAF data repository. This type of data will be reviewed by the

~~technical~~ Field Team ~~l~~Lead and the geotechnical data will be maintained in the electronic project files and provided in project reports.

6.3 Handling and Management of Project Generated Data

Data handling and management procedures are established to effectively process analytical and measurement data generated during field activities such that the relevant data are readily accessible and accurately maintained. There are multiple activities involved in the recording, storage, processing, and maintenance of project datasets and systems to manage these. In order to ensure that data are accurately recorded and stored, data tracking systems will be implemented. Automated and manual QC checks will be conducted to verify that data have been accurately recorded and appropriately stored. Corrective actions will be taken and documented in the event data have not been properly handled. General data handling and management as well as information on naming conventions, loading, and reporting of laboratory analytical data are discussed in this section.

The following subsections describe~~s~~ the data handling and management of data collected during field activities at Kirtland AFB, including onsite field and measurement data and offsite laboratory data. Field measurement and analytical data will be loaded into an EQuIS® database using Microsoft® Excel files and laboratory~~or~~ EDDs provided in the appropriate format per the templates ~~developed~~ provided by the data management ~~group~~team. These files will be saved and stored in Kirtland AFB project-specific folders located on the EA secure server.

6.3.1 Data Management Processes for Field-Related Data

Three general types of data will be collected and recorded in the field:

- Data to support sample collection and analysis
- Field measurements
- Field observations.

Project data collected during monitoring, investigation, and remediation sampling activities will be managed and stored using the EQuIS® Environmental Data Management System (Version 6.4).~~, which is a Structured Query Language database management system and allows for automatic import of EDDs.~~ The types of field data to be managed in EQuIS® include field sampling parameters collected during well sampling and vapor monitoring, water level~~s~~ measurements, sampling observations, and sample location information such as coordinates, etc. Field data will be recorded on the appropriate forms or electronically, and reviewed and transferred to the field data electronic format~~EDDs~~ as appropriate. The EDDs will be reviewed for accuracy and completeness against field records prior to being loaded into the EQuIS® database. The Data Management Lead will be responsible for ensuring that all field data files uploaded into EQuIS and ERPIMS are maintained on the corporate ~~USAF~~ project server along with the ERPIMS submittal files and the project-specific database.

Field data that cannot be integrated into the database (i.e., site photographs, field logbooks, or field forms) will be stored electronically in the project-specific network folders and/or in the project files, along with supporting metadata such as author/creator of data, date, location, and a brief description. The Field Team L~~l~~eads will be responsible for ensuring that all field data files are stored electronically in the project-specific network folders and all paper copies scanned and ~~are~~ stored electronically in the project folders.

6.3.2 Analytical Data Management and Data Validation

Procedures for collecting field samples for laboratory analysis and the types of analyses to be conducted during the field activities are provided in Table 3-1 of the QAPjP (Appendix A). This section provides an overview of the EDD to be used for analytical data, the EDD loading process, field data verification, and analytical data validation. Record-by-record review of hard copy to electronic data transmittals from laboratories will be verified including validation qualifiers provided by the validation subcontractor.

Data management staff will review data and records received from the field team, subcontractor laboratories, and other subcontractors using the following process to ensure accuracy:

- Review field notes, logbooks, and field forms~~.~~
- Verify field coordinates with the Geographic Information System group~~.~~
- Record-by-record review of hard copy or electronic data transmittals from laboratories to data validators against the records loaded in the database for all validated results~~.~~
- For data transmitted through subcontractors (not including the laboratories), 5-10 percent of loaded data records will be checked against data transmittals to verify import procedures~~.~~
- For calculated or reported total analyte results, calculations will be performed on 100 percent of data to verify concentrations.

Laboratories will be required to submit their results in ERPIMS and EQuIS® EDD formats to be~~. As one or more delivery groups are completed, these will be transmitted electronically to the Data Management Lead or~~ obtained from the laboratory secure website. Designated data management personnel will check and load the EDDs into the EQuIS® and ERPIMS database systems. Any errors in the EDD for a given sample delivery group will prevent loading of data from that sample delivery group and the issue will be communicated to the Laboratory Project Manager for correction and resubmission. Analytical data will be managed in EQuIS® for validation and reporting purposes. The ERPIMS data deliverables will be submitted to the USAF data management subcontractor and processed for upload to the USAF data repository.

One hundred percent of the analytical data generated by the subcontractor laboratories in support of the coring project and drinking water supply sampling will undergo EPA Stage 3 validation in accordance with the requirements in the project QAPJP. Soil vapor validation requirements for specific SVMPs are specified in the Section 3.1.5~~relevant subsection~~. Validation qualifiers will be applied to the data results in the EQuIS® EDD and uploaded to the project database. Validation qualifiers will be included in the upload to the USAF data repository.

6.4 Data Security

The information systems that will house the BFF data, including field and analytical data as well as other electronic information, include systems maintained and managed within contractor offices. Servers located in contractor facilities are physically secured in locked buildings and rooms with access limited to authorized personnel.

Corporate servers are electronically secured behind firewalls with multiple layers of anti-malware software that protect the firewall, the local area network, and e-mail networks. The servers are backed up nightly. Corporate servers and networking equipment are connected to battery-based uninterruptable power supplies with automated shutdown procedures in the event of a power outage.

7. QUALITY ASSURANCE/QUALITY CONTROL

QA/QC activities for the soil and water sampling will be conducted in accordance with the processes and procedures documented in the QAPjP (Appendix A).

8. WASTE MANAGEMENT

IDW generated during the implementation of this project will be managed ~~consistent with the procedures outlined in the Waste Management Plan of the Base-wide Plans (USAF, 2004) unless otherwise~~as specified in this Work Plan.

Prior to initiation of field activities, EA will ensure that all waste management procedures have been refined and approved by NMED and that all waste streams and volumes have been properly planned for. This is especially important when large volumes of liquids from well drilling and development are produced at an off-Base drilling location. Waste volumes will be minimized to the extent practical and eliminate the potential for the local population's exposure to IDW during and after work hours. IDW will be stored for no longer than 90 days prior to disposal; refer to Figure 3-~~9~~11 for the location of the IDW storage area.

8.1 Water Investigation-Derived Waste

All excess water generated during ~~KAFB-106S1-KAFB-106S9~~ well development, sampling, or during drinking water supply sampling events will be 100% ~~percent~~ captured and contained during generation. The following categories of water are discussed in the paragraphs below:

- **Non-hazardous water** generated from:
  - Purging or development of wells prior to sampling for which the sampling data for two consecutive preceding sampling events document no contaminants are present at concentrations that met the definition of characteristic hazardous waste (40 Code of Federal Regulations [CFR] Part 261 [2015]).
  - Decontamination water from equipment cleaning across all site activities.
- **Hazardous/potentially hazardous water** generated from:
  - Purging or development of wells during sampling events for which any data from two consecutive preceding sampling events have documented that contamination is present at concentrations that exceed the characteristic hazardous waste toxicity criteria (40 CFR Part 261.24).
  - Purge water from wells for which historical data show water quality fluctuating between non-hazardous and hazardous classification.
  - Purge water that had concentrations relatively close to the regulatory standard in 40 CFR Part 261.24 (e.g., water that exhibited benzene above 0.4 milligrams per liter in at least one of the previous two events).
- **Water of unknown quality** generated from development and sampling of new wells (i.e. KAFB-106S1) will rely on actual sample results from the IDW for waste profiling.

The QAPjP in Appendix A presents additional information regarding analytical requirements.

8.1.1 Non-Hazardous Water

Non-hazardous water generated from groundwater sampling activities may contain concentrations of dissolved iron and manganese that exceed the influent acceptance limits specified in the GWTS O&M Plan (USACE, 201~~6~~7d). Non-hazardous water will be managed as described below depending on dissolved metals concentrations.

8.1.1.1 Non-Hazardous Water with Dissolved Metals Exceeding Groundwater Treatment System Influent Acceptance Limits

IDW water that contains dissolved iron and manganese exceeding the GWTS influent acceptance limits will be kept segregated by point of origin both during transport and in storage and will not be discharged directly to the GWTS. Upon generation, the water will be placed in dedicated drums and transported to "pending analysis" storage facility where the drums will be labeled and stored pending laboratory analytical results. The storage containers will not be left unattended at off-Base locations during work hours. This water will be profiled for offsite disposal based on the analytical data from the sample collected from the well purged.

8.1.1.2 Non-Hazardous Water with Dissolved Metals Less than the Groundwater Treatment System Influent Acceptance Limits

For IDW waste~~r~~ meeting the dissolved iron and manganese GWTS influent acceptance limits, the water will be segregated while in storage until waste profile analytical data are available. Fluids purged or generated at the wellheads will be placed, to the acceptable filling capacity, in 55-gallon drums or larger containers (totes) that are secured to a truck bed and, upon conclusion of the work day, transferred to the IDW storage area. The storage containers will not be left unattended at off-Base locations during work hours. The quantity of IDW water from each well and the total quantity of water transferred to the GWTS will be recorded. A minimal amount of fines is anticipated to be present in this water and pre-filtering before batching into the GWTS is not anticipated.

If, for any reason, the GWTS cannot accept the purge water as it is generated (e.g., shut down for maintenance), the water will be temporarily stored in the IDW storage area on pallets and properly labeled until it can be discharged to the GWTS.

8.1.2 Hazardous/Potentially Hazardous Water

Characteristically hazardous water generated from any well development or sampling activities will be kept segregated by point of origin both during transport and in storage. Upon generation, the water will be placed in dedicated drums and transported to the less than 90-day accumulation area where the drums will be labeled and stored pending laboratory analytical results. The storage containers will not be left unattended at the residential sites during work hours. This water will be profiled for disposal based on the analytical data from the sample collected from the well purged. A minimal amount of fines is anticipated to be present in this water. Water generated from purging of new wells due to undocumented water quality will be treated the same way as the hazardous water until proven ~~that it is~~ non-hazardous. The quantity of water purged from each well will be recorded.

8.1.3 Water of Unknown Quality

Water of unknown quality associated with drilling activities will initially be placed in portable tanks located at the wellhead where it is produced. The fines will be allowed to settle before the water will be

transported, on a daily basis, using vacuum trucks from the wellhead to a centralized storage area where it will be pumped in storage tanks. The quantity of water extracted during development of each well and the total quantity of water transferred into the storage tank will be recorded. Upon conclusion of the development or when the storage tank ~~reached~~ capacity is reached, one water sample will be collected from a spigot situated at the bottom of the tank; proper disposal will take place upon receipt of analytical results. The sample will be analyzed for the analytical suites presented in Table 8-1. Upon receipt of the analytical results confirming that the water is non-hazardous and that the dissolved iron and manganese meet the GWTS influent acceptance limits, the water will be batched through the GWTS. A pre-filter to capture fines is anticipated for well development water. If the water is hazardous based on toxicity characteristics, it will be disposed of offsite in accordance with NMED regulations. If the water does not meet the GWTS influent acceptance limits, the IDW water will be profiled for offsite disposal.

