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

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NMED
Hazardous Waste
Bureau

Colonel David S. Miller
Commander
377th Air Base Wing
2000 Wyoming Blvd SE
Kirtland AFB NM 87117

FEB 11 2020

Mr. Kevin Pierard
Bureau Chief
Hazardous Waste Bureau (HWB)
New Mexico Environment Department (NMED)
2905 Rodeo Park Drive East, Building 1
Santa Fe NM 87505-6303

Dear Mr. Pierard

Attached, please find the *Final In-Situ Bioremediation Long-Term Monitoring Work Plan, Bulk Fuels Facility, Solid Waste Management Units (SWMUs) ST-106/SS-111*, Kirtland Air Force Base (AFB), New Mexico dated February 2020. This work plan was prepared to describe the groundwater monitoring activities to be conducted at existing groundwater monitoring, extraction, and injection wells associated with an in-situ bioremediation (ISB) pilot test that was initiated in 2017 at the Bulk Fuels Facility remediation site. To continue evaluating long-term ISB performance, existing pilot test wells will be monitored on a quarterly basis for contaminant, geochemical, and microbial parameters.

If you have any questions or concerns, please contact Ms. April Fitzner at commercial line (505) 853-1803 or email april.fitzner@us.af.mil; or Mr. Sheen Kottkamp at commercial line (505) 846-7674 or email sheen.kottkamp.1@us.af.mil.

Sincerely

DAVID S. MILLER, Colonel, USAF
Commander

Attachment:
Final In-Situ Bioremediation Long-Term Monitoring Work Plan, SWMUs ST-106/SS-111, February 2020.

cc:
NMED-OOTS (Pruett), letter
NMED-HWB (Cobrain), letter and CD
NMED-RPD (Stringer), letter and CD
EPA-Region 6 (King, Ellinger), letter and CD
SAF-IEE (Lynnes), electronic only
AFCEC/CZ (Renaghan, Clark, Kottkamp, Segura, Fitzner), electronic only
USACE-ABQ District Office (Moayyad, Phaneuf, Dreeland, Cordova, Kunkel, Salazar), electronic only
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KIRTLAND AIR FORCE BASE
ALBUQUERQUE, NEW MEXICO

FINAL
IN SITU BIOREMEDIATION LONG-TERM MONITORING WORK PLAN
BULK FUELS FACILITY
SOLID WASTE MANAGEMENT UNITS ST-106 AND SS-111

February 2020

377 MSG/CEI
2050 Wyoming Boulevard SE
Kirtland Air Force Base, New Mexico 87117-5270

KIRTLAND AIR FORCE BASE
ALBUQUERQUE, NEW MEXICO

FINAL
IN SITU BIOREMEDIATION LONG-TERM MONITORING WORK PLAN
BULK FUELS FACILITY
SOLID WASTE MANAGEMENT UNITS ST-106/SS-111

February 2020

Prepared for
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14. ABSTRACT

This In Situ Bioremediation (ISB) Long-Term Monitoring Work Plan was prepared for the Kirtland Air Force Base (AFB) Bulk Fuels Facility, Solid Waste Management Units ST-106/SS-111 located on Kirtland AFB in Albuquerque, New Mexico. This Work Plan was prepared in accordance with all applicable federal, state, and local laws and regulations, including the New Mexico Hazardous Waste Act, New Mexico Statutes Annotated 1978, the New Mexico Water Quality Act, New Mexico Hazardous Waste Management Regulations, Resource Conservation and Recovery Act, and the Water Quality Control Commission Regulations. A pilot test was initiated in 2017 to investigate anaerobic ISB of 1,2-dibromoethane (EDB). The objective to demonstrate anaerobic ISB of EDB was successfully achieved, with greater than 97 percent reduction in EDB concentrations observed at five of the six shallow wells. This work plan describes continued efforts to evaluate the performance of the ISB pilot test and includes continued monitoring of existing pilot test wells on a quarterly basis.

15. SUBJECT TERMS

Bulk Fuels Facility Spill, Solid Waste Management Units ST-106/SS-111, long-term monitoring, in situ bioremediation

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40 CFR 270.11
DOCUMENT CERTIFICATION

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.

DAVID S. MILLER, Colonel, U.S. Air Force Commander, 377th Air Base Wing	11 Feb 20 Date

This document has been approved for public release.

KIRTLAND AIR FORCE BASE 377th Air Base Wing Public Affairs	4 FEB 20 Date

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PREFACE

This In Situ Bioremediation Long-Term Monitoring Work Plan has been prepared by Aptim Federal Services, LLC (APTIM) for Kirtland Air Force Base under U.S. Army Corps of Engineers Contract Number W912DY16D0022, Delivery Order W912PP19F0053. It pertains to the Kirtland Air Force Base Bulk Fuels Facility Spill, Solid Waste Management Units ST-106/SS-111, located in Albuquerque, New Mexico. This Work Plan was prepared in accordance with all applicable federal, state, and local laws and regulations, including the New Mexico Hazardous Waste Act, New Mexico Statutes Annotated 1978, the New Mexico Water Quality Act, New Mexico Hazardous Waste Management Regulations, Resource Conservation and Recovery Act, and the Water Quality Control Commission Regulations.

Kathleen E Romalia

Kathleen Romalia, PE, PMP
APTIM
Project Manager

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ACRONYMS AND ABBREVIATIONS

AFB	Air Force Base
APP	Accident Prevention Plan
APTIM	Aptim Federal Services, LLC
BFF	Bulk Fuels Facility
bgs	below ground surface
CFR	Code of Federal Regulations
DOT	Department of Transportation
EDB	1,2-dibromoethane/ethylene dibromide
EDD	electronic data deliverable
EPA	U.S. Environmental Protection Agency
FCV	flow control valve
IDW	Investigation-derived waste
ISB	in situ bioremediation
KAFB	Kirtland Air Force Base
NAPL	non-aqueous phase liquid
NMED	New Mexico Environment Department
NTU	nephelometric turbidity units
pH	potential of hydrogen
QAPP	Quality Assurance Project Plan
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
USACE	U.S. Army Corps of Engineers
VOA	Volatile Organic Analysis
VOC	Volatile Organic Compound
Work Plan	In Situ Bioremediation Long-Term Monitoring Work Plan

EXECUTIVE SUMMARY

This In Situ Bioremediation (ISB) Long-Term Monitoring Work Plan (Work Plan) describes groundwater monitoring activities to be conducted at existing groundwater monitoring, extraction, and injection wells associated with an ISB pilot test that was initiated in 2017 at the Kirtland Air Force Base (AFB) Bulk Fuels Facility site (Solid Waste Management Units ST-106/SS-111). This Work Plan was developed by Aptim Federal Services, LLC for Kirtland AFB under U.S. Army Corps of Engineers (USACE) Contract Number W912DY16D0022, Delivery Order W912PP19F0053. The investigation and remediation of the Bulk Fuels Facility leak is being implemented pursuant with the corrective action provisions in Part 6 of the Resource Conservation and Recovery Act Permit (U.S. Environmental Protection Agency Identification Number NM9570024423) issued to Kirtland AFB by the New Mexico Environment Department (NMED, 2010) and applicable federal, state, and local laws and regulations. The pilot test was performed pursuant to the NMED-approved *Ethylene Dibromide In Situ Biodegradation Pilot Test Work Plan* (USACE, 2016a) and the Phase 3 Notification Letter (USACE, 2018a). To continue evaluating longer-term ISB performance, existing pilot test wells will be monitored on a quarterly basis for contaminant, geochemical, and microbial parameters. This Work Plan also describes proposed activities for evaluating the condition of wells used previously for extraction and injection of groundwater and amendments associated with the ISB pilot test.

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1. INTRODUCTION

This In Situ Bioremediation (ISB) Long-Term Monitoring Work Plan (Work Plan) describes groundwater monitoring activities conducted at existing groundwater monitoring, extraction, and injection wells associated with an ISB pilot test that was initiated in 2017 at the Kirtland Air Force Base (AFB) Bulk Fuels Facility (BFF) site (Solid Waste Management Units ST-106/SS-111). This Work Plan was developed by Aptim Federal Services, LLC (APTIM) for the U.S. Army Corps of Engineers (USACE) under Contract Number W912DY16D0022, Delivery Order W912PP19F0053 as a follow-on plan to the New Mexico Environment Department (NMED)-approved *Ethylene Dibromide In Situ Biodegradation Pilot Test Work Plan* (USACE, 2016a).

The investigation and remediation of the BFF leak are being implemented pursuant with the corrective action provisions in Part 6 of the Resource Conservation and Recovery Act (RCRA) Permit (U.S. Environmental Protection Agency [EPA] Identification Number NM9570024423) issued to Kirtland AFB by the NMED (2010) and applicable federal, state, and local laws and regulations. The NMED Hazardous Waste Bureau is the lead regulatory agency.

1.1 Work Plan Organization

The Work Plan is divided into the following sections:

- ***Section 1, Introduction***—Presents an introduction to the plan and the scope of activities and organization of the Work Plan.
- ***Section 2, Background Information***—Presents the site description, operational history, brief discussion of the ISB pilot test, and permitting requirements.
- ***Section 3, Site Conditions***—Presents the site conditions, including regional and site-specific geology, hydrogeology, and geochemistry.
- ***Section 4, Scope of Activities***—Presents the scope of activities.

- ***Section 5, Investigation Methods and Approach***—Presents the long-term monitoring approach and details regarding the treatment system well assessment.
- ***Section 6, Monitoring and Sampling***—Provides information on groundwater monitoring and sampling requirements.
- ***Section 7, Waste Management Plan***—Presents information on the management and disposal of the waste generated during this project.
- ***Section 8, Data Management and Reporting***—Presents information on the management of data and reporting requirements.
- ***Section 9, Project Schedule***—Presents a brief project schedule.
- ***Section 10, Accident Prevention Plan***—Presents information on the Accident Prevention Plan.
- ***References***—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, Field Forms.

2. BACKGROUND INFORMATION

2.1 Site Description

Kirtland AFB is located in Bernalillo County in central New Mexico, southeast of the City of Albuquerque and adjacent to the Albuquerque International Sunport (Figure 2-1). The BFF is located in the northwestern portion of Kirtland AFB and was the historic source of fuel constituents found in the Solid Waste Management Units ST-106/SS-111 groundwater plume. The existing pilot test wells are located in an area just south of Randolph Road, at the location identified on Figure 2-2. The water table at the test location occurs approximately 480 feet below ground surface (bgs), and the pilot test groundwater wells are screened within the Santa Fe Group at depths ranging from 463 to 523 feet bgs. Well screens of the shallow monitoring wells were placed to target the highest ethylene dibromide (EDB) concentrations (i.e., approximately the top 20 feet of the aquifer). Table 2-1 summarizes well completion details for the existing wells.

2.2 Site History

From 1953 until 1999, the BFF included a tank holding area where bulk shipments of fuel were received and a fuel loading area where individual fuels trucks were filled. Kirtland AFB removed the underground piping at the facility from service in 1999 due to discovery of an underground leak. It is believed that the leak occurred from the underground piping as fuel was transferred from railcars to the pump house. Through extensive characterization activities, Kirtland AFB discovered groundwater impacted by fuel constituents and the migration of dissolved-phase fuel constituents northeast and north of Kirtland AFB.

Kirtland AFB enacted both voluntary and NMED Hazardous Waste Bureau-directed interim measures. 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 EDB plume.

2.3 In Situ Bioremediation Pilot Test

A pilot test was conducted to investigate anaerobic ISB of EDB in groundwater associated with the BFF site. The pilot test was primarily designed to evaluate the extent to which potential treatment amendments for in situ biostimulation enhance anaerobic EDB biodegradation processes.

The pilot test area included groundwater injection, extraction, and monitoring wells installed near the existing monitoring well cluster that includes Kirtland AFB (KAFB)-106062, KAFB-106063, and KAFB-106064, approximately 300 feet to the east of Building 1024 (Figure 2-2). A fabricated system contained within a 20-foot long Conex box was used for amending and recirculating groundwater.

The pilot test was implemented in four phases. Groundwater samples were collected at extraction, injection, and the six groundwater monitoring wells during the active and the passive portions of the pilot test phases, except for Phase 4, which did not include an active recirculation portion. Evaluation of the test was completed through the comprehensive groundwater sampling which assessed both direct and indirect indicators of EDB biodegradation.

The objective to demonstrate anaerobic ISB of EDB was successfully achieved, with greater than 97 percent reduction in EDB concentrations observed at five of the six shallow wells. Results of the pilot test are included in the *Ethylene Dibromide In Situ Biodegradation Pilot Test Report* (USACE, 2019a).

2.4 Permitting

Permitting is not anticipated to be required for the ISB long-term monitoring activities described in this work plan. Groundwater samples will be collected using dedicated bladder pumps at the existing groundwater wells. No additional ground disturbance will be performed. All investigation-derived waste (IDW) will be stored and disposed of in accordance with state and federal regulations. A fugitive dust permit will be submitted to include both the ISB pilot test area and injection well KAFB-7 work areas, since both tasks will be performed under the same contract. Monitoring and reporting will be performed pursuant to the RCRA Permit (NMED, 2010).

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3. SITE CONDITIONS

This section describes site conditions, including regional and site-specific geology, hydrogeology, and geochemistry. Previous investigation results are presented in the Phase I RCRA Facility Investigation (RFI) Report (USACE, 2018b).

3.1 Regional Geology

The geology of the Kirtland AFB area varies in accordance with the regional geology. The eastern portion of Kirtland AFB is mountainous, with elevations reaching 7,900 feet above mean sea level. These mountains are composed of Precambrian metamorphic, igneous (primarily granite), and Paleozoic sedimentary rock (primarily marine carbonates). The western portion of the base (which includes the BFF) lies within the Albuquerque Basin. Geologic features in this area of the basin include travertine and unconsolidated and semi-consolidated piedmont deposits, as well as aeolian, lacustrine, and stream channel deposits.

In general, the surficial geology is characterized by recent deposits (i.e., mixtures of sandy silt and silty sand with minor amounts of clay and gravel), Ortiz gravel (i.e., alluvial piedmont sand and gravel deposits), and the Santa Fe Group (i.e., a mixture of sand, silt, clay, gravel, cobbles, and boulders). Generally, the northern and western portions of Kirtland AFB are dominated by unconsolidated geologic units; consolidated units predominate in the eastern half of the base. Kirtland AFB lies within the eastern portion of the Albuquerque Basin, which contains the through-flowing Rio Grande. The Albuquerque Basin is approximately 100 miles long and 25 miles wide, and extends from Cochiti to San Acacia (Water Authority, 2016). The deposits within the Albuquerque Basin consist of interbedded gravel, sand, silt, and clay. Generally, sedimentary deposits of the Santa Fe Group are more than 3,000 feet thick in most of the basin (Kelley, 1977). Seven million years ago, the Ancestral Rio Grande entered the Albuquerque Basin

(Connell and Love, 2009; Hawley, 1978), which has been continuously filled by three depositional systems: alluvial fans, axial Ancestral Rio Grande fluvial system, and fluvial fans.

3.2 Site-Specific Geology

In general, the BFF is underlain by approximately 200 feet of relatively fine-grained alluvial fan deposits, with some alternating and laterally discontinuous coarse-grained zones. Underlying these easterly derived alluvial fan deposits are relatively coarse-grained Ancestral Rio Grande deposits, with a few laterally discontinuous fine-grained zones (AECOM, 2015).

3.3 Regional Hydrogeology

The groundwater system at Kirtland AFB and in the Albuquerque area lies within the Albuquerque Basin, also referred to as the Middle Rio Grande Basin. The basin is part of the Rio Grande Rift. As the Rio Grande Rift spread, the Albuquerque Basin filled with sediments several miles thick, most of which are referred to as the Santa Fe Group. The unit consists of unconsolidated sediments that thin toward the basin boundary. Edges of the basin are marked by normal faults. Overlying the Santa Fe Group are the Pliocene Ortiz gravel and Rio Grande fluvial deposits.

Generally, the upper and middle units of the Santa Fe Group contain the most productive portion of the regional aquifer that supplies groundwater to the City of Albuquerque, the Raymond G. Murphy Veteran's Administration Medical Center, Kirtland AFB, and private water supply wells. The most permeable parts of the aquifer system are composed of coarse-grained Ancestral Rio Grande deposits.

Transmissivity estimates for the aquifer system have ranged widely due to variations in both the thickness and hydraulic conductivity across the basin but estimates from aquifer tests (mostly in Albuquerque drinking water supply wells) generally fall between about 3,000 feet squared per day and 70,000 feet squared per day. These values were used to estimate horizontal hydraulic conductivities as ranging from about 4 feet per day to 150 feet per day (Thorn et al., 1993). Regional flow directions in the aquifer are dominated by groundwater pumping of drinking water supply wells operating across the basin.

3.4 Site-Specific Hydrogeology

The aquifer near the BFF ranges from 450 feet to 480 feet bgs and is an unconfined aquifer dominated by the sediments described in Section 3.2. The fine-grained clayey unit, located at approximately 300 feet below the water table (roughly 800 feet bgs), functions as an aquitard and can be considered the bottom of the water table (unconfined) aquifer (USACE, 2016b).