8.2 Soil ~~and Drilling Mud~~ Investigation-Derived Waste

Soil ~~and drilling mud (if used)~~ will be 100% ~~percent~~ captured and contained at the drill site during coring and/or well drilling. All necessary equipment will be provided to contain and transport soil IDW back to the IDW storage area for further handling (i.e., characterization, temporary storage, and disposal). IDW soil ~~and drilling mud~~ from drilling sites will be collected, secured, and transported in 20-cubic yard lined roll-off bins to the IDW storage area pending receipt of waste characterization profiling results.

For profiling of solid waste ~~(soil cuttings and drilling mud)~~, each roll-off containing soil will be characterized for disposal at the Kirtland AFB Construction and Demolition (C&D) Landfill with a 5-point composite IDW sample. Depending on the type and provenance of the waste, the samples will be analyzed for the suites outlined in Table 8-1. Soil will have to meet the waste acceptance criteria for the Kirtland C&D Landfill (USAF, 2009). The suite for profiling soil originating at locations where extraction and observation wells are installed is reduced, as it is historically known that the waste from that general location is petroleum-based.

Once the analytical results for soil ~~and drilling mud~~ IDW are received and reviewed, a Request for Disposal letter will be provided to Kirtland AFB for approval to dispose of the contents of each container. All documentation regarding waste characterization and disposal will be provided in the appendices of the document describing the activities during which waste was generated.

Should the petroleum levels exceed what the Kirtland C&D Landfill is allowed to accept (benzene, toluene, ethylbenzene, and toluene >50 milligrams per kilogram [mg/kg], benzene >10 mg/kg, or total petroleum hydrocarbons >100 mg/kg), it will require characterization as “special waste” and disposed at an offsite permitted landfill. Samples will be handled per Section 3.2.17 of this Work Plan. The QAPjP (Appendix A) presents additional information regarding analytical requirements.

~~8.3 Residual Field Screening Investigation-Derived Waste~~

~~All waste soil associated with the PetroFLAG™ field screening will be treated as suspect hazardous waste contaminated with methanol. The soil will be containerized and stored in the 90-day accumulation area pending final waste characterization. Unused methanol product will also be shipped off-site as hazardous waste.~~

9. ACCIDENT PREVENTION PLAN/SITE SAFETY AND HEALTH PLAN

The safety requirements for the field implementation of this project are addressed in the companion document, *APP for the Kirtland AFB BFF Expansion of the GWTS and Vadose Zone Treatability Studies (Revision ~~4~~5)* that also contains the SSHPs (EA, 2017). All field personnel associated with the project will be required to read and understand the elements of the APP, and the document will be available at the project location at all times. ~~Please specify that the plan will be read by all field personnel and made available at whatever location(s) that are appropriate.~~

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FIGURES

TABLES

APPENDIX A

Quality Assurance Project Plan

APPENDIX B

Bioventing Well Design, Air-Lift Enhanced Bioremediation Well Design, and Dual-Completion Soil Vapor/Groundwater Wells

APPENDIX C

Relevant Standard Operating Procedures from Kirtland AFB Basewide Plan (Appendix B; 2004)

APPENDIX D

Soil Vapor Sampling SOP

APPENDIX E

Water Supply Well Monitoring SOP

APPENDIX F

Field Forms

APPENDIX G

Definition of Land Survey Objective/Measuring Points and Land Survey Campaign among the Kirtland Air Force Base Monitoring Well Network

APPENDIX H

~~PetroFLAG™ Soil Analyses~~
Project Schedule

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~~APPENDIX I~~

~~Project Schedule~~

Table 3-1
Continuous Coring Location Rationale

Boring Identification	Rationale for Location	Total Maximum Borehole Depth (ft bgs)	Total Designated Coring Interval	Completed as Well
KAFB-106V1	Located in source area near SVMW-10 and SVMW-11 (high total hydrocarbons in vapor); observation well for bioventing test	275	0-275	Yes
KAFB-106V2	Located in source area near SVMW-10 and SVMW-11 (high total hydrocarbons in vapor); observation well for bioventing test	275	0-275	Yes
ST106-SBBG	Located south of the BFF in area without hydrocarbon impacts	515	415-515	No
KAFB-106S1	Located near KAFB-106076; historical LNAPL present in well	510	0-510[a]	Yes
KAFB-106S2	Located near KAFB-106008; historical LNAPL present in well	510	250-510[a]	Yes
KAFB-106S3	Located near KAFB-106014 north of ESTCP; historical LNAPL present in well	512	407-512[a]	Yes
KAFB-106S4	Located near KAFB-106005; historical LNAPL present in well	504	350-504[1]	Yes
KAFB-106S5	Located near KAFB-106010; historical LNAPL present in well	503	403-503[a]	Yes
KAFB-106S6 (Optional)	Located north of KAFB-106010; potential data gap location; well will be drilled pending results of KAFB-106S5	503	403-503[a]	Yes
KAFB-106S7 (Optional)	Located near KAFB-106028; historical LNAPL present in well; will be drilled pending results of KAFB-106S3 and KAFB-106S5	506	409-506[a]	Yes
KAFB-106S8 (Optional)	Located near KAFB-106006; historical LNAPL present in well; will be drilled pending results of KAFB-106S1, KAFB-106S2, and KAFB-106S9	510	250-510[1]	Yes
KAFB-106S9	Located near KAFB-106059 (highest dissolved benzene in groundwater); historical LNAPL present in well; will be drilled first in sequence and data will drive decisions for subsequent cores	508	0-508	Yes

bgs = Below ground surface
BFF = Bulk Fuels Facility
ft = Foot/feet
LNAPL = liquid non-aqueous phase liquid
TBD = to be determined
[a] Designated coring interval is proposed based on historical data and for planning purposes; actual coring intervals may be refined based on field observations and data collected, to follow decision logic presented in Figure 3-2.

Table 3-2
Drilling Summary for Continuous Coring Locations

	Total Planned Drilling Depth	Sonic Coring Interval	Total Core Footage Required	ARCH 11-3/4 Advance Drilling (ft)	ARCH 9-5/8 Advance Drilling (ft)	Sonic 10-in Advanced Drilling (ft)	Total Sonic 8 inch-4-inch Drilling (ft)	ARCH 9-5/8 Reaming (ft)	Nominal Borehole Diameter Needed for Well Construction (inch)	Plug and Abandon (ft)
Continuous Core Locations										
KAFB-106V1	275	0-275	275	0	0	0-275	--	0	10	NA
KAFB-106V2	275	0-275	275	0	0	0-275	--	0	10	NA
KAFB-106S1	510	0-510	510	0	0	0	0-510	0-510	10	NA
ST106-SBBG	515	415-515	100	0	0	0-415	415-515	0	NA	512
KAFB-106S2	510	250-510	260	0-250	0	0	250-510	250-510	10	NA
KAFB-106S3	512	407-512	105	0-250	250-407	0	407-512	407-512	10	NA
KAFB-106S4	504	350-504	154	0-250	250-350	0	350-504	350-504	10	NA
KAFB-106S5	503	403-503	100	0-250	250-403	0	403-503	403-503	10	NA
KAFB-106S9	508	0-508	508	0	0	0	0-508	0-508	10	NA
Optional Continuous Core Locations										
KAFB-106S6	503	403-503	100	0-250	250-403	0	403-503	403-503	10	NA
KAFB-106S7	506	409-506	97	0-250	250-409	0	409-506	409-506	10	NA
KAFB-106S8	510	250-510	260	0-250	0	0	250-510	250-510	10	NA