Multiple investigations have been conducted at the BFF to characterize physical aquifer properties in respect to the dissolved-phase EDB plume. Investigation results indicate that physical aquifer properties such as hydraulic conductivity are highly variable across the site. This variability corresponds with the depositional history of the Santa Fe Group.

Based on data reviewed for the pilot test design, the groundwater gradient in the pilot test area was less than 0.002 foot/foot (First Quarter 2016), and the direction of groundwater flow had shifted from north-northeast to a more east-southeast direction, likely due to continuing water-conservation practices and seasonal fluctuations, as discussed in the Second Quarter 2018 Quarterly Monitoring Report (USACE, 2018c). According to the Second Quarter 2019 Quarterly Monitoring Report (USACE, 2019b), groundwater flow direction within the pilot test area is still in an east-southeast direction.

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4. SCOPE OF ACTIVITIES

The purpose of this Work Plan is to continue evaluating longer-term ISB performance at existing pilot test wells through quarterly groundwater monitoring of contaminant, geochemical, and microbial parameters. The analyses proposed in this Work Plan will help evaluate the continued degradation of EDB, or its possible rebound. Additionally, continued quarterly monitoring will be useful in assessing the fluctuating regional groundwater depth and the impact to concentrations measured at the pilot test wells. This Work Plan also describes the proposed activities for evaluating ISB extraction and injection well performance in order to maintain the existing ISB system.

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5. INVESTIGATION METHODS AND APPROACH

The ISB treatment zone will be monitored at a quarterly frequency in a manner consistent with the *Ethylene Dibromide In Situ Biodegradation Pilot Test Work Plan* (USACE, 2016a) to evaluate long-term performance of ongoing ISB and to evaluate possible rebound of EDB. A minimum of three monitoring events will be performed upon NMED approval of this Work Plan. Groundwater sampling and water level measurements associated with the long-term monitoring are described in Section 6.

Additionally, conditions of the ISB extraction and injection wells and associated equipment (e.g., pumps) will be investigated during this work to help guide design and operation of such recirculation systems in the future at the site. During the pilot test, hydraulic performance at associated extraction and injection wells was noted to decrease, as observed primarily through greater drawdown/mounding of the water table during water recirculation activities. Downhole equipment and piping will be removed from the ISB extraction and injection wells to assess their condition. These system components will not be reinstalled in situ during the long-term monitoring activities described herein. Assessment of the extraction and injection wells is discussed in Section 5.3 below.

5.1 Long-Term Monitoring Details

Long-term monitoring of ISB pilot test performance began upon completion of the final Phase 3 sampling event on November 19, 2018. One sampling event was conducted from January 16 to January 21, 2019 in accordance with the NMED-approved *Ethylene Dibromide In Situ Biodegradation Pilot Test Work Plan* (USACE, 2016a). This work plan describes efforts to continue monitoring and evaluating the long-term performance of the ISB pilot test.

5.2 Monitoring Frequency and Location

Nine existing wells will be sampled on a quarterly basis, including six monitoring wells, two extraction wells, and one injection well previously utilized for recirculating water and amendments to facilitate the ISB pilot test. Figure 2-2 shows locations of these existing wells.

5.3 Extraction and Injection Well Assessment

Well manifolds and all downhole equipment (drop pipe, valves, transducer, and pump) will be removed from each well (KAFB-106EX1, KAFB-106EX2, and KAFB-106IN1), their conditions will be assessed, and they will be stored on site for future possible use. Further, the condition of these wells will also be assessed using a downhole video camera.

5.3.1 Removal of Downhole Equipment

In order to assess the condition of the extraction and injection wells and associated equipment (e.g., pumps, Baski valve, etc.), the following equipment will be removed from each well:

- Wellhead manifold
- 1.25-inch drop pipe (pipe for transducer)
- KSPI 700 submersible hydrostatic level transducer
- 1.5-inch threaded steel drop pipe
- Check valves
- Baski flow control valve (FCV; injection well only)
- Grundfos 25S50-26, 5.5 horsepower pump (extraction wells only)
- Grundfos 5SQE-10-410, 2.3 horsepower pump (injection well only)

Nitrogen lines to the Baski FCV will be disconnected and secured within the well vault, or other suitable location. The condition of the downhole Baski FCV, submersible pumps, check valves, and drop pipes will be assessed once out of the well. A list of equipment removed from the extraction and injection wells will be maintained including the storage location, and photographs of each item will be taken. Downhole equipment will remain out of the well until additional injections are warranted. All downhole equipment will be decontaminated, covered, and stored at the ISB pilot test yard off of the ground surface. Prior to any reinstallation of the equipment in the future, the Grundfos pumps will be tested at the surface in a manner that simulates conditions at depth to check operability. Additionally, the well bottom will be tagged after removal of the downhole equipment to determine if formation material or filter pack has entered the well.

5.3.2 Downhole Video Survey

After the downhole equipment has been removed, and the sediment in the well is allowed to settle, the well will be surveyed using a video camera. The camera will be arranged so that the sides and bottom of the well can be viewed. The video footage will be evaluated to determine what, if any, well rehabilitation is needed.

5.3.3 Bladder Pump Installation

After existing extraction and injection well downhole infrastructure is removed from the wells, APTIM will install three dedicated bladder pumps for sampling. The bladder pumps will be QED MicroPurge® Model P1101HM bladder pumps; the same model that is installed in the ISB pilot test monitoring wells. The QED bladder pumps will be hung on a poly-coated stainless steel hanging cable such that the pump intake area is set at approximately the middle point of the saturated screen interval. The top of the pump string will include a single aluminum well cap with access to the discharge line, hanging cable, and air-line. This hanging well cap will fit into the top of the sanitary well seal. Well tubing will be twin-bonded, Teflon™- lined polyethylene and consists of a ¼-inch outside diameter air supply line and a 3/8-inch outside diameter water discharge line. The twin-bonded tubing will be long enough to extend above the ground surface to limit entry into the well vaults.

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6. MONITORING AND SAMPLING

Groundwater data collected during long-term monitoring will support the evaluation of ongoing ISB performance and possible rebound of EDB concentrations. Sampling will be conducted quarterly using the methods and procedures described in the following subsections. Quarterly sampling is sufficient to identify possible rebound of EDB concentrations if it occurs during the extended period of monitoring.

6.1 Groundwater Monitoring

Groundwater monitoring will consist of measuring groundwater and non-aqueous phase liquid (NAPL) levels (if observed), measuring field parameters, and use of low-flow sampling procedures to collect representative groundwater samples for field and laboratory analysis. Groundwater sampling will be performed by low-flow methods using dedicated bladder pumps. Sampling and analysis of all regulated compounds will be conducted in accordance with the Quality Systems Manuals for Environmental Laboratories, Version 5.3 (U.S. Department of Defense, 2019) and the RCRA Permit (NMED, 2010).

6.1.1 Measuring Groundwater and NAPL Depths

Depth to water and depth to NAPL, if observed, will be measured in each well using a Solinst Model 122 interface probe, or similar device from a surveyed reference point. Measurements will be made to the nearest 0.01 foot. Groundwater elevations will be calculated using static water levels. Measurements will be made immediately before purging and sampling, and during purging to monitor any drawdown. If continued drawdown of the water level occurs during purging, the pump rate will be decreased to stabilize the water.

6.1.2 Well Purging Requirements

Groundwater wells will be purged using low-flow purging techniques utilizing dedicated bladder pumps (QED MicroPurge® Model P1101HM bladder pumps). Purging rates will be below one liter per minute, and will depend on the optimal pump cycle that has been established for each well. Bladder pumps will operate through use of a high pressure controller and nitrogen as operating gas. Bladder pumps fill by hydrostatic pressure. As the inside of the pump's bladder fills with water, the bladder expands. This filling and expanding of the bladder is referred to as the "refill" half of the pump cycle. When air pressure is applied to the outside of the bladder, the bladder is squeezed, forcing the water up the discharge tubing. This is referred to as the "discharge" half of the pump cycle.

During purging activities, the following field water quality parameters will be monitored using a flow-through cell water quality meter (or equivalent) consistent with the *Ethylene Dibromide In Situ Biodegradation Pilot Test Work Plan* (USACE, 2016a): dissolved oxygen, potential of hydrogen (pH), oxidation reduction potential, turbidity, conductivity, and temperature. Purging will be considered completed when field water quality parameters have stabilized according to the requirements listed below for three consecutive readings:

- Dissolved oxygen +/- 0.3 milligrams per liter
- Oxidation-reduction potential +/- 10 millivolts
- Turbidity <10 nephelometric turbidity units (NTUs) or +/- 10 percent when <10 NTUs cannot be achieved
- Conductivity +/- 3 percent microohms per centimeter
- pH +/- 0.1 units
- Temperature +/- 10 percent degrees Celsius or degrees Fahrenheit

6.1.3 Sample Collection

All groundwater samples will be collected using dedicated, bladder pumps installed in the groundwater wells. Samples for volatile organic analysis (VOA) will be collected first. The samples will be carefully filled to avoid overflow and potential loss of preservative. If bubbles appear, the VOA vial will be topped off in an attempt to remove the entrained air or a new vial will be used if a sample preservative is used.