ARCH = air-rotary casing hammer
ft = foot/feet

Table 3-3
Proposed Sampling Plan for Continuous Coring

								Continuous Coring Sampling Guide (CCSG)																		
													Analysis	Core Sample Management	VOCs (SW5035A/8260C)	EDB (SW8011)	TPH-GRO/DRO/ORO (SW5035A/8015D)	LNAPL Transmissivity and Mobility - grain size, fluid properties, capillary pressure air/water drainage, free product mobility, relative permeability, and hydraulic conductivity [effective\total porosity %Vb]	LNAPL Physical Properties - gravity, hydrocarbon analysis, flashpoint, viscosity (Product)	LNAPL Components (ASTM D4052, D6733, D93, D445)	Mineralogy (XRD/EDAX)	QuantArray-Chlor (qPCR)	Moisture (ASTM D2216)	Temperature	LNAPL Fluorescence	
													Laboratory	ALS	TestAmerica	TestAmerica	TestAmerica	PTS Laboratories	Saybolt LP, Core Companies	Saybolt LP, Core Companies	IMR Metallurgical Services	Microbial Insights	DB Stephens	Field Measurement	PTS Laboratories	
			Designated Coring Interval					Target Sample Depths					Unit	NA	mg/kg	mg/kg	mg/kg	grain size (mm), fluid properties, capillary pressure (cm) air/water drainage (mD), free product mobility, relative permeability (mD), and hydraulic conductivity (cm/s)	gravity, hydrocarbon analysis, flashpoint (°C), viscosity (centipoise\centistokes) (Product)	Weight % Liq. Volume % Mole % Molecular Weight	Mineral Composition %	Bulk Cell Count (#/g), soluble MMO as Cell count	%	°C	Visual Determination	
								Top of Sample Depth	Sample ID	Sample Interval (depth, bgs)	Sample Interval (elev., ft)	Anticipated Soil Media (USCS)	Anticipated Soil Media	Container	Box and Bag Core	3 x EnCore samplers; 1 x 4-oz glass	1 x 8-oz glass	1 x 8-oz glass	2 inch x 6 inch core in sleeve sealed in ziplock bag (shipped frozen with dry ice for mobility analysis)	1 x 8-oz glass	1 x 8-oz glass	1 x 4-oz glass	1 x 8-oz glass	Double ziplock or sealed bucket (2.5 kg of soil)	--	2 inch x 6 inch core in sleeve sealed in ziplock bag (shipped frozen with dry ice for mobility analysis)	
														Preservative	--	None; Cool 6°C	None; Cool 6°C	None; Cool 6°C	--	NA None; Cool 6°C	NA None; Cool 6°C	--	None; Cool 6°C	--	--	--	
														Prep Hold Time	--	48 hours	14 days	--	--	--	--	--	--	--	--	--	
LOCID	Ground Elevation (ft amsl)	Total Proposed Coring Depth (ft bgs)	Top	Bottom	Lowest Measured Groundwater Elevation (ft amls)	Historical High Groundwater Elevation (ft, amsl)	Expected Depth to Water (ft bgs) (July 2017)							Analytical Hold Time	--	14 days	40 days	14 days	--	--	--	--	48 hours	--	--	--	Rationale
KAFB-106V1	5342	275	0	275	NA	NA	473.22 (KAFB-106001)	0-100' highest PID reading (>1,000 ppm) will be sampled[a]							X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Highest PID reading (>1,000 ppm) within 100' depth interval
								100	KAFB-106V1-100	100-105	5242-5237	SP	Poorly Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	High PID reading in SVEW-04/05 and SVMW-11 during construction; high hydrocarbon soil vapor readings in SVMW-11 in Q3 2016; sand between silt layers
								115	KAFB-106V1-115	115-120	5227-5222	SP	Poorly Graded Sand		X	X	X	X		X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	High PID reading in SVEW-04/05 and SVMW-11 during construction; high hydrocarbon soil vapor readings in SVMW-11 in Q3 2016; sand between silt layers
								158	KAFB-106V1-158	158-163	5184-5179	SP	Poorly Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	High PID reading in SVEW-04/05 and SVMW-11 during construction
								215	KAFB-106V1-215	215-220	5127-5122	SW	Well Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	High PID reading in SVEW-04/05 and SVMW-11 during construction
								250	KAFB-106V1-250	250-255	5092-5087	SP	Poorly Graded Sand		X	X	X	X		X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	High PID reading in SVEW-04/05 and SVMW-11 during construction; high hydrocarbon soil vapor readings in SVMW-11 in Q3 2016
								270	KAFB-106V1-270	270-275	5072-5067	SP	Poorly Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	High PID reading in SVEW-04/05 and SVMW-11 during construction; high hydrocarbon soil vapor readings in SVMW-11 in Q3 2016; SVMW-11 readings directly above lean clay layer which might extend to V1 location
KAFB-106V2	5342	275	0	275	NA	NA	474.50 (KAFB-106001)	0-100' highest PID reading (>1,000 ppm) will be sampled[a]							X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Highest PID reading (>1,000 ppm) within 100' depth interval
								100	KAFB-106V2-100	100-105	5242-5237	SP	Poorly Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	High PID reading in SVEW-04/05 and SVMW-11 during construction; high hydrocarbon soil vapor readings in SVMW-11 in Q3 2016; sand between silt layers
								115	KAFB-106V2-115	115-120	5227-5222	SP	Poorly Graded Sand		X	X	X	X		X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	High PID reading in SVEW-04/05 and SVMW-11 during construction; high hydrocarbon soil vapor readings in SVMW-11 in Q3 2016; sand between silt layers
								158	KAFB-106V2-158	158-163	5184-5179	SP	Poorly Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	High PID reading in SVEW-04/05 and SVMW-11 during construction
								215	KAFB-106V2-215	215-220	5127-5122	SW	Well Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	High PID reading in SVEW-04/05 and SVMW-11 during construction
								250	KAFB-106V2-250	250-255	5092-5087	SP	Poorly Graded Sand		X	X	X	X		X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	High PID reading in SVEW-04/05 and SVMW-11 during construction; high hydrocarbon soil vapor readings in SVMW-11 in Q3 2016
								270	KAFB-106V2-270	270-275	5072-5067	SP	Poorly Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	High PID reading in SVEW-04/05 and SVMW-11 during construction; high hydrocarbon soil vapor readings in SVMW-11 in Q3 2016; SVMW-11 readings directly above lean clay layer which might extend to V2 location
ST106-SBBG	5345	515	415	515	4852	4930	478.05 (KAFB-106007)	0 - 100' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								110 - 200' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								210 - 300' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								310 - 400' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								410 - 450' highest PID reading (>1000 ppm) will be sampled[a]							X	X	X	X		X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Highest PID reading (>1000 ppm) within depth interval
								465	ST106-SBBG-465	465-470	4880-4875	SW	Well Graded Sand		X	X	X	X		X (If LNAPL Present)	X (If LNAPL Present)	X	X	X	X	X (If LNAPL Present)	Above water level
								475	ST106-SBBG-475	475-480	4870-4865	SW	Well Graded Sand		X	X	X	X		X (If LNAPL Present)	X (If LNAPL Present)	X	X	X	X	X (If LNAPL Present)	Near water table interface
								483	ST106-SBBG-483	483-488	4862-4857	SW/SM	Well Graded Sand/Silty Sand		X	X	X	X				X	X		X		Saturated zone
								493	ST106-SBBG-493	493-498	4852-4847	SW/SM	Well Graded Sand/Silty Sand		X	X	X	X				X	X		X		Saturated zone
								507	KAFB-106BG-507	507-512	4838-4833	SM/SP	Silty Sand/Poorly Graded Sand		X	X	X	X				X	X		X		Saturated zone

Table 3-3
Proposed Sampling Plan for Continuous Coring

Continuous Coring Sampling Guide (CCSG)

LOCID	Ground Elevation (ft amsl)	Total Proposed Coring Depth (ft bgs)	Designated Coring Interval Top	Designated Coring Interval Bottom	Lowest Measured Groundwater Elevation (ft amsl)	Historical High Groundwater Elevation (ft, amsl)	Expected Depth to Water (ft bgs) (July 2017)	Target Sample Depths: Top of Sample Depth	Sample ID	Sample Interval (depth, bgs)	Sample Interval (elev., ft)	Anticipated Soil Media (USCS)	Anticipated Soil Media	Analysis	Core Sample Management	VOCs (SW5035A/8260C)	EDB (SW8011)	TPH-GRO/DRO/ORO (SW5035A/8015D)	LNAPL Transmissivity and Mobility - grain size, fluid properties, capillary pressure air/water drainage, free product mobility, relative permeability, and hydraulic conductivity [effective\total porosity %Vb]	LNAPL Physical Properties - gravity, hydrocarbon analysis, flashpoint, viscosity (Product)	LNAPL Components (ASTM D4052, D6733, D93, D445)	Mineralogy (XRD/EDAX)	QuantArray-Chlor (qPCR)	Moisture (ASTM D2216)	Temperature	LNAPL Fluorescence	Rationale
														Laboratory	ALS	TestAmerica	TestAmerica	TestAmerica	PTS Laboratories	Saybolt LP, Core Companies	Saybolt LP, Core Companies	IMR Metallurgical Services	Microbial Insights	DB Stephens	Field Measurement	PTS Laboratories	
														Unit	NA	mg/kg	mg/kg	mg/kg	grain size (mm), fluid properties, capillary pressure (cm) air/water drainage (mD), free product mobility, relative permeability (mD), and hydraulic conductivity (cm/s)	gravity, hydrocarbon analysis, flashpoint (°C), viscosity (centipoise\centistokes) (Product)	Weight % Liq. Volume % Mole % Molecular Weight	Mineral Composition %	Bulk Cell Count (#/g), soluble MMO as Cell count	%	°C	Visual Determination	
														Container	Box and Bag Core	3 x EnCore samplers; 1 x 4-oz glass	1 x 8-oz glass	1 x 8-oz glass	2 inch x 6 inch core in sleeve sealed in ziplock bag (shipped frozen with dry ice for mobility analysis)	1 x 8-oz glass	1 x 8-oz glass	1 x 4-oz glass	1 x 8-oz glass	Double ziplock or sealed bucket (2.5 kg of soil)	--	2 inch x 6 inch core in sleeve sealed in ziplock bag (shipped frozen with dry ice for mobility analysis)	
														Preservative	--	None; Cool 6°C	None; Cool 6°C	None; Cool 6°C	--	NA None; Cool 6°C	NA None; Cool 6°C	--	None; Cool 6°C	--	--	--	
														Prep Hold Time	--	48 hours	14 days	--	--	--	--	--	--	--	--	--	
														Analytical Hold Time	--	14 days	40 days	14 days	--	--	--	--	48 hours	--	--	--	
KAFB-106S1	5344	510	0	510	4852	4930	473.52 (KAFB-106076)	0-100' highest PID reading (>1,000 ppm) will be sampled[a]							X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Highest PID reading (>1,000 ppm) within 100' depth interval
								110 - 200' highest PID reading (>1,000 ppm) will be sampled[a]							X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Highest PID reading (>1,000 ppm) within 100' depth interval
								210 - 270' highest PID reading (>1,000 ppm) will be sampled[a]							X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Highest PID reading (>1,000 ppm) within depth interval
								279	KAFB-106S1-279	279-284	5065-5060	CL	Lean Clay		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Petroleum odor reported in KAFB-106076 during construction; clay likely to retain organics
								300 - 400' highest PID reading (>1,000 ppm) will be sampled[a]							X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Highest PID reading (>1,000 ppm) within depth interval
								414	KAFB-106S1-414	414-419	4930-4925	SP	Poorly Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Petroleum odor reported in KAFB-106076 during construction; historical high water table
								459	KAFB-106S1-459	459-464	4885-4880	SM	Silty Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Petroleum odor reported in KAFB-106076 during construction; silt likely to retain organics
								469	KAFB-106S1-469	469-474	4875-4870	SM	Silty Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)	X	X	X	X	X (If LNAPL Present)	Zone where LNAPL may be smeared; historic odor in KAFB-106076; near water table interface
								489	KAFB-106S1-489	489-494	4855-4850	SP	Poorly Graded Sand		X	X	X	X	X			X	X		X		Saturated zone; petroleum odor reported in KAFB-106076 during construction; historical low water table
KAFB-106S2[b]	5349	510	250	510	4852	4930	480.12 (KAFB-106008)	0 - 100' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								110 - 200' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								210 - 240' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within depth interval
								250 - 350' highest PID reading (>1,000 ppm) will be sampled[a]							X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Highest PID reading (>1,000 ppm) within depth interval
								360 - 410' highest PID reading (>1,000 ppm) will be sampled[a]							X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Highest PID reading (>1,000 ppm) within depth interval
								419	KAFB-106S2-419	419-424	4930-4925	SW	Well Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Zone where LNAPL may be smeared; historical high water table
								474	KAFB-106S2-474	474-479	4875-4870	SW	Well Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)	X	X	X	X	X (If LNAPL Present)	Zone where LNAPL may be smeared; near water table interface
								499	KAFB-106S2-499	499-504	4850-4845	SW	Well Graded Sand		X	X	X	X	X			X	X		X		Saturated zone; historical low water table
KAFB-106S3[b]	5349	512	407	512	4853	4930	478.41 (KAFB-106014)	0 - 100' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								110 - 200' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								210 - 300' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								310 - 400' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								424	KAFB-106S3-424	424-429	4925-4920	SW/SM	Well Graded Sand/Silty Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Zone where LNAPL may be smeared; historical high water table; finer-grained lithology likely to retain organics
								459	KAFB-106S3-459	459-464	4890-4885	GP/SW	Poorly Graded Gravel/Well Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Zone where LNAPL may be smeared
								474	KAFB-106S3-474	474-479	4875-4870	SW	Well Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)	X	X	X	X	X (If LNAPL Present)	Zone where LNAPL may be smeared; near water table interface
								489	KAFB-106S3-489	489-494	4860-4855	GW	Well Graded Gravel		X	X	X	X	X			X	X		X		Saturated zone; historical low water table; highest PID reading from KAFB-106014
KAFB-106S4[b]	5344	504	350	504	4852	4930	475.11 (KAFB-106005)	0 - 100' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								110 - 200' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								210 - 300' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								310 - 340' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within depth interval
								350 - 410' highest PID reading (>1,000 ppm) will be sampled[a]							X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Highest PID reading (>1,000 ppm) within depth interval
								414	KAFB-106S4-414	414-419	4930-4925	SP	Poorly Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Zone where LNAPL may be smeared; historical high water table
								464	KAFB-106S4-464	464-469	4880-4875	CL	Lean Clay		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)	X	X	X	X	X (If LNAPL Present)	Zone where LNAPL may be smeared, odor reported from KAFB-106005 construction; near water table interface; clay likely retain organics
								494	KAFB-106S4-494	494-499	4850-4845	SP	Poorly Graded Sand		X	X	X	X	X			X	X		X		Saturated zone; historical low water table; odor reported from KAFB-106005 construction