Samples for non-VOA analysis (poly bottles) will be collected following collection of the VOA samples. Samples collected for dissolved iron, manganese, and ortho-phosphate will be field filtered using a 0.45-micron filter. If field filtration is not performed, the sample label and chain-of-custody form will be clearly marked to state that laboratory filtration is required. Sample location, analytical group, sample count, analytical and preparation method, sample container and preservation requirements, and hold times are summarized in Table 6-1.

6.1.4 Sample Packing 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 this Work Plan. Specific procedures for packaging and shipping groundwater samples are presented below:

1. A sample label, completed with indelible ink, will be attached to the sample bottle.
2. A picnic cooler (e.g., Coleman or other sturdy 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, or Styrofoam beads, will be placed in the bottom of the liner.
3. The containers will be placed in the lined picnic cooler. Cardboard separators may be placed between the containers at the discretion of the shipper.
4. All samples for chemical analysis must be shipped cooled to 4 degrees Celsius with ice. All samples will require icing before shipment. A temperature blank will be included in each shipment of samples.
5. 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.
6. A copy of the chain-of-custody form will be placed inside the cooler.
7. The cooler will be closed and taped shut with strapping tape (filament-type).
8. 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.

9. The cooler of samples will be shipped via an overnight carrier. A standard air bill is necessary for shipping environmental samples.

6.1.5 Sample Custody

Sampling information will be recorded on a chain-of-custody form and sample collection forms for tracking. All entries will be legible and recorded in indelible ink. In addition to providing a custody exchange record for the samples, the chain-of-custody serves as a formal request for sample analyses. The chain-of-custody form will be completed, signed, and distributed as follows:

- One copy retained for inclusion in the project files.
- The original sent to the analytical laboratory with the sample shipment.

After the laboratory receives the samples, the sample custodian will inventory each shipment before signing for it, and note on the original chain-of-custody form any discrepancy in the number of samples, temperature of the cooler, or broken samples. The Project Chemist will be notified immediately of any problems identified with shipped samples. The Project Chemist will in turn notify the Project QC Manager, and together they will determine the appropriate course of action.

The laboratory will archive the samples and maintain their custody as required by the contract or until further notification from the Project Chemist, at which time the samples will either be disposed by the laboratory.

6.1.6 Sample Documentation

Sample collection logs, purge logs, and chain-of-custody forms will be completed by field personnel during monitoring and sampling activities. All sample documentation will be submitted with the Quarterly ISB Summary Memorandum (Section 8.2). Example sample collection logs, purge logs, and chain-of-custody forms are provided in Appendix A. All sample documentation will be submitted with the Quarterly ISB Summary Memorandum (Section 8.2).

Field personnel or the project chemist will coordinate with the off-site laboratories for shipment and receipt of sample bottles, coolers, ice packs, chain-of-custody forms, and custody seals. All project-related data will be maintained and archived in the electronic project files.

6.1.7 Decontamination Procedures

Decontamination of all groundwater sampling and measurement equipment will include washing with Alconox®, or similar, and a subsequent rinse with deionized water. Dedicated sampling equipment will not require pre-sampling decontamination once installed into wells. Decontamination is required for all measurement or sampling equipment prior to reuse in any site wells.

6.2 Analytical Methods

Groundwater samples will be submitted for laboratory analysis to assess concentrations of site contaminants, geochemical conditions, and microbial activity.

The following analyses will be performed to assess concentrations of identified site contaminants:

- Volatile organic compounds (VOCs) by EPA Method 8260B
- EDB by EPA Method 8011

The following analyses will be performed to help assess site geochemical conditions:

- Dissolved iron and manganese by EPA Method 6010C
- Anions (bromide, nitrate, nitrite, chloride, and sulfate) by EPA Method 9056A
- Nitrate and nitrite as nitrogen by EPA Method 353.2
- Iodide by EPA Method 300.0
- Alkalinity by Standard Method 2320B
- Dissolved ortho-phosphate by Standard Method 4500 PE

The following analyses will also be performed to help assess microbial and degradation activity:

- Reduced/dissolved gases by RSK SOP-175
- Volatile fatty acids by EPA Method 300 Modified
- Microbial Community by QuantArray-Chlor

Samples collected for VOCs, EDB, dissolved iron and manganese, anions, nitrate, nitrite, and alkalinity will be submitted to ALS Environmental located in Houston, Texas. Samples collected for iodide will be submitted to ALS Environmental in Cincinnati, Ohio. Samples collected for reduced/dissolved gases and volatile fatty acid analyses will be submitted to the APTIM Lawrenceville Laboratory located in Lawrenceville, New Jersey. Quant-Array Chlor samples will be submitted to Microbial Insights, Inc. located in Knoxville, Tennessee. Sample results will be reported at reporting limits that are below applicable regulatory limits. Laboratory reporting limits for each analytical suite and the applicable regulatory limits are summarized in Table 6-2.

6.3 Quality Assurance

Quality assurance and quality control protocols associated with the sampling and analysis activities for regulated compounds will be pursuant with the Quality Systems Manuals for Environmental Laboratories, Version 5.3 (U.S. Department of Defense, 2019) and the RCRA Permit (NMED, 2010). Equipment calibration procedures and field quality control samples are discussed in the sections below.

6.3.1 Calibration Procedures and Frequency

All field instruments will be calibrated in accordance with manufacturers’ recommendations. Calibration will be performed within a day of use. A record of calibration will be made in the field logbook each time a field instrument is calibrated.

The calibration procedures for off-site analyses will follow the established EPA SW-846 guidelines for the specific method, where applicable. Certified standards will be used for calibrations and calibration check measurements, where applicable. A separate laboratory calibration record will be maintained by laboratory quality assurance personnel, where applicable.

6.3.2 Field Quality Control Samples

Internal quality control data provide information for identifying and defining qualitative and quantitative limitations associated with measurement data. Field quality control samples will be collected as part of each quarterly sampling event and will include field duplicate, matrix spike, matrix spike duplicates, and trip blank samples, as applicable. Field duplicate samples will be collected at a frequency of 10 percent of the total number of laboratory samples for that quarterly sampling event, or a minimum of one per event. Field duplicate samples will not be collected for microbial analysis. Matrix spike/matrix spike duplicate samples will be collected at a frequency of 5 percent of the total number of laboratory samples for that quarterly sampling event, or a minimum of one per event. Trip blank samples will be shipped with coolers containing samples for VOC analysis. Additionally, a temperature blank will be included with each shipment of groundwater samples from the field to the offsite laboratory. Field quality control samples are summarized in Table 6-3.

6.3.3 Laboratory Quality Control Samples

To ensure acceptable data quality, laboratory QC analysis will be performed for each applicable method. Laboratory QC samples will include method blanks, initial and continuing calibration blanks, surrogates, LCSs, and internal standards. Laboratory QC requirements for regulated compounds are consistent with the Quality Systems Manuals for Environmental Laboratories, Version 5.3 (U.S. Department of Defense, 2019).

6.4 Bladder Pump Maintenance

Decreased discharge volume is common with bladder pumps, as the Teflon™ bladder creases with use over time and is not able to open to full capacity during recharge/filling. If a well does not produce water, steps will be taken to troubleshoot the issue. If required, the dedicated pump and tubing may be pulled from the well for inspection and repair/replacement.

7. WASTE MANAGEMENT PLAN

Waste will be managed in accordance with applicable local, state, and federal regulations, as well as Kirtland AFB requirements. IDW anticipated to be generated during long-term monitoring and well assessment activities will consist of well purge water, decontamination water, and waste materials associated with these activities (personal protective equipment, disposable sampling equipment, and other inert material). Waste characterization requirements, details regarding waste handling, and transportation and disposal details are summarized in the sections below.

7.1 Waste Characterization

IDW will be characterized using data obtained from the analysis of groundwater samples collected during quarterly monitoring activities, through analysis of samples collected directly from the waste, through knowledge of waste-generating process, or through a combination of these methods. A hazardous waste evaluation will occur for all waste generated at the site. Liquid IDW will be sampled for the following parameters:

- Anions by EPA Method 300
- Nitrate by EPA Method 353.2
- Dissolved metals by EPA Method 6010
- Total lead by EPA Method 6010
- Semivolatile organic compounds by EPA Method 8270
- VOCs by EPA Method 8260
- EDB by EPA Method 8011

It is anticipated that all liquid IDW will require offsite disposal as non-hazardous or hazardous waste.

7.2 Waste Handling

IDW will be managed in secured hazardous waste accumulation areas (less-than 90-day) or non-hazardous waste storage areas from the time it is generated until it is removed from the site. An inventory of IDW containers will be maintained onsite in a logbook to demonstrate that accumulation time frames have not been exceeded. Liquid IDW will be contained in 55-gallon, open-top metal drums (hazardous) and 275-gallon totes (non-hazardous). Containers will remain closed except during addition or removal of waste. Hazardous waste will be removed from the site within 90 days of generation. The date of generation is the day that a waste is first placed in a container.

7.2.1 Waste Storage Area

Hazardous IDW will be stored in the less than 90-day accumulation area on secondary containment pads. The less than 90-day accumulation area will contain appropriate emergency response equipment, including spill kits and a fire extinguisher, and an emergency eyewash station. The site-specific hazardous material contingency plan and inspection forms will be stored in a water-tight container within the accumulation area. The less than 90-day accumulation area is enclosed by security fencing equipped with barbed wire and a locked gate.

7.2.2 Labeling

The labeling of waste containers will be in accordance with all applicable regulations. Labels will include the type of waste, location from which the waste was generated, and accumulation start date.

Containers used to store/accumulate waste will include an “Analysis Pending” sticker which can be a temporary label used until analytical results are received and reviewed. This label will include the accumulation start date and well identification information. After the waste is characterized, "Analysis Pending" labels will be immediately replaced with one of the following labels:

- "Hazardous Waste" (Resource Conservation and Recovery Act hazardous waste) - Pre-printed hazardous waste labels with the following information:
  - Generator information (name, address)
  - Kirtland EPA identification number
  - Applicable EPA waste number(s) (e.g., D018)
  - Accumulation start date
  - Proper Department of Transportation (DOT) shipping name
  - Prior to transport applicable DOT markings (49 Code of Federal Regulations [CFR], Part 172, Subpart D) and the manifest number must be added (for containers of less than 110-gallon capacity)

The label must also provide the generator name and address, and the manifest document number.

- "Non-Hazardous Waste" - Preprinted labels with the following information:
  - Accumulation start date
  - Generator name
  - EPA Identification number
  - Waste-specific information (e.g., purge water)

7.2.3 Inspections

The less than 90-day accumulation area will be inspected on a weekly basis for evidence of corrosion, bulging containers, discharges, and leaks. Additionally, labels will be checked for accuracy or replacement. Any deficiencies observed or noted during inspection will be corrected immediately. Inspections will be recorded on Inspection Logs (Appendix A).

7.2.4 Training

Field personnel will be trained in the proper handling of hazardous waste. All personnel will have completed Occupational Safety and Health Administration 29 CFR 1910.120 Hazardous Waste Operations and Emergency Response training.

7.3 Profile and Shipping Documentation

Prior to offsite disposal of waste, APTIM will provide Kirtland AFB with a waste approval package for each waste stream. This package will include a waste profile naming Kirtland AFB as the generator of the waste, analytical summary table(s) applicable to the waste, land disposal restriction notification for any hazardous wastes if generated, a completed waste manifest, and any other applicable information necessary for Kirtland AFB to complete its review of the disposal package and signature as the generator. The signed profile will then be submitted to the disposal facility for acceptance and approval. Once approval confirmation is received from the disposal facility, transportation can be scheduled. Confirmation of the waste profile approval will be received prior to scheduling of offsite transportation of the waste. The generator (Kirtland AFB) and the transporter must sign the manifest prior to the load of waste leaving the site. A copy of this manifest will be retained and the original signed manifest will be returned to the generator for their records. The Treatment, Storage, or Disposal Facility will provide a copy of the facility-signed manifest to the generator.

The highest concentrations observed in IDW and initial groundwater samples will be used to generate waste profiles. Quarterly groundwater analytical data will be reviewed to determine if the waste profiles require updating (if higher concentrations are observed). This will eliminate the need to frequently sample liquid IDW generated during sampling activities.

7.4 Transportation

Following waste characterization, the waste will be picked up by a transportation company with appropriate licenses and health and safety requirements for transportation to the selected disposal facility as determined by the waste profile. It is anticipated that liquid IDW generated from monitoring activities will be placed in 55-gallon steel drums (hazardous) and 275-gallon totes (non-hazardous). Those containers will be directly loaded into the transport vehicle using a forklift for disposal by the subcontractor. All containers will be properly closed and secured prior to transport offsite.

All vehicles will be inspected prior to loading. Transport vehicles will be directed to the pickup location by APTIM personnel. After loading the transport vehicle, APTIM personnel and the driver will complete the necessary shipping papers. Any applicable DOT placarding of the vehicle will then occur as will a walk-around inspection of the transport vehicle. APTIM reserves the right to reject any transport vehicle without proper permits and licenses, or that appears to be unsuitable for transport according to DOT regulations.

7.5 Disposal

It is anticipated that both non-hazardous and hazardous liquid IDW will be transported to Advanced Chemical Treatment in Albuquerque, New Mexico. Waste manifests will be completed for each load leaving the Site to document the method of disposal, quantity of material disposed, and the final disposition location.

7.6 Waste Minimization Plan

In order to minimize the volume of waste, the following general rules will be applied:

- Do not contaminate materials unnecessarily:
- Plan work ahead, based on the work procedure to be used.

- Take only the material (i.e., chemicals) needed to perform the work activity. Additional material can be brought to the work location if it is found to be necessary. Materials can be stored in large containers but the smallest reasonable container will be used to transport the material to the location where it is needed.
- Maintain cleaning and extra sampling supplies outside any potentially contaminated area to keep them clean and to minimize additional waste generation.
- Maintain or construct prefabricated materials, barriers, support equipment, etc., outside potentially contaminated areas.
- Perform mixing of detergents or decontamination solutions outside potentially contaminated areas.
- Do not place media considered hazardous for different reasons together.
- Use drop cloths or other absorbent material to contain small spills or leaks.
- Use containers to minimize the spread of contamination.
- Do not place contaminated materials with clean materials.
- Decontaminate and re-use material and equipment when practical. Use volume reduction techniques when practicable.
- Verify that waste containers are solidly packed to minimize the number of containers.
- Use only the size of container to meet needs (i.e., do not use a drum or garbage can when a small polyethylene bag will do).
- Use less hazardous substances whenever possible (i.e., bring only the volume of standard solutions needed for testing, use minimal amounts of decontamination water and solvent rinses).

7.7 Recordkeeping

The following records and documents will be maintained on site to track waste leaving the site:

- Transportation and offsite disposal records, including:
  - Profiles and associated characterization data
  - Waste manifests, and weight tickets
  - Designated offsite facility waste receipts, land disposal restriction

    notifications/certification, certificates of disposal/destruction
  - Field transportation and disposal log

- Training records
- Inspection records

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8. DATA MANAGEMENT AND REPORTING

Long-term monitoring will be conducted for a minimum of three quarterly events. Groundwater monitoring data will be validated and long-term performance of the ISB system will be assessed. Field activities, analytical results, and evaluations of the data will be documented in quarterly and annual memoranda/reports. Any proposed changes to the long-term monitoring program will be submitted in an Addendum to this Work Plan for NMED approval.

8.1 Data Review

Four laboratories will provide analytical results in support of long-term monitoring activities: ALS Environmental in Houston, Texas; ALS Environmental in Cincinnati, Ohio; Microbial Insights, Inc. in Knoxville, Tennessee; and the APTIM laboratory in Lawrenceville, New Jersey. Section 6.2 discusses the specific analyses performed by each laboratory. The laboratories will provide results in either portable document format (PDF) or electronic data deliverable (EDD) format, or both. EDDs will be checked against the laboratory reports, and then loaded to the project database (EQUIS). The EDD will be used for applying the electronic data review process. When appropriate, analytical data will undergo a Stage 2B data review by the Project Chemist. EPA qualifiers (J, U, etc.) will be assigned to the sample results that were outside of established control criteria. Data not sufficient to meet data quality objectives will be excluded from data evaluations.

All project-related data will be maintained and archived in electronic project files. All data generated in support of this contract will be maintained in accordance with the contract requirements.

8.2 Quarterly ISB Summary Memoranda

Quarterly ISB Summary Memoranda will be prepared to document ISB field activities, monitoring results, and ISB performance for each quarter. The Quarterly ISB Memorandum will be included with the BFF Quarterly Monitoring Report (prepared by others) for submittal to NMED.