Table 3-3
Proposed Sampling Plan for Continuous Coring

Continuous Coring Sampling Guide (CCSG)

LOCID	Ground Elevation (ft amsl)	Total Proposed Coring Depth (ft bgs)	Designated Coring Interval: Top	Designated Coring Interval: Bottom	Lowest Measured Groundwater Elevation (ft amsl)	Historical High Groundwater Elevation (ft, amsl)	Expected Depth to Water (ft bgs) (July 2017)	Target Sample Depths: Top of Sample Depth	Sample ID	Sample Interval (depth, bgs)	Sample Interval (elev., ft)	Anticipated Soil Media (USCS)	Anticipated Soil Media	Analysis	Core Sample Management	VOCs (SW5035A/8260C)	EDB (SW8011)	TPH-GRO/DRO/ORO (SW5035A/8015D)	LNAPL Transmissivity and Mobility - grain size, fluid properties, capillary pressure air/water drainage, free product mobility, relative permeability, and hydraulic conductivity [effective\total porosity %Vb]	LNAPL Physical Properties - gravity, hydrocarbon analysis, flashpoint, viscosity (Product)	LNAPL Components (ASTM D4052, D6733, D93, D445)	Mineralogy (XRD/EDAX)	QuantArray-Chlor (qPCR)	Moisture (ASTM D2216)	Temperature	LNAPL Fluorescence	Rationale
														Laboratory	ALS	TestAmerica	TestAmerica	TestAmerica	PTS Laboratories	Saybolt LP, Core Companies	Saybolt LP, Core Companies	IMR Metallurgical Services	Microbial Insights	DB Stephens	Field Measurement	PTS Laboratories	
														Unit	NA	mg/kg	mg/kg	mg/kg	grain size (mm), fluid properties, capillary pressure (cm) air/water drainage (mD), free product mobility, relative permeability (mD), and hydraulic conductivity (cm/s)	gravity, hydrocarbon analysis, flashpoint (°C), viscosity (centipoise\centistokes) (Product)	Weight % Liq. Volume % Mole % Molecular Weight	Mineral Composition %	Bulk Cell Count (#/g), soluble MMO as Cell count	%	°C	Visual Determination	
														Container	Box and Bag Core	3 x EnCore samplers; 1 x 4-oz glass	1 x 8-oz glass	1 x 8-oz glass	2 inch x 6 inch core in sleeve sealed in ziplock bag (shipped frozen with dry ice for mobility analysis)	1 x 8-oz glass	1 x 8-oz glass	1 x 4-oz glass	1 x 8-oz glass	Double ziplock or sealed bucket (2.5 kg of soil)	--	2 inch x 6 inch core in sleeve sealed in ziplock bag (shipped frozen with dry ice for mobility analysis)	
														Preservative	--	None; Cool 6°C	None; Cool 6°C	None; Cool 6°C	--	NA None; Cool 6°C	NA None; Cool 6°C	--	None; Cool 6°C	--	--	--	
														Prep Hold Time	--	48 hours	14 days	--	--	--	--	--	--	--	--	--	--	
														Analytical Hold Time	--	14 days	40 days	14 days	--	--	--	--	48 hours	--	--	--	
KAFB-106S5	5343	503	403	503	4851	4930	471.86 (KAFB-106010)	0 - 100' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								110 - 200' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								210 - 300' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								310 - 400' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								413	KAFB-106S5-413	413-418	4930-4925	SW	Well Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Zone where LNAPL may be smeared, historical high water table
								468	KAFB-106S5-468	468-473	4875-4870	SW	Well Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)	X	X	X	X	X (If LNAPL Present)	Zone where LNAPL may be smeared; near water table interface
								478	KAFB-106S5-478	478-483	4865-4860	SW	Well Graded Sand		X	X	X	X	X			X	X		X		Saturated zone; moderate PID reading in KAFB-106010 during construction
								488	KAFB-106S5-488	488-493	4855-4850	SW	Well Graded Sand		X	X	X	X	X			X	X		X		Saturated zone; moderate PID reading in KAFB-106010 during construction
KAFB-106S6 (Opt)[b]	5343	503	403	503	4851	4930	471.86 (KAFB-106010)	0 - 100' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								110 - 200' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								210 - 300' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								310 - 400' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								413	KAFB-106S5-413	413-418	4930-4925	SW	Well Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Zone where LNAPL may be smeared, historical high water table
								468	KAFB-106S5-468	468-473	4875-4870	SW	Well Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)	X	X	X	X	X (If LNAPL Present)	Zone where LNAPL may be smeared; near water table interface
								478	KAFB-106S5-478	478-483	4865-4860	SW	Well Graded Sand		X	X	X	X	X			X	X		X		Saturated zone; moderate PID reading in KAFB-106010 during construction
								488	KAFB-106S5-488	488-493	4855-4850	SW	Well Graded Sand		X	X	X	X	X			X	X		X		Saturated zone; moderate PID reading in KAFB-106010 during construction
KAFB-106S7 (Opt)[b]	5348	506	409	506	4852	4930	477.49 (KAFB-106028)	0 - 100' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								110 - 200' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								210 - 300' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								310 - 400' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								418	KAFB-106S7-418	418-423	4930-4925	SW	Well Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Zone where LNAPL may be smeared, historical high water table
								468	KAFB-106S7-468	468-473	4880-4875	SP/SW	Poorly Graded Sand/Well Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)	X	X	X	X	X (If LNAPL Present)	Zone where LNAPL may be smeared; moderate PID reading in KAFB-106028 during construction; near water table interface
								481	KAFB-106S7-481	481-486	4867-4862	SP/SW	Poorly Graded Sand/Well Graded Sand		X	X	X	X	X			X	X		X		Saturated zone; moderate PID reading in KAFB-106028 during construction
								493	KAFB-106S7-493	493-498	4855-4850	SW/GP	Well Graded Sand/Well Graded Gravel		X	X	X	X	X			X	X		X		Saturated zone; high PID reading in KAFB-106028 during construction; historical low water table
KAFB-106S8 (Opt)[b]	5349	510	250	510	4852	4930	479.89 (KAFB-106006)	0 - 100' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								110 - 200' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								210 - 240' highest PID reading (>500 ppm) will be sampled[a]										X									Highest PID reading (>500 ppm) within 100' depth interval
								250 - 350' highest PID reading (>1,000 ppm) will be sampled[a]							X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Highest PID reading (>1,000 ppm) within depth interval
								360 - 410' highest PID reading (>1,000 ppm) will be sampled[a]							X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Highest PID reading (>1,000 ppm) within depth interval
								419	KAFB-106S8-419	419-424	4930-4925	SP	Poorly Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Zone where LNAPL may be smeared, historical high water table
								474	KAFB-106S8-474	474-479	4875-4870	SW	Well Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)	X	X	X	X	X (If LNAPL Present)	Zone where LNAPL may be smeared; near water table interface
								499	KAFB-106S8-499	499-504	4850-4845	SP	Poorly Graded Sand		X	X	X	X	X			X	X		X		Saturated zone; historical low water table

Table 3-3
Proposed Sampling Plan for Continuous Coring

Continuous Coring Sampling Guide (CCSG)																										
			Designated Coring Interval					Target Sample Depths						Analysis	Core Sample Management	VOCs (SW5035A/8260C)	EDB (SW8011)	TPH-GRO/DRO/ORO (SW5035A/8015D)	LNAPL Transmissivity and Mobility - grain size, fluid properties, capillary pressure air/water drainage, free product mobility, relative permeability, and hydraulic conductivity [effective\total porosity %Vb]	LNAPL Physical Properties - gravity, hydrocarbon analysis, flashpoint, viscosity (Product)	LNAPL Components (ASTM D4052, D6733, D93, D445)	Mineralogy (XRD/EDAX)	QuantArray-Chlor (qPCR)	Moisture (ASTM D2216)	Temperature	LNAPL Fluorescence	
														Laboratory	ALS	TestAmerica	TestAmerica	TestAmerica	PTS Laboratories	Saybolt LP, Core Companies	Saybolt LP, Core Companies	IMR Metallurgical Services	Microbial Insights	DB Stephens	Field Measurement	PTS Laboratories	
														Unit	NA	mg/kg	mg/kg	mg/kg	grain size (mm), fluid properties, capillary pressure (cm) air/water drainage (mD), free product mobility, relative permeability (mD), and hydraulic conductivity (cm/s)	gravity, hydrocarbon analysis, flashpoint (°C), viscosity (centipoise\centistokes) (Product)	Weight % Liq. Volume % Mole % Molecular Weight	Mineral Composition %	Bulk Cell Count (#/g), soluble MMO as Cell count	%	°C	Visual Determination	
								Top of Sample Depth	Sample ID	Sample Interval (depth, bgs)	Sample Interval (elev., ft)	Anticipated Soil Media (USCS)	Anticipated Soil Media	Container	Box and Bag Core	3 x EnCore samplers; 1 x 4-oz glass	1 x 8-oz glass	1 x 8-oz glass	2 inch x 6 inch core in sleeve sealed in ziplock bag (shipped frozen with dry ice for mobility analysis)	1 x 8-oz glass	1 x 8-oz glass	1 x 4-oz glass	1 x 8-oz glass	Double ziplock or sealed bucket (2.5 kg of soil)	--	2 inch x 6 inch core in sleeve sealed in ziplock bag (shipped frozen with dry ice for mobility analysis)	
														Preservative	--	None; Cool 6°C	None; Cool 6°C	None; Cool 6°C	--	NA None; Cool 6°C	NA None; Cool 6°C	--	None; Cool 6°C	--	--	--	
														Prep Hold Time	--	48 hours	14 days	--	--	--	--	--	--	--	--	--	
														Analytical Hold Time	--	14 days	40 days	14 days	--	--	--	--	48 hours	--	--	--	
LOCID	Ground Elevation (ft amsl)	Total Proposed Coring Depth (ft bgs)	Top	Bottom	Lowest Measured Groundwater Elevation (ft amsl)	Historical High Groundwater Elevation (ft, amsl)	Expected Depth to Water (ft bgs) (July 2017)																				Rationale
KAFB-106S9	5345	508	0	508	4852	4930	476.27 (KAFB-106059)	0 - 100' highest PID reading (>1,000 ppm) will be sampled[a]							X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Highest PID reading (>1,000 ppm) within depth interval
								110 - 200' highest PID reading (>1,000 ppm) will be sampled[a]							X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Highest PID reading (>1,000 ppm) within depth interval
								210 - 300' highest PID reading (>1,000 ppm) will be sampled[a]							X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Highest PID reading (>1,000 ppm) within depth interval
								310 - 400' highest PID reading (>1,000 ppm) will be sampled[a]							X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Highest PID reading (>1,000 ppm) within depth interval
								415	KAFB-106S9-415	415-420	4930-4925	SW	Well Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)			X	X	X (If LNAPL Present)	Zone where LNAPL may be smeared, historical high water table
								470	KAFB-106S9-470	470-475	4875-4870	SW	Well Graded Sand		X	X	X	X	X	X (If LNAPL Present)	X (If LNAPL Present)	X	X	X	X	X (If LNAPL Present)	Zone where LNAPL may be smeared; near water table interface
								490	KAFB-106S9-490	490-495	4855-4850	SP/GW	Poorly Graded Sand/Well Graded Gravel		X	X	X	X	X			X	X		X		Saturated zone; near historical low water table
														Total Maximum Number of Samples[c] :	78	78	78	108	68	51	51	26	26	51	66	51	
														Total Minimum Number of Samples :	51	51	51	50	41	0	0	26	26	36	51	0	