8.3 Annual ISB Report

An annual ISB Report will be prepared to document and assess the findings and effectiveness of ISB activities conducted during the year. Field activities will be summarized and monitoring data will be assessed and evaluations presented in the report. A Data Quality Summary Report will be included in the Annual ISB Report.

9. PROJECT SCHEDULE

The following includes a list anticipated dates for key tasks associated with long-term monitoring at the ISB pilot test wells:

- Quarterly Monitoring Events – a minimum of three quarterly monitoring events will be performed upon NMED approval of this Work Plan.
- Weekly Inspections – beginning December 2019.
- Quarterly ISB Summary Memoranda – submitted within 90 days of the end of the calendar quarter.
- Annual ISB Report – submitted within 90 days of the end of fourth quarter.

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10. ACCIDENT PREVENTION PLAN

A comprehensive Accident Prevention Plan (APP), including the Site Safety and Health Plan for both the ISB pilot test area and injection well KAFB-7 work will be submitted to Kirtland AFB. The APP complies with the appropriate standards contained in Chapter 29, CFR, Section 1910; 29 CFR 1926; Safety and Health Requirements Manual, Engineer Manual 385-1-1 (USACE, 2014); and Unified Facilities Guide Specifications, Governmental Safety Requirements, Section 01 35 26 (USACE et al., 2015).

The APP include names and organization chart of key personnel and alternates, safety and health assessments and risk analysis, site description, education and training, personnel protective equipment, medical surveillance, heat/cold stress, and air monitoring procedures, engineering controls, standard operating procedures, work practices, exclusion zones, decontamination approach, and emergency response and equipment.

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FIGURES

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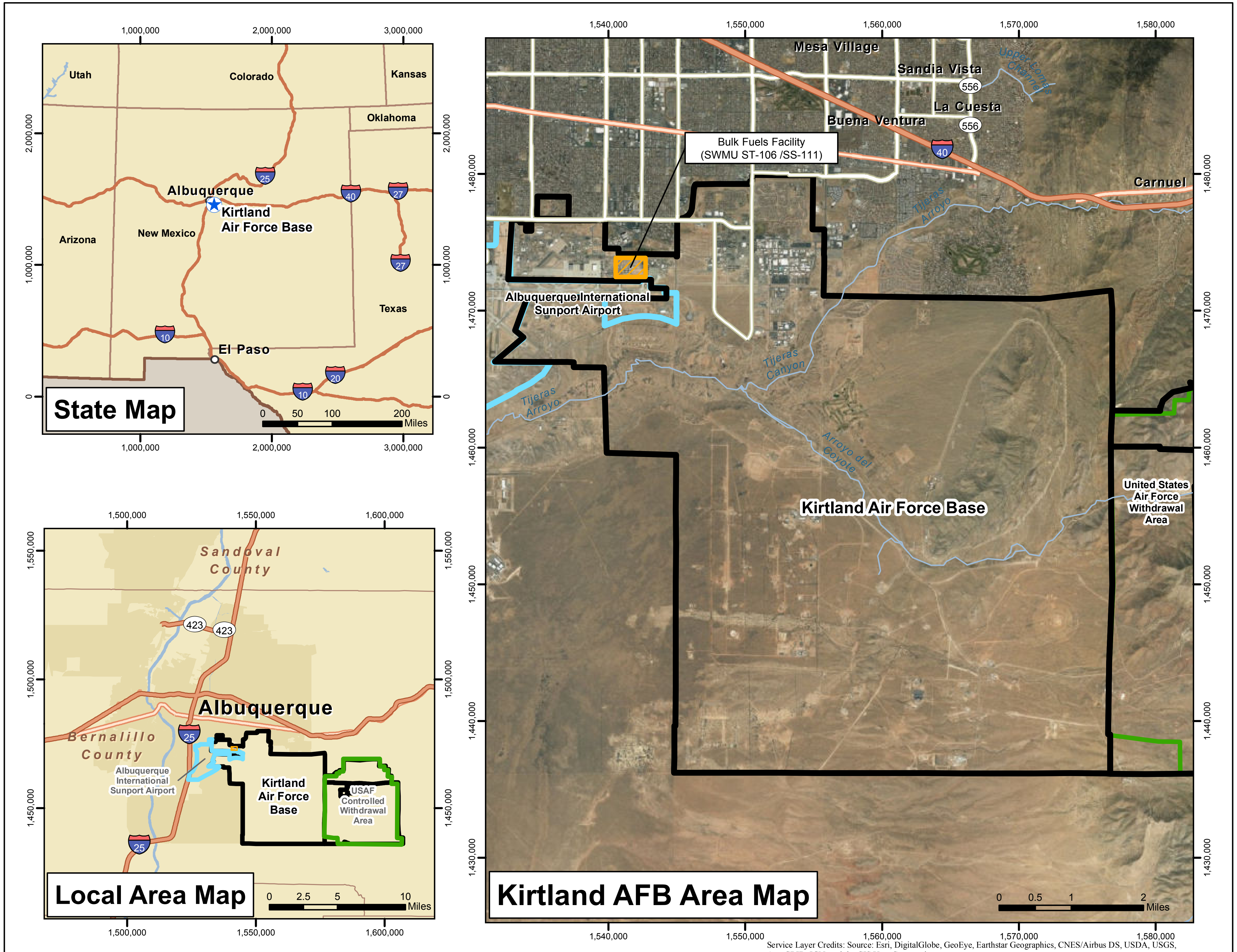

Legend

- Kirtland Air Force Base Installation Boundary
- Bulk Fuels Facility (SWMU ST-106/SS-111)
- Albuquerque International Sunport Airport
- United States Air Force Withdrawal Area
- Major Highways
- Highways
- Major Roads
- Rivers

SWMUs = Solid Waste Management Unit
AFB = Air Force Base
USAF = United States Air Force

N

Revision Date: 11/05/19

Projection : NAD83 State Plane New Mexico Central FIPS3002 Feet

IN SITU BIOREMEDIATION
LONG-TERM MONITORING WORK PLAN
KIRTLAND AIR FORCE BASE, NEW MEXICO

FIGURE 2-1

AREA LOCATION MAP

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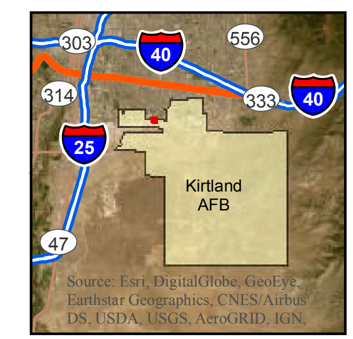
Legend

- Existing Monitoring Well
- Pilot Test Injection/Extraction Well
- Pilot Test Monitoring Well
- Fence Line
- Natural Gas Line
- Wastewater Line
- Water Line
- Electrical Cable Line
- Construction Fence
- Truck Exit Route
- Pilot Test Trench Location for Water Pipe and Subsurface Electrical
- Pilot Test System Location
- Pilot Test Existing Electrical Tie-in
- Electrical Service Line
- Storage Shed

KAFB = Kirtland Air Force Base



SITE LOCATION

Revision Date: 11/05/19

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0 15 30 60

Feet

1 inch = 60 feet

Projection : NAD83 State Plane New Mexico Central FIPS3002 Feet

IN SITU BIOREMEDIATION
LONG-TERM MONITORING WORK PLAN
KIRTLAND AIR FORCE BASE, NEW MEXICO

FIGURE 2-2

SITE LOCATION MAP

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TABLES

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Table 2-1
Well Completion Details

Well ID	Well Type	Screened Interval (feet bgs)[a]	Well Depth (feet bgs)[a]	Pump Intake[a]	Casing Diameter
KAFB-106EX1	Extraction	487 - 502	507	491	6.00
KAFB-106EX2	Extraction	487 - 502	507	491	6.00
KAFB-106IN1	Injection	477 – 497	502	492	6.00
KAFB-106MW1-S	GWM	463 - 498	500.5	488	4.00
KAFB-106MW1-I	GWM	513 - 523	528	518	3.00
KAFB-106MW2-S	GWM	463 - 498	500.5	488	4.00
KAFB-106MW2-I	GWM	513 - 523	528	518	3.00
KAFB-106063	GWM	508 – 523	528	511	5.00
KAFB-106064	GWM	488 - 508	513	495	5.00

Notes:
[a]Screened interval, well depth, and pump intake for existing wells KAFB-106063 and KAFB-106064 are measured from top of casing (approximately 3 feet above ground surface).

bgs – below ground surface.

GWM – groundwater monitoring.
ID – identification.

KAFB – Kirtland Air Force Base.

Table 6-1
Analytical Requirements

Sample Locations	Analytical Group	Sample Count[a]	Analytical Method	Container	Preservation Requirements	Maximum Holding Time
KAFB-106063 KAFB-106064 KAFB-106MW1S KAFB-106MW1I KAFB-106MW2S KAFB-106MW2I KAFB-106EX1 KAFB-106EX2 KAFB-106IN1	VOCs	27	EPA 8260C	3x40-mL volatile organic analysis (VOA) vials	6°C with HCl to pH<2, no headspace	14 days
	EDB	27	EPA 8011	3x40-mL VOA vials	6°C, no headspace	14 days
	SVOCs	27	EPA 8270D	2x1 L glass	6°C	7 days for extraction and 40 days for analysis
	Dissolved Metals	27	EPA 6020A	1x250-mL polyethylene screw-cap	Filter with 0.45 um capsule filter in the field, 6°C with HNO_3 to pH<2	6 months
	Total Lead	27	EPA 6020A	1x250-mL polyethylene screw-cap	6°C with HNO_3 to pH<2	6 months
	Anions	27	EPA 300.0	1x250-mL polyethylene screw-cap	6°C	48 hours for nitrate and nitrite and 28 days for all other anions
	Alkalinity	27	SM 2320B	1x250-mL polyethylene screw-cap	6°C	14 days
	Dissolved Ortho-Phosphate	27	SM 4500 PE	1x250-mL polyethylene screw-cap	Filter with 0.45 um capsule filter in the field, 6°C	48 hours
	VFAs	27	EPA 300.0	2x40-mL VOA vials	6°C	14 days
	Dissolved Gases	27	RSK 175	2x40-mL VOA vials	6°C with HCl to pH<2	14 days
	Microbial Community	27	QuantArray-Chlor	1-liter polyethylene screw-cap (x1)	6°C	48 hours

Table 6-1
Analytical Standard Operating Procedure Requirements

Notes:
[a] Sample count is for parent samples only. Field quality control samples are summarized in Table 6-3. It is anticipated that three quarterly sampling events will be completed.
°C – degrees Celsius.
EDB – ethylene dibromide.
EPA – U.S. Environmental Protection Agency.
HCl – hydrochloric acid.
HNO_3 – nitric acid.
KAFB – Kirtland Air Force Base.
mL – milliliter.
MS/MSD – matrix spike/matrix spike duplicate.
No. – number.
SM – Standard Method.
SVOC – semivolatile organic compound.
VFA – volatile fatty acid.
VOC – volatile organic compound.

Table 6-2
Laboratory Reference Limits and Comparison Criteria

Analyte	CAS Number	Units	EPA MCL[a]	NMWQCC Standard[b]	Project Quantitation Limit Goal	Laboratory-Specific		
						LOQ	LOD	DL
VOCs by EPA Method 8260C								
Acetone	67-64-1	µg/L	None	None	4	2	1	0.4
Benzene	71-43-2	µg/L	5	5	2	1	0.5	0.2
n-Butyl Benzene	104-51-8	µg/L	None	None	2	1	0.5	0.4
2-Butaone	78-93-3	µg/L	None	None	4	2	1	0.5
sec Butyl Benzene	135-98-8	µg/L	None	None	2	1	0.5	0.3
tert Butyl Benzene	98-06-6	µg/L	None	None	2	1	0.5	0.3
Carbon Disulfide	75-15-0	µg/L	None	None	4	2	1	0.6
Chloromethane	74-87-3	µg/L	None	None	2	1	0.5	0.2
2-Chlorotoluene	95-49-8	µg/L	None	None	2	1	0.5	0.3
1,2-Dibromomethane[c]	106-93-4	µg/L	0.05	0.05	1	1	0.5	0.2
Dichlorodifluoromethane	75-71-8	µg/L	None	None	2	1	0.5	0.3
1,2-Dichloroethane	107-06-2	µg/L	5	5	2	1	0.5	0.2
cis-1,2-Dichloroethene	156-59-2	µg/L	70	70	2	1	0.5	0.2
Ethylbenzene	100-41-4	µg/L	700	700	2	1	0.5	0.3
2-Hexaone	591-78-6	µg/L	None	None	4	2	1	1
Isopropylbezene	98-82-8	µg/L	None	None	2	1	0.5	0.3
p-Isopropyltoluene	99-87-6	µg/L	None	None	2	1	0.5	0.3
Methylene Chloride	75-09-2	µg/L	5	5	4	2	1	0.4
Naphthalene	91-20-3	µg/L	None	30	2	1	0.5	0.3
4-Methyl-2-Pentanone	108-10-1	µg/L	None	None	4	2	1	0.7

Table 6-2
Laboratory Reference Limits and Comparison Criteria

Analyte	CAS Number	Units	EPA MCL[a]	NMWQCC Standard[b]	Project Quantitation Limit Goal	Laboratory-Specific		
						LOQ	LOD	DL
VOCs by EPA Method 8260C								
Methyl-t-Butyl Ether	1634-04-4	µg/L	None	100	2	1	0.5	0.2
n—Propylbenzene	103-65-1	µg/L	None	None	2	1	0.5	0.3
Tetrachloroethylene	127-18-4	µg/L	5	5	2	1	0.5	0.3
Toluene	108-88-3	µg/L	1,000	1,000	2	1	0.5	0.2
1,1,2-Trichloroethane	79-00-5	µg/L	5	5	2	1	0.5	0.5
Trichloroethene	79-01-6	µg/L	5	5	2	1	0.5	0.3
Trichlorofluoromethane	75-69-4	µg/L	None	None	2	1	0.5	0.3
1,3,5-Trimethylbenzene	108-67-8	µg/L	None	None	2	1	0.5	0.3
1,2,4-Trimethylbenzene	95-63-6	µg/L	None	None	2	1	0.5	0.5
Vinyl Chloride	75-01-4	µg/L	2	2	2	1	0.5	0.2
Xylenes	1330-20-7	µg/L	10,000	620	2	1	0.5	0.2
EDB by EPA Method 8011								
1,-2-Dibromomethane	106-93-4	µg/L	0.05	0.05	0.04	0.02	0.01	0.003
SVOCs by EPA Method 8270D								
1-Methylnaphthalene[d]	90-12-0	µg/L	None	30	0.2	0.1	0.05	0.01
2-Methylnaphthalene[d]	91-57-6	µg/L	None	30	0.2	0.1	0.05	0.019
Acetophenone	89-86-2	µg/L	None	None	0.4	0.2	0.1	0.024
Dissolved Gases by RSK 175								
Methane	74-82-8	µg/L	None	None	4	2	NA	0.286
Ethane	74-84-0	µg/L	None	None	8	4	NA	0.647

Table 6-2
Laboratory Reference Limits and Comparison Criteria

Analyte	CAS Number	Units	EPA MCL[a]	NMWQCC Standard[b]	Project Quantitation Limit Goal	Laboratory-Specific		
Dissolved Gases by RSK 175								
Ethene	74-85-1	µg/L	None	None	10	5	NA	0.838
Propane	74-98-6	µg/L	None	None	12	6	NA	0.852
Acetylene	74-86-2	µg/L	None	None	20	10	NA	2.01
VFA by EPA Method 300.0 Modified								
Lactic Acid	50-21-5	mg/L	None	None	2	1	NA	0.112
Acetic Acid	64-19-7	mg/L	None	None	2	1	NA	0.047
Propionic Acid	79-09-4	mg/L	None	None	2	1	NA	0.185
Formic Acid	64-18-6	mg/L	None	None	2	1	NA	0.022
VFA by EPA Method 300.0 Modified (continued)								
Butyric Acid	107-9-6	mg/L	None	None	2	1	NA	0.144
Pyruvic Acid	113-24-6	mg/L	None	None	2	1	NA	0.032
Valeric Acid	109-52-4	mg/L	None	None	2	1	NA	0.258
Dissolved and Total Metals by EPA Method 6020A								
Dissolved Iron	7439-89-6	mg/L	None	1	0.4	0.2	0.05	0.012
Dissolved Manganese	7439-96-5	mg/L	None	0.2	0.01	0.005	0.001	0.0007
Total Lead	7439-92-1	mg/L	0.015	0.015	0.01	0.005	0.001	0.0006
Anions by EPA Method 300.0								
Nitrate	14797-55-8	mg/L	10	10	0.2	0.1	0.1	0.03
Nitrite	14797-65-0	mg/L	1	1	0.2	0.1	0.1	0.03
Chloride	16887-00-6	mg/L	None	250	1	0.5	0.5	0.2
Sulfate	14808-79-8	mg/L	None	600	1	0.5	0.5	0.2
Bromide	24959-67-9	mg/L	None	None	0.2	0.1	0.1	0.03