[a] One sample with the highest PID reading will be collected from this depth interval, only if PID reading(s) >500 ppm (above designated coring interval), or >1,000 ppm within designated coring interval. PID readings are scheduled for every 10 ft of core length.
[b] Actual coring interval will be revised, if needed, following initial data collection. See Figure 3-2.
[c] Includes an additional sample beyond the planned total planned depth, to be included if LNAPL is still indicated at this depth
Note: PID readings will be collected every 20 ft above the designated coring interval, and every 10 ft within the designed coring interval, or at any depth interval where qualitative data (e.g. staining, odor, etc.) indicate possible NAPL.
Note: All extracted core will be iced in the field prior to sample collection.
amsl = above mean sea level
bgs = below ground surface
cm = centimeter
DRO = diesel-range organics
ray
EDB = ethylene dibromide
ft = foot/feet
g = grams
GRO = gasoline-range organics
Kg = kilogram
LNAPL = light non-aqueous phase liquid
mg = milligrams
mm = millimeter
MMO = methane monooxygenase
NA = not appliable
Opt = optional
ORO = oil-range organics
oz = ounce
sat = saturated
TPH = total petroleum hydrocarbons
UNK = unkown
unsat = unsaturated
USCS = Unified Soil Classification System
VOCs = volatile organic compounds
XRD = x-ray diffraction
% = percent
°C = degrees Centigrade
= number

Standard Operating Procedure

SWMU ST-106/SS-111 Soil Vapor Monitoring

This standard operating procedure (SOP) describes requirements for soil vapor monitoring (SVM) at solid waste management unit (SWMU) ST-106/SS-111 at Kirtland Air Force Base (AFB). All field personnel collecting soil vapor samples are required to be trained and fully understand the sampling procedure outlined in this document. Any and all questions will be addressed prior to the start of sampling via a field sampling orientation led by the Project Field Lead.

During sampling, the condition of each well port will be examined by the field personnel to confirm the integrity of each fitting and to immediately address and mitigate any problems or replace any defective parts.

1.1 Pre-Sampling Steps

1.1.1 Horiba Model MEXA 584L Calibration

During sampling of each soil vapor well, field parameters including total hydrocarbons (HC), oxygen (O_2), and carbon dioxide (CO_2) will be measured using a Horiba Mexa 584L auto emissions analyzer (Horiba) or equivalent.

~~The Horiba is sold as an engine exhaust monitoring instrument, and the measurement of field parameters during soil vapor monitoring is not the manufacturer's intended purpose. However, while not the intended use of the instrument, the Horiba's sampling ability and the non-dispersive infrared detector and chemical cell detector make it an appropriate instrument for total soil vapor HC, CO_2, and O_2 analyses.~~

The Horiba manufacturer's calibration procedure, which was developed for engine exhaust monitoring, has been modified to better calibrate the instrument for measuring soil vapor petroleum HC, O_2 and CO_2 concentrations. The modified calibration method includes a more representative calibration gas, more frequent calibration than specified by the manufacturer, frequent calibration checks (HC, O_2 and CO_2) during daily Horiba usage, and real-time data analysis to look for indicators of potential calibration deviations.

At the beginning of every work day, the Horiba will be calibrated for air-phase petroleum HC and CO_2 against a calibration standard of known concentrations in a premixed gas cylinder. The Horiba will also be calibrated for O_2 against atmospheric concentrations. At the middle of each work day (or no more than 5 hours after the start of work), a calibration check will be performed on the Horiba to determine whether the calibration of any of the parameters has drifted since the morning calibration. If the calibration check results are outside of 5% of the calibration gas standards, then the Horiba will be recalibrated prior to additional sampling.

The same calibration gas cylinder will be used to calibrate every Horiba instrument and ~~the same person will complete~~ calibration will be completed at the beginning of each day to ensure consistent calibrations. The calibration gas consists of 1,600 parts per million by volume (ppmv) propane, 13.0% (percent) CO_2, and the remaining volume will consist of nitrogen. This calibration gas mixture was selected to accurately calibrate the Horiba for the gases that are present in the vadose zone during soil vapor sampling and respiration/rebound testing, specifically, CO_2 and HC (calibrated as propane).

The initial daily calibration of the instrument will be performed by applying the pre-mixed gas into the

calibration port located on top of the instrument. The calibration steps listed in the Horiba manual for applying the calibration gas and the sequence of key strokes listed will be followed to complete calibration. After calibration, HC and CO_2 concentrations should be within 5% of the known calibration gas values.

The Horiba Instruction Manual goes through the calibration of each compound. During the calibration of HC, the Horiba will display three numbers as shown in the Horiba Instruction Manual. The top number is the known value of the calibration gas (propane at 1,600 ppmv). The middle number will be constant for a particular instrument, but will vary from instrument to instrument; this number is the factory calibration setting for that instrument that corresponds to the input value of the calibration gas. The bottom number will change as the calibration gas is applied and read by the instrument. Both the middle and bottom numbers are reporting the gas as hexane rather than propane; hexane is the standard for HC for the Horiba instrument. The conversion between hexane and propane for the Horiba is approximately one half the concentration. Thus, a reading of 800 ppmv reported as hexane by the detector is the equivalent of 1,600 ppmv as propane. Once the gas is applied, the bottom HC number on the display should read within 5% of the middle number. A value of approximately 800 ppmv HC is expected after the Horiba instrument is calibrated.

After calibration is confirmed, the same calibration gas will be used to fill a 3 liter Tedlar® ~~gas sampling~~vapor collection bag. The customized sampling system will be used to complete the calibration as follows:

Step 1. Disconnect all ~~quick connect pneumatic~~ fittings from sampling system with the exception of the hose. This ensures the system is sealed from all points except through the hose.

Step 2. Visually check that the red drain separator O-ring (approximately 2-inches in diameter) is visible at the opening of the sample inlet port, which is located on the front of the Horiba and to the right of the screen display. Insert the male pneumatic fitting on the end of the Horiba sampling tube to the female quick connect on the sampling system and ensure a secure fit.

Step 3. Ensure that the sampling system is purged according to the steps listed below under Section 1.1.2- Cross Contamination Purging for Sampling System.

Step 4. Once within the given values, attach the Tedlar® bag to the ~~male pneumatic~~ fitting at the end of the braided stainless steel tubing.

Step 5. Open the Tedlar® bag valve to allow the calibration gas to be pulled through the sampling system.

Step 6. Record the instrument read-outs when the instrument has stabilized and compare the results to the calibration gas concentrations.

The mid-day calibration check will be performed using the same technique as the “flow through” portion of initial calibration described in steps one through six above.

If the values for HC, O_2 and CO_2 are within 5% of the calibration values made using the calibration port, the calibration process is complete. As stated previously, the Horiba ~~read-outs for~~reports HC ~~are reported~~ as hexane. A value of approximately 800 ppmv HC is expected. All other gas composition values should

match the calibration gas values. If values are outside of this range, perform a leak check as described below and follow the calibration process again.

If at any point during sampling, a reading for HC, O_2 or CO_2 reaches an unreasonable value (e.g., an O_2 concentration greater than 22%) or if a data value falls outside the trend indicated by previous readings at a given SVMP, a calibration check will be triggered. The expected range of values are: for HC - from 0 to 40,000 ppmv, for percent O_2 from 0 % to 22%, and for percent CO_2 from 0% to 15%. If any readings are outside of these ranges, a calibration check must be made and if necessary, the instrument will be recalibrated.

1.1.2 Cross Contamination Purging for Sampling System

The sampling system must be purged with ambient air before being attached to a SVMP sample port to minimize the potential for cross contamination between sample collections. To ensure the entire sample train is thoroughly purged, attach the pump to the setup and flush atmospheric air through the quick connect port and the nylon tubing. All ~~quick connect pneumatic~~ fittings are to be opened during this process ~~by placing a male fitting into the female fitting~~ to allow for flow. Monitor the purging effectiveness using the Horiba to ensure no contaminants are still present and only ambient air is being read. Correct values for ambient air must be less than 5 ppmv HC, between 20% to 22% for percent O_2, and 0% for percent CO_2. Complete instrument purging must be performed after sampling each SVMP.

1.1.3 Leak Check of Sample System

At the beginning of each day, the sampling system will be leak checked by using the pump to apply vacuum to the sampling system as follows:

Step 1. Cap the male pneumatic fitting on the end of the nylon tubing with a spare female quick disconnect fitted to a vacuum/pressure gauge.

Step 2. Connect the SVMP purging/sampling pump to one of the quick disconnect fittings on the sample system and evacuate the air from the sample system to establish a vacuum.

Step 3. Disconnect the pump and immediately record the vacuum reading from the pressure/vacuum gauge.

Step 4. After 10 minutes have elapsed, check and record the vacuum reading on the gauge.

Step 5. Verify that the starting and ending vacuum readings are within 10% to ensure that the sampling system is not leaking.

Step 6. If the two vacuum readings are not within 10% of each other, check the conditions of the seals and repeat the leak test until the sampling system is confirmed to be air tight.

1.2 Soil Vapor Sampling Procedures

1.2.1 Sample Train Setup

The Horiba analyzer must be turned on, warmed up, and calibrated according to the steps stated above and then attached to the sampling system. The Horiba analyzer is turned on for the first time at the beginning of the day and remains in the on position throughout the day. The Horiba analyzer is plugged

into the 12V DC outlet in the project vehicle using an AC inverter. All other equipment is gas powered or will be powered by generator, and can be powered off between sampling at each well. The pump is attached and sealed to the setup by a quick connect fitting. It is important that no pneumatic fittings besides the tubing to the soil vapor well port are attached prior to turning on the pump.

1.2.2 Static Pressure Measurement

Before taking the static pressure reading, the manometer instrument must be zeroed to atmospheric pressure. The screen should read 0.00 inches of water column (in WC). After confirming that the manometer is zeroed, the following procedure is used to connect the sampling system to the SVMPs and measure the static (also called baseline) pressure, to assure readiness for purging and sampling:

Step 1. Connect the manometer to the ~~quick connect on~~ the side of the sampling system opposite of the ~~Bottle-Vac~~~~summa~~SUMMA® sample collection port ~~(see Figure 1)~~.

Step 2. Verify that the manometer reads 0.00 in WC.

Step 3. ~~Insert the male quick connect fitting on the end of the nylon tubing to the female quick disconnect fitting on the top of~~Connect nylon tubing to the SVMP and ensure a secure connection.

Step 4. Monitor the change in manometer readings over time and record the pressure/vacuum reading when the meter stabilizes.

Note: Static pressure readings have typically ranged from +2.00 in (pressure) to -12.00 in WC (vacuum) at each soil vapor well port.