Table 6-2
Laboratory Reference Limits and Comparison Criteria

Analyte	CAS Number	Units	EPA MCL[a]	NMWQCC Standard[b]	Project Quantitation Limit Goal	Laboratory-Specific		
Anions by EPA Method 300.0								
Iodide	7553-56-2	mg/L	None	None	0.4	0.2	0.2	0.2
Anions by SM4500 PE								
Dissolved Phosphate	7778-78-0	mg/L	None	None	0.1	0.05	0.05	0.01
Wet Chemistry by SM2320B								
Alkalinity	3812-32-6	mg/L	None	None	10	5	5	5

Notes:

[a] U.S. Environmental Protection Agency (EPA) the maximum contaminant level (MCL) from the Regional Screening Level Summary Table, November 2019 (EPA, 2019).
[b] New Mexico Water Quality Control Commission (NMWQCC) Groundwater Standards are from 20.6.2.3103 New Mexico Administrative Code (NMAC).
[c] The LOQ/LOD/Detection Limit (DL) for EDB by EPA Method 8260C exceed the EPA MCL requirement. For each groundwater sample, EDB will be analyzed by both EPA Methods 8260C and 8011. The LOQ for EDB by EPA Method 8011 meets the EPA MCL requirement.
[d] The regulatory standard is the total concentration of naphthalene and monomethylnaphthalenes.
µg/L - micrograms per liter.
mg/L - milligram per liter.
NA - not available.

Table 6-3
Field Quality Control Sample Summary Table

Matrix	Analytical Group	No. of Primary Sampling Locations	No. of Field Duplicates	No. of MS/MSDs	No. of Field Blanks	No. of Equipment Rinse Blanks	No. of Trip Blanks	Total No. of Samples to Laboratory
Liquid (GW)	VOCs EDB SVOCs Dissolved Metals (iron and manganese) Total Lead Anions[a] Dissolved Gases VFAs Alkalinity Microbial Community	9 wells samples quarterly	10 percent (minimum of 1 per quarter)	5 percent (minimum of 1 per quarter)	None (dedicated sampling equipment will be used)	None (dedicated sampling equipment will be used)	1 per shipment (assumes 12 shipments of VOCs)	42 (estimated)

Notes:
It is anticipated that three quarterly sampling events will be completed.
[a] Anions include: bromide, nitrate, nitrite, chloride, sulfate, dissolved ortho-phosphate, and iodide.
EDB – ethylene dibromide.
GW – groundwater.
MS/MSD – matrix spike/matrix spike duplicate.
No. – number.
VFA – volatile fatty acid.
VOC – volatile organic compound.

APPENDICES

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APPENDIX A
FIELD FORMS

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Weekly 90-Day Hazardous Waste Storage Area Inspection Log

Inspection Date:

Inspector:

Facility: RAPID Response ESTCP Pilot Test Site, Kirtland AFB

Description	Requirement Met? (Y, N, N/A)	Correction Date	Comments/Corrective Action Taken
Safety equipment onsite (eye wash, etc.)			
Is eye wash station full			
Has fire extinguisher been inspected recently			
Area secure to prevent unauthorized entry (fencing, lock, etc.)			
Personnel using sign-in inventory logs			
Area posted with appropriate cautionary signage			
Spill control equipment onsite			
Spill control equipment sufficient for quantity of waste (1.5 times the largest drum volume)			
Is the spill kit inventory complete?			
Secondary containment free from external leaks			
Any visible signs of leaking containers (if yes, contact EHS Manager)			
Containers compatible with waste being stored			
Do any drums show signs of damage (bulging, dented, etc.)			
Containers properly sealed			
All containers labeled with "Hazardous Waste" label			
Labels visible for inspection			
Accumulation start dates present on labels			
Information on all labels is legible and not faded			
Are any waste accumulation dates greater than 90 days			
Aisles and gateways free of obstructions			
Is the area free of debris and other materials			
Adequate separation of incompatible materials			

CALIBRATION LOG

Page of

Project Name/Location: ______________________________ Project No. ____________

Equipment Number and Use (Screening or Analytical)	Equipment Name (Manufacturer and Model ID)	Date and Time of Calibration	Calibration Standard Used (Manufacturer and Lot Number)	Equipment Rating (include Units and Tolerance)	Comments/Observations	Calibrator=s Initials

Note: Complete calibration and record information before use for all test equipment that requires calibration.

CHAIN OF CUSTODY

APTIM

Reference Document #

GW Sampling

Project Number:

Project Name / Location:

Purchase Order #:

Shipment Date:

UPS Number:

Project Manager: Kathleen Romalia

Send Report To: Susan Huang
Phone Number: 925-288-2099
Address: 4005 Port Chicago Hwy
City: Concord, CA 94520
susan.huang@aptim.com

Lab Destination:

Mon-Fri DELIVERY

Lab Contact Name:

Phone #:

Sampler's Name(s):

Sample ID Number	Location	Date	Time	Method	Matrix	# of containers	Preservative / Container	Requested Analyses			

Turnaround Time: **Standard 21 Day** ☐ 24-hr ☐ 48-hr

All Methods ☐ 3-day

Level Of QC Required: I II (III) IV Project Specific unless IV requested

Relinquished By:	Date: Time:	Received By:	Date: Time:
Relinquished By:	Date: Time:	Received By:	Date: Time:

GROUND WATER SAMPLE COLLECTION LOG

Project Name: KAFB RAPID ESTCP
Site Location: Kirtland AFB, SWMU ST-106/SS-111
Project No.: 500433
Well ID: KAFB-106
Sample ID 106
Date / Time Collected ____________

EQUIPMENT / NOTES

Sample Collected by: ____________
Purging Method/Equipment: Micropurge
Sampling Equipment.: ☐ Bladder Pump ☐ Other ____________
Flow Rate During Purging : ____________
Note: Flowrate for VOC sampling should be no greater than 1 L/min
Daily field instrument calibration verification performed? **Yes** ___ **No** ___

PURGING INFORMATION

Measuring Point ____________
Casing ID (in.) ____________
Approximate depth of pump inlet*(ft): ____________
Depth to Water - Initial (DTWi) (ft) ____________
Length of Casing (ft): N/A
Depth to Well Bottom (ft) ____________
Screen Interval (ft): ____________

FIELD CONDITIONS

Weather Conditions: ☐ Sunny ☐ Rain ☐ Wind ☐ Cloudy Temperature: ____________

Time of Reading	Volume Purged (mL)	Dynamic Depth to Water	Conductivity (mS/cm)	Temperature (°C)	pH	Turbidity (NTU)	ORP (mV)	DO (mg/L)
Purge Stabilization Criteria	--	--	±10%	± 10%	±10%	± 10%	± 10 mV	± 10%

☐ **Duplicate or MS/MSD Collected:** ____________

If the water level is above the top of the screen, the pump should be set at the approximate mid-point of the screen. If the water level is below the top of the screen, set the pump between the water level and the bottom of the screen.

Recharge: ____________
Pump on: ____________
Discharge: ____________
First Water: ____________
psi (start): ____________
QED Controller #: ____________
psi (finish): ____________
YSI #: ____________
Water level #: ____________
Turbidity Meter #: ____________

Sample Collection Log

501397 ISB LTM – Groundwater

Location Code ____________________ RFA/COC Number_______________________

Sample Number ___________________ Collection Date _______________________

Sampling Method _____________________ Collection Time _______________________

Sample Type ____________________ Start Depth_____________________

QC Code___________________________ End Depth_______________________

Sampling Equipment_________________________ Sample Matrix____________________

QC Partners___________________________ Sample Team____________________

Containers:

Analytical Suite	Filtered	Qty	Size	Container Type	Preservative	Lab
EDB by 8011	NA	3	40 mL	VOA Vials	HCl	ALS Environmental
VOCs by 8260	NA	3	40 mL	VOA Vials	None	ALS Environmental
O-Phosphate by SM4500 PE	Yes	1	250 mL	Poly Bottle	None	ALS Environmental
Dissolved Fe and Mn by 6020A	Yes	1	250 mL	Poly Bottle	HNO3	ALS Environmental
Alkalinity by SM2320B	NA	1	250 mL	Poly Bottle	None	ALS Environmental
Anions (Chloride, Iodide, Sulfate, Bromide, Nitrate-Nitrite) by EPA 300	NA	1	250 mL	Poly Bottle	None	ALS Environmental
Reduced/Dissolved Gases by RSKSOP-175/EPA 3810	NA	2	40 mL	VOA Vials	HCl	APTIM
VFA by EPA 300m	NA	2	40 mL	VOA Vials	None	APTIM
Quant-Array Chlor	NA	1	1 L	Poly Bottle	None	Microbial Insights

Comments/Descriptions.

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Logged By/Date: ______________________ ***Reviewed By/Date:*** ______________________