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1.2.3 Well Purging

Stagnant soil vapor is purged from the SVMP as follows:

Step 1. ~~Tum~~ Turn on the SVMP sampling pump, verify the operation of the flow rotameter, and check for potential leaks as necessary.

Step 2. Consult the Purge Table (Table 1) for the initial purge volume.

Step 3. Connect the female quick disconnect on the terminal end of the sampling system to the male quick connect on the vacuum side of the soil vapor monitoring sampling pump and start timing the purge cycle. (Note: Use the flow rate on the rotameter and the pre-calculated purge volume to quickly calculate the purge time. The purge time is determined by the well port diameter, well depth, and rate of the pump; all of which are known before sampling with the exception of the flowrate. The amount of vapor needed to be removed is based on one well casing volume.)

Step 4. After adequately purging for the appropriate time, quickly disconnect the sampling system from the vacuum pump. (Note: The sampling system is to remain connected to the SVMP for the duration of sampling.)

Step 5. Allow the manometer reading to return to within 0.10 in. WC of the static pressure reading before moving to the next step in the sampling procedure.

1.2.4 Horiba Readings

Once the SVMP has been purged, the following procedure is used to take and record HC, O_2 and CO_2 measurements using the calibrated Horiba:

Step l. Ensure that the Horiba is turned on and functioning properly.

Step 2. Record the manometer reading.

Step 3. Insert the male quick connect fitting into the female quick connect fitting on the terminal side of the sampling system and ensure a tight connection.

Step 4. Observe the Horiba O_2 reading for stability or for a maximum of one minute, whichever comes first.

Step 5. Record the O_2, CO_2, and HC readings and quickly disconnect the Horiba. Photograph the Horiba reading for quality control (QC) reference. Include the well number in the picture.

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1.2.5 ~~Bottle Vac~~Soil Vapor Sampling

The following procedure will be used when collecting ~~Bottle Vac™~~soil vapor samples for laboratory analyses:

Step 1. Check the vacuum in the ~~a Bottle Vac™~~~~summa~~SUMMA® canister prior to sampling by taking a vacuum reading using a lab-supplied vacuum gauge or equivalent.

- ~~The gauge is connected to the bottle through a quick connect set in the same way that the bottle is connected to the sampling system~~Confirm the valve is closed.
- Remove the brass cap.
- Attach the gauge. Take care to not cross thread the gauge onto the canister. The gauge should be snug with no apparent rattles prior to collecting the initial vacuum reading.
- Attach brass cap to side of gauge tee fitting to ensure a closed train.
- Open and close valve quickly (a few seconds)
- Read vacuum on gauge. (Note: ~~Bottles~~ canisters are required to be within ~~10%-25 of~~ to -2~~6~~9.9 inches of mercury (in Hg) of vacuum. If ~~a lower vacuum is~~the measured ~~pressure~~vacuum is outside of this tolerance, do not use the ~~Bottle-Vac™~~canister for sample collection).~~)~~
- Record initial vacuum reading on chain-of-custody, verify valve is closed, and remove gauge.
- Replace the brass cap.

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Step 2. With the nylon tubing still connected to the well port, record the static pressure indicated on the manometer read-out.

Step 3. Connect the ~~Bottle Vac™~~~~summa~~SUMMA® canister to the ~~specialized female pneumatic~~ connection on the sample system ~~(see Figure 1)~~.

- Confirm the valve is closed.

- Remove the brass cap.
- Attach the particulate filter.
- Connect the ~~summa~~SUMMA® canister to the connection on the sampling system
- Open valve ½ turn – fill canister.
- Disconnect the ~~summa~~SUMMA® canister after two minutes or once the manometer reads -5 inches of mercury, whichever comes first (Note: it is the intent to leave some vacuum in the canister for the laboratory to determine sample integrity upon receiving samples)
- Close valve by hand tightening knob clockwise.
- Repeat Step 1 to determine vacuum / pressure.
- Replace brass cap.

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~~Step 4. Disconnect the Bottle-Vac™ after two minutes or once the manometer reading returns to static pressure, whichever comes first.~~

~~Step 5. Check the vacuum in the Bottle-Vac™ after removing from the sampling system. (Note: The vacuum should read no higher than 0.10 in Hg of vacuum. If there is still a positive vacuum reading, re-attach the Bottle-Vac™ to the sampling system for two additional minutes before checking the pressure once more; repeat as necessary.)~~

~~Bottle-Vacs~~~~Summa~~SUMMA® canisters will be shipped to the specified laboratory, and analyzed for the appropriate analytical methods listed in the Work Plan.

1.2.6 Sample Packaging and Shipping

Sample packaging and shipping requirements are designed to maintain sample integrity from the time a sample is collected until it is received at the analytical laboratory. All chain-of-custody forms, sample ~~labels~~tags, custody seals, and other sample documents will be completed as specified in the QAPjP. Specific procedures for packaging and shipping of environmental samples are presented below:

- A sample tag ~~label~~, completed with indelible ink, will be attached to the ~~sample bottle~~canister.
- The filled ~~Bottle-Vac™~~~~summa~~SUMMA® canisters will be placed in the ~~individual~~ cardboard box in which ~~it was~~ the canisters were received from the laboratory~~shipped~~. The sample number will be written on the top of the box. Each individual box will be boxed in groups of four or eight in the larger boxes in which they were shipped.
- A copy of the chain-of-custody form will be placed inside the box.
- The box will be closed and taped shut with strapping tape (filament-type).
- Custody seals will be placed on the box. Clear tape will be placed over the custody seals to help prevent them from being accidentally torn or ripped off.
- The box of samples will be shipped via Fed Ex ground. A copy of the shipping bill will be retained for the field records and sent electronically to the project chemist.

Table 1. Soil Vapor Monitoring Point Construction Parameters and Pre-Calculated Purge Volumes
Bulk Fuels Facility Area
Kirtland Air Force Base, Albuquerque, New Mexico

SVM Location ID	SVMP ID	Screened Interval (ft)		Well Diameter (in)	Casing Area (sq ft)	Filter Pack Volume (cu ft)[1]	Purge Volume (cu ft)
		Top	Bottom				
SVMW-01	SVMW-01-050	50	52.5	0.5	0.00136	0.409	0.481
	SVMW-01-100	100	102.5	0.5	0.00136	0.409	0.549
	SVMW-01-250	250.7	253.2	0.5	0.00136	0.409	0.754
	SVMW-01-300	308.5	310	0.5	0.00136	0.245	0.668
SVMW-02	SVMW-02-050	50	52.5	0.5	0.00136	0.409	0.481
	SVMW-02-100	97	99.5	0.5	0.00136	0.409	0.545
	SVMW-02-150	150	152.5	0.5	0.00136	0.409	0.617
SVMW-03	SVMW-03-050	50	52.5	0.5	0.00136	0.409	0.481
	SVMW-03-100	100	102.5	0.5	0.00136	0.409	0.549
	SVMW-03-250	250	252.5	0.5	0.00136	0.409	0.753
	SVMW-03-300	300	302.5	0.5	0.00136	0.409	0.822
SVMW-04	SVMW-04-050	50	52.5	0.5	0.00136	0.409	0.481
	SVMW-04-100	98	100.5	0.5	0.00136	0.409	0.546
	SVMW-04-250	250	252.5	0.5	0.00136	0.409	0.753
	SVMW-04-300	297.5	300	0.5	0.00136	0.409	0.818

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Table 1. Soil Vapor Monitoring Point Construction Parameters and Pre-Calculated Purge Volumes
Bulk Fuels Facility Area
Kirtland Air Force Base, Albuquerque, New Mexico

SVM Location ID	SVMP ID	Screened Interval (ft)		Well Diameter (in)	Casing Area (sq ft)	Filter Pack Volume (cu ft)[1]	Purge Volume (cu ft)
		Top	Bottom				
SVMW-05	SVMW-05-050	50	52.5	0.5	0.00136	0.409	0.481
	SVMW-05-100	100	102.5	0.5	0.00136	0.409	0.549
	SVMW-05-230	229.5	231	0.5	0.00136	0.245	0.560
	SVMW-05-290	287.5	290	0.5	0.00136	0.409	0.804
SVMW-06	SVMW-06-050	50	52.5	0.5	0.00136	0.409	0.481
	SVMW-06-100	99.5	102	0.5	0.00136	0.409	0.548
	SVMW-06-252	252	254.5	0.5	0.00136	0.409	0.756
	SVMW-06-302	302.5	305	0.5	0.00136	0.409	0.825
SVMW-07	SVMW-07-050	49.5	52	0.5	0.00136	0.409	0.480
	SVMW-07-100	95.5	98	0.5	0.00136	0.409	0.543
	SVMW-07-150	147.5	150	0.5	0.00136	0.409	0.614
SVMW-08[2]	SVMW-08-050	50	52.5	0.5	0.00136	0.379	0.451
	SVMW-08-100	100	102.5	0.5	0.00136	0.379	0.519
	SVMW-08-250	250	252.5	0.5	0.00136	0.379	0.723
SVMW-09	SVMW-09-050	50	52.5	0.5	0.00136	0.379	0.451
	SVMW-09-100	100	102.5	0.5	0.00136	0.379	0.519
	SVMW-09-250	250	252.5	0.5	0.00136	0.379	0.723
	SVMW-09-266	266	268.5	0.5	0.00136	0.379	0.745

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Table 1. Soil Vapor Monitoring Point Construction Parameters and Pre-Calculated Purge Volumes
Bulk Fuels Facility Area
Kirtland Air Force Base, Albuquerque, New Mexico

SVM Location ID	SVMP ID	Screened Interval (ft)		Well Diameter (in)	Casing Area (sq ft)	Filter Pack Volume (cu ft)[1]	Purge Volume (cu ft)
		Top	Bottom				
SVMW-10	SVMW-10-050	50	52.5	0.5	0.00136	0.379	0.451
	SVMW-10-100	100	102.5	0.5	0.00136	0.379	0.519
	SVMW-10-150	150	152.5	0.5	0.00136	0.379	0.587
	SVMW-10-250	250	252.5	0.5	0.00136	0.379	0.723
SVMW-11	SVMW-11-050	50	52.5	0.5	0.00136	0.379	0.451
	SVMW-11-100	100	102.5	0.5	0.00136	0.379	0.519
	SVMW-11-250	250	252.5	0.5	0.00136	0.379	0.723
	SVMW-11-260	260	262.5	0.5	0.00136	0.379	0.737
SVMW-12	SVMW-12-150	150	152.5	0.5	0.00136	0.379	0.587
	SVMW-12-250	250	252.5	0.5	0.00136	0.379	0.723
	SVMW-12-350	350	352.5	0.5	0.00136	0.379	0.860
	SVMW-12-450	450	452.5	0.5	0.00136	0.379	0.996
SVMW-13	SVMW-13-150	150	152.5	0.5	0.00136	0.379	0.587
	SVMW-13-250	250	252.5	0.5	0.00136	0.379	0.723
	SVMW-13-350	350	352.5	0.5	0.00136	0.379	0.860
	SVMW-13-450	450	452.5	0.5	0.00136	0.379	0.996
SVMW-14	SVMW-14-150	150	152.5	0.5	0.00136	0.379	0.587
	SVMW-14-250	250	252.5	0.5	0.00136	0.379	0.723
	SVMW-14-350	350	352.5	0.5	0.00136	0.379	0.860
	SVMW-14-450	450	452.5	0.5	0.00136	0.379	0.996

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Table 1. Soil Vapor Monitoring Point Construction Parameters and Pre-Calculated Purge Volumes
Bulk Fuels Facility Area
Kirtland Air Force Base, Albuquerque, New Mexico

SVM Location ID	SVMP ID	Screened Interval (ft)		Well Diameter (in)	Casing Area (sq ft)	Filter Pack Volume (cu ft)[1]	Purge Volume (cu ft)
		Top	Bottom				
SVMW-15	SVMW-15-150	150	152.5	0.5	0.00136	0.379	0.587
	SVMW-15-250	250	252.5	0.5	0.00136	0.379	0.723
	SVMW-15-350	350	352.5	0.5	0.00136	0.379	0.860
	SVMW-15-450	450	452.5	0.5	0.00136	0.379	0.996
KAFB-106028	KAFB-106028-150	148.75	151.25	0.5	0.00136	0.379	0.585
	KAFB-106028-250	248.75	251.25	0.5	0.00136	0.379	0.722
	KAFB-106028-350	348.75	351.25	0.5	0.00136	0.379	0.858
	KAFB-106028-450	448.75	451.25	0.5	0.00136	0.379	0.994
SVEW-01	SVEW-01-260	245	260	4	0.08727	2.274	24.963
SVEW-02/03	SVEW-02-060	45	60	2	0.02182	2.274	3.583
SVEW-02/03	SVEW-03-160	145	160	2	0.02182	2.274	5.764
SVEW-04/05	SVEW-04-313	298	313	2	0.02182	2.274	9.102
SVEW-04/05	SVEW-05-460	445	460	2	0.02182	2.274	12.309
SVEW-06/07	SVEW-06-060	45	60	2	0.02182	2.274	3.583
SVEW-06/07	SVEW-07-160	145	160	2	0.02182	2.274	5.764
SVEW-08/09	SVEW-08-260	245	260	2	0.02182	2.274	7.946
SVEW-08/09	SVEW-09-460	443	457	2	0.02182	2.122	12.092
SVEW-10	SVEW-10-410	400	410	2	0.02182	1.516	10.461
SVEW-11	SVEW-11-410	400	410	2	0.02182	1.516	10.461
SVEW-12	SVEW-12-410	400	410	2	0.02182	1.516	10.461
SVEW-13	SVEW-13-410	400	410	2	0.02182	1.516	10.461

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Table 1. Soil Vapor Monitoring Point Construction Parameters and Pre-Calculated Purge Volumes
Bulk Fuels Facility Area
Kirtland Air Force Base, Albuquerque, New Mexico

SVM Location ID	SVMP ID	Screened Interval (ft)		Well Diameter (in)	Casing Area (sq ft)	Filter Pack Volume (cu ft)[1]	Purge Volume (cu ft)
		Top	Bottom				
KAFB-106108	KAFB-106108-025	15.3	25.3	0.75	0.00307	2.259	2.337
	KAFB-106108-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106108-150	140.2	150.2	0.75	0.00307	1.517	1.978
	KAFB-106108-250	240.3	250.3	0.75	0.00307	1.517	2.285
	KAFB-106108-350	340.3	350.3	0.75	0.00307	1.517	2.592
	KAFB-106108-450	440	450	3	0.04909	1.517	23.607
KAFB-106109	KAFB-106109-025	15.2	25.2	0.75	0.00307	2.259	2.336
	KAFB-106109-050	40.1	50.1	0.75	0.00307	2.259	2.413
	KAFB-106109-150	140	150	0.75	0.00307	1.517	1.978
	KAFB-106109-250	240.2	250.2	0.75	0.00307	1.517	2.285
	KAFB-106109-350	340.6	350.6	0.75	0.00307	1.517	2.593
	KAFB-106109-450	440	450	3	0.04909	1.517	23.607
KAFB-106110	KAFB-106110-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106110-050	40.1	50.1	0.75	0.00307	2.259	2.413
	KAFB-106110-150	140.3	150.3	0.75	0.00307	1.517	1.979
	KAFB-106110-250	240	250	0.75	0.00307	1.517	2.284
	KAFB-106110-350	340.2	350.2	0.75	0.00307	1.517	2.592
	KAFB-106110-450	440	450	3	0.04909	1.517	23.607

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Table 1. Soil Vapor Monitoring Point Construction Parameters and Pre-Calculated Purge Volumes
Bulk Fuels Facility Area
Kirtland Air Force Base, Albuquerque, New Mexico

SVM Location ID	SVMP ID	Screened Interval (ft)		Well Diameter (in)	Casing Area (sq ft)	Filter Pack Volume (cu ft)[1]	Purge Volume (cu ft)
		Top	Bottom				
KAFB-106111	KAFB-106111-025	15.2	25.2	0.75	0.00307	2.259	2.336
	KAFB-106111-050	40.1	50.1	0.75	0.00307	2.259	2.413
	KAFB-106111-150	140.3	150.3	0.75	0.00307	1.517	1.979
	KAFB-106111-250	240.3	250.3	0.75	0.00307	1.517	2.285
	KAFB-106111-350	340.4	350.4	0.75	0.00307	1.517	2.592
	KAFB-106111-450	440.3	450.3	3	0.04909	1.517	23.621
KAFB-106112	KAFB-106112-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106112-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106112-150	140	150	0.75	0.00307	1.517	1.978
	KAFB-106112-250	240	250	0.75	0.00307	1.517	2.284
	KAFB-106112-350	339	349	0.75	0.00307	1.517	2.588
	KAFB-106112-450	439	449	3	0.04909	1.517	23.558
KAFB-106113	KAFB-106113-020	10	20	0.75	0.00307	2.259	2.320
	KAFB-106113-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106113-150	140	150	0.75	0.00307	1.517	1.978
	KAFB-106113-250	240	250	0.75	0.00307	1.517	2.284
	KAFB-106113-350	340	350	0.75	0.00307	1.517	2.591
	KAFB-106113-450	440	450	3	0.04909	1.517	23.607

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Table 1. Soil Vapor Monitoring Point Construction Parameters and Pre-Calculated Purge Volumes
Bulk Fuels Facility Area
Kirtland Air Force Base, Albuquerque, New Mexico

SVM Location ID	SVMP ID	Screened Interval (ft)		Well Diameter (in)	Casing Area (sq ft)	Filter Pack Volume (cu ft)[1]	Purge Volume (cu ft)
		Top	Bottom				
KAFB-106114	KAFB-106114-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106114-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106114-150	140	150	0.75	0.00307	1.517	1.978
	KAFB-106114-250	235	245	0.75	0.00307	1.517	2.269
	KAFB-106114-350	340	350	0.75	0.00307	1.517	2.591
	KAFB-106114-450	439.6	449.6	3	0.04909	1.517	23.587
KAFB-106115	KAFB-106115-025	14.6	24.6	0.75	0.00307	2.259	2.335
	KAFB-106115-050	39.6	49.6	0.75	0.00307	2.259	2.411
	KAFB-106115-150	144.6	154.6	0.75	0.00307	1.517	1.992
	KAFB-106115-250	239.6	249.6	0.75	0.00307	1.517	2.283
	KAFB-106115-350	339.6	349.6	0.75	0.00307	1.517	2.590
	KAFB-106115-450	439.6	449.6	3	0.04909	1.517	23.587
KAFB-106116	KAFB-106116-025	10	19.45	0.75	0.00307	2.135	2.194
	KAFB-106116-050	40	49.45	0.75	0.00307	2.135	2.287
	KAFB-106116-150	140	149.45	0.75	0.00307	1.434	1.892
	KAFB-106116-250	240	249.45	0.75	0.00307	1.434	2.199
	KAFB-106116-350	340	349.45	0.75	0.00307	1.434	2.506
	KAFB-106116-450	440	448.95	3	0.04909	1.358	23.396

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Table 1. Soil Vapor Monitoring Point Construction Parameters and Pre-Calculated Purge Volumes
Bulk Fuels Facility Area
Kirtland Air Force Base, Albuquerque, New Mexico

SVM Location ID	SVMP ID	Screened Interval (ft)		Well Diameter (in)	Casing Area (sq ft)	Filter Pack Volume (cu ft)[1]	Purge Volume (cu ft)
		Top	Bottom				
KAFB-106117	KAFB-106117-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106117-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106117-150	140	150	0.75	0.00307	1.517	1.978
	KAFB-106117-250	240	250	0.75	0.00307	1.517	2.284
	KAFB-106117-350	340	350	0.75	0.00307	1.517	2.591
	KAFB-106117-450	440	450	3	0.04909	1.517	23.607
KAFB-106118	KAFB-106118-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106118-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106118-160	150	160	0.75	0.00307	1.517	2.008
	KAFB-106118-265	255	265	0.75	0.00307	1.517	2.330
	KAFB-106118-350	340	350	0.75	0.00307	1.517	2.591
	KAFB-106118-450	440	450	3	0.04909	1.517	23.607
KAFB-106119	KAFB-106119-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106119-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106119-150	140	150	0.75	0.00307	1.517	1.978
	KAFB-106119-250	240	250	0.75	0.00307	1.517	2.284
	KAFB-106119-350	340	350	0.75	0.00307	1.517	2.591
	KAFB-106119-450	440	450	3	0.04909	1.517	23.607

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Table 1. Soil Vapor Monitoring Point Construction Parameters and Pre-Calculated Purge Volumes
Bulk Fuels Facility Area
Kirtland Air Force Base, Albuquerque, New Mexico

SVM Location ID	SVMP ID	Screened Interval (ft)		Well Diameter (in)	Casing Area (sq ft)	Filter Pack Volume (cu ft)[1]	Purge Volume (cu ft)
		Top	Bottom				
KAFB-106120	KAFB-106120-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106120-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106120-150	140	150	0.75	0.00307	1.517	1.978
	KAFB-106120-250	240	250	0.75	0.00307	1.517	2.284
	KAFB-106120-350	340	350	0.75	0.00307	1.517	2.591
	KAFB-106120-450	434	444	3	0.04909	1.517	23.312
KAFB-106121	KAFB-106121-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106121-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106121-145	135	145	0.75	0.00307	1.517	1.962
	KAFB-106121-250	240	250	0.75	0.00307	1.517	2.284
	KAFB-106121-350	340	350	0.75	0.00307	1.517	2.591
	KAFB-106121-440	434	444	3	0.04909	1.517	23.312
KAFB-106122	KAFB-106122-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106122-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106122-150	140	150	0.75	0.00307	1.517	1.978
	KAFB-106122-250	240	250	0.75	0.00307	1.517	2.284
	KAFB-106122-350	340	350	0.75	0.00307	1.517	2.591
	KAFB-106122-450	434	444	3	0.04909	1.517	23.312

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Table 1. Soil Vapor Monitoring Point Construction Parameters and Pre-Calculated Purge Volumes
Bulk Fuels Facility Area
Kirtland Air Force Base, Albuquerque, New Mexico

SVM Location ID	SVMP ID	Screened Interval (ft)		Well Diameter (in)	Casing Area (sq ft)	Filter Pack Volume (cu ft)[1]	Purge Volume (cu ft)
		Top	Bottom				
KAFB-106123	KAFB-106123-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106123-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106123-150	140	150	0.75	0.00307	1.517	1.978
	KAFB-106123-250	240	250	0.75	0.00307	1.517	2.284
	KAFB-106123-350	340	350	0.75	0.00307	1.517	2.591
	KAFB-106123-450	432	442	3	0.04909	1.517	23.214
KAFB-106124	KAFB-106124-025	15.1	25	0.75	0.00307	2.236	2.313
	KAFB-106124-050	40.1	50	0.75	0.00307	2.236	2.390
	KAFB-106124-150	140.1	150	0.75	0.00307	1.502	1.962
	KAFB-106124-250	240.1	250	0.75	0.00307	1.502	2.269
	KAFB-106124-350	340.1	350	0.75	0.00307	1.502	2.576
	KAFB-106124-450	440.1	450	3	0.04909	1.502	23.592
KAFB-106125	KAFB-106125-025	15.2	25	0.75	0.00307	2.214	2.291
	KAFB-106125-050	40.2	50	0.75	0.00307	2.214	2.367
	KAFB-106125-150	140.2	150	0.75	0.00307	1.487	1.947
	KAFB-106125-250	240.2	250	0.75	0.00307	1.487	2.254
	KAFB-106125-350	340.2	350	0.75	0.00307	1.487	2.561
	KAFB-106125-450	440.2	450	3	0.04909	1.487	23.576

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Table 1. Soil Vapor Monitoring Point Construction Parameters and Pre-Calculated Purge Volumes
Bulk Fuels Facility Area
Kirtland Air Force Base, Albuquerque, New Mexico

SVM Location ID	SVMP ID	Screened Interval (ft)		Well Diameter (in)	Casing Area (sq ft)	Filter Pack Volume (cu ft)[1]	Purge Volume (cu ft)
		Top	Bottom				
KAFB-106126	KAFB-106126-025	15.1	25	0.75	0.00307	2.236	2.313
	KAFB-106126-050	40.1	50	0.75	0.00307	2.236	2.390
	KAFB-106126-150	140.1	150	0.75	0.00307	1.502	1.962
	KAFB-106126-250	240.1	250	0.75	0.00307	1.502	2.269
	KAFB-106126-350	340.1	350	0.75	0.00307	1.502	2.576
	KAFB-106126-450	440.2	450	3	0.04909	1.487	23.576
KAFB-106127	KAFB-106127-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106127-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106127-150	140	150	0.75	0.00307	1.517	1.978
	KAFB-106127-250	240	250	0.75	0.00307	1.517	2.284
	KAFB-106127-350	340	350	0.75	0.00307	1.517	2.591
	KAFB-106127-450	440	450	3	0.04909	1.517	23.607
KAFB-106128	KAFB-106128-025	15.04	25.04	0.75	0.00307	2.259	2.336
	KAFB-106128-050	40.07	50.07	0.75	0.00307	2.259	2.413
	KAFB-106128-150	140.19	150.19	0.75	0.00307	1.517	1.978
	KAFB-106128-250	240.29	250.29	0.75	0.00307	1.517	2.285
	KAFB-106128-350	340.39	350.39	0.75	0.00307	1.517	2.592
	KAFB-106128-450	440.06	450.06	3	0.04909	1.517	23.610

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Table 1. Soil Vapor Monitoring Point Construction Parameters and Pre-Calculated Purge Volumes
Bulk Fuels Facility Area
Kirtland Air Force Base, Albuquerque, New Mexico

SVM Location ID	SVMP ID	Screened Interval (ft)		Well Diameter (in)	Casing Area (sq ft)	Filter Pack Volume (cu ft)[1]	Purge Volume (cu ft)
		Top	Bottom				
KAFB-106129	KAFB-106129-025	15.1	25.1	0.75	0.00307	2.259	2.336
	KAFB-106129-050	39.7	49.7	0.75	0.00307	2.259	2.412
	KAFB-106129-150	140.2	150.2	0.75	0.00307	1.517	1.978
	KAFB-106129-250	240.1	250.1	0.75	0.00307	1.517	2.285
	KAFB-106129-350	337.4	347.4	0.75	0.00307	1.517	2.583
	KAFB-106129-450	440.7	450.7	3	0.04909	1.517	23.641
KAFB-106130	KAFB-106130-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106130-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106130-150	150	160	0.75	0.00307	1.517	2.008
	KAFB-106130-250	240	250	0.75	0.00307	1.517	2.284
	KAFB-106130-350	340	350	0.75	0.00307	1.517	2.591
	KAFB-106130-450	440	450	3	0.04909	1.517	23.607
KAFB-106131	KAFB-106131-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106131-055	45	55	0.75	0.00307	2.259	2.428
	KAFB-106131-150	140	150	0.75	0.00307	1.517	1.978
	KAFB-106131-245	235	245	0.75	0.00307	1.517	2.269
	KAFB-106131-350	340	350	0.75	0.00307	1.517	2.591
	KAFB-106131-450	430	440	3	0.04909	1.517	23.116

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Table 1. Soil Vapor Monitoring Point Construction Parameters and Pre-Calculated Purge Volumes
Bulk Fuels Facility Area
Kirtland Air Force Base, Albuquerque, New Mexico

SVM Location ID	SVMP ID	Screened Interval (ft)		Well Diameter (in)	Casing Area (sq ft)	Filter Pack Volume (cu ft)[1]	Purge Volume (cu ft)
		Top	Bottom				
KAFB-106132	KAFB-106132-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106132-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106132-175	164	174	0.75	0.00307	1.517	2.051
	KAFB-106132-250	240	250	0.75	0.00307	1.517	2.284
	KAFB-106132-350	340	350	0.75	0.00307	1.517	2.591
	KAFB-106132-450	440	450	3	0.04909	1.517	23.607
KAFB-106133	KAFB-106133-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106133-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106133-170	160	170	0.75	0.00307	1.517	2.039
	KAFB-106133-250	240	250	0.75	0.00307	1.517	2.284
	KAFB-106133-350	339	349	0.75	0.00307	1.517	2.588
	KAFB-106133-450	439	449	3	0.04909	1.517	23.558
KAFB-106134	KAFB-106134-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106134-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106134-170	160	170	0.75	0.00307	1.517	2.039
	KAFB-106134-250	240	250	0.75	0.00307	1.517	2.284
	KAFB-106134-350	340	350	0.75	0.00307	1.517	2.591
	KAFB-106134-450	440	450	3	0.04909	1.517	23.607

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Table 1. Soil Vapor Monitoring Point Construction Parameters and Pre-Calculated Purge Volumes
Bulk Fuels Facility Area
Kirtland Air Force Base, Albuquerque, New Mexico

SVM Location ID	SVMP ID	Screened Interval (ft)		Well Diameter (in)	Casing Area (sq ft)	Filter Pack Volume (cu ft)[1]	Purge Volume (cu ft)
		Top	Bottom				
KAFB-106135	KAFB-106135-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106135-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106135-150	140	150	0.75	0.00307	1.517	1.978
	KAFB-106135-250	240	250	0.75	0.00307	1.517	2.284
	KAFB-106135-350	340	350	0.75	0.00307	1.517	2.591
	KAFB-106135-450	440	450	3	0.04909	1.517	23.607
KAFB-106136	KAFB-106136-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106136-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106136-150	140	150	0.75	0.00307	1.517	1.978
	KAFB-106136-250	240	250	0.75	0.00307	1.517	2.284
	KAFB-106136-350	340	350	0.75	0.00307	1.517	2.591
	KAFB-106136-450	440	450	3	0.04909	1.517	23.607
KAFB-106137	KAFB-106137-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106137-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106137-150	140	150	0.75	0.00307	1.517	1.978
	KAFB-106137-250	240.1	250.1	0.75	0.00307	1.517	2.285
	KAFB-106137-350	340.5	350.5	0.75	0.00307	1.517	2.593
	KAFB-106137-450	440	450	3	0.04909	1.517	23.607

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Table 1. Soil Vapor Monitoring Point Construction Parameters and Pre-Calculated Purge Volumes
Bulk Fuels Facility Area
Kirtland Air Force Base, Albuquerque, New Mexico

SVM Location ID	SVMP ID	Screened Interval (ft)		Well Diameter (in)	Casing Area (sq ft)	Filter Pack Volume (cu ft)[1]	Purge Volume (cu ft)
		Top	Bottom				
KAFB-106138	KAFB-106138-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106138-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106138-150	140	150	0.75	0.00307	1.517	1.978
	KAFB-106138-250	240	250	0.75	0.00307	1.517	2.284
	KAFB-106138-350	340	350	0.75	0.00307	1.517	2.591
	KAFB-106138-450	440	450	3	0.04909	1.517	23.607
KAFB-106139	KAFB-106139-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106139-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106139-150	140	150	0.75	0.00307	1.517	1.978
	KAFB-106139-250	240	250	0.75	0.00307	1.517	2.284
	KAFB-106139-350	340	350	0.75	0.00307	1.517	2.591
	KAFB-106139-450	440	450	3	0.04909	1.517	23.607
KAFB-106140	KAFB-106140-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106140-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106140-150	141.8	151.8	0.75	0.00307	1.517	1.983
	KAFB-106140-250	240	250	0.75	0.00307	1.517	2.284
	KAFB-106140-350	340	350	0.75	0.00307	1.517	2.591
	KAFB-106140-450	440	450	3	0.04909	1.517	23.607

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Table 1. Soil Vapor Monitoring Point Construction Parameters and Pre-Calculated Purge Volumes
Bulk Fuels Facility Area
Kirtland Air Force Base, Albuquerque, New Mexico

SVM Location ID	SVMP ID	Screened Interval (ft)		Well Diameter (in)	Casing Area (sq ft)	Filter Pack Volume (cu ft)[1]	Purge Volume (cu ft)
		Top	Bottom				
KAFB-106141	KAFB-106141-025	15	25	0.75	0.00307	2.259	2.336
	KAFB-106141-050	50	60	0.75	0.00307	2.259	2.443
	KAFB-106141-170	160	170	0.75	0.00307	2.259	2.781
	KAFB-106141-250	240	250	0.75	0.00307	2.259	3.026
	KAFB-106141-350	340	350	0.75	0.00307	2.259	3.333
	KAFB-106141-450	440	450	3	0.04909	2.259	24.348
KAFB-106142	KAFB-106142-030	20	30	0.75	0.00307	2.259	2.351
	KAFB-106142-050	40	50	0.75	0.00307	2.259	2.412
	KAFB-106142-170	160	170	0.75	0.00307	2.259	2.781
	KAFB-106142-250	240	250	0.75	0.00307	2.259	3.026
	KAFB-106142-350	340	350	0.75	0.00307	2.259	3.333
	KAFB-106142-450	440	450	3	0.04909	2.259	24.348

[1]borehole casing factor = (((10 inch diameter/12 inches)^2)(3.14159/4))(0.3 porosity) = 0.1636

[2]SVMW-08-266 is clogged and cannot be sampled

